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Review Article

INFLUENCE OF ACTIVE GAMES AND PLAY ON CHILDREN'S COGNITION: A SYSTEMATIC REVIEW

INFLUÊNCIA DOS JOGOS E BRINCADEIRAS ATIVOS NA COGNIÇÃO DE CRIANÇAS: UMA REVISÃO SISTEMÁTICA

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RESUMO

Jogos e brincadeiras são estratégias para auxiliar no desenvolvimento cognitivo do público infantil. Contudo ainda existem lacunas sobre os efeitos e associações dos jogos e brincadeiras ativos na cognição de crianças. Assim, o objetivo é sintetizar a influência dos jogos e brincadeiras ativos na cognição de crianças. As bases de dados foram: Lilacs, PsycINFO, Pubmed, Scielo e Scopus. Foram incluídos artigos com delineamento observacional ou experimental. A qualidade dos artigos foi avaliada com a RoB 2. Cinco estudos foram incluídos seguindo os critérios de elegibilidade. Todos os estudos apresentaram delineamento experimental, dois realizados de forma crônica e três de forma aguda. Três estudos apresentaram efeitos positivos dos jogos e brincadeiras na atenção, tempo de reação e funções executivas: controle inibitório, raciocínio lógico, fator verbal, fator numérico, fator espacial e inteligência geral. Quanto à qualidade metodológica dos estudos é necessário melhor descrição e utilização do processo de alocação da randomização, maior cuidado na análise de dados e evitar múltiplas avaliações para uma variável. Conclui-se que jogos e brincadeiras ativos podem gerar efeito positivo para a atenção e funções executivas de crianças. Mais estudos são necessários para compreensão da relação de parâmetros como intensidade, duração e tipos de atividades com a cognição.

Palavras-chave: Jogos e brinquedos. Cognição. Criança.

ABSTRACT

Games and play are strategies to assist in the cognitive development of children. However, there are still gaps about their effects and associations when it comes to children's cognition. Thus, the objective is to synthesize the influence of active games and play on the cognition of children. The databases searched were: Lilacs, PsycINFO, Pubmed, Scielo and Scopus. Articles with observational or experimental design were included. Their quality was evaluated by means of RoB 2. Five studies were included, in accordance with the eligibility criteria. All studies had an experimental design, with two being conducted chronically, and three, acutely. Three studies showed positive effects of games and play on attention, reaction time, and executive functions: inhibitory control, logical reasoning, verbal factor, numerical factor, spatial factor, and general intelligence. Regarding the methodological quality of the studies, it is necessary to better describe and use the randomization allocation process, be more careful with data analysis, and avoid multiple assessments for a single variable. It is concluded that active games and play can generate a positive effect on the attention and executive functions of children. Further research is needed for an understanding of the relationship that parameters such as intensity, length and types of activities have with cognition.

Keywords: Games and playthings. Cognition. Child.

Introduction

Engaging in games and play is a very present experience in childhood and has a major share in children's development[1]. During these activities, they can be provided with various motor stimuli (e.g., walking, jumping, kicking, running, rolling), which contributes to children's motor development[2]. The interaction between motor skills and cognitive functions, such as tactile exploration or postural control challenges, also stimulates the Central Nervous System[3]. Furthermore, social stimulation is a constant presence in games

and play, since children are always communicating and interacting, due to the goals and strategies of the activities[4].

Thus, the stimuli arising from engagement in games and play can assist in the process of integral development in childhood, in terms of cognition, motricity and affection[5]. However, the habit of playing among children is nowadays less and less noticeable, due to factors such as lack of safety, scarcity of spaces for play, which can consequently affect their mental health[6].

On the other hand, research has used games and play in various ways, with differences in their approach and purposes, but with the aim of understanding their possible contributions to children's lives. Thus, we can highlight their application to: Cognitive therapy; Teaching strategy for school content; Active electronic games; Behavioral assessment; Engagement in physical activity[7-10].

Active games and play that promote engagement in physical activity can be defined as a physical activity that helps with energy expenditure, is usually done in an open environment, promotes fun, and should be performed at any intensity[11].

They are currently a basic content for the education of children and adolescents and can meet the level of physical activity recommended daily, of moderate to vigorous intensity, by the World Health Organization (WHO)[12]. Moreover, whether through the playground in the school environment, whether in school physical education or in interventions, they can be important to raise children's physical activity levels and positively impact their health as a whole[13].

Silva and collaborators[14] observed that opposition games and play of moderate to vigorous intensity were able to benefit children's visual attention and academic performance. Additionally, interventions that can favor a more active school environment and reduce sedentary behavior through physical activity (games, breaks, sports, motor activities) can have a positive impact on cognitive functions (such as memory, attention, and motivation) and enhance the development of complex neural circuits and synaptic connections[15].

Some neurophysiological hypotheses have been postulated to explain possible changes in physical activity and its intensity (from moderate to vigorous), so we can speculate that active games and play: 1) increase cerebral blood flow; 2) boost the neurogenesis process 3) boost the angiogenesis process; 4) bring about a greater expression of brain-derived neurotrophic factor (BDNF); 5) promote a greater electrical activation of the cerebral cortex; 6) promote a greater activation of neurotransmitters; 7) improve the brain structure[16,17].

Notwithstanding findings on the benefits of games and play for children, to the best of our knowledge, there is no systematic review on the influence of active games and play on children's cognition, taking into account observational and experimental studies. In this sense, the main purpose of this study is to synthesize the scientific literature about the influence of active games and play on children's cognition.

Methods

Search and selection strategies

This systematic review was carried out following the guidelines of The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[18]. The review was registered and published in PROSPERO (CRD42021239900).

The databases used in this review were: Lilacs, PsycINFO, Pubmed, Scielo, and

Scopus. The terms used in the search were structured from the following blocks: 1st block (play, "play and game", "play and playthings", "active play", "pretend play", "free play", "risky play", "outdoor play", "creative play", "unstructured play", "outdoor time"); 2nd block (children, schoolchild, infant, kid, toddler, youngster); 3rd block (cognition, "cognitive function", "executive function", attention, memory, motivation). The article search strategy did not have a date established as a parameter for including articles, and the process ended on April 25, 2021.

The search strategy was established in blocks, using the Boolean operator "OR" in order to separate the terms and their respective synonyms. To join all blocks, the Boolean operator "AND" was used. No filter was applied during the search process in the databases.

The articles found in the databases should contain the descriptors at least in the title, abstract or keywords so that the material could be integrated into the review for the selection stage. The entire article search, selection and analysis process was conducted by peers, independently, without contact or consultation between researchers. At the end of each stage of the verification process, divergences regarding the inclusion or exclusion of articles were resolved by a third researcher. Articles identified from the references and that met the eligibility criteria were included in the review.

The first stage of the selection was the search in the databases. After this process, data relating to each database was stored in the Endnote x9 program. Subsequently, duplicate studies were checked, and then the two authors read the titles and abstracts of the articles in order to verify whether they met the inclusion criteria. In case of disagreement between the two authors over the selection of a study, a third author would resolve the conflict. After approval of the articles in accordance with the inclusion criteria, they were read in full. For excluded articles, the reason was stated, based on the inclusion and exclusion criteria mentioned above.

Eligibility criteria

The following inclusion criteria were adopted: all studies that investigated the association and/or effect of active games and play on children's cognitive functions; studies that used active games and/or play as one of their intervention strategies; quantitative studies with observational and experimental designs; studies with humans aged 3-12 years old; studies that fitted into the PICOS (Population, Intervention, Comparator, Outcomes and Study Design) strategy. The exclusion criteria were: studies that investigated the influence of electronic games on cognition; games and play that were not characterized as physical activity; books, review articles, dissertations and theses; studies that did not assess cognitive functions; studies that did not address games and play as an intervention strategy.

After the steps already mentioned, information about the year of publication, study location, and children's characteristics (age, sex, number of participants) was extracted and recorded. As for the characteristics of the intervention/exposure, the type (acute or chronic), length, activities and intensity of active games and play were extracted. Additionally, the variables and objective measures of cognitive functions were identified. On the results of the studies included in the review, the p value and effect size were obtained. Finally, the methodological quality of the articles included in the review was analyzed. All stages, as well as the construction of the flowchart, and the analyses during the review were carried out in accordance with the PRISMA-P[18] standard.

Quality assessment

The Revised Cochrane risk-of-bias tool for randomized trials (RoB 2) was used to

assess the methodological quality of the studies[19]. RoB 2 is intended to assess the risk of bias in randomized trials through five domains (1 - bias from the randomization process; 2 - bias due to deviations from intended interventions; 3 - bias from absent results data; 4 - bias in result measuring; 5 - bias in selection of reported results). Each RoB 2 domain has signaling questions responsible for judging the risk of bias of the analyzed study. These are objective questions, and the answer options are: (1) Yes; (2) Probably yes; (3) Probably not; (4) No; (5) No information. This process was conducted by peers, and if there was any disagreement between the two authors, the third author would be consulted.

Results

In the present study, the search in the databases returned 3,812 articles. After duplicate articles were checked, taking into account title, author and year of publication, 844 duplicate studies were excluded. Thus, 2,968 were selected to have their title and abstract read, with 2,927 studies being excluded for not meeting the PICOS strategy and the inclusion criteria of the review. For the full reading stage, 41 articles were included. After reading and analysis following the eligibility criteria, 37 studies were excluded, with only four remaining. Finally, one article was included from the references, totaling five studies included in the review and quality analysis (Figure 1). Among these studies, three had a Randomized Crossover Clinical Trial (RCCT) design, all verifying the effect of games and play acutely on cognitive parameters[20-22]. The other two studies had a Randomized Clinical Trial (RCT) design, verifying the effect chronically. It is worth noting that no study with an observational design met the eligibility criteria of the review.

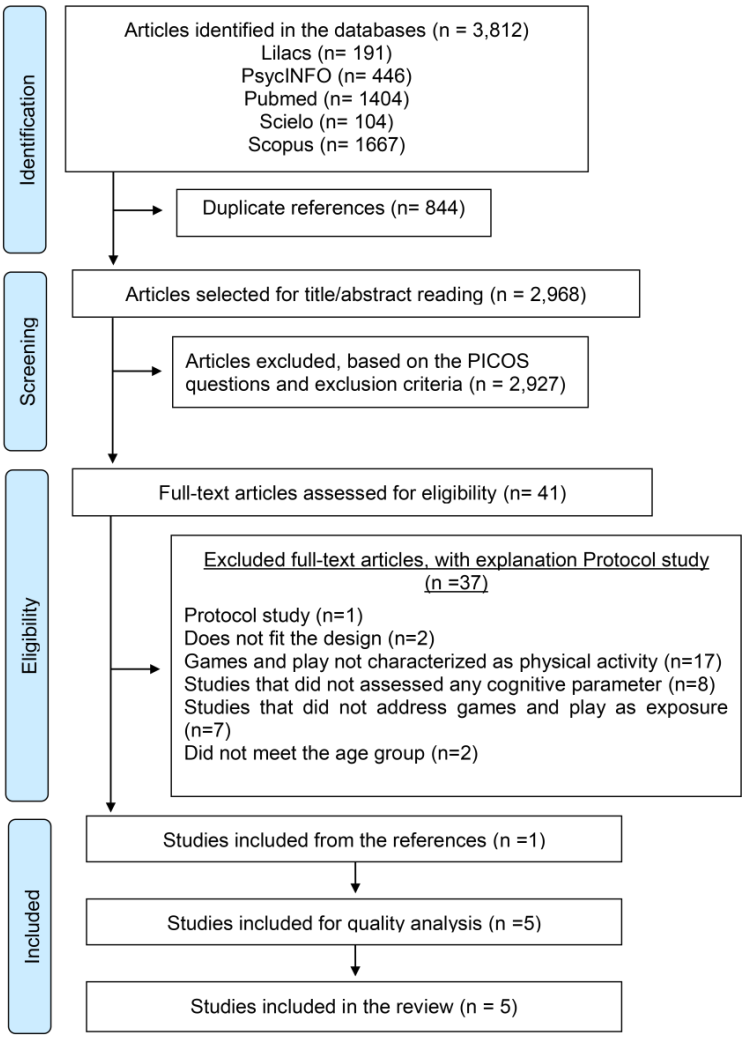

Figure 1. Flowchart of steps, according to PRISMA
Source: The authors

Regarding the characteristics of the participants, all included studies were carried out with children aged between 4 and 12 years old, of both sexes. However, only in the study by Mezghanni et al.[22], the sex of the participants was not mentioned.

The total number of participants in the studies included in that review ranged from 27 to 460, with highlight to the studies by Sánchez-López et al.[23] and Pesce et al.[24], which presented a larger sample than the other studies due to both having adopted a cluster randomized clinical trial design.

All articles included in that review have a randomized clinical trial design, as shown in Table 1, with the purpose of investigating the effect of games and play on the central nervous system. In this sense, with regard to the characteristics of the exposure, two studies presented the length/time of exposure in a chronic manner, in the cluster format[23,24], and three had an acute characteristic[20-22].

Table 1. Methodological information from the studies included in the review and that investigated the influence of active games and play on children's cognition.

Author, year	Exposure	Comparison	Cognitive

			variables
EFRAIM et al., 2021 (RCCT)	Type: Acute; Length: 3h; Activity: Active games, sports games; Intensity: NI.	Type: Acute; Length: 3h; Activity: sedentary games; Intensity: NI.	IC, fMRI Functional analysis of brain regions.
SÁNCHEZ-LÓPEZ et al., 2019 (RCT)	Type: Chronic; Length: PA 1 year, 3x a week, 60 minutes; Activity: Traditional mid-class break games, sports games, games for developing motor skills, intervention with parents and teachers, changes in the school environment; Intensity: Moderate to vigorous.	Type: Chronic; Length: 1 year; Activity: No intervention (normal school routine); Intensity: NI.	Logical Reasoning, Verbal Factor, Numerical Factor, Spatial Factor, General Intelligence.
MEZGHANNI et al., 2019 (RCCT)	Type: Acute; Length: NI Activity: Mid-class break games – hunting and fishing games. Intensity: NI.	Type: Acute; Length: NI Activity: No intervention (normal school routine); Intensity: NI.	Visual-spatial capacity; Recognition, Reaction time, Focused attention.
TANDON et al., 2018 (RCCT)	Type: Acute; Length: 15 minutes; Activity: Aerobic games Intensity: Moderate to vigorous.	Type: Acute; Length: 15 minutes; Activity: sedentary activities; Intensity: NI.	IC; Working memory; Cognitive flexibility.
PESCE et al., 2016 (RCT)	Type: Chronic; Length: 1 hour per week 6 months; Activity: School physical education cognitively enriched through deliberate games; Intensity: Moderate to vigorous.	Type: Chronic; Length: 1 hour per week 6 months; Activity: Traditional physical education classes; Intensity: Moderate to vigorous.	IC, Working memory, Attention.

Note: n= number of participants; m=male; f=female ; ±=standard deviation; RCCT=randomized crossover clinical trial; RCT=randomized clinical trial; IC=inhibitory control; p=level of statistical significance; PA=physical activity; NI=no information.
Source: The authors

Sánchez-López et al.[23] carried out a multicomponent exposure containing three combined strategies: 1) traditional mid-class break games, sports games, games for developing motor skills, activities with music; 2) health promotion using pamphlets, information and guides for parents and teachers of the students in the study; 3) changes to the mid-class break environment with boards, circuits and equipment to promote a more physically active place. The exposure was held during one academic year. The experiences of games and play took place three times a week, lasting 60 minutes, with moderate to vigorous intensity. Pesce et al.[24] conducted an intervention program lasting 1 hour per week for 6 months. The activities were proposed through cognitively enriched school physical education based on deliberate games of moderate to vigorous intensity.

About the studies that investigated the effect of games and play acutely on children's cognition, Efraim et al.[20] used 3 hours of exposure to various physically active games such as: bean bag toss, basketball, football, volleyball, walking on the track, Pokémon Go, fitness test. There was no mention of an intensity assessment during the intervention. Another acute study investigated the effects of active games and play during mid-class breaks and their impacts throughout the day on children's cognition. The activities performed were hunting game and fishing game; the exact time of the mid-class break/exposure was not reported, and the intensity of the activities was not assessed[22].

Tandon et al.[21] used 15 minutes of aerobic physical activity as an intervention strategy, with games and play – more specifically, chase games, running, and jumping activities. The intensity of the activities was monitored by an accelerometer, with moderate to vigorous intensity being predominantly observed.

All included studies investigated the effect of games and play on some cognitive parameter in the target audience, as shown in Table 2. The studies by Tandon et al.[21] and Pesce et al.[24] presented the effects of the comparison group on inhibitory control. Pesce et al.[24] verified the effect of ball skills on level of motor development, and how this change can impact inhibitory control.

It was found that three studies presented the effect of the intervention strategy from games and play on children's cognition[20,22,23]. Efraim et al.[20] observed that the group that experienced active games showed significantly better performance for inhibitory control compared to the control group. Sánchez-López et al.[23], in their turn, observed that the multicomponent intervention, in a chronic form, with active games and play as one of the main intervention strategies, was able to generate an effect in all assessments of cognitive performance, referring to the pre x post condition, compared to the control group. Finally, Mezghanni et al.[22] found that games and play during mid-class breaks had a positive impact on children's focused attention and reaction time throughout the day.

Table 2. Information on the results of the studies included in the review and that investigated the influence of active games and play on children's cognition.

Author, year (design)	Results	Effect size	Interpretation
EFRAIM et al., 2021 (RCCT)	IC (p=0.01).	IC = 0.50	Medium
SÁNCHEZ-LÓPEZ et al., 2019 (RCT)	Logical Reasoning (p<0.01); Verbal Factor (p<0.01); Numerical Factor (p<0.01); Spatial Factor (p<0.01); General intelligence (p<0.01).	Logical Reasoning = 1.14 Verbal Factor = 1.17 Numerical Factor = 0.99 Spatial Factor = 1.09 General intelligence = 1.48	Large Large Large Large Large
MEZGHANNI et al., 2019 (RCCT)	Focused attention (p < 0.00); Reaction time (p = 0.01).	Focused attention = 0.37 Reaction time = 0.20	Small Small
TANDON et al., 2018 (RCCT)	IC (p < 0.00)	IC = 0.22	Small
PESCE et al., 2016 (RCT)	IC (p < 0.05)	IC = 0.21	Small

Note: RCCT=randomized crossover clinical trial; RCT=randomized clinical trial; IC=inhibitory control; p=level of statistical significance.

Source: The authors

A quality analysis of the studies included in this review was performed using RoB 2: a revised tool for assessing risk of bias in randomized trials (Figure 2). Regarding the "randomization process" analysis criterion, all studies raised "some concerns" as to their risk of bias, since no study reported whether the allocation process was concealed. Furthermore, the study by Sánchez-López et al.[23] showed many differences in relation to baseline data before the intervention.

As for the "deviations from intended interventions" criterion, all studies presented "low risk of bias", except for that by Sánchez-López et al.[23], which was classified as raising "some concerns" due to participants and their caregivers knowing their attribution in relation to the exposures in the study. However, one of the authors' explanations was that they used the strategy of the intervention activities being previously chosen by students/participants in order to increase compliance with the proposed activities. All studies were classified as "low risk of bias" in relation to the "absent results data" and "results measuring" criteria.

Finally, with regard to the "selection of reported results" criterion, one study presented "low risk of bias"[20], and one study was indicated as raising "some concerns" due to not presenting the data/results from both periods of the RCCT design[22]. Still on this criterion, three studies were classified as "high risk of bias", mainly because they ran multiple statistical analyses that were not part of the study's preliminary strategies[23,24], as well as due to multiple measurement analyses (various assessment instruments) for a single variable[21].

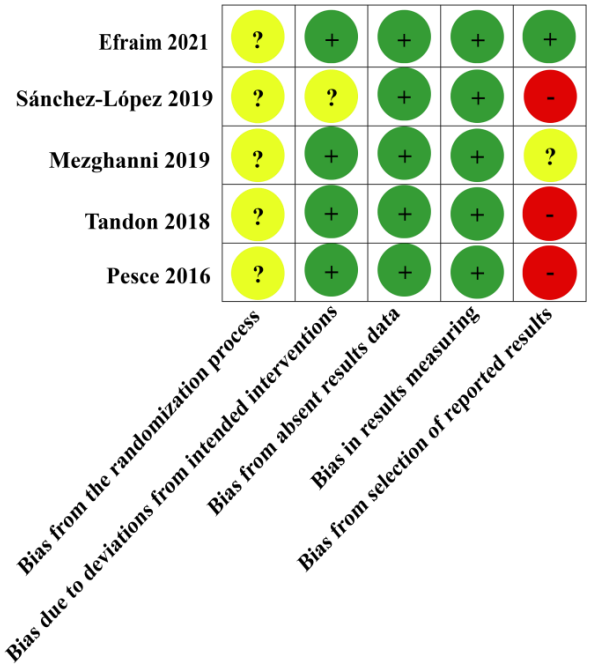

Figure 2. Study quality analysis
Source: The authors

Discussion

The purpose of this systematic review was to synthesize articles in the literature that investigated the effects, correlations and associations of active games and play on

children's cognition. To date, no systematic review has summarized the influence of active games and play, as well as their outcomes, on a child's brain, taking into account observational and experimental studies.

In the present study, two articles reported results opposing the hypotheses found in the literature. Engagement in games and play, from the perspective of promoting physical activity, did not generate an effect on inhibitory control, but a comparison between conditions (sedentary or normal routine activity)[21,24] did.

Tandon et al.[21] and Pesce et al.[24], because interventions with active games and play do not have effects on cognition, brought possible explanations for the results obtained, such as: the chosen measuring instrument; transition between conditions (intervention and control) for the assessments; sample size; differences in baseline characteristics; non- blinding in the allocation process and non-blinding of the teachers involved in the intervention. On the other hand, different studies have indicated other possible explanations for the lack of effect of physical activity on a child's brain, such as: difference from teacher to teacher when carrying out the interventions; students' difficulty raising their intelligence scores; and low level of cognitive stimuli arising from the intervention activity[25,26]. However, three articles indicated that active games and play have positive effects on children's cognitive parameters (Figure 3)[20,22,23].

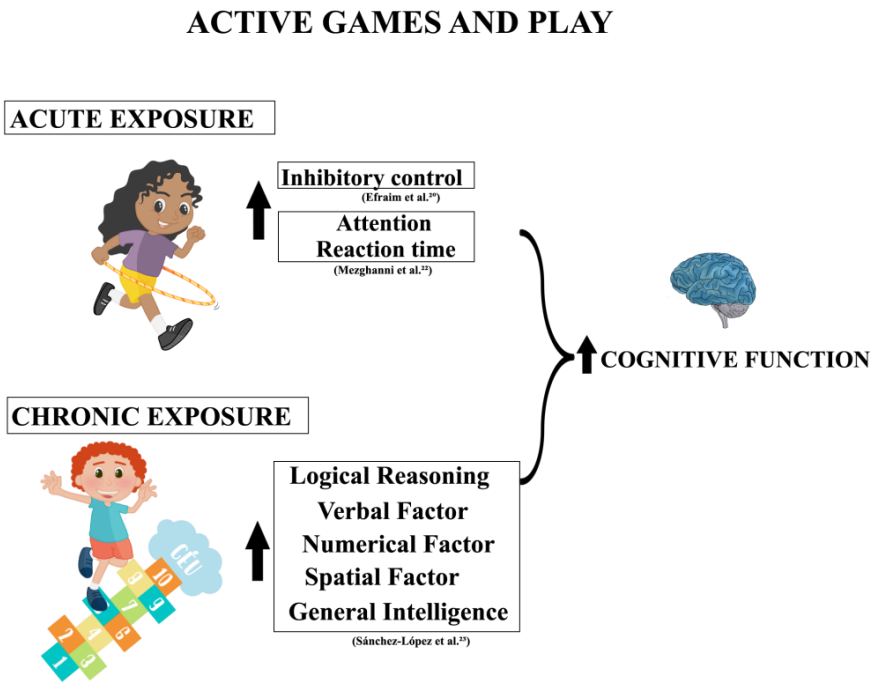

Figure 3. Effects of games and play on children's cognition
Source: The authors

Regarding the positive effects of active games and play summarized in this systematic review, the study by Mezghanni et al.[22] highlights as possible explanations that activities developed during mid-class breaks play an important role in modulating children's brains, with the following highlights: cognitive reorientation due to "active break/interval"; increased cerebral blood flow; greater activation of neurotransmitters and learning resulting from the activities experienced. Indeed, the study by Egger et al.[27] corroborates these findings, as they reported that recess and breaks during classes with

physical activity, and using games as a strategy, can contribute to improving the cognitive functions of school-aged children.

Following these assumptions, physical activity done in the classroom or during the school routine, according to a recent systematic review with meta-analysis, can have a positive impact on academic performance, but further research is needed to provide a more solid base to these results[28].

Engagement in physical activity through games and play or multicomponent intervention programs, such as the study by Sánchez-López et al.[23], can promote adaptations that impact brain regions such as the prefrontal cortex and cerebellum, and positively influence children's executive functions (inhibitory control, logical reasoning, verbal factor, numerical factor, spatial factor, and general intelligence). Thus, these changes in brain regions can lead to improved cognitive performance[29]. Furthermore, one of the hypotheses suggested is the possibility of helping increase BDNF expression and, consequently, stimulating the neuronal production process[30]. In addition to the neurobiological factor, the characteristics of playing and the stimuli that this activity can provide (ability to solve problems, management of emotions, cooperation, visuospatial stimuli) are capable of generating positive adaptations for the central nervous system[26].

Efraim et al.[20] used a different approach from the other articles included in this review by investigating brain implications from increased sedentary play *versus* active play after school on neural measures of eating control and inhibitory control. One of the outcomes presented was that the sedentary playing condition showed lower executive function performance (inhibitory control) compared to the active playing condition. In addition, the sedentary playing condition may make children more prone to resorting to foods with higher calorie content. In this sense, providing an active environment by increasing the availability of physical activities resulting from games, sports and aerobic activities can generate beneficial effects on executive functions[31].

Positive changes in executive functions, such as inhibitory control, selective attention, and working memory are fundamental to the daily lives of children, helping them with daily tasks, and very present in the school environment[32,33]. These brain functions are directly linked to writing, reading, arithmetic calculations, social communication, learning, and academic performance[34].

In summary, the main claims about the effect of active games and play on children's brains are related to the characteristics and stimuli that the activities can provide, as well as to possible neurobiological adaptations. The motor/muscular activity resulting from games and play can promote signaling to various brain regions such as the motor cortex, prefrontal cortex, limbic system, and hippocampus. From this, they can stimulate attention, executive functions, emotions, and the reward system, and, consequently, contribute to the development of the child's brain[35].

Another very important parameter directly related to effects and adaptations as to children's cognitive functions is the intensity of the activities performed. Several studies and reviews point out that physical activities of moderate to vigorous intensity are crucial to generating positive changes in children's cognition[36,37]. Physical activity interventions of moderate to vigorous intensity can induce the production of Vascular Endothelial Growth Factor (VEGF) and thus boost the angiogenesis process, that is, increase cerebral vascularization. contributing to greater blood and oxygen supply to the brain[38]. Moreover, it promotes the action of Insulin-Like Growth Factor 1 (IGF-1), which, in its turn, signals and raises the amount of BDNF in the brain, bringing about an increase in the production of neurons[39,40].

In this review, only the studies by Sánchez-López et al.[23], Tandon et al.[21], and Pesce et al.[24] determined or monitored the intensity of the games and play carried out. Considering this parameter is fundamental and can contribute to a better understanding of the possible effects of these activities, as well as to more effective intervention programs with regard to favorable changes to a child's brain.

Although the results found are very interesting for this scientific field, in our systematic review study we can observe some limitations: 1) inclusion of only five databases in the article search process; 2) small number of articles included in the review;
3) non-inclusion of articles published in another language. However, this was the first synthesis of the literature through a systematic review on the influence of active games and play on children's cognitive functions. Another important point of this review was the identification of the effect size of the included articles, enabling a greater breadth of the practical significance of the results, concomitantly with the analysis of the methodological quality level.

Despite the small number of studies found, the results reaffirm the importance of active games and play for children's cognition. From a practical point of view, it is interesting to increase the time made available for this activity in the school environment, in combination with intervention programs outside school hours. Moreover, public policies aimed at offering more spaces and opportunities for children to experience active games and play are of utmost importance to increase their time of exposure to these activities.

Regarding the assessment of the methodological quality of the included studies, a greater methodological caution with respect to the participants allocation process and a greater concern with the data analysis strategy are essential. Another important point concerns assessments of cognitive function; it is necessary to avoid using multiple tests for a single cognitive measure.

However, it is important to be cautious when extrapolating these findings due to little evidence on the influence of active games and play on children's brain. We highlight that further research is needed, with an experimental, cross-sectional, longitudinal and correlational design, to support this field of science.

Conclusion

Based on the synthesis carried out in this review, our findings elucidate that active games and play can have effects on children's cognition. Of the five studies selected, three of them indicated positive effects of games and play on focused attention, reaction time, and executive functions (inhibitory control, logical reasoning, verbal factor, numerical factor, spatial factor, and general intelligence).

However, despite having investigated physically active games and play, those studies differ in terms of length, exposure time, assessment instruments, and interventions applied. Understanding these parameters and controlling the intensity of activities is fundamental to filling the current gaps in the literature on the subject. Nevertheless, and based on this review, we can identify experimental evidence in the literature about the effects of active games and play on cognition. Therefore, encouraging this sort of experience can be fundamental for cognitive development in childhood.

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