

# Virtual Reality Games in the Rehabilitation of Cancer Patients: Systematic Literature Review

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*Jogos de Realidade Virtual na Reabilitação de Pacientes Oncológicos: Revisão Sistemática da Literatura*

*Juegos de Realidad Virtual en la Rehabilitación de Pacientes con Cáncer: Revisión Sistemática de la Literatura*

Matheus Renyer Queiroz Vitor<sup>1</sup>; Amanda Souza Araújo<sup>2</sup>; Camille Maria de Holanda Angelim Alves<sup>3</sup>; Juliana Ramiro Luna Castro<sup>4</sup>; Vanessa Ximenes Farias<sup>5</sup>

## ABSTRACT

**Introduction:** Physiotherapy is beneficial for the rehabilitation of cancer patients. However, as this is a monotonous activity for many patients, it has been losing its space to new techniques such as gametherapy, which uses virtual reality videogames as a rehabilitative and preventive instrument. **Objective:** To investigate the effects of gametherapy on cancer patients. **Method:** Systematic literature review following the PRISMA guide. The search for articles was performed in PubMed, LILACS, MEDLINE and PEDro databases, using the descriptors neoplasm, cancer, virtual reality rehabilitation and physiotherapy. Controlled clinical trials and prospective studies published in Portuguese, English or Spanish in the last 12 years (July 2010 to July 2022) were eligible. **Results:** There were 94 studies identified, and nine were included in the final sample. Of the selected clinical trials, five used Nintendo Wii, two used Xbox and one used virtual reality glasses. The studies showed that gametherapy reduced symptoms of anxiety, fatigue and depression, improved fine and gross motor skills, and reduced fear of moving. However, it was not as effective as traditional therapy in decreasing chronic pain. **Conclusion:** Gametherapy has positive effects on health-related variables in cancer patients, standing out the decrease in cancer-related fatigue. In addition, it favors a reduction in the length of stay of inpatients, and increases patient adherence to treatment.

**Key words:** rehabilitation; virtual reality; physical therapy modalities; neoplasms.

## RESUMO

**Introdução:** A fisioterapia mostra-se benéfica na reabilitação de pacientes oncológicos. Todavia, por se tratar de uma atividade monótona para muitos pacientes, vem perdendo seu espaço para novas técnicas como a gameterapia, que utiliza jogos eletrônicos de realidade virtual como instrumento reabilitador e preventivo. **Objetivo:** Investigar os efeitos da gameterapia em pacientes oncológicos. **Método:** Revisão sistemática da literatura seguindo o guia PRISMA. A busca dos artigos foi realizada nas bases PubMed, LILACS, MEDLINE e PEDro, utilizando os descritores *neoplasm, cancer, virtual reality, rehabilitation e physiotherapy*. Foram considerados elegíveis ensaios clínicos controlados e estudos prospectivos publicados nas línguas portuguesa, inglesa ou espanhola nos últimos 12 anos (julho de 2010 a julho de 2022). **Resultados:** Foram identificados 94 estudos, sendo nove considerados elegíveis para compor a amostra final. Dos ensaios clínicos selecionados, cinco utilizaram *Nintendo Wii*, dois utilizaram *Xbox* e um usou óculos de realidade virtual. Os estudos mostram que a gameterapia promoveu redução dos sintomas de ansiedade, fadiga e depressão, melhorou a coordenação motora fina e geral, e diminuiu o medo de se movimentar. Entretanto, não foi tão eficaz quanto a terapia tradicional para diminuir a dor crônica. **Conclusão:** A gameterapia exerce efeitos positivos sobre variáveis pertinentes à saúde em pacientes oncológicos, destacando-se a diminuição da fadiga relacionada ao câncer. Além disso, favorece a redução do tempo de internação de pacientes hospitalizados e aumenta a adesão dos pacientes ao tratamento.

**Palavras-chave:** reabilitação; realidade virtual; modalidades de fisioterapia; neoplasias.

## RESUMEN

**Introducción:** La fisioterapia es beneficiosa en la rehabilitación de pacientes oncológicos. Sin embargo, por ser una actividad monótona para muchos pacientes, ha ido perdiendo su espacio para nuevas técnicas como la gameterapia, que utiliza videojuegos de realidad virtual como instrumento reabilitador y preventivo. **Objetivo:** Investigar los efectos de la gameterapia en pacientes con cáncer. **Método:** Revisión sistemática de la literatura siguiendo la guía PRISMA. La búsqueda de artículos se realizó en PubMed, LILACS, MEDLINE y PEDro, utilizando los descriptores *neoplasia, cáncer, realidad virtual, rehabilitación y fisioterapia*. Se consideraron elegibles los ensayos clínicos controlados y los estudios prospectivos publicados en portugués, inglés o español en los últimos 12 años (julio de 2010 a julio de 2022). **Resultados:** Se identificaron 94 estudios, de los cuales nueve fueron considerados elegibles para componer la muestra final. De los ensayos clínicos seleccionados, cinco usaron *Nintendo Wii*, dos usaron *Xbox* y uno usó gafas de realidad virtual. Los estudios muestran que la terapia de juego redujo los síntomas de ansiedad, fatiga y depresión, mejoró la coordinación motora fina y general y disminuyó el miedo a moverse. Sin embargo, no fue tan eficaz como la terapia tradicional para disminuir el dolor crónico. **Conclusión:** La terapia de juego tiene efectos positivos en variables relacionadas con la salud en pacientes con cáncer, destacando la disminución de la fatiga relacionada con el cáncer. Además, favorece la reducción del tiempo de hospitalización de los pacientes hospitalizados y aumenta la adherencia del paciente al tratamiento.

**Palabras clave:** rehabilitación; realidad virtual; modalidades de fisioterapia; neoplasias.

<sup>1-5</sup>Faculdade Rodolfo Teófilo. Fortaleza (CE), Brazil.

<sup>5</sup>Hospital Universitário Walter Cantídio. Fortaleza (CE), Brazil.

<sup>1</sup>E-mail: [matheusrenyer@gmail.com](mailto:matheusrenyer@gmail.com). Orcid iD: <https://orcid.org/0000-0002-0972-123X>

<sup>2</sup>E-mail: [amanda.araujo@frt.edu.br](mailto:amanda.araujo@frt.edu.br). Orcid iD: <https://orcid.org/0000-0003-0129-8980>

<sup>3</sup>E-mail: [camille.holanda@frt.edu.br](mailto:camille.holanda@frt.edu.br). Orcid iD: <https://orcid.org/0000-0001-7967-4128>

<sup>4</sup>E-mail: [juliana.ramiro@frt.edu.br](mailto:juliana.ramiro@frt.edu.br). Orcid iD: <https://orcid.org/0000-0002-0105-6378>

<sup>5</sup>E-mail: [vanxfarias@gmail.com](mailto:vanxfarias@gmail.com). Orcid iD: <https://orcid.org/0000-0001-9631-6576>

**Corresponding author:** Vanessa Ximenes Farias. Rua dos Amigos, 100, Torre 2, Apto. 1001 – Cambéba. Fortaleza (CE), Brazil. CEP 60822-168. E-mail: [vanxfarias@gmail.com](mailto:vanxfarias@gmail.com)



## INTRODUCTION

Cancer is the main public health problem worldwide, it is among the four main causes of death before 70 years of age in many countries. Life habits and other factors associated with better socioeconomic conditions and urbanization process stand out as determinants of increase of incidence and mortality by cancer, in addition to aging and population growth<sup>1</sup>.

Chemotherapy is one of the modalities of cancer treatment, it is a systemic medication-based therapy to stop the growth of cancer cells, killing or preventing them to divide<sup>2</sup>. These medications are called chemotherapies or antineoplastics administered at regular intervals following protocols that vary according to therapeutic regimens<sup>3</sup>. However, chemotherapy can cause side effects as nausea, vomits, diarrhea, in addition to renal, reproductive, hematologic disorders, psychologic changes as depression and anxiety and other problems strongly affecting the quality-of-life of the patient, and debilitating fatigue<sup>4</sup>, for instance.

Functionality is an important physiologic aspect negatively affected in cancer patients submitted to chemotherapy<sup>5,6</sup>. It can be defined as the ability to perform activities or functions that affect simple and complex behaviors of daily life, its compromise can make these patients unsuitable to conduct basic tasks as selfcare<sup>7</sup> independently.

Studies show that physical activity is an effective intervention to minimize chemotherapy adverse side effects, improving physiologic and psychologic functions during the whole oncologic treatment<sup>8,9</sup>. Virtual reality (VR)-based interventions have been proven as a potentially useful technology to treat oncologic patients, since physical activity has positive effects on the functionality, psychologic aspects and cancer-related fatigue and can be adopted even in debilitated patients, in addition of being more amenable than conventional physiotherapy<sup>10,11</sup>.

VR is a computer-generated tridimensional approach able to simulate an actual environment lived by the user by stimulating sensory channels, utilizing specific hardware and softwares<sup>12,13</sup>. It was adopted by medical care at the end of the 1990s when computer technology advances promoted a significant improvement of programming tools<sup>12</sup>.

The utilization of electronic games as a therapeutic resource is also known as gametherapy, which is able to optimize the process of motor and/or cognitive stimulation<sup>14</sup>. It can be useful to improve perception, concentration, memory, visuospatial organization, executive functions among cognitive skills developed through training and knowledge apprenticeship through

the game, which facilitates the performance of new tasks in other settings<sup>15</sup>.

Several benefits of gametherapy as therapeutic resource to rehabilitate patients with different pathologies have been reported as improvement of motor coordination skills, agility, mobility, carry weight, postural adjustments, balance, trunk rotation and muscle strength of lower limbs<sup>16</sup>.

Gametherapy as a tool to rehabilitate neurologic disorders in adults and children has been widely investigated to treat functional deficits, functional ability of older individuals and rehabilitation of musculoskeletal disorders<sup>17,18</sup>. However, studies evaluating the effects of gametherapy as adjuvant therapy of cancer therapy are still scarce. The objective of the present study is to investigate the effects of gametherapy on functionality, level of fatigue and quality-of-life related aspects as pain, anxiety and depression in oncologic patients.

## METHOD

Systematic review registered at the International Prospective Register of Systematic Review – PROSPERO, registration number CRD42021236623 and conducted according to the recommendations of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)<sup>19</sup>.

The strategy PICO, P – population, I – intervention, C – comparison, O – outcomes guided the research question: “Does gametherapy as physiotherapeutic resource contribute to improve the functionality, level of fatigue and quality-of-life related aspects as pain, anxiety and depression of adult oncologic patients?”

Two independent investigators searched articles published in English and Portuguese at the databases in the last 12 months (July 2020 to July 2022). Terms extracted from Health Science Descriptors (DeCS) and Medical Subject Headings (MeSH) were combined through Boolean operators OR and AND in Portuguese – *fisioterapia fisioterapia OR especialidade em fisioterapia OR reabilitação AND oncologia OR neoplasia OR câncer AND realidade virtual OR terapia de exposição à realidade virtual AND exercícios OR terapia por exercício* and in English – *physiotherapy OR physical therapy specialty OR physical therapy OR rehabilitation AND oncology OR neoplasm OR cancer AND virtual reality OR virtual reality exposure therapy AND exercises OR exercise therapy*.

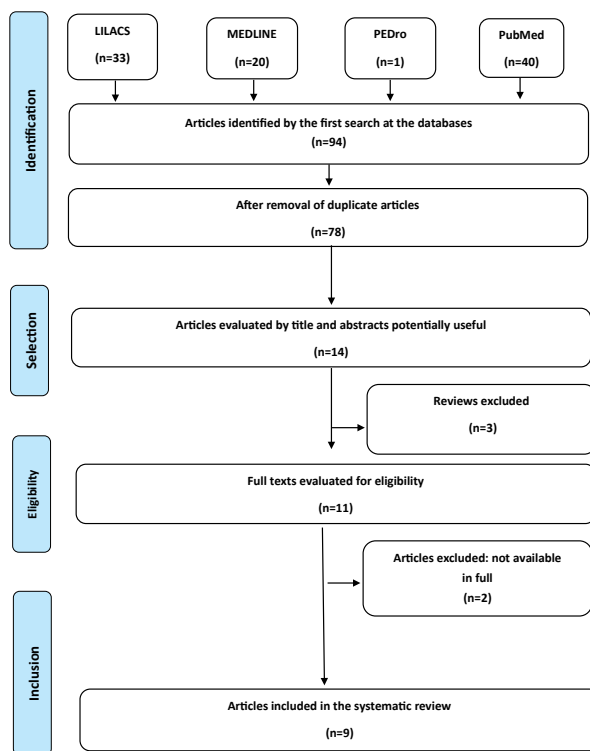
Prospective studies and controlled clinical trials have been selected with the strategy PICO: adult patients (older than 18 years of age) diagnosed with cancer (population), gametherapy (intervention), therapy with exercises/physiotherapy (comparison), improve the functionality,

level of fatigue, pain, anxiety and depression improvement (outcomes). Full articles published in English, Portuguese and Spanish available electronically were selected.

Studies which failed to present online full abstracts, with children and adolescents and unrelated to the theme were excluded.

Two independent investigators conducted the search and application of inclusion criteria according to a standard protocol. They read the title earlier identified, then the abstracts and the full text to form the sample as shown in Figure 1. The instrument created by Ursi ES<sup>20</sup> was adapted and applied to extract the following data: identification of the article (title, author(s), journal, year of publication, country/language); local (institution); methodology (objectives, design, sample size; inclusion and exclusion criteria); description of the interventions (line of treatment, number of sessions, duration), data processing (statistic software), outcomes and evaluation; main results and conclusions.

The PEDro scale was adopted to assess the methodological quality of the randomized or quasi-randomized clinical trials to classify the studies which evaluated the clinical practice performed by the physiotherapist. The assessment was made by two authors independently and a third reviewer was called if discrepancies emerged.



**Figure 1.** Flowchart of search strategy at the databases according to PRISMA checklist

## RESULTS

Of the 94 studies identified at the four databases, 11 were eligible for systematic review, nine of which were ultimately included after reading the full text. The search process is portrayed in Figure 1.

Table 1 presents the characteristics of the studies. Of the nine selected, four were randomized clinical trials, four were single-arm pre-post intervention (prospective) and one was controlled clinical trial with sample by convenience. All the 207 patients investigated by the studies selected were adults older than 18 years of age diagnosed with cancer or survivors. The VR-based interventions were immersive and non-immersive lasting from three to ten weeks. The main outcomes analyzed were anxiety, depression, fatigue, functional ability, reduction of the pain and adherence to treatment.

According to the scale PEDro, the methodological quality of the randomized or quasi-randomized clinical trials selected presented the following results: of the five studies, two scored 5/10, two, 6/10 and one, 7/10.

## DISCUSSION

The systematic review demonstrated the positive effects of gametherapy on several physical symptoms of cancer patients. The studies selected suggest this modality can be incorporated to improve the outcomes as fatigue, levels of anxiety and depression, functionally and pain.

Cancer-related fatigue (CRF) is a persistent symptom, a subjective feeling of emotional, cognitive, physical or exhaustion associated with cancer or its treatment and disproportional to the physical activity exerted<sup>30</sup>. It is a multifactorial and complex disorder related to the decline of the quality-of-life. Physical fitness is so damaged in some patients to the extent of affecting the activities of daily life as, for instance, bathing, dressing and feeding<sup>31</sup>.

CRF is a symptom analyzed in three studies included in the present review. Hoffman et al.<sup>21</sup> investigated the effects of gametherapy with Nintendo Wii Fit Plus during six weeks on CRF of patients submitted to thoracotomy and noticed its decline and increased perception of efficacy of self-management of fatigue. The result of the initial study was ratified post additional ten-week continuous intervention.

A randomized clinical trial with 38 individuals with several types of cancer conducted by Oliveira et al.<sup>27</sup> showed that intervention with Xbox 360 improved the perception of fatigue and quality-of-life. A recent meta-analysis which evaluated the efficacy of VR-based interventions in cancer related symptoms management

Table 1. Characteristics of the articles included

Author	Type of study	Sample	Age	Intervention	Results/Conclusions	PEDro Scale
Hoffman et al. <sup>21</sup>	Single arm, prospective study, sample by convenience	7 individuals with non-small cell lung cancer NSCLC	64.6 years (53-73)	Gametherapy (Walking and Balance exercise with Nintendo Wii Fit Plus), once a day, 6 weeks. Light intensity (3 MET) equivalent to ADL. Walking, increasing 5 minutes each week	Patients positively impacted by intervention at home improving CRF, balance and adherence to the treatment	NA
Hoffman et al. <sup>22</sup>	Single arm, prospective study, sample by convenience	7 individuals with NSCLC postthoracotomy	65 years	Walk with Nintendo Wii for 30 minutes per day, 5 days a week for 6 weeks. Progressive time increase tolerated by the patient. Balance exercises with Nintendo Wii Fit Plus 5 days per week for 6 weeks	The intervention was safe, viable, well-tolerated and highly acceptable. Significant improvement of CRF	NA
Yoon et al. <sup>23</sup>	Randomized controlled clinical trial	40 individuals with stable brain tumor	Intervention group: 48.6 years ( $\pm 11.3$ ); control group: 50 years ( $\pm 17.5$ )	The intervention group performed the virtual reality program 30 minutes per session for 9 sessions and conventional occupational therapy 30 mins per session for 6 sessions for 3 weeks, whereas the control group received conventional occupational therapy alone 30 minutes per session for 15 sessions for 3 weeks	Patients of the intervention group improved the function of the arm/elbow/forearm and more efficacy of the fine motor function and general coordination better than control group ( $p < 0.01$ )	5
Tsuda et al. <sup>24</sup>	Single-arm prospective study with sample by convenience	9 individuals with hematologic neoplasms receiving chemotherapy	63.5 years (61-76)	Gametherapy (Wii Balance Board), once a day, five times a week from the start of chemotherapy treatment until hospital discharge for approximately 20 minutes each session	The patients investigated kept their physical ability and biopsychosocial functioning, in addition to being enjoyable and effective	NA
House et al. <sup>25</sup>	Single-arm prospective study with sample by convenience	12 women with chronic pain post breast cancer surgery	57.8 years (20.4)	Gametherapy with BrightArm Duo, evolving from 20 to 50 minutes, twice a week for 8 weeks. Each session consisted in playing a series of customized games	The results of the therapeutic intervention indicate improvement of cognition, shoulder range, strength, function and depression ( $p < 0.05$ )	NA
Schumacher et al. <sup>26</sup>	Randomized controlled clinical trial	42 individuals submitted to HSCT	Intervention group: 56 years of age (21-65); Control group: Physiotherapy: 56.5 years (23-69)	Intervention group: Nintendo Wii (Wii Sports, Wii Fit and Wii Balance Board) Control group: Eccentric and concentric exercises, walking, stretching and muscle strength with resistance band (TheraBand), 30 minutes per days, 5 times a week	The patients reported Nintendo Wii therapy was effective and agreeable, in addition to fatigue and biopsychosocial improvement. None of the patients had treatment-related complication	5
Oliveira et al. <sup>27</sup>	Randomized controlled clinical trial	38 individuals with several types of cancer	Control group: 57.62 years ( $\pm 7.57$ ); Cancer group: 61.46 years ( $\pm 8.79$ )	Gametherapy with Xbox 360 Kinect, duration according to the patients' tolerance, maximum 50 minutes, 2-3 times a week for a total study duration of 8-10 weeks	Gametherapy with Xbox was effective in reducing symptoms of fatigue, increasing perceived quality-of-life and improving the pattern of deltoid muscle contraction in patients with cancer ( $p < 0.05$ )	6
Feyzioglu et al. <sup>28</sup>	Randomized controlled clinical trial	40 women with breast cancer with axillary dissection	Intervention group: 50.84 years (8.53); Control group: 51 years (7.06)	Intervention group: gametherapy with Xbox 360 Kinect, sessions of 45 minutes (35 min games + 5 min massage + 5 min passive mobilization), 2 times a week during 6 weeks. Control group: conventional therapy 45 minutes/session, 2 times a week for 6 weeks	Patients improved balance, fear of standing on two feet, gain of ROM and muscle strength ( $p < 0.01$ ) for both groups with no significant difference among them. The intervention group reduced the fear of movement ( $p < 0.05$ ) while the control group improved functionality better	7
Garrett et al. <sup>29</sup>	Randomized controlled clinical trial	12 individuals with chronic pain associated with cancer	Intervention group – VR: 59 years (37-62); control group – non-VR: 58 years (45-73)	Four interventions were applied (two with cognitive involvement and two with meditation), each intervention lasted 30 minutes/day, 6 times a week	Overall, participants reported mixed results with VR for chronic pain, some thought it was quite effective in relieving pain during the intervention. The main mechanism of action appears to be a powerful form of distraction	6

**Captions:** CA = cancer; NSCLC = non-small cell lung cancer; MET = multiple equivalent metabolic; ADL = activities of the daily life; CRF = cancer related fatigue; HSCT = hematopoietic stem-cells transplantation; ROM = range of motion; VR = virtual reality; NA = not applicable.

corroborated these findings and noticed a significant decline of post-intervention CRF<sup>32</sup>.

Pain is highly prevalent and anguishing in patients with cancer. van den Beuken-van Everdingen et al.<sup>33</sup> concluded that the incidence of pain ranges from 24% to 60% and nears 58% to 69% in patients with cancer in active treatment and advanced stage of the disease, respectively. For 30% of the patients post curative therapy, the symptom is present.

House et al.<sup>25</sup> investigated the effects of VR-intervention in patients with chronic pain post breast cancer surgery and concluded that the 8-week treatment with BrightArm Duo reduced 20% the intensity of pain.

Two randomized clinical trials part of the present review found similar effects<sup>28,29</sup>. For post-mastectomized breast cancer patients, a significant decline of the intensity of the pain evaluated with the pain visual analogue scale was revealed after 6-week treatment with Xbox 360 Kinect<sup>28</sup>.

Hoffman et al.<sup>21</sup> demonstrated that the use of Nintendo Wii Fit Plus for six weeks to rehabilitate oncologic patients has positively improved the functionality of these individuals, due to the increase of the number of steps counted with pedometer and by the Karnofsky index. A study conducted in 2014 to investigate the follow-up of this same group ratified the result after analyzing the effect of continuation of the proposed investigation and improvement of functionality.

The study of Yoon et al.<sup>23</sup> analyzed the effect of VR-based intervention with Immersive Rehabilitation Exercise (IREX) in patients with brain tumor post-surgery, chemotherapy or radiotherapy over the function of the upper limb among other variables. The investigators noticed that this type of intervention three times a week associated with occupational therapy twice a week for three weeks improved remarkably the functioning of the upper limb, expressed by the highest score of the Fugl-Meyer assessment, of the modified Barthel index and increase of speed of movements.

House et al.<sup>25</sup> investigated the effect of VR-based intervention on the functionality of the upper limb of women with chronic pain post breast cancer surgery; the intervention utilized BrightArm Duo twice a week for eight weeks and revealed improvement although not significant of the functionality analyzed with the Fugl-Meyer assessment, Chedoke Arm and Hand Activity Inventory-9 (CAHAI-9) for bimanual activities and Jebsen Hand Function Test (JHFT) for hand function. The level of independence for activities of the daily life involving the upper limb as measured by the Upper Extremity Functional Index 20 (UEFI-20) presented significant increase at the end of the treatment<sup>25</sup>.

Oncohematologic inpatients undergoing chemotherapy were submitted to Nintendo Wii Fit-based rehabilitation five times a week while hospitalized and were able to keep the physical and social performance<sup>24</sup>.

A randomized clinical trial with 40 women with breast cancer post-mastectomy evaluated the effect of Xbox 360 Kinect as physiotherapeutic resource on variables as pain, handgrip strength and functionality and compared with conventional physiotherapy<sup>28</sup>. The authors utilized the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire and concluded that functionality of the upper limb at the end of the treatment improved for the group using Xbox although no significant difference of this parameter was found after comparing with control group (conventional physiotherapy).

Depression and anxiety are psychiatric disorders frequently found in patients with cancer and usually impact the quality-of-life, the adherence to the treatment and survival<sup>34</sup>. According to Mitchell et al.<sup>35</sup>, depression and anxiety affect nearly 20% and 10% of the patients with cancer, respectively, regardless of the disease stage.

Three studies<sup>24-26</sup> investigated herein analyzed the effects of gametherapy on depression and anxiety of patients with cancer. Tsuda et al.<sup>24</sup> showed that the intervention with Nintendo Wii Fit Plus in patients with hematologic neoplasms admitted for chemotherapy reduced anxiety and promoted significant minimization of depression measured by the Hospital Anxiety and Depression Scale (HADS). The study by Schumacher et al.<sup>26</sup> with patients submitted to hematopoietic stem-cells transplantation has also relied on HADS to evaluate the effects of gametherapy on depression utilizing the same Nintendo Wii Fit, reaching the same results and improvement of emotional well-being, similar to women with chronic pain post-mastectomy submitted to gametherapy rehabilitation with improvement of depression evaluated with Beck's depression inventory<sup>25</sup>.

Most of controlled intervention studies analyzed according to the methodology of PEDro scale presented scores equal or lower than 6/10, which can put the reliability of the results in question and consequently the external validity since important variables of control were not addressed, a possible limitation of the study. Likewise, the heterogeneity of VR-based games utilized in different studies, protocols and follow-up time and types of cancer investigated are other limitations, which hamper qualitative evaluations and analyzes of outcomes.

Randomized controlled clinical trials with well-defined methodologies, prolonged follow-up with representative samples of the population and low risk of bias are necessary to best analyze the benefits of gametherapy for cancer patients with more robust results.

## CONCLUSION

Intervention in cancer patients through gametherapy is little investigated yet. Although vast scientific evidence of its use in many pathologies exist, especially, neurologic, the safety of this population and the estimated goals can limit the applicability in clinical practice. Ultimately, the systematic review exposed the paucity of studies but, nevertheless, it was possible to elucidate that it has positive impacts while reducing anxiety, depression and level of fatigue and increasing their functionality.

## CONTRIBUTIONS

Matheus Renyer Queiroz Vitor, Amanda Souza Araújo, Camille Maria de Holanda Angelim Alves, Juliana Ramiro Luna Castro and Vanessa Ximenes Farias contributed substantially to the study design, acquisition, analysis and/or interpretation of the data, wording and critical review. They approved the final version to be published.

## DECLARATION OF CONFLICT OF INTERESTS

There is no conflict of interests to declare.

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