**Exergames and autism spectrum disorder[1]**

**Exergames y Trastorno del Espectro Autista**

**Exergames e transtorno do espectro do autismo**

[Research Article]

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**Abstract**

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The aim of this study is, through an integrative literature review, to verify the effects of interventions based on exergaming on executive functions and motor skills in children with ASD. This study is an integrative review of the literature structured in the Pubmed and Medline database with the descriptors verified in DeCs/Mesh: "autism spectrum disorder," "Exergaming," "Cognition," "Motor skill" adjunct to the Boolean operator, "AND" or "OR." The search included integrative reviews, systematic reviews, meta-analyses, randomized clinical trials, and clinical cases in English. Three studies were eligible to be included and analyzed qualitatively in this integrative review. The intervention with exergames for children with ASD produces positive results in increasing the time these children are exposed to physical activities due to the great motivation generated by the game. However, no significant effects were found on the development or gain of motor skills.

**Keywords:** autism spectrum disorder, cognition, exergaming, exercise, motor skill.

**Abstracto**

El objetivo de este estudio es, a través de una revisión integrativa de la literatura, verificar los efectos de las intervenciones basadas en exergaming en las funciones ejecutivas y habilidades motoras en niños con TEA. Este estudio es una revisión integradora de la literatura estructurada en la base de datos Pubmed y Medline con los descriptores verificados en DeCs/Mesh: "Trastorno del espectro autista", "Exergaming", "Cognición", "Habilidad motora" adjunto al operador booleano., "AND" o "OR". La búsqueda incluyó revisiones integradoras, revisiones sistemáticas, metanálisis, ensayos clínicos aleatorizados y casos clínicos en inglés. tres estudios fueron elegibles para ser incluidos y analizados cualitativamente en esta revisión integradora. La intervención con exergames para niños con TEA produce resultados positivos al aumentar el tiempo de exposición de estos niños a actividades físicas debido a la gran motivación que genera el juego. Sin embargo, no se encontraron efectos significativos en el desarrollo o ganancia de habilidades motoras.

**Palabras llave:** cognición, desorden del espectro autista, ejercicio, exergaming, habilidad motora.

**Resumo**

O objetivo deste estudo é, por meio de uma revisão integrativa da literatura, verificar os efeitos de intervenções baseadas em exergames nas funções executivas e habilidades motoras em crianças com TEA. Este estudo trata-se de uma revisão integrativa da literatura estruturada nas bases de dados Pubmed e Medline com os descritores verificados no DeCs/Mesh: "transtorno

do espectro do autismo", "Exergaming", "Cognição", "Habilidade motora" adjunto ao operador booleano, "AND" ou "OR". A busca incluiu revisões integrativas, revisões sistemáticas, metanálises, ensaios clínicos randomizados e casos clínicos em inglês. Três estudos foram elegíveis para serem incluídos e analisados qualitativamente nesta revisão integrativa. A intervenção com exergames para crianças com TEA produz resultados positivos no aumento do tempo que essas crianças ficam expostas às atividades físicas devido à grande motivação gerada pelo jogo. No entanto, não foram encontrados efeitos significativos no desenvolvimento ou ganho de habilidades motoras.

**Palavras-chave:** transtorno do espectro do autismo, conhecimento, exerjogo, exercício, habilidade motora.

## Introduction

Autistic Spectrum Disorder (ASD) is a neurodevelopmental condition that is not degenerative. It is characterized by challenges in social interaction and communication, along with the presence of restricted interests and stereotyped behaviors (American Psychiatric Association [APA], 2013; Arberas and Ruggieri, 2019).

ASD has neurobiological underpinnings, high heritability (Arberas and Ruggieri, 2019), and its prevalence, based on research conducted by the United States Centers for Disease Control and Prevention (Maenner et al., 2021), is now estimated at a child with ASD in every 36 children. Over the past three decades, there has been a notable rise in these prevalence figures. However, there is still no consensus whether this increase is due to the significant increase in cases or the improvement of diagnostic criteria (Zeidan et al., 2022).

Currently, its cause is still unknown, but scientific literature is moving towards genetic study, with the biological issues involved in ASD becoming increasingly stronger (Mercadante e Leckman, 2013).

The inflexibility of behavior and the difficulty in dealing with changes is common to the three levels of support (American Psychiatric Association [APA], 2013). Generally, individuals with lower impairment levels, support level 1, may be better able to function autonomously. However, they can remain socially naive and vulnerable, with difficulties in adaptive behavior. Individuals with level 2 require substantial support, as they will have a severe deficit in verbal and non-verbal social communication, with limitations in initiating

social interactions and reduced or abnormal responses to the communicative intentions of others. Level 3 also shows a severe deficit in verbal and non-verbal communication and a minimal response to interaction with others.

ASD presents a delay in motor development as one of its deficits, as well as a low quality in the proficiency of motor skills. Thus, these issues may worsen deficits in language development and social skills (Vito and Santos, 2020). Therefore, there is a need for early diagnosis and treatment, with a wide range of non-pharmacological interventions that can be made available to stimulate and favor the neuropsychomotor development of the affected child. Among these interventions, exergaming is included, which is characterized by an active video game in which the system captures and virtualizes the player's movements (Johnson-Glenberg, 2019).

Exergaming can act as a virtual environment for learning new movements and sports gestures, helping to increase caloric expenditure and as an academic education tool (Hickingbotham et al., 2021; Hilton et al., 2014). The evidence support that it can act as an additional stimulus for children with ASD since they have a particular predilection for more sedentary and indoor activities, which include visual-spatial skills, such as those based on screens.

Therefore, the objective of this study is to use an integrative literature review to examine the impact of interventions rooted in exergaming on the executive functions and motor skills of children with Autistic Spectrum Disorder (ASD).

**Methods**

This study involves an integrative literature review conducted using the Pubmed and Medline databases. The search utilized specific keywords from DeCs/Mesh, including "Autism Spectrum Disorder," "Exergaming," "Cognition," and "Motor skill," combined with the Boolean operators "AND" or "OR." The search criteria encompassed integrative reviews, systematic reviews, meta-analyses, randomized clinical trials, and clinical cases published in English.

**Term definition**

This review provides clear and accurate definitions of the following terms to ensure coherence in the manuscript:

● Autistic Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by challenges in social interaction and communication, along with restricted

interests, stereotyped behavior, and basic motor stereotypes. It is classified into three levels of impairment. This study includes articles focusing on children with ASD levels 1 and 2 who do not have intellectual deficits.

● Cognition encompasses various mental abilities such as learning, thinking, memory, reasoning, and problem-solving (Ferreira et al., 2021). This review includes articles that examine the use of exergames to enhance these skills in children with ASD.

● Motor skills involve both simple and complex tasks that vary in execution quality and proficiency. These skills can be enhanced and automated through practice.

**Selection criteria**

Studies that investigated treatment based on exergames for children with ASD with an outcome involving cognitive and motor performance were included in this integrative review. Studies were considered eligible when (1) they were integrative reviews, systematic reviews, meta-analyses, randomized clinical trials or clinical case presentations; (2) have been published or accepted for publication in a peer-reviewed journal; (3) participants were children with ASD at level 1 or 2 who were able to perform the proposed activities; (4) analyzed the effects of exergaming on ASD; (5) observed effects were on cognition or on motor skills. In the selected studies, the following were observed: (1) year of publication; (2) sample; (3) study design; (4) if the children in the sample included, in addition to ASD, intellectual deficit; (5) the target variables were measured: cognition and motor skills. Studies were excluded when (1) they included adults with ASD; (2) included children with ASD level 3 or with an intellectual deficit associated with ASD; (3) the analyzed outcome did not include the variables cognition and motor skills; (4) studies published in languages other than English; (5) studies prior to 2017.

**Studies analysis**

Four researchers analyzed the selected studies' titles, abstracts, and full text. Duplicates and those in which the abstract did not provide information on using exergaming to acquire cognition or motor skills for children with ASD were excluded. After this selection, the selected articles were read, culminating in elaborating the descriptive table of the characteristics of each selected work (Table 1).

**Results**

The initial search of the database yielded a total of 14 journal articles. After removing duplicates (n=4) during the screening, further exclusions were made. Two articles were

excluded (n=2) based on unrelated topics following title analysis. During the eligibility process, four studies were excluded based on their abstracts (n=4). Upon full-text analysis, one article was eliminated (n=1) as it didn't provide relevant results for the variables of interest in this review. As a result, three studies remained eligible for qualitative inclusion and analysis in this integrative review (n=3). For a visual representation of the selection process, refer to Figure 1, which outlines the study extraction flow diagram leading to the final selection of three articles.

**Figure 1**

*PRISMA Flow Chart of studies included in this review that met the inclusion criteria.*
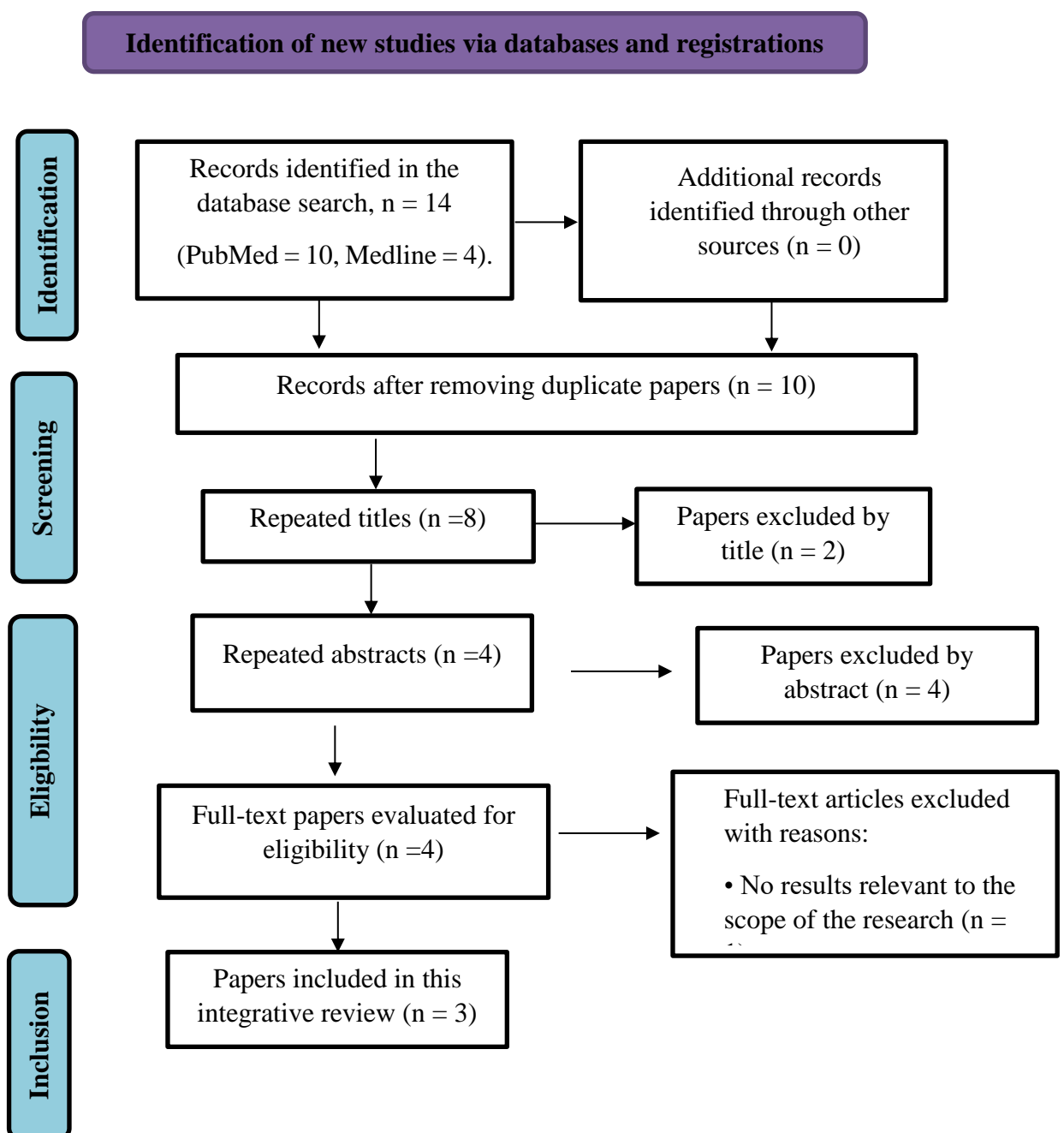
**Table 1**

*Description of the selected papers.*

| Paper identification | Study design | Sample | Target variable | Outcome |
|---|---|---|---|---|
| Lima et al. (2020). | Review | 5 studies | Cognition and motor skills | Exergames can be considered a potential tool to improve cognitive functions; however, they did not have positive responses in improving motor skills. |
| Milajerdi et al. (2021). | RCT | Total n= 60 G. Kinect=20 G. Spark=20 G. Controle=20 | Cognition and motor skills | Improved function of motor skills in the SPARK group, and only the group that used the Kinect had improvement in executive functions. |
| Fang et al. (2019). | Systematic review | 10 studies | Cognition and motor skills | Exergaming interventions demonstrated positive effects on physical fitness, executive function, and self-perceived motor skills performance. Nevertheless, the impact on emotional control and motor skill development did not show significant results. |

**Discussion**

It's well established that children with ASD often prioritize screen-based activities for recreation, leading to extended periods of exposure. Unfortunately, this exposure typically lacks any therapeutic or developmental intent. (Mazurek e Wenstrup, 2013). Thus, it can be said that exergaming is a promising approach to providing opportunities for children with ASD to participate in physical activities (Fang et al., 2019). Corroborating the study by Fang et al. (2019), the findings of Lima et al. (2020) indicate that an exergame is a potential tool in the treatment of children with ASD, especially for increasing physical activity, developing executive functions (EF) and decreasing stereotyped movements. In their review article, the authors point out that the exergame has many positive points, such as fun, interaction with other players, and the possibility of full-body movement by practitioners. These points led the authors to suggest that this type of game may favor the engagement of children with ASD in more vigorous physical activities (Lima et al., 2020).

Milajerdi et al. (2021) compared the effect of two types of interventions in children with ASD, one based on traditional physical activity and the other using exergame as an intervention strategy. The authors aimed to verify the cognitive responses and motor skills in response to the interventions above. In the group that used the exergame as an intervention, there was no increase or development of motor skills. However, this group showed a significant improvement concerning executive functions. These findings align with the study by Lima et al. (2020), who highlighted that exergames could be considered a potential tool to improve cognitive functions. However, they did not positively respond to improving motor skills (MS).

The authors attribute the non-improvement of MS in children with ASD due to the relatively low "dose" of correctly performed exercises (Milajerdi et al., 2021). Fang et al. (2019) points out that the methodological quality of the studies carried out is insufficient, thus hindering a more robust analysis of the results of the exergame on MS.

The exergame positively affected the performance of self-perceived motor skills, which implies a greater motivation for practitioners to engage in physical activities. However, no significant results were observed in the development or acquisition of MS in children with ASD in the Systematic Review presented by Fang et al. (2019). Regarding MS, the three studies of this integrative review point in the same direction: the exergame is an excellent strategy to increase the level and engagement of children with ASD in the practice of physical activities. However, this approach has yet to show significant results in developing MS for this population (Fang et al., 2019; Lima et al., 2020; Milajerdi et al., 2021).

An interesting point about the development of MS is the need for a movement professional to conduct interventions, thus being able to provide structured instructions aimed at gains in this area, especially with children with ASD (Fang et al., 2019).

Another analysis variable of this integrative review is cognition, which appears, for the most part, as executive functions in the selected studies. In the randomized clinical study by Milajerdi et al. (2021), it can be observed that the group that performed the exergame-based intervention showed a significant difference between the control group and the group that did a traditional physical activity, having the best conceptual responses, as well as a decrease in errors, when compared the pre and post-test. This same study shows no relationship or correlation between MS and EF in any of the groups for children with ASD.

In line with this study, significant improvements were observed in the EF of children with ASD after ten weeks of intervention with exergame, emphasizing working memory and metacognition (Fang et al., 2019). Another highlight concerning EF was a positive response to task switching in the post-test (Fang et al., 2019).

Previous findings in research with exergaming and ASD also stated that this type of intervention increases the motivation of children with ASD to participate in the activity and develops EF. However, it does not have a significant performance in the development of MS, and this can be seen in the study by Hilton et al. (2014), in a pilot study, who found that after 30 sessions of two minutes of intervention based on exergaming, only working memory and strength and agility components obtained improvements significantly.

The studies included in this integrative review follow the same trend, showing substantial improvements in EF, increased motivation, and irrelevant motor performance (Fang et al., 2019; Lima et al., 2020; Milajerdi et al., 2021).

**Conclusion**

This integrative literature review indicates that the intervention with exergames for children with ASD produces positive results in increasing the time these children are exposed to physical activities due to the great motivation generated by the game. However, no significant effects were found on the development or gain of motor skills. Unlike executive functions, in which all analyzed studies showed improvements in the EF of children with ASD after an intervention based on the exergame. Future studies on this topic are needed to determine the dose-response control relationship, especially in randomized clinical trials.

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