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# CORE COMPONENTS OF REHABILITATING CHILDREN WITH BRAIN CANCER USING EXERGAMES: A SCOPING REVIEW

## *COMPONENTES CENTRAIS DA REABILITAÇÃO A CRIANÇAS COM TUMOR CEREBRAL COM RECURSO A EXERGAMES: UMA SCOPING REVIEW*

## *COMPONENTES CENTRALES DE LA REHABILITACIÓN DE NIÑOS CON CÁNCER CEREBRAL MEDIANTE EXERGAMES: UNA REVISIÓN DE ALCANCE*

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## ABSTRACT

**Introduction:** Child cancer is a rare phenomenon carrying alterations in physical condition, that influence the way they develop. Due to the implications resulting from brain tumors it is necessary to define, implement and evaluate interventions that minimize the functional impact on the child, specifically those that utilize exergames. So, the aim of this study is to map the literature related to the use of exergames in the motor rehabilitation of school-aged children with brain tumors.

**Methodology:** Scoping Review method, according to Joanna Briggs Institute. Two independent reviewers carried out the review which included studies incorporating school-aged children with a brain tumor, who resorted to exergames in motor rehabilitation programs. Research was carried out without a time limit, accessing to EBSCOHost, Web of Science, Scopus, and grey literature.

**Results:** Three publications were included. The intervention varied between 8 to 12 weeks including 3 to 5 sessions per week, with an estimated time of 30 to 45 minutes per session. The most used gaming platform was Nintendo® Wii. Several evaluation tools have been applied, to obtain data about physical fitness, functionality, quality of life, neuropsychological state, and self-concept.

**Discussion:** Intervention programs differ one from another, particularly in the criteria for their prescription, duration, and assessment tools, as well as the game platforms used. The programs are evaluated at an early stage and at the end and can be extended up to 3 months after the end of the program.

**Conclusion:** Further investigation should be carried to examine the characteristics of interventions aimed at children with cancer, namely the frequency, intensity, type, and duration of physical exercise, as well as the influence of exergames on the rehabilitation of children with brain tumors. The scarcity of research on this topic justifies investing in primary studies to clarify the impact of the intervention of specialist nurses in Rehabilitation Nursing in this field. The analysis of interventions that can be implemented by specialist nurses for children with cancer is an emerging issue, to promote informed decision-making in Rehabilitation Nursing, as well as to identify priority areas for research.


**Descriptors:** Child; Exergaming; Brain Neoplasms; Rehabilitation.


## RESUMO

**Introdução**: O cancro infantil é um fenómeno raro que acarreta alterações na condição física, que influenciam o desenvolvimento da criança. Devido às implicações resultantes dos tumores cerebrais é necessário definir, implementar e avaliar intervenções que minimizem o impacto funcional na criança, nomeadamente as que recorrem aos jogos eletrónicos de movimento. Neste sentido, o objetivo deste estudo é de mapear a literatura relacionada com a utilização de *exergames* na reabilitação motora de crianças em idade escolar com tumor cerebral.

**Metodologia:** Recurso à metodologia de Scoping Review, de acordo com o Joanna Briggs Institute. Dois revisores independentes realizaram a revisão que inclui estudos que incorporam crianças em idade escolar com tumor cerebral, com utilização de *exergames* em programas de reabilitação motora. A pesquisa foi realizada sem limite de tempo, acedendo ao EBSCOHost, Web of Science, Scopus e literatura cinzenta.

**Resultados:** Foram incluídas 3 publicações. A intervenção variou entre 8 a 12 semanas, incluindo 3 a 5 sessões por semana, com um tempo estimado de 30 a 45 minutos por sessão. A plataforma de jogo mais utilizada foi a Nintendo® Wii. Foram aplicados vários instrumentos de avaliação, para obter dados sobre a aptidão física, a funcionalidade, a qualidade de vida, o estado neuropsicológico e o autoconceito.

**Discussão:** Os programas de intervenção divergem entre si, nomeadamente nos critérios para a sua prescrição, duração e instrumentos de avaliação, bem como nas plataformas de jogo utilizadas. A avaliação dos programas é efetuada num estadio inicial e no final, podendo estender-se até 3 meses após o término do programa.

**Conclusão:** Mais investigação deve ser desenvolvida de forma a aferir as características das intervenções dirigidas à criança com cancro, nomeadamente a frequência, intensidade, tipo e duração do exercício físico, bem como a influência dos jogos eletrónicos de movimento na reabilitação de crianças com tumores cerebrais. A escassez de investigação sobre este tópico justifica a investida em estudos primários, que permitam clarificar o impacto da intervenção do enfermeiro especialista em Enfermagem de Reabilitação neste domínio. A análise das intervenções passíveis de serem implementadas pelo enfermeiro especialista à criança com cancro é uma temática emergente, no sentido de promover uma tomada de decisão em Enfermagem de Reabilitação fundamentada, bem como identificar áreas prioritárias de investigação.


**Descritores:** Criança; Jogos Eletrónicos de Movimento; Neoplasias Encefálicas; Reabilitação.


## RESUMEN

**Introducción:** El cáncer infantil es un fenómeno poco frecuente que provoca cambios en el estado físico que influyen en el desarrollo del niño. Debido a las implicaciones de los tumores cerebrales, es necesario definir, implementar y evaluar intervenciones que minimicen el impacto funcional en los niños, en particular aquellas que utilizan *exergames*. Con esto en mente, el objetivo de este estudio es mapear la literatura sobre el uso de *exergames* en la rehabilitación motora de niños en edad escolar con tumores cerebrales.

**Metodología:** Utilizando la metodología Scoping Review, según el Instituto Joanna Briggs. Dos revisores independientes llevaron a cabo la revisión, que incluyó estudios que incorporaban a niños en edad escolar con tumores cerebrales que utilizaban *exergames* en programas de rehabilitación motora. La búsqueda se realizó sin límite de tiempo, accediendo a EBSCOHost, Web of Science, Scopus y literatura gris.

**Resultados:** Se incluyeron tres publicaciones. La intervención osciló entre 8 y 12 semanas, incluyendo de 3 a 5 sesiones por semana, con un tiempo estimado de 30 a 45 minutos por sesión. La plataforma de juego más utilizada fue Nintendo® Wii. Se utilizaron diversos instrumentos de evaluación para obtener datos sobre la forma física, la funcionalidad, la calidad de vida, el estado neuropsicológico y el autoconcepto.

**Discusión:** Los programas de intervención difieren entre sí, sobre todo en los criterios para su prescripción, la duración y las herramientas de evaluación, así como en las plataformas de juego utilizadas. Los programas se evalúan al principio y al final, y pueden prolongarse hasta 3 meses después de su finalización.

**Conclusión:** Deberían realizarse más investigaciones para evaluar las características de las intervenciones dirigidas a niños con cáncer, concretamente la frecuencia, la intensidad, el tipo y la duración del ejercicio físico, así como la influencia de los juegos electrónicos de movimiento en la rehabilitación de niños con tumores cerebrales. La escasez de investigaciones sobre este tema justifica la inversión en estudios primarios para aclarar el impacto de la intervención de las enfermeras especializadas en enfermería de rehabilitación en este ámbito. El análisis de las intervenciones que pueden llevar a cabo las enfermeras especializadas en niños con cáncer es un tema emergente, con el fin de promover la toma de decisiones informadas en Enfermería de Rehabilitación, así como para identificar áreas prioritarias de investigación.

**Descriptores:** Niño; Videojuego de Ejercicio; Neoplasias Encefálicas; Rehabilitación.

## INTRODUCTION

Cancer in children and teenagers has a low incidence, when compared to other age groups, being 15.3 per 100.000 per year [1]. This is assumed to be the second leading cause of death in children in developed countries, however, due to technical and scientific development associated with the treatment of the disease, the probability of being cured is a proven reality in this population [2]. In any case, the survival rates in developed countries report percentages above 80%, showing a clear improvement, when compared to previous years [3, 4]. Central Nervous System (CNS) tumors, which include brain tumors, are the most common solid tumors in pediatric age, occupying a large slice of childhood cancer [1, 4]. Thus, throughout diagnosis and treatment, children suffer alterations in their physical fitness and activity, which impairs their physical performance and development. These are more evident during treatment; however, they remain present for several years after the end of the treatment, even after the remission of the disease [5-8]. Effectively, limitations to cardiorespiratory capacity, muscular strength, and balance are some of the aspects mentioned in the literature [9], accompanied by other variables such as well-being, emotional distress, alteration of self-concept and perception of quality of life, aspects potentially altered during the process of disease and treatment, as well as in the long term as survivors [10-13].

Whilst analyzing children with oncologic disease, Badr and colleagues [10] have identified lower quality of life and physical performance scores in teenagers and young adults with tumors of the CNS, when compared to other survivors. Such fact might be related with the location and aggressiveness of the disease and the way of treatment (surgery and radiotherapy) leading to larger incapacity scores in these people and consequent neurological sequelae. These aspects are related to the functional alterations that children face, specifically when it comes to muscular strength, coordination, balance, and flexibility [6, 14].

On the one hand, evidence suggests that establishing structured physical activity interventions and exercise programs are strategies that improve physical performance and reduce symptoms associated with the disease and treatment, such as fatigue and activity intolerance [15-17]. Although more studies that demonstrate this relation are necessary, the implementation of interventions that promote physical exercise in these patients has shown to be efficient in reducing hospitalization days and costs, as well as, improving functionality [18].

Globally, the practice of physical activity throughout childhood and adolescence is recommended, having benefits in muscle and bone development, cardiorespiratory capacity, cognitive function, cardio-metabolic function as well as, mental health [11, 19]. The World Health Organization (WHO) advocates that, healthy children and teenagers exercise for at least 60 minutes a day (from moderate to vigorous intensity, mostly aerobic). [20, 21]. Similar recommendations are advocated for children who have survived an oncological disease [22].

Even though, the benefits of physical exercise are evident for children and teenagers affected by this condition, as well as the survivors, there is a lack of interventions and delineated programs in conventional care provided to this population [23, 24]. Adding to this fact, most patients and their families don't have access to programs designed specifically for their problems and needs, not only because the centers are unable to provide such programs, but also due to the challenges families may face in getting to these places. For this reason, the development and implementation of interventions focusing on exercise, guaranteeing safety and regularity, directed to children with oncological disease becomes necessary. These aspects are considered by the Network ActiveOncoKids, that suggest strategies of change based on the development of physical activity programs for these people, with an improvement of the structures that provide these services, enabling a more effective support to children and their families [23]. To that effect, virtual reality is assumed to be a strategy with potential to positively influence the adherence of participants by creating more pleasant and motivating tasks in comparison to conventional therapies [25]. It consists of the use of technology, with the aim of maintaining an environment that the user can interact with. Included in this domain are video games that are conceptualized as an interactive form of entertainment, in which the player electronically controls images that appear on a screen, being possible to be played from home utilizing special platforms or computers [26]. Thus, one of the biggest strengths of this strategy is associated with a significant increase in motivation and adherence to the exercise regime. Besides, there are other aspects to take into consideration, such as pleasure and satisfaction in the practice of exergames and the improvement in cognition, functionality and physical fitness [27]. Given the immediate and long-term implications that brain tumors have in school-aged children (6-12 years old), it becomes necessary to define, implement and evaluate interventions that will minimize the functional consequences for children. However, little is known about the content and organization of the interventions, especially those that use exergames as a strategy to increase children's motivation when it comes to adhering to the activities or prescribed exercises.

For these reasons, the present Scoping Review (ScR) aims to map the literature related to the use of exergames in the motor rehabilitation of school-aged children with brain tumors, in any context or country.

## METHODS

A ScR was carried out following the orientations of the Joanna Briggs Institute (JBI) [28, 29], and whose protocol is registered in Open Science Framework (OSF) Registries, with registration DOI https://doi.org/10.17605/OSF.IO/ZMFKQ.

The investigation question which guided the study, created by the PCC mnemonic (Participants, Context and Concept) was "What scientific knowledge is available regarding the use of exergames in the motor rehabilitation of school-aged children with a brain tumor?". The inclusion and exclusion criteria used is shown in Table 1.

**Table 1: Inclusion and exclusion criteria according to PCC mnemonic.**

| Participants | Concept | Context | Sources of evidence |
|---|---|---|---|
| All studies including school-aged children with brain tumors (6 to 12 years old). | All studies that use exergames for children's motor rehabilitation. | All studies developed at any context (in or outpatient), in any country. | Studies of any level of evidence.<br>Inclusion of grey literature.<br>Search without time limit.<br>Studies that clearly describe the intervention.<br>Studies in Portuguese, English and Spanish. |

For this study the following stages were carried out: definition of the research strategy, identification and selection of relevant studies, data extraction, data synthesis and presentation, and interpretation of the results [29]. The whole process was assisted by a librarian and peer reviewed by another librarian [29].

The research strategy was based on three stages, in line with the recommendations of JBI. The first stage included performing a search using MEDLINE (through PubMed) and Cumulative Index to Nursing and Allied Health Literature (CINAHL) with the descriptors found on Medical Subject Headings (MeSH): Child, Neoplasms, Brain Neoplasms, Virtual Reality, Augmented Reality, Video Games, Computer Games, Exergames, Gamification. An analysis of the words contained in the title, abstract and subject terms was then carried out to identify other similar terms.

The second stage concerns the structuring of the research strategy, with the combination of all the terms found, adapting them to the specificity of each database or aggregator and resorting to Boolean operators "OR" and "AND" and the tool "*" to strengthen the search and guarantee that new variations of the same word are created. In the protocol displayed on OSF, data about information sources and their respective strategy is described.

In the third stage, the references selected in stage two were analyzed with the objective of mapping unidentified studies on the research strategy, as well as manual research in relevant entities for the topic in study. The selection process for the studies took place in November of 2022, according to the research strategy published in the protocol registered on OSF.

The studies obtained in each one of the databases were exported to a reference management software (Endnote® X21) and the duplicated references were removed. Next, the studies were exported to the Rayyan® software for analysis and selection. The use of this software facilitated the process of blind screening of articles by the two researchers. Two investigators independently, analyzed the studies by title, abstract and integral text, according to the inclusion and exclusion criteria. In the case of divergences between the two investigators, these were solved by a third investigator, responsible for deciding whether that study should be included or not. The articles that resulted of the first triage were submitted to the inclusion criteria via an Instrument of Relevance/Eligibility Analysis, adapted for that purpose and exposed in the protocol registered on OSF.

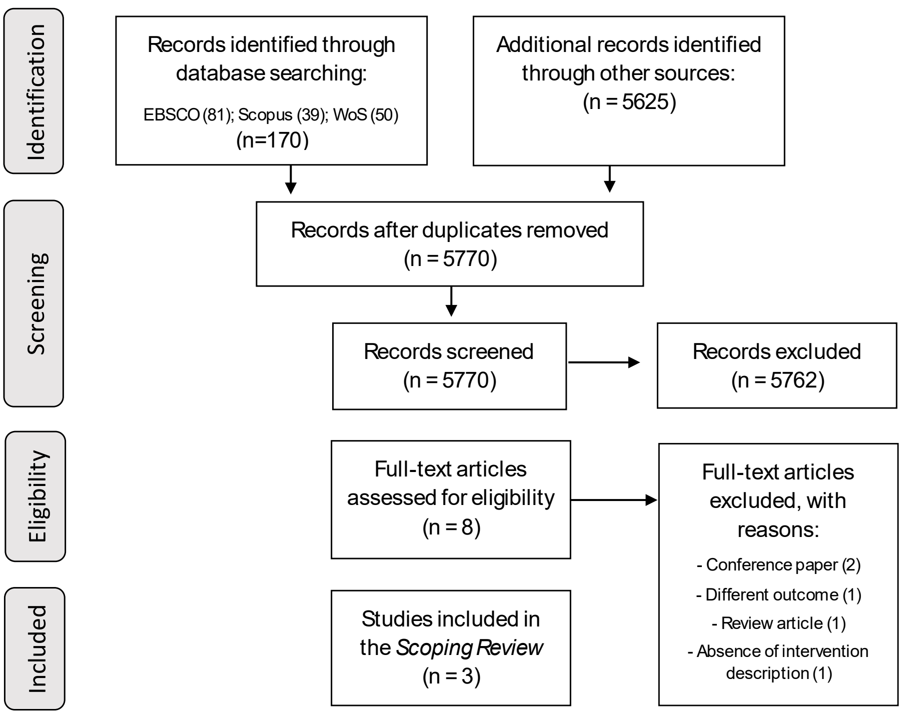
For the data extraction, an instrument was elaborated with the objective of registering the main characteristics of the studies, as well as the main pieces of evidence found. It encompassed the following topics: title, author, year and place of publication, objectives, method, population, context, intervention, main results, and conclusions. The data obtained was organized using the characteristics of the studies, description of Frequency, Intensity, Time, and Type of Intervention (FITT) criteria and evaluation of interventions.

The Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-SCR) checklist was used to guide the reporting of this review [30].

## RESULTS

The research on the data sources identified 5795 potentially eligible articles, 170 of which have originated in the EBSCO aggregator, the Web of Science (WOS) and the Scopus databases and the remaining originated from grey literature and hand searching, as presented in Figure 1. Duplicates were removed. Then, after reading their title and abstract, 5762 articles were excluded, with 8 articles remaining for integral analysis. After an integral reading 5 registers were excluded for the following reasons: conference article [31, 32], an article that evaluated outcomes are different from those defined in the concept of this revision [33], revision article which primary articles were already included in the present ScR [34] and one article that does not describe in a clear way the implemented intervention [35]; remaining 3 that met the eligibility criteria.

**Figure 1: PRISMA Flow Diagram for the ScR process, PRISMA-ScR**



The three articles included in the integral analysis (36-38) diverge in the year of their publication. They were published between the years of 2016 and 2018, an aspect related to the scarcity of evidence associated with the subject under study. When it comes to the type of study, they included randomized pilot studies (n=2) (36, 37) and a randomized and controlled study protocol (38).

The population of the articles included in the review consider children with brain tumors, having finished treatment (surgery, radiation, or chemotherapy) at least 12 months beforehand. The number of children varies between 13 (36, 37) and 150 (38). The last study (38) is a randomized study protocol where the sample size is estimated. The rehabilitation programs are implemented in the cities of Gothenburg and Zurich in Sweden and Switzerland respectively. In the studies developed in Zurich (36, 37), children with the following neoplasms were included: anaplastic astrocytoma, pilocytic astrocytoma, choroid plexus carcinoma, germ cell tumor, medulloblastoma, and primitive neuroectodermal tumor; whilst the investigation to be developed by Valentin and colleagues (38) will include children with neoplasms both involved with the CNS or not.

All the intervention programs took place at home, although a big part of the evaluation has been performed at the hospital, by the research team or appropriately habilitated professionals.

When it comes to FITT criteria, as presented in Table 2, the frequency of training sessions varies between 3 and 5 days a week, being that most (36, 37) are situated in the latter. The duration of the programs described lasts at least, in what concerns the implementation of the intervention, between 8 to a maximum of 12 weeks, being that the evaluation follow-up might reach a duration of three months.

The intensity of the exercise is not clearly described in these studies. However, Valentin and colaborators (38) indicate that the difficulty level of the training program should be permeable and adjusted to the performance of each participant. On the one hand, Sabel and colleagues (36) refer that the study participants were instructed to initiate the intervention with video games that require a more demanding exercise intensity (at least for 10 minutes), before moving on to others, such as exercises to train balance. The repetitions associated with each exercise are not described in the articles analyzed.

Considering the duration of the session, it varies between 30 and 45 minutes, being a point of consensus throughout the studies. On the one hand, the type of intervention is based on the description of the content of the intervention, the proposed exercises and strategies or resources to do those same exercises. Thus, considering that this ScR objective is understanding the available evidence regarding motor rehabilitation of children with brain tumors, utilizing exergaming, it is important to identify which are the gaming platforms being used and the games to which the authors resort to. In this way, the Nintendo® Wii (n=2) (36, 37) associated to the ''Balance Board'' is used more frequently than the XBOX® Kinect (n=1) (38). For the concretization of the intervention program, the following video games are used, Wii Sports, Wii Sports Resort®, Wii Fit®, and Wii Fit Plus®, besides the dancing video games Just Dance® and Michael Jackson - the Experience®. In the study developed by Valentin and colleagues(38), the video games used are not described. In parallel, distance supervision or coaching sessions are advocated with the aim of potentiating and monitoring the adherence of the participants to the study.

Lastly, the evaluation of the results obtained from the different programs varies according to the specific goals of each study, as well as the indicators that the investigators attempt to test. Nonetheless, the evaluation of certain aspects such as physical activity and actigraphy, through accelerometers, the neuropsychological state, physical condition, functionality, physical fitness, quality of life, and physical self-concept are aspects usually present in the scope of evaluation. One study evaluates the components of neuroplasticity associated with the training of cognition and exergaming, through neuroimaging (38).

The moment of evaluation of the programs in analysis is situated in two distinct periods, in the beginning and the end of the intervention. In some situations, there is an intermediate evaluation (36, 37), or, in the study performed by Valentin and colleagues (38), a long-term evaluation is planned, that is, three months after the ending of the intervention program.

**Table 2: Summary of articles included for the ScR**

| Study | Type of study | Population and Sample size/ Context | Objectives | Results (Intervention) | Results (Strategy) | Results (Measurements) |
|---|---|---|---|---|---|---|
| Sabel, Sjölund et al. [37] | Randomized pilot study | 7 girls and 6 boys.<br>Ages (μ): 12.5 years.<br>Children who completed treatment for a brain tumor between 1 and 5 years earlier. | To explore the effects of active video gaming on energy expenditure levels during gaming sessions as well as overall for the duration of the intervention.<br>To evaluate the compliance to the study protocol over time and to evaluate the general feasibility of the method.<br>To evaluate its effect on physical functioning, by a standardized measure of physical performance validated for children and adolescents. | **Frequency:** 5 days a week (at least).<br>**Type:** aerobic and anaerobic.<br>**Session time**: 30 minutes per day (minimum).<br>**Program duration:** 10-12 weeks (compensate moments of incapacity to exercise).<br>**Setting:** Home. | **Nintendo® Wii:**<br>Wii Sports®.<br>Wii Fit® and Wii Fit plus®.<br>Just Dance® and Michael Jackson – the Experience®. | **Physical activity and energy expenditure:**<br>SenseWear® Pro 2 Armband.<br>**Physical functioning:**<br>BOT-2*. |
| Sabel, Sjölund et al. [36] | Randomized pilot study | 13 children.<br>Ages (μ): 12.5 years.<br>Children diagnosed with a brain tumor after 2003 and completed treatment 1 to 5 years ago. | To explore the effects of active video gaming on cognitive functions.<br>To evaluate the effects of active video gaming on the execution of activities of daily living. | **Frequency:** 5 days a week (at least).<br>**Type:** aerobic and anaerobic type games.<br>**Session time**: 30 minutes per day (minimum)<br>**Program duration:** 10-12 weeks.<br>**Setting:** Home. | Nintendo® Wii and the Balance Board®. | **Cognitive function:**<br>Short Test Battery.<br>**Activities of daily living:**<br>Motor and Process Skills. |

| Study | Type of study | Population and Sample size/ Context | Objectives | Results (Intervention) | Results (Strategy) | Results (Measurements) |
|---|---|---|---|---|---|---|
| Valentin, Noëmi et al. (38) | Protocol of a randomized controlled trial. | Planned sample: 150 children.<br><br>Eligibility criteria (experimental group):<br>Age: 7–16 years<br>Previous diagnosis of cancer with or without CNS involvement in the past ten years<br>Ended treatment at least 12 months prior to participation.<br><br>Eligibility criteria (control group):<br>Healthy children and adolescents, without intervention. | To contribute to the prevention of a further decline of cognitive functions and scholastic problems.<br>To compare the efficacy of two different trainings (computerized working memory training and exergaming) aiming to foster cognitive performance in pediatric cancer survivors.<br>To examine the relationship between training related cognitive change and training related change in brain structure and function. | **Experimental group (A and B):**<br><br>**Frequency:** 3 days a week.<br><br>**Intensity:** adaptive and adjusted based on the user's performance.<br><br>**Session time**: 45 minutes per day.<br><br>**Program duration:** 8 weeks, with 3 months follow-up.<br><br>**Setting:** Home.<br><br>**Monitoring:** a coach will provide weekly supervision by phone call to the child's home. | **Group A:** Cogmed RM®.<br><br>**Group B:** XBOX Kinect®.<br><br>**Group C:** No intervention. | **Physical assessment:**<br>Actigraphy through an accelerometer (7 to 10 days).<br>German motor performance test and $VO_2$max† test.<br><br>**Self-concept:**<br>Physical self-description: PSDQ-S‡.<br><br>**Neuropsychological status:**<br>Executive function: D–EFS™§ and BRIEF\|\|.<br>Visuospatial working memory: WMTB-C¶.<br>Verbal working memory: Number Recall, Word Order, Atlantis, Rover of the German version of the Kaufman Assessment Battery for Children.<br>Processing speed: Coding, Cancellation, Symbol search tests of the German Version of the Wechsler Intelligence Scale for Children.<br>Intelligence quotient and manual dexterity: TONI-4** and Grooved Pegboard test.<br>Psychological attributes: SDQ††.<br><br>**Neuro, functional and structural imaging:**<br>Magnetic resonance imaging.<br><br>**Quality of life:**<br>The Kidscreen.<br><br>**Resources:**<br>Resources in children and adolescents: FRKJ 8–16‡‡.<br><br>**Adherence:**<br>Training diary.<br><br>**Acceptability and feasibility:**<br>Satisfaction questionnaires. |

*The Bruininks-Osteretsky Test of Motor Performance; †Maximal oxygen consumption; ‡Physical Self-Description Questionnaire; §Color-Word Interference Test of the Delis–Kaplan Executive Function System; ||Behavior Rating Inventory of Executive Function; ¶Working Memory Test Battery for Children; **Test of Nonverbal Intelligence; ††Strengths and Difficulties Questionnaire; ‡‡The questionnaire on resources in children and adolescents.

## DISCUSSION

The goal of this ScR was to map the literature related to the use of exergames in the motor rehabilitation of school-age children (6-12 years of age) with a brain tumor, in any context or country.

To answer this goal, three articles have been included in this review, two of which are randomized pilot studies and a protocol of a randomized and controlled experimental study. From the analysis of the type of study, as well as the number of studies included for integral analysis, the scarcity of literature about the topic in discussion becomes evident, justifying the option of the ScR methodology, based on the principles of the JBI – to identify and analyze knowledge gaps [29].

Although this review includes studies regardless of the year of their publication, the included articles were published from 2016 onwards. This aspect can be justified by the way this topic is studied, considering it is a recent area of research [39].

Effectively the use of video games has been gradually increasing, being a current leisure activity in the life of individuals, adults, and children. Doi and colaborators [40], determined in their study that, per day and in weekdays 62,9% of teenagers played 1h or less per day, 27% played three hours or less per day, and 10,1% played over three hours a day.

Clearly, the resort to this platform has advantages and disadvantages for children's health, where the negative aspects are centered on the increase of violent and sedentary behaviors, as well as the dependency associated with gaming. However, these aspects can be managed or controlled, being that the benefits may largely surpass the negative aspects, especially when used with the goal of functional therapeutics in children with brain tumors. In this way, Rahmani and colleagues [39] indicate that video games improve cognitive abilities and academic performance, if used moderately. On the one hand, the emotional, cognitive and social development was described by Vorderer and colaborators [41]. The potential of video games is being explored in the health area, especially in the scope of education in healthcare, through serious games which are video games with therapeutic goals, beyond simple entertainment [42]. Another slope of virtual reality, in this case emergent, are the exergames, resource under scrutiny in this article.

Concerning to the population in study, the included articles intervene in school-aged children with brain tumors, having ended treatment (surgery, radiation, chemotherapy), at least 12 months beforehand. This aspect is relevant for the discussion, given that the evidence suggests that the installation of handicaps, especially in physical activity, are mostly, after the diagnosis and during treatment, prolonging after the ending of the disease [5, 17]. In this way, this aspect points towards the implementation of interventions directed at the minimization of functional sequels right after the definition of the diagnosis. Despite this ScR focus the use of exergames on school-aged children with brain tumors, all the studies included for analysis consider a wider age range. This may be related with the scarcity of the evidence associated to the theme, as well as the difficulty of recruiting participants with the necessary eligibility criteria for experimental studies, considering that childhood cancer is a rare phenomenon [1].

The three articles, included in the present ScR, test areas of cognition, physical status, and quality of life, resorting to the strategy of exergaming, being evaluated in a multifaceted, quantitative, and qualitative perspective. On the one hand, the preferred location for the implementation of this strategy is at home, allowing the individuals to integrate the intervention programs without dislocating. Effectively, this strategy frequently resorts to consoles that can be connected to the television, devices which are usually present in the homes of the individuals, which facilitates the economic viability of the implementation of this kind of intervention [27]. However, some challenges may emerge with this approach due to the possible lack of adherence and inability to specify and adapt the games in a context where professional supervision is not always guaranteed, being a limitation to overcome.

Considering the frequency and intensity of the interventions adopted in the articles that were analyzed, these diverge or are not clearly explicit. The frequency of interventions varies between three to 5 days a week, with a duration of 8 to 12 weeks, with the possibility of a follow-up (evaluation) three months afterwards. Effectively, in defining the interventions, these fields are the ones that are more difficult to delimit. Braam and colleagues [43], evaluated, in their review, the effect of an intervention based on physical exercise on the children's physical fitness during and after the oncologic disease. The articles analyzed presented a minimum of 10 weeks of intervention, lasting up to 2 years, being that four studies maintained the intervention based on exercise during the remission period of the disease. In the study performed by Benzing and colaborators [33], resorting to exergames, the intervention was implemented for 8 weeks, three times a week, reaching 12 weeks, through evaluation follow-up. The intensity adopted by these authors went from moderate to vigorous. This aspect is aligned with the FITT recommendations, described by the American College of Sports & Medicine (ACSM) [44], that whilst not being precise and systematic in what concerns the person with cancer, given the diversity of the population affected by this pathology, as well as their condition, attest that it is important to avoid inactivity during and after the treatment, being the exercise safe during these periods. The consensus indicates 30 to 60 minutes of moderate to vigorous exercise, at least 5 days a week, although the existing evidence in this population lacks investigation. The intensity of the exercise is not clear in the studies in question, suggesting that it must be adapted to the performance of each participant [38], or decreasing [36], where the information about the number of repetitions is nonexistent.

The time of intervention is another criterion to be considered in the analysis of the included articles. In this way, the children's participation time, per day, varied between 30 and 45 minutes per session, being framed in the exercise recommendations emanated by the ACSM [44]. In effect, the exercise prescription for healthy children is considered by the ACSM and by the WHO, that advocate the practice of physical activity, mostly aerobic, for at least 60 minutes a day. Besides this recommendation, they indicate that aerobic activities of vigorous intensity as well as muscle and bone strengthening activities must be incorporated at least three times a week [21, 44]. In effect, recent evidence suggests that establishing exercise programs promotes cerebral plasticity, with positive effects in functional recovery after a neuronal injury. Through potentiating the alteration of brain anatomy, circuit and function, exercise might be considered as an effective intervention for the promotion of the recovery of children with brain tumors [45].

When it comes to the type of intervention, that is, its content and the way it stems, all the authors resort to exergames, most of them through the Nintendo® Wii platform. Less frequently the XBOX® Kinect is also used. The way the intervention is developed is not clearly described, as there is not a discriminated exposition of the existence of warm-up, aerobic and anaerobic training, and relaxing/stretching stages, as is recommended by the ACSM [44]. Besides the practice of video games, other interventions were implemented in parallel, as education sessions for health, coaching, and supervised practice.

Lastly, the evaluation of the results obtained from the different programs varies according to the specific goals of each study, as well as the indicators that the investigators attempt to test. These include aspects such as physical condition, specifically, physical activity and fitness, functionality, self-concept, quality of life, and, frequently, neuropsychological status. These indicators are found in other studies, adding others such as fatigue, Body Mass Index, muscular strength, and coordination [13, 14, 46, 47]. On the one hand, the revision article by Braam and colleagues [43] includes studies that evaluate cardiorespiratory capacity, body composition, flexibility, muscular strength and endurance, level of daily physical activity, quality of life, fatigue and potentially adverse effects related to the intervention.

In fact, studies that evaluate the efficiency of physical exercise, as an intervention, in physical performance and fitness have shown positive effects [6, 48]. However, the understanding of these effects becomes difficult, considering the extended amount of evaluation instruments used, given the complexity and diversity of the population being studied.

In this way, in the systematic revision performed by Grimshaw and colaborators [49] the evaluation instruments faced towards the functional capacity and physical performance of children are synthesized, having as a primary goal the description of their psychometric properties. In this study the evaluation measures which the investigators most frequently resorted to were: The Musculoskeletal Society Scoring System, the Time Up and Go (TUG) (3 m and stairs), the 6-minute walking test, the Bruininks-Oseretsky Test of Motor Proficiency (BOT)-2, the Movement Assessment Battery for Children, the actigraphy and the Godin Leisure-Time Questionnaire.

On the one hand, Shank and colleagues [50] describes the instruments used in children with cancer, in the domain of physical activity/exercise, in intervention programs in the community. They focus areas like motor performance, literacy, fatigue, well-being and quality of life, and behaviors of health search. This study, being a ScR, identifies many instruments for the indicators described above, distinguishing those focused-on fatigue, for example, The Fatigue Scale; on functional capacity, like Wee-FIM: Functional Independence for Children; and on quality of life - Pediatric Quality of Life Inventory (PedsQL), on its various versions.

More recently, in the systematic review conducted by Söntgerath and colaborators [51], the measurement instruments that evaluate the cardiorespiratory capacity, muscular strength, speed and gait, balance and flexibility, functional capacity, and, lastly, the motor performance both in children with active oncologic disease and in survivors, were summarized.

More frequently, the cardiorespiratory capacity was evaluated by a cardiopulmonary exercise test, the 6 and 9-Minute Walking Test. Muscular strength can be evaluated with various tools, however, objectively, the dynamometry of the lower, upper members, and torso musculature, as well as tests of maximum repetition are some of the most used. Speed and gait, being intimately related topics, are measured using a short distance run evaluation and biomechanics and electromyography evaluation platforms, respectively. To identify gains in balance and flexibility the rehabilitation programs frequently resort to evaluating posture and the Berg scale, as well as goniometry and the Sit and Reach test. In a more global way, the functional capacity and motor performance are evaluated by the TUG test (3m, 10m and stairs), by the Functional Mobility Assessment, by the three versions of the BOT (BOTMP, BOT-2, BOT-2 SF), and by the test for motor performance in the oncology (MOON-test) [51]. From the information that emerges from this revision, it is noticeable the diversity of evaluation instruments possible of being used in each domain, sensitive to various ages and health conditions and sickness of each child.

The elements that come from the children's self-evaluation are an emergent topic, however relevant in the evaluation of children with cancer. According to Meryk and colleagues [52], the subjective daily evaluation performed by the patient allows for the early identification of installed incapacities and deficits, allowing the health professionals to act in a more rapid way, resulting in bigger survival rates and potentiating the improvement of the quality of life. These authors suggest resorting to patient-reported outcome measurements (PROMs), through ePROtect, that makes 6 daily questions related to four domains: pain, nausea and loss of appetite, physical function, and sleep disturbance. ePROtect was recognized as an easy-to-use application for daily self-reporting of symptoms during cancer therapy and may include 6 to 8 questions adapted from the Pediatric Quality of Life Inventory (PedsQL) 3.0 Cancer Module. The main objective of this application is to assesses symptom burden in those domains on the previous day, facilitating communication between family, patient and health professionals [53].

The moment of evaluation of the programs in analysis is situated in two different periods, in the beginning, and end of the intervention. In some situations, there is an intermediate evaluation [36-38], or, on the one hand, a long-term evaluation, that is, three months after the end of the intervention program [38]. This aspect diverges on the consulted studies, depending on the objectives and the outcomes to measure.

In fact, technology is frequently incorporated, in the areas of health and education, towards its promotion, improving domains such as the knowledge and capacity over certain themes, optimizing healthy lifestyles and health searching behaviors. The exergames imply physical activity through the practice of a video game, being able to constitute an interesting alternative to conventional rehabilitation, especially in pediatric age, where the motivation and adherence to the exercise regime may be a challenge. This strategy is an alternative tool in the motor rehabilitation of an individual, promoting the improvement of their physical condition as well as their motivation and adherence to exercise in a more original and engaging way [54, 55].

Considering the benefits of physical exercise in children with cancer, specifically in their muscular strength, balance, coordination, flexibility, functionality and quality of life [43, 46], besides the psycho-emotional potentiated by the release of endorphins [56], the growing interest in exergames is clear. In this way, the participation of children with brain tumors in intervention programs focusing on physical exercise points towards an improvement in motor performance and psychological status, which contribute to the reduction of fatigue and improvement of general quality of life [43].

As limitations, we point out the fact that the comparison between the available evidence and the included studies is limited, considering that most of the investigation is done on children with leukemia, with potentially different needs and problems, from those that are experienced by children with brain tumors. On the one hand, the definition of criteria associated with the prescription of physical exercise in pediatric and oncological populations, is not yet completely established and defined, having the need to create interventions specifically for this population. Thus, the suggestion of the most adequate and sensitive evaluation tools is key, given the dispersion of instruments found in the literature.

Hence, under the perspective of investigation and given the heterogeneity of evidence found, the structuring of an intervention program in this domain is suggested, resorting to different strategies, or training platforms, to identify the best strategy and resource, having as a basis the implemented FITT criterion. The selection of the more appropriate FITT criteria for the population and context of acting is, equally, emergent given the scarcity of associated literature, especially in the domain of the intensity of the prescription of the exercise. Besides these aspects, the identification of strategies and resources to be used should take into consideration not only the children's status but also their age, development stage, and family condition.

## CONCLUSION

In fact, this study has allowed us to realize that cancer can start before the age of 20, and when it does, a variety of problems and needs, in the medical, psychological, ethical, and social fields emerge, which deserves a concerted answer, in its various areas of action.

The presented results show the lack of evidence in the area being studied, as well as the emergent need for its development. This revision summarizes the frequency, intensity, type, and time of the used interventions to date, as well as the main resources used, the evaluation tools, and the indicators sensitive to the used strategies.

In a perspective of clinical practice, the need for the implementation of rehabilitation programs based on exercise and physical activity in this population is clear, given the promising evidence in this sense.

This data supports the need to perform research, resorting to more robust samples, with a degree of evidence superior to the one available at that time, in the sense of evaluating the viability, safety, and efficiency of the intervention to test.

In the future, studies will be necessary in pediatric oncology, that implement interventions in the scope of rehabilitation, resorting to exergames. This aims to evaluate the components of the intervention or program outlined, to sustain it, based on the evidence and the best practice in this area. For that, the components of the intervention must be defined, and adjusted to the real needs of children and their families, considering all the development stages and contexts of which this dyad is a part of.

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## ETHICAL DISCLOSURES

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