Effects of Exergaming on Physical Function and Rehabilitation Adherence in Pediatric Oncology: Systematic Review

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Efeitos do Exergaming *na Função Física e Adesão à Reabilitação na Oncologia Pediátrica: Revisão Sistemática*

Efectos del *Exergaming* en la Función Física y el Compromiso con la Rehabilitación en Oncología Pediátrica: Revisión Sistemática

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ABSTRACT

Introduction: Children with cancer, and even cancer survivors, tend to present some immediate or delayed physical impairments related to the disease or its treatment. Exergaming can be a promising tool to improve the physical fitness and quality of life of pediatric oncology patients and facilitate rehabilitation adherence. **Objective:** To investigate the effects of exergaming on physical function, rehabilitation adherence, and quality of life in pediatric oncology patients. **Method:** Systematic review based on PRISMA and registered in PROSPERO. The search was conducted in the PEDro, MedLine/PubMed, LILACS, Cochrane Library, and SciELO databases, with no year/language restrictions, including only randomized clinical trials. The methodological quality of the selected articles was assessed using the PEDro scale, and the risk of bias was evaluated using the Risk of Bias 2.0 tool. **Results:** Four articles with good methodological quality and concerns regarding the risks of bias were included. The total sample consisted of 163 participants, aged between 3 and 17 years old. One of the studies that investigated motor performance observed a significant improvement in body coordination, while two other studies found no differences in this outcome. Another study observed a significant improvement in fatigue and functional capacity after the intervention. Adherence was considered good in the exergaming group in two studies. **Conclusion:** Evidence shows that exergaming has good adherence and may be beneficial for improving exercise tolerance and cancer-related fatigue in children with cancer and survivors, although its effects on motor performance are uncertain.

Key words: Child Care; Exergaming; Rehabilitation; Cancer Survivors; Systematic Review.

RESUMO

Introdução: Crianças com câncer, e até sobreviventes, tendem a apresentar algum comprometimento físico imediato ou tardio relacionados à doença ou ao tratamento. O *exergaming* pode ser um recurso promissor para melhorar a aptidão física e qualidade de vida de pacientes oncológicos pediátricos, além de facilitar a adesão à reabilitação. **Objetivo:** Investigar os efeitos do *exergaming* sobre a função física, adesão à reabilitação e qualidade de vida de pacientes oncológicos pediátricos. **Método:** Revisão sistemática desenhada com base no PRISMA e registrada na PROSPERO. A busca foi feita nas bases de dados PEDro, MedLine/PubMed, LILACS, Biblioteca Cochrane e SciELO, sem restrição de ano/idioma, incluindo apenas ensaios clínicos randomizados. A qualidade metodológica dos artigos selecionados foi avaliada por meio da escala PEDro e o risco de viés pela *Risk of Bias* 2.0. **Resultados:** Foram incluídos quatro artigos com boa qualidade metodológica e preocupações em relação aos riscos de viés. A amostra total foi de 163 participantes, com idade entre 3 e 17 anos. Um dos estudos que investigaram o desempenho motor observou melhora significativa na coordenação corporal, enquanto outros dois estudos não observaram diferenças nesse desfecho. Outro estudo observou melhora significativa da fadiga e capacidade funcional após a intervenção. A adesão foi considerada boa no grupo *exergaming* em dois estudos. **Conclusão:** Evidencia-se que o *exergaming* tem boa adesão e pode ser benéfico em melhorar a tolerância ao exercício e a fadiga oncológica em crianças com câncer e sobreviventes, embora seus efeitos sobre o desempenho motor sejam incertos.

Palavras-chave: Cuidado da Criança; Jogos Eletrônicos de Movimento; Reabilitação; Sobreviventes de Câncer; Revisão Sistemática.

RESUMEN

Introducción: Los niños con cáncer, y los sobrevivientes, suelen presentar compromisos físicos inmediatos o tardíos relacionados con la enfermedad o su tratamiento. El *exergaming* es un recurso prometedor para mejorar la aptitud física y calidad de vida de pacientes oncológicos pediátricos, además de facilitar el compromiso con la rehabilitación. **Objetivo:** Investigar los efectos del *exergaming* sobre la función física, el compromiso con la rehabilitación y la calidad de vida de los pacientes oncológicos pediátricos. **Método:** Revisión sistemática diseñada con base en PRISMA y registrada en PROSPERO. La búsqueda incluyó las bases de datos PEDro, MedLine/PubMed, LILACS, Biblioteca Cochrane y SciELO, sin restricción de año/idioma, considerando solo ensayos clínicos aleatorizados. La calidad metodológica de los estudios fue evaluada con la escala PEDro, y el riesgo de sesgo, con el *Risk of Bias* 2.0. **Resultados:** Se incluyeron cuatro estudios de buena calidad metodológica, con algunas preocupaciones respecto a sesgo. La muestra total fue de 163 participantes, de 3 a 17 años. Un estudio observó mejora significativa en la coordinación corporal, mientras que otros dos no encontraron diferencias en el desempeño motor. Un cuarto estudio mostró mejora en la fatiga y capacidad funcional. Dos estudios reportaron compromiso con el *exergaming*. **Conclusión:** El *exergaming* parece tener buen compromiso y puede ser beneficioso para mejorar la tolerancia al ejercicio y la fatiga en niños con cáncer y sobrevivientes, aunque sus efectos sobre el desempeño motor siguen siendo inciertos.

Palabras clave: Cuidado del Niño; Videojuego de Ejercicio; Rehabilitación; Supervivientes de Cáncer; Revisión Sistemática.

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INTRODUCTION

Childhood cancer is the second-leading cause of death among children and adolescents aged 1-19 years, surpassed only by accidents[1]. The combination of different therapeutic modalities – including chemotherapy, surgery, radiotherapy, immunotherapy, and organ or hematopoietic stem cell transplantation – significantly increases the survival rates of these patients[2]. The average survival of pediatric oncological patients is 80%, with free survival rates varying according to cancer type, from 40% for those with the poorest prognosis to 100% for cases with a favorable prognosis[3].

Pediatric oncology patients typically present nonspecific signs and symptoms, which progress rapidly and exhibit aggressive characteristics. The most common types of cancer in this context are: leukemias (26%), epithelial tumors (14%), lymphomas (14%), and central nervous system tumors (13%)[4]. Moreover, just like the neoplasm, the type of treatment also generates acute and late functional complications that impact the quality of life of these patients, such as muscle fatigue, pain, decreased strength, and range of motion[5-7].

Multidisciplinary care in pediatric oncology involves physiotherapeutic action to preserve, maintain, develop, and restore the kinetic-functional integrity of patients' organs and systems[8,9]. In this process, the prevention and treatment of respiratory, motor, and circulatory complications that limit daily life activities and worsen quality of life stand out. Furthermore, given the pediatric population, incorporating playful elements into therapy is essential[6,10]. Among the physiotherapeutic modalities, kinesiotherapy is the main utilized therapeutic resource, and playing with exercise games encourages the child's participation during physiotherapy by combining fun and learning, fostering a less traumatic and more humanized treatment environment[8].

The practice of physical activity is considered a complementary therapy to cancer treatment, and, in this context, kinesiotherapy is essential as an intervention for neutralizing or minimizing the delayed effects in the physical and mental health of pediatric oncological patients and survivors of cancer or oncological treatment[9,11]. Gamification, in particular, demonstrates a positive impact by enhancing physical activity levels and exercise frequency[12,13]. This tool can be an additional playful resource that demands attention, sustaining patient motivation, improving attention, and fostering better treatment adherence[14,15]. For instance, Peyrachon and Rébilard[16] demonstrated the benefits of video games in improving endurance, cancer-related fatigue, quality of life, and autonomy of adult patients with cancer.

Based on this evidence, this systematic review aims to evaluate the effects of exergaming on the physical function, rehabilitation adherence, and quality of life of pediatric oncological patients compared to conventional physiotherapy, traditional exercise programs, or usual care.

METHOD

Systematic review designed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[17] 2020 criteria and registered on the PROSPERO[18] platform (CRD42024533476). According to the PICO acronym strategy: Children with cancer or survivors (population); exergaming (intervention); conventional physiotherapy, traditional exercise programs, or usual care (control); physical function (primary outcome), adherence to rehabilitation, and quality of life (secondary outcomes).

The review included randomized clinical trial studies (RCTs) that investigated the effect of exergaming on the physical function of pediatric oncological patients, including children and adolescents in the 3-19-years age group, according to the World Health Organization (WHO). Eligible studies should evaluate at least one of these primary outcomes of physical function: motor abilities, muscle strength, cardiorespiratory ability, and cancer-related fatigue. The secondary outcomes of interest were adherence to rehabilitation and quality of life. Studies whose samples were not exclusively composed of pediatric oncological patients or incomplete articles were excluded.

The article search was conducted between April and May 2024 by two blind independent reviewers in the Physiotherapy Evidence Database (PEDro), MEDLINE/PubMed, Latin American and Caribbean Center on Health Sciences Information (LILACS), Cochrane Library, and Scientific Electronic Library Online (SciELO) databases, with no restriction on year of publication or language. The search strategy used the following Medical Subject Headings (MeSH) descriptors: "Exergaming" combined with "Disabled Children", "Child", along with synonyms or entry terms, established with boolean operators AND and OR (Chart 1). In case the search results diverged, a third author would redo the process, but it was not the case.

After the search process, the two reviewers blindly screened the results by reading the title and abstract to verify which studies were considered eligible according to the established criteria. Next, after full selection and reading, the blinding was removed to solve disagreements by consensus, with the participation of a third author.

Chart 1. Cross-referencing performed according to the selected databases

Database	Search strategy
Cochrane Library	(Exergaming) OR (Exergamings) OR (Active-Video OR Gaming Active Video Gaming) OR (Active-Video Gamings) OR (Gaming, Active-Video) OR (Gamings, Active-Video) OR (Exergames) OR (Exergame) AND (Child) OR (Children with cancer) OR (Pediatric cancer patient) OR (Childhood cancer survivors) OR (Adolescent oncology patients) OR (Pediatric oncology) OR (Pediatric cancer care) OR (Childhood oncology) OR (Pediatric oncologic care) AND (Randomized Controlled Trial) OR (Clinical Trial)
LILACS	(Exergaming) AND (Children)
PeDRO	Exergaming AND Oncology AND Clinical trial
PubMed/MEDLINE	("Exergaming"[Mesh]) AND ("Child"[Mesh] OR "Disabled Children"[Mesh])
SciELO	((Exergaming) OR (Exergamings) OR (Active-Video OR Gaming Active Video Gaming) OR (Active-Video Gamings) OR (Gaming, Active-Video) OR (Gamings, Active-Video) OR (Exergames) OR (Exergam)) AND ((Children) OR (Children with cancer) OR (Pediatric cancer patient) OR (Childhood cancer survivors) OR (Adolescent oncology patients) OR (Pediatric oncology) OR (Pediatric cancer care) OR (Childhood oncology) OR (Pediatric oncologic care))

Finally, a chart was designed including data from each article: author and year, sample, assessment methods, intervention, and results.

The methodological quality was also assessed independently by two researchers using the PEDro scale, consisting of 11 items (Table 1). This scale evaluates the methodology of studies regarding their inclusion criteria, allocation of subjects, blinding of the involved, and analysis of results[19]. Each contemplated criterion scores 1 point, and the total score is the sum of those points; however, criterion 1 is not considered in the score as it assesses the study's external validity, so the maximum these studies could score was 10 points. The authors defined that studies that scored 6 points or more were classified as good quality, the ones scoring between 4 and 5 had an acceptable quality, and studies scoring under 4 were evaluated as low quality.

The risk of bias analysis was conducted using the Risk of Bias[20] 2.0 (RoB 2.0) tool, a revised version provided by the Cochrane Collaboration for RCTs. To identify the possible risk biases, RoB 2.0 examines the following aspects of an RCT: bias in the randomization process, deviations from the planned intervention, bias due to absent data, bias in measuring outcomes, and bias in reporting results.

RESULTS

A total of 563 studies were identified in the databases, and after the duplicate removal and selection process, eight articles were considered eligible for full-text review.

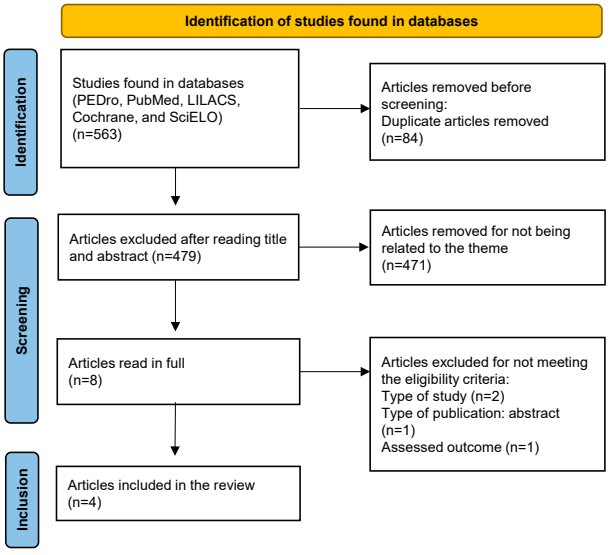

Figure 1. Flowchart showing the selection process of the articles based on the PRISMA protocol
Source: Adapted from PRISMA[17].

Following assessment, four studies met this review's inclusion and exclusion criteria (Figure 1).

The final sample comprised 163 children and adolescents (aged 3-17 years) with cancer or in survivorship, including both sexes. Two studies involved active cancer patients[21,22], while the other two focused on survivors[23,24]. The studies compared the exergaming intervention with health promotion guidance[21,22] or a waitlist control group receiving usual care[23,24] (Table 2). Exergaming protocols were generally similar in duration, ranging from five to ten weeks at moderate-to-vigorous intensity, with daily

Table 1. Methodological quality assessment according to the PEDro scale for each included study

Author(s)/Year	Criteria											Total
	1*	2	3	4	5	6	7	8	9	10	11	
Masoud et al. (2023) [20]	X	X		X				X	X	X	X	6/10
Benzing et al. (2020) [21]	X	X	X	X			X	X	X	X	X	8/10
Hamari et al. (2019) [19]	X	X		X				X	X	X	X	6/10
Sabel et al. (2016) [22]	X	X		X			X	X	X	X	X	7/10

Captions: 1. Eligibility criteria were specified; 2. Random allocation of subjects; 3. Concealed allocation of subjects; 4. Groups were similar at baseline; 5. Blinding of subjects; 6. Blinding of therapists; 7. Blinding of assessors; 8. Measured 85% of results; 9. Intention of treatment; 10. Comparison between groups; 11. Precision and variability. *Disregarded from the final score.

sessions of 30-60 minutes. The weekly frequency of the programs diverged between studies, the activities were performed twice[22], three times[23], or five times[24] per week, while one of the studies did not specify the frequency[21].

Evaluation instruments and tests were different for each study, and only two studies used the same scale, the Pediatric Quality of Life Multidimensional Fatigue Scale (Ped-QLMFS), to assess fatigue as an outcome[21,22]. The motor performance was assessed using the Bruininks-Oseretsky Test 2 (BOT-2)[24], German Motor Test[23], and Movement Assessment Battery for Children-2 (M-ABC2)[21] scales. Finally, only one study measured the functional/endurance ability using the 6-minute walk test (6MWT)[22]. None of the retrieved studies assessed the outcome of participants' quality of life.

Regarding adherence, two studies presented a high participation rate in the group that practiced exergaming, between 77%[21] and 89%[24], and the main reported reasons for not fulfilling the program were illness or trip[21,24]. However, one study showed significantly lower adherence, only 47,6% completed at least 20 of the 25 scheduled sessions[23].

The included studies presented a good methodological quality overall, with the main limitations being concealed allocation of subjects and assessors (Table 1). Considering the intervention type, blinding of subjects and therapists is not possible. Regarding the risk of bias, some concerns were identified, mainly about deviations from the intended intervention and measurement of outcomes due to the methodological limitations mentioned previously (Figure 2).

DISCUSSION

This study aimed to evaluate the effects of exergaming on physical function and rehabilitation adherence in pediatric oncology patients. Despite the broad search, the number of articles included in this review was limited. Additionally, the selected studies presented a regular degree of evidence, considering the methodological quality and risk of bias analysis. Significant heterogeneity in both sample characteristics and assessment methods among studies limited direct comparability of results[21-24].

Physical exercise has a beneficial, measurable, and known impact on children's health, especially in children who survived an oncological condition[11]. Therefore, regular practice of physical activity should be integrated for the rehabilitation and health promotion of children who have or survived cancer[11,25]. Exergaming strengths, in addition to being a playful activity, include the possibility of being practiced with or without supervision and within a home program.

Physical activity favors the development of physical and motor aptitude of children and adolescents, playing a key role in promoting health, preventing diseases, and improving quality of life[26]. Regarding motor performance, of the studies that investigated the effect of exergaming in this outcome, only Sabel et al.[24] reported a significant difference in motor performance after 10 weeks of intervention, specifically concerning body coordination of brain tumor survivors. Yoon et al.[27] also identified significant improvements in upper limb function in the box and block test, Fugl-Meyer scale, and manual function test in adult patients with brain tumors when comparing occupational therapy to exergaming and without that intervention.

Other studies with 8-week protocols failed to demonstrate differences concerning motor performance[21,23]. Hamari et al.[21] reported low fidelity to the intervention and issues with data collection as limitations for their study, while Benzing et al.[23] presented a substantial sample heterogeneity. Contrastingly, a systematic review that investigated the effect of physical activity in the development of motor abilities in healthy children included seven studies with the exergaming modality as intervention, five of which presented significant effects after the intervention[28].

Masoud et al.[22] measured aerobic ability by the 6MWT[22] and observed a significant statistical improvement in

Table 2. General characteristics of the included studies

Author(s), year (Country)	N. analyzed, mean age, gender	Sample	Intervention	Outcomes	Results
Masoud et al. 2023 (Saudi Arabia)[20]	N=45 analyzed; 9.04 (±2.3) years at CG and 9.04 (±2.4) years at EG; 10 (22%) girls at CG and 10 (22%) at EG	Children with acute lymphoblastic leukemia	CG: Instructed to practice physical activity for 60 min and 2x/week EG: Moderate intensity exergaming for 60 min, 2x/week, for 5 weeks	Functional ability/ resistance (6MWT) and fatigue (Ped-QLMFS)	Significant difference between groups in favor of EG in fatigue ($F_{(1.63, 70.37)}$ = 30.82; p = .00) and functional ability/resistance ($F_{(1.43)}$ = 16.06, p = .00)
Benzing et al. 2020 (Switzerland)[21]	N=69 analyzed; 11.1 (±2.4) years at CG, 10.7 (±2.4) at WMG, and 11.8 (±1.0) years at EG; 8 (11%) girls at CG, 11 (15%) at WMG, and 12 (17%) at EG	Survivors of pediatric cancer	CG: Usual care (waiting list) WMG: work memory game, 3x/week, for 45 min over 8 weeks; EG: Exergaming 3x/week, for 45 min over 8 weeks; moderate to vigorous intensity	Motor performance (WMG)	No difference between groups regarding motor performance. Adherence to EG: 47.6% completed at least 20 of 25 sessions
Hamari et al. 2019 (Finland)[19]	N=36 analyzed; 7.9 (3-15) years at CG and 7.8 (3-16) years at EG; 5 (13%) girls at CG and 5 (13%) in EG	Children with cancer	CG: Usual care (waiting list) EG: Exergaming 30 min/day, 5x/week, over 10 weeks, able to extend for 12 weeks	Fatigue (Ped-QLMFS) and motor performance (M-ABC2 test)	No difference between groups regarding motor performance and fatigue. Adherence rate of EG was 77%
Sabel et al. 2016 (Sweden)[22]	N=13 analyzed; 13.2 (±1.9) years at CG and 11.9 (±3.6) years at EG; 3 (23%) girls at CG and 4 (30%) at EG	Survivors of childhood brain tumors	CG: Usual care (waiting list) EG: Exergaming 30 min/day, 5x/week, over 10 weeks, able to extend for 12 weeks + coaching session	Motor performance - agility, body coordination, manual coordination, muscle strength, and fine motor skills (BOT-2)	There was a difference between groups in favor of EG in body coordination with a mean improvement of 4.55 points on the scale (CI 95%: 0.45 to 8.64; p = 0.021), mainly in bilateral coordination, with a mean improvement of 2.18 (CI 95%: 0.31 a 4.05, p = 0.047). No difference between groups in the other outcomes. Adherence to coaching sessions was 89%

Captions: BOT-2 = Bruininks-Oseretsky Test 2; F = F test result to determine if there are significant differences between groups; CI = Confidence interval; CG = Control group; EG = Exergaming group; WMG = Work memory group; M-ABC2 test = Movement Assessment Battery for Children-2 test; min = minutes; Ped-QLMFS = Pediatric quality of life multidimensional fatigue scale; 6MWT = 6-minute walk test.

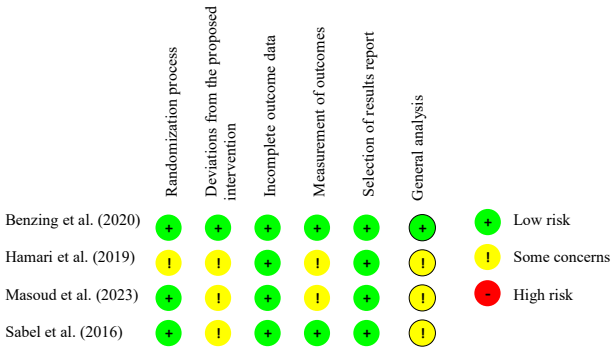

Figure 2. Risk of bias analysis of the included studies

the functional/resistance ability after the intervention. In adult patients with prostate cancer, Villumsen et al.[29,30] compared home exergaming with usual care, and the intervention group presented significant improvement in the 6MWT and serum biomarkers of cardiac risk factors. Considering the pediatric population, an RCT in children in a school setting observed significant improvements in oxygen intake after a 12-week exergaming intervention[31]. A second RCT that assessed cardiorespiratory aptitude of children with excess weight and overweight also had significant improvements in oxygen intake, in addition to a reduction in cardiac frequency of the group who did exergaming, corroborating the benefits of this intervention in the aerobic ability of the pediatric population[32].

Regarding fatigue outcomes, two studies evaluated this parameter, with only Masoud et al.[22] reported a significant improvement after the exergaming intervention[21]. The systematic reviews by Tough et al.[7] and Peyrachon and Rébillard[16] on adult individuals with cancer also reported a significant reduction in cancer-related fatigue in favor of the group who practiced exergaming. However, similar to Hamari et al.[21], the RCT by Villumsen et al.[30] found no intergroup differences post-intervention.

Children's adherence to exergaming was considered good in two studies[21,24], consistent with the findings in the review by Tough et al.[7]. In contrast, Benzing et al.[23] considered their study participation rate low, since fewer than 50% of the participants completed 80% of sessions, despite the intervention being held at home with weekly phone calls and a token motivation system[23], in addition to being less frequent when compared to other protocols. The authors highlighted that the lack of consistency in the results of home programs shows the need for professional supervision to optimize results[21,22]. Furthermore, Sabel et al.[24] suggest this intervention can be enhanced through multiplayer games to stimulate high-intensity physical activity with a competitive incentive, in addition to socialization. Finally, Dos Santos et al.[25] identified that incorporating exergaming into an exercise program can increase patients' self-efficacy.

The main limitation of the included studies was the short intervention duration [21-23], which impaired the study of the effects of this therapeutic resource in the long term. Generally, RCTs use interventions that last from 8- to 16-week to capture adaptations like improvement in cardiorespiratory ability, muscle strength, and other metabolic parameters. Moreover, the non-blinding of evaluators[21,22], low fidelity to the intervention, issues with data collection[21], small and heterogeneous samples[21], and participants' withdrawal from the intervention[23] can also be considered limitations.

The main limitations in this review were the number of studies included, significant heterogeneity in sample characteristics, and the use of different measurements to assess the outcomes of interest. Moreover, no studies that assessed the quality of life of this population after intervention were identified. Thus, there is a need for more RCTs to assess the effects of exergaming on the evaluated outcomes and others, like balance and coordination, to make evidence more dependable.

The meta-analysis for this study was initially considered but ended up being discarded due to the high heterogeneity of the few eligible studies, which compromised the reliability of the presented results.

CONCLUSION

In this context of pediatric oncology, exergaming emerges as a viable intervention that promotes regular physical activity at a moderate to vigorous intensity. Incorporating active video games may enhance patient adherence to an exercise program. A clinically relevant improvement in coordination, cancer-related fatigue, and functional endurance is also observable. However, further RCTs and controlled studies are necessary to robustly confirm its efficacy on motor performance.

CONTRIBUTIONS

Tayla Teixeira Lima has substantially contributed to the study design, planning, data acquisition, analysis, and interpretation, as well as the wording. Jaqueline Barreto Côrtes dos Santos Lima and Ana Quenia Gomes da Silva Allahdadi have substantially contributed to the study design, planning, and wording. Camila de Santana Ferreira has contributed to data acquisition, analysis, and interpretation; and wording. Vanessa Maria Santos Silva has substantially contributed to the study design and wording. All the authors approved the final version for publication.

DECLARATION OF CONFLICT OF INTERESTS

There is no conflict of interest to declare.

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