European Journal of Oncology Nursing 72 (2024) 102665

Contents lists available at ScienceDirect

European Journal of Oncology Nursing

journal homepage: www.elsevier.com/locate/ejon

Exergame-based rehabilitation for cancer patients undergoing abdominal surgery: Effects on pain, anxiety, depression, and fatigue - A pilot study

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ARTICLE INFO

Keywords:
Games
Exergames
Pain
Anxiety
Depression
Fatigue neoplasms
Rehabilitation

ABSTRACT

Purpose: This study aimed to determine the efficacy of an exergame rehabilitation program on pain, anxiety or depression, and fatigue in oncology patients undergoing abdominal surgery.

Methods: The randomized controlled trial evaluated the efficacy of exergame rehabilitation on Pain, Anxiety, Depression, and Fatigue in oncology patients undergoing abdominal surgery. Patients were recruited from October 2022–March 2023 and were randomly assigned to the intervention group (postoperative traditional rehabilitation plus an exergame rehabilitation program) or control group (postoperative traditional rehabilitation). Data were collected at three different times: on admission, in the first 48 h, and on the 7th day after surgery.

Primary outcomes were evaluated and monitored with different validated instruments: numeric rating scale (NRS) for pain, Hospital Anxiety and Depression Scale (HADS) to assess the level of anxiety and depression, and the Fatigue Assessment Scale (FAS) to assess physical and psychological fatigue. The length of stay and program completion were secondary outcomes.

Results: A total of 128 postoperative patients were recruited. Of these, 58 patients were excluded from the study due to clinical complications related to the surgical procedure (n = 53) or healthcare staff-related reasons (n = 5). Both the control and intervention groups were the same size (n = 35). Lower pain scores were observed on the 7th postoperative day in the group subject to the "exergame rehabilitation program" ($p = 0.006$). No statistically significant differences were observed for anxiety and depression between the 2 groups. Regarding fatigue, statistically significant differences were observed on admission ($p = 0.03$), which disappeared 48 h after surgery ($p = 0.143$). Differences between the groups were observed again on the 7th day after surgery ($p = 0.005$).

Conclusions: The intervention using exergames was effective in reducing the postoperative pain of the patient undergoing major abdominal surgery and in restoring the levels of fatigue before surgical intervention. However, no differences were observed for anxiety or depression. Future studies with larger samples should be carried out.

1. Introduction

Postoperative complications can occur after any surgery and can lead to increased morbidity and mortality, as well as increased length of stay and healthcare costs (van Kooten et al., 2021). Complex gastrointestinal surgery (e.g., colorectal, gastric, and esophageal resections) is associated

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https://doi.org/10.1016/j.ejon.2024.102665
Received 22 September 2023; Received in revised form 25 June 2024; Accepted 10 July 2024
Available online 14 July 2024

with high rates of surgical and nonsurgical complications (Busweiler et al., 2017; van Kooten et al., 2021).

Non-surgical complications may influence long-term survival through other pathophysiological mechanisms, such as decreasing cardiorespiratory capacity due to postoperative complications such as acute myocardial infarction or pulmonary embolism (van Kooten et al., 2021). In addition, it is possible to experience short-term impairments as a result of surgery, where pain and respiratory limitations or other functional limitations can occur. Of note, fatigue is the most prevalent cross-sectional side effect during cancer treatment (Jones et al., 2016). This symptom prevails from the beginning to the end of treatment, persists for years, and negatively influences quality of life (QoL) (O'Higgins et al., 2018). Cancer-related fatigue (CRF), according to the National Comprehensive Cancer Network, "*is a distressing, persistent and subjective sense of physical, emotional, and/or cognitive tiredness or exhaustion related to cancer or cancer treatment that is not proportional the recent activity performed and interferes with usual functioning*" (Berger et al., 2015). CRF is a symptom that is not traditionally considered a sequelae of treatment; however, it undoubtedly impacts quality of life. It is one of the most prevalent and challenging symptoms experienced with cancer, being reported in more than half of patients, with higher rates in patients who undergo or received trimodality therapy (radiotherapy, quimiotherapy, and surgery) (Frick et al., 2017; Santa Mina et al., 2020). The distress induced by CRF impacts the prehabilitation and the rehabilitation process (Santa Mina et al., 2020) during the whole continuum of care and includes surgery-related fatigue, which cannot be relieved by rest or sleep (Al Maqbali et al., 2021; Fabi et al., 2020).

Anxiety and depression are important concerns that negatively affect QoL and prognosis in cancer patients. Cancer patients undergoing surgery, in particular, are burdened with two types of stress: associated with the surgery itself and the diagnosis of cancer (Matsushita et al., 2005). In the perioperative period, psychological manifestations may negatively influence treatment and QoL (Matsushita et al., 2005). The turning point phase is recognized on the third day after the patient's surgery when a pathway response to biological normalization trends starts. At the same time, patients are expected to start to augment and return to their daily activities and activities toward their surroundings. Hence, the third postoperative day is characterized by changes in the patient's physical and mental conditions (Araya et al., 2022). In patients with digestive cancer, there is a considerable prevalence of symptoms of anxiety and depression, generally around 20% (Zamani and Alizadeh-Tabari, 2021), which may be aggravated by operative complications associated with surgery and by their own physical "burden" and this may affect their clinical outcomes (Harris et al., 2020, 2021).

Given this, many studies have focused on reducing complications through improving surgical techniques; however, relatively few have addressed improving peri-operative care (Martos-Benitez et al., 2016), which may include gamification, namely through the use of interactive video games called exergames.

Exergames are defined as the combination of exercise and play and are a relatively new idea in rehabilitation where the user uses physical movements (limbs or whole body) to interact with a game (Tough et al., 2018). These resources have also been considered a fun and enjoyable method of physical activity, potentially increasing motivation to participate in exercise and rehabilitation programs (Oliveira et al., 2018), promoting a sense of accomplishment, and, as it is enjoyable, contributing to adherence to this therapeutic intervention (de Oliveira et al., 2020).

Physical exercise programs improve physical fitness, quality of life, aerobic capacity, muscular strength, depression, and well-being (Cramp and Byron-Daniel, 2012). Exergaming has been shown to reduce fatigue in cancer patients, including muscle fatigue, and increase leg muscle strength (da Silva Alves et al., 2017).

There are several exergaming applications, such as games interactively connected to motion detection devices (e.g., "Kinect©", "Wii Fit©" and "PlayStation©" sports games). Other applications are interactive walking or cycling, with a treadmill or exercise bike connected to a screen, on which digital video images of the environment are displayed. Exergames can differ in their intervention styles, which may enhance different outcomes. Some use front cameras in a process of stimulation and imitation or emulation of movements. In the context of postoperative rehabilitation of patients undergoing abdominal surgery and acute stroke (Keshner et al., 2019). Compared to other options, Wii Fit® utilizes a balance board and motion-sensitive controller that can assist in rehabilitation after surgery in the inpatient surgical unit due to its functional and mobility-related benefits and management of postoperative symptoms.

This study aimed to determine the efficacy of exergaming, with a balance board and motion-sensitive controllers, on pain, anxiety, depression, and fatigue in the postoperative period of major abdominal surgery.

2. Methods

2.1. Study design

The pilot study evaluated the efficacy of an exergame rehabilitation program on pain, anxiety, and fatigue in oncological patients undergoing abdominal surgery. The intervention was made using the Medical Research Council (MRC) theoretical framework, which divides complex intervention research into four phases: development or identification of the intervention, feasibility, evaluation, and implementation (Skivington et al., 2024). In this study, we focus on evaluation and how an exercise-based intervention can possibly impact four targeted outcomes: pain, anxiety, depression, and fatigue in a real post-surgical setting.

Patients were recruited from two inpatient Surgery Units of a large oncology hospital in northern Portugal and randomly distributed into two groups. In the "Intervention group," the intervention was implemented using exergames (detailed in the intervention section), and in the control group, the usual standard treatment was used for these patients in the postoperative period. Randomization was carried out at the time of admission to the hospital. Patients with surgery scheduled for odd-numbered days were allocated to the intervention group, and those scheduled for even-numbered days were allocated to the control group. Both groups were subjected to identical surgery procedures and treatment protocols during hospitalization, except for the intervention in terms of post-surgical rehabilitation: control group vs. intervention group. This study was carried out in accordance with the CONSORT guidelines for this type of study (Eldridge et al., 2016).

2.2. Participants

From October 2022 to March 2023, 163 patients who underwent major abdominal surgery were assessed for eligibility. A total of 128 postoperative patients were recruited. Of these, 58 patients were excluded from the study due to clinical complications related to the surgical procedure (n = 53) or healthcare staff-related reasons (n = 5). Both the control and intervention groups were the same size (n = 35) (Fig. 1). Importantly, this sample size per group arm follows the estimated stepped rule of thumb (Lancaster et al., 2004; Whitehead et al., 2016), where more than thirty participants were necessary to conduct this pilot study and estimate different parameters.

Inclusion criteria for the study included patients scheduled for abdominal surgery and expected hospitalization in the two inpatient surgery units, patients who were conscious and oriented in time and space, and patients who provided informed consent. Regarding the exclusion criteria, the following aspects were considered: patients with cognitive deficits; patients with motor deficits (e.g., hemiparesis); patients with severe visual impairment (without the possibility of correction using glasses/lenses); patients with clinical indications not to perform lifting or mobilization; patients requesting a place in the

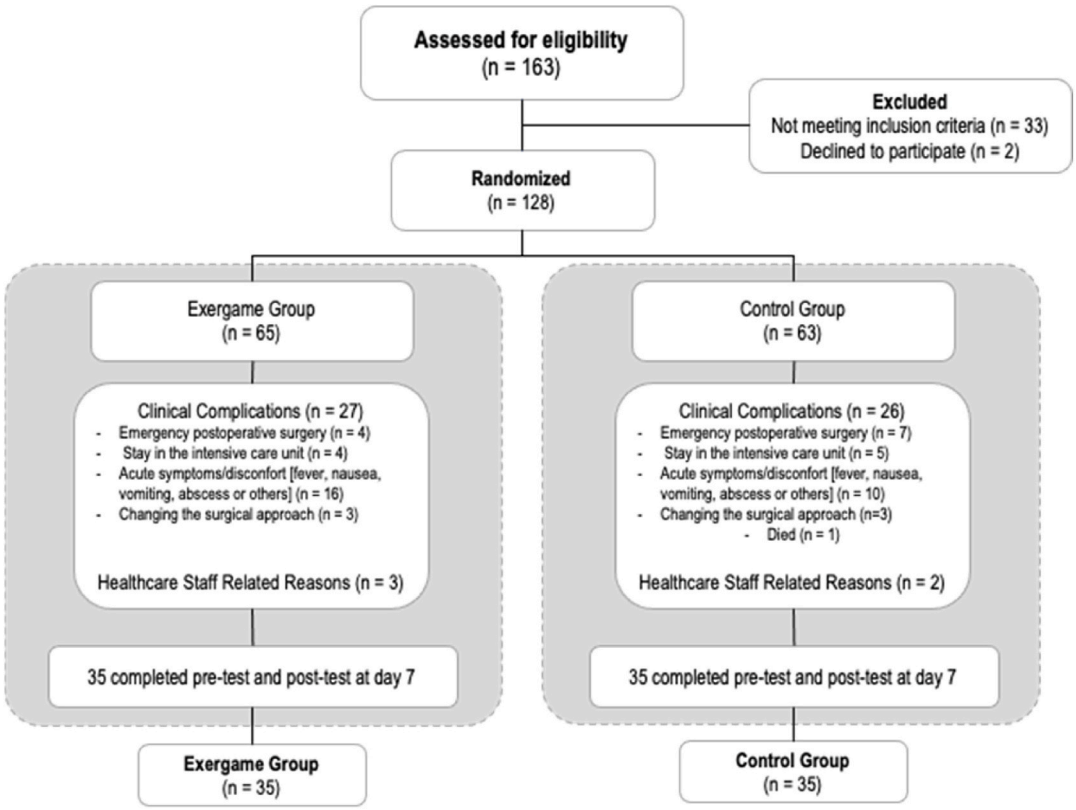

Fig. 1. The flowchart of included participants.

Intensive Care Unit (ICU) or Intermediate Care Unit (IMCU); patients undergoing abdominal surgery scheduled for diagnosis/staging purposes (Exploratory laparotomies/staging laparoscopies).

2.3. Intervention

A 42″ LED television equipped with a Nintendo Wii® console was positioned in front of the patients. Gameplay and console operation were explained to all participants before the start of the study. All aspects of the intervention were supervised by a healthcare rehabilitation professional. Individual sessions were conducted in an adapted and equipped room. Prior to the start of the session, safety conditions were always ensured through a clinical and physical checklist screening.

Four Wii Fit® games, using Nintendo Wii®, were selected for the intervention: Wii Fit Aerobics - Basic Step, Wii Fit - Balance Games Penguin Slide, Wii Fit Super Hula Hoop, and Wii Fit Training Plus – Bird's-Eye Bull's-Eye, with the objective of rehabilitating these patients during the postoperative period. In each session, the patient played the 4 games. On the 2nd and 3rd postoperative days, the total duration of the intervention was 15 min, on the 4th and 5th postoperative days it was 20 min, and on the 6th and 7th days it was 30 min (Table 1).

The control group received the usual care provided for this type of surgery until discharge, including early mobilization, such as early rising from bed and ambulation.

2.4. Outcome assessments

The assessment was structured into 2 distinct parts; the first related to socio-demographic and clinical characterization, and the second to evaluate and monitor the study outcomes. Primary outcomes: pain, anxiety, depression, and fatigue were evaluated and monitored with different validated instruments. Pain was monitored using a numeric rating scale (NRS) in which the patient assessed their pain level using a score from 0 to 10, where 0 means no pain and 10 means maximum pain (Breivik et al., 2008). The Hospital Anxiety and Depression Scale (HADS) was used to assess the level of anxiety and depression (Pais-Ribeiro et al., 2007). It is a self-reported scale in which the patient is asked about their status regarding how they have been feeling in the last week. It consists of 14 questions, 7 related to depression and another 7 related to anxiety. Each item has a score from 0 to 3, with a maximum possible score of 21 points for each symptom. From 0 to 7 points, it is classified as "Unlikely", from 8 to 11 points as "Possible" (questionable or doubtful), and a classification from 12 to 21 points as "Probable".

The Fatigue Assessment Scale (FAS) was used to assess physical and psychological fatigue (Alves, 2017). This scale consists of 10 items; each item is evaluated on a five-point Likert scale, where 1 corresponds to "Never" and 5 corresponds to "Always". The higher the score, the higher the fatigue levels. Length of stay and program completion were assessed as secondary outcomes.

2.5. Statistical analysis

The Statistical Package for the Social Sciences (SPSS®), version 26, was used to carry out statistical analyses using an α of 0.05 and a statistically significant level of $p < 0.05$ for a 95% confidence interval (CI). Descriptive statistics were used to describe participants. Group homogeneity tests were carried out. Regarding quantitative data, the Shapiro–Wilk test was applied to determine normality distribution. All data were described as mean $\pm$ standard deviation (SD), and mean differences and non-parametric tests were used in non-normal distributions. The effectiveness of the exergames in the intervention group was compared to the control group using the Mann-Whitney test or chi-square test, according to the variable under study and considering non-normal data distributions. A conservative per-protocol analysis was conducted, considering the population who completed the study without protocol violations.

Table 1
Data collection and intervention.

Time	Intervention Group[a]	Control Group
Admission	Data collection: CSDC, NRS, HADS, FAS	Data collection: CSDC, NRS, HADS, FAS
2nd postoperative day	Data collection: NRS, HADS, FAS Intervention: 15 min Game 1: 6 min, Game 2: 3 min Game 3: 3 min, Game 4: 3 min	Data collection: NRS, HADS, FAS Usual care
3rd postoperative day	Intervention: 15 min Game 1: 6 min, Game 2: 3 min Game 3: 3 min, Game 4: 3 min	Usual care
4th postoperative day	Intervention: 20 min Game 1: 6 min, Game 2: 6 min Game 3: 5 min, Game 4: 3 min	Usual care
5th postoperative day	Intervention: 20 min Game 1: 6 min, Game 2: 6 min Game 3: 5 min, Game 4: 3 min	Usual care
6th postoperative day	Intervention: 30 min Game 1: 10 min, Game 2: 6 min Game 3: 8 min, Game 4: 6 min	Usual care
7th postoperative day	Data collection: NRS, HADS, FAS Intervention: 30 min Game 1: 10 min, Game 2: 6 min Game 3: 8 min, Game 4: 6 min	Data collection: NRS, HADS, FAS Usual care

CSDC: Clinical and Sociodemographic characterization; NRS: Numeric pain rating scale, HADS: Hospital Anxiety and Depression Scale (HADS), FAS: Fatigue Assessment scale; Game 1: Wii Fit Aerobics - Basic Step, Game 2: Wii Fit - Balance Games Penguin Slide, Game 3: Wi Fit Training Plus - Birds Eye Bulls Eye, Game 4: Wii Fit - Hula Hoop.
[a] In addition to the usual care.

2.6. Ethics statement

At the time of data collection, the patient was informed of the identity of the person responsible for the study, the purposes of the study, and other information, such as how to exercise the right of access and rectification. Written informed consent was obtained from all study participants. Patients' participation was voluntary. The study was authorized by the institution's Ethics Committee (171/2022). In addition, written approval was obtained from the institution's board of directors.

3. Results

3.1. Participant characteristics

The study analyzed the outcomes of 70 patients who underwent major abdominal surgery. This sample was divided into two groups, each with 35 patients who completed the study protocol (as previously presented in section *2.2. Participants*). The clinical and sociodemographic characteristics of the sample of this study are presented in Table 2. We can observe that in the control group the majority of individuals are male (25 people), aged between 39 and 81 years (mean = 62.3). In the intervention group, the majority of patients were also male (20 people), aged between 30 and 78 years (mean = 63.1), with no statistically significant differences between the groups ($p = 0.823$). For the sociodemographic variables studied, there were only statistically significant differences in marital status ($p < 0.001$).

Table 2
Clinical and sociodemographic characteristics.

Variables		Control	Intervention	
		n = 35	n = 35	
Gender, n (%)	Male	25 (71.4)	20 (57.1)	0.318
	Female	10 (28.6)	15 (42.9)	
Median age, years (range)		62.3 (39–81)	63.1 (30–78)	0.823
Median BMI, value (range)		25.21 (14.69–32.37	25.28 (17.72–33.62)	0.66
Marital Status, n (%)	Single	0 (0)	6 (17.1)	<0.001
	Married/ Union	31 (88.6)	27 (77.1)	
	Divorced	2 (5.7)	1 (2.9)	
	Widowed	2 (5.7)	1 (2.9)	
Admission Diagnosis, n (%)	Intestinal Cancer	25 (71.4)	20 (57.1)	0.78
	Gastric Cancer	7 (20.0)	12 (34.3)	
	Others	3 (8.6)	3 (8.6)	
Metastatic Disease, n (%)	Yes	11 (31.4)	6 (17.1)	0.265
	No	24 (68.6)	29 (82.9)	
Chemotherapy, n (%)	Yes	10 (28.6)	11 (31.4)	0.999
	No	25 (71.4)	24 (68.6)	
Radiotherapy, n (%)	Yes	9 (25.7)	6 (17.1)	0.56
	No	26 (74.3)	29 (82.9)	
Practice of physical activity, n (%)	Yes	8 (22.9)	11 (31.4)	0.591
	No	27 (77.1)	24 (68.6)	

BMI – body mass index.

3.2. Study outcomes

The results of the primary outcomes are presented in Table 3. At the time of admission, the majority of participants in both groups reported having no pain (score 0 by NRS: $n = 29$ in the control group and $n = 27$ in the intervention group), with mean values of 0.6 and 1.3 in the two groups, respectively ($p = 0.444$). At 48 h after surgery, only 4 participants of the control group and 5 participants of the intervention group reported having no pain. Pain increased in both groups, with no statistically significant differences observed ($p = 0.299$), with mean pain values in the intervention group 3.4 (±2.7) compared to the control group 4.0 (±2.7). On the 7th day after surgery, there were more participants with no pain (score 0 by NRS) in the intervention group ($n = 17$) versus the control group ($n = 9$). There were lower mean pain values in the intervention group (mean = 1.1 ± 1.6) compared to the control group (mean = 2.2 ± 1.8), with statistically significant differences ($p = 0.006$).

No significant differences were found between the groups in terms of anxiety and depression ($p > 0.05$). Both groups presented higher HADS scores for anxiety than for depression.

At the admission, 54.3% ($n = 19$) of the control group participants presented fatigue versus 31.4% ($n = 11$) in the intervention group. Two days after surgery, the frequency of patients with fatigue increased in both groups: 68.6% ($n = 24$) in the control group versus 51.4% ($n = 18$) in the intervention group. On the 7th postoperative day, we verified a small decrease in the number of patients with fatigue in the control group: 62.9% (n = 22) versus a smaller number of patients with fatigue in the intervention group, 37.1% (n = 13). In terms of mean fatigue values, there were significant differences between the groups at the time of admission ($p = 0.03$), with higher fatigue observed in the control group (22.6 ± 7.7) and lower ones in the intervention group (18.7 ± 5.1). At 48 h after surgery, fatigue values were similar between the two groups, without statistically significant differences ($p = 0.143$), with mean values of 24.2 (±6.6) for the control group and 25.5 (±8.1) for the

Table 3
Analysis of differences between the Control Group and Intervention Group for pain, anxiety, depression, and fatigue (*Mann-Whitney test*).

SCALE		1st Assessment		2nd Assessment		3rd Assessment	
		Control	Intervention	Control	Intervention	Control	Intervention
Pain	mean (±SD)	0.6 (1.6)	1.3 (2.7)	4.0 (2.7)	3.4 (2.7)	2.2 (1.8)	1.1 (1.6)
	p-value	0.444		0.299		0.006	
Anxiety	mean (±SD)	8.2 (4.2)	7.6 (3.8)	7.8 (3.9)	6.9 (3.4)	7.5 (4.1)	6.2 (3.7)
	p-value	0.6		0.336		0.143	
Depression	mean (±SD)	5.4 (3.5)	4.8 (3.6)	6 (3.5)	4.9 (3.3)	6 (3.6)	4.3 (3.2)
	p-value	0.416		0.174		0.051	
Fatigue	mean (±SD)	22.6 (7.7)	18.7 (5.1)	24.2 (6.6)	25.5 (8.1)	23.9 (6.9)	19.0 (6.3)
	p-value	0.03		0.143		0.005	

intervention group. The assessment of fatigue carried out on the 7th postoperative day showed statistically significant differences between the two groups ($p = 0.005$), with lower mean fatigue scores observed in the intervention group (19.0 ± 6.3) compared to the values observed in the control group (23.9 ± 6.9). There were no statistically significant differences in the length of stay between the study groups. The control group had an average of days of hospitalization of 8.4 (±4.0) days, compared to the intervention group with an average of 7.7 (±1.9) days ($p = 0.621$).

All patients in the intervention group completed the exergame rehabilitation protocol without any dropouts and with good adherence.

4. Discussion

This study aimed to determine the efficacy of exergaming on pain, anxiety, depression, and fatigue in the postoperative period of major abdominal surgery. As technology becomes more prevalent in rehabilitation, emerging technologies, like exergames, encourage patients to be more engaged in their recovery (Fernandes et al., 2022; Scherer et al., 2021). Exergaming combines exercise with play, in which the patient uses physical movements to interact with the game, which has been used by people with cancer (Fernandes et al., 2022; Oliveira et al., 2018). Despite the growing popularity of these resources, no published reports discuss the effectiveness of exergames on pain, anxiety, depression, and fatigue in patients after abdominal cancer surgery.

Regarding fatigue, people diagnosed with cancer undergoing chemotherapy, radiotherapy, and/or surgery have higher rates of perceived fatigue during and after treatment (Karthikeyan et al., 2012; Muthanna et al., 2023).

A broad review study on the topic (effects of prehabilitation and exercise rehabilitation on fatigue in patients undergoing surgery), which included 13 studies on patients with lung cancer, showed that none reported a statistically significant decrease in fatigue (Voorn et al., 2023). In a previous systematic review (Codima et al., 2021) in which physical training using exergames was performed by patients with lung cancer undergoing surgery, an exercise program lasting at least four weeks was recommended to improve the patient's performance. Therefore, it is expected that programs like these, to be effective, must have a minimum duration of at least four weeks, with their intervention extended after the patient's clinical discharge. In the present study, the intervention was only limited to the 7th postoperative day, so its extension over time (more than 4 weeks) could be studied in the future, including considering the intervention after the patient's clinical discharge.

Currently, there is a general agreement that preoperative optimization of the patient's physical condition may contribute to lower some potential post-operative complications (de Klerk et al., 2021; van der Hulst et al., 2021). Recently, Klerk et al. (de Klerk et al., 2021) showed that a multimodal prehabilitation program before elective surgery for colorectal cancer, in high-risk patients reduces postoperative complications and unplanned readmissions and shortens the average length of stay when compared with standard treatment (de Klerk et al., 2021). An aspect that could also be explored in future interventions of this program, is the use of exergames for pre-operative optimization. A wide range of risk factors, such as fatigue or others, are susceptible to action in peri-operative care and prehabilitation programs, leading to better results in the postoperative period in high-risk patients (van Kooten et al., 2021).

Regarding anxiety and depression, in the present study, we did not find statistically significant differences at the three timepoints in which these variables were measured.

Anxiety and depression can increase in the postoperative period and may result from various complications caused by surgery (such as pain, nausea, or vomiting), leading to psychological reactions to stress that are manifested in these two symptoms (Liu and Wang, 2022).The clinical worsening is associated with poor quality of life and higher anxiety and postoperative depression in patients with gastric cancer (Liu and Wang, 2022), with a lower turning point response rate after the third day of rehabilitation. In another study, in patients with gastric cancer, it was found that depression increased from before surgery to before discharge and did not return to the preoperative level 6 months after discharge, but no significant effect was observed for anxiety (Matsushita et al., 2005).

In relation to patients with gastrointestinal cancer undergoing major abdominal surgery, it is often postoperative complications that cause long-term functional impairments that exacerbate the degrees of anxiety and depression observed in these patients (Fransgaard et al., 2021; Warps et al., 2022). This may also be often further worsened, due to the effects of neoadjuvant chemotherapy to which these patients are subjected (Wu et al., 2020).

In the present study, there is possible selection bias, as there were patients who did not complete the study due to complications/intercurrences in the postoperative period (Fig. 1), which was similar for both groups: emergency surgery due to bleeding or correction of anastomoses ($n = 11$), stay in intensive care after elective surgery ($n = 9$), uncontrollable vomiting ($n = 9$) or others. It is worth noting that these patients withdrew before starting the experimental phase (48h and 7 days after surgery), with no dropout in this time frame, and all 70 patients included in the study completed it with an application of a conservative per-protocol analysis.

Depression that accompanies cancer is referred to as secondary depression, which is reactive in response to a complex and stressful event that exceeds a person's adaptive capabilities (Kulpa et al., 2014). Depression negatively affects the course of the disease, the treatment and recovery process, the patient's interaction during the treatment process, the selection of coping strategies, the type of relationships with people, and the receipt of social support (Kulpa et al., 2014). Other factors that can influence levels of anxiety and depression are also described in the literature. Specifically, female patients are more likely to experience anxiety and depression feelings following hormonal flux, while the sensitivity of males towards emotional change was relatively weak (Boehmer et al., 2022; McHenry et al., 2014) or patients with higher TNM stage obtained limited treatment efficacy and unsatisfying clinical outcomes, then their anxiety and depression degrees were aggravated (Shimada et al., 2021).

Approximately 77–86% of patients experience postoperative pain

after abdominal surgery (Gan et al., 2014; Warfield and Kahn, 1995). Appropriate and comprehensive pain management can reduce discomfort and morbidity after surgery, improve patient outcomes, and decrease clinical costs. Pain intensity and tolerance depend on the location of the incision, the surgical procedure, the type of anesthesia, and each patient's own perception and experience of pain (Sun et al., 2021). Severe pain after surgery can discourage patients from adhering to lung expansion and pulmonary rehabilitation techniques and early mobilization, resulting in pain-related hypoventilation, atelectasis, and a substantial increase in the risk of cardiorespiratory complications (Chandler et al., 2020).

Major abdominal surgery is a common complex procedure with a sizeable impact on altering the patient's functionality and can lead to postoperative complications and delayed recovery (Visioni et al., 2018). For this reason, rehabilitation for patients following major abdominal surgery is an essential part of the recovery process, promoting better physical functionality, pain relief, prevention of complications, and faster and safer reintegration into activities of daily living (Visioni et al., 2018).

Early rehabilitation intervention, especially early mobilization, effectively prevents postoperative complications and improves the patient's functional capacity and quality of life (de Almeida et al., 2017; Gustafsson et al., 2013). Early mobilization after surgery has been clinically recommended and advocated to reduce the risk of cardiovascular and pulmonary complications in the postoperative period (Chandler et al., 2020).

Compared to other groups, cancer patients have lower quality of life, functionality, range of movement, decreased strength, and increased pain and fatigue (Tough et al., 2018). Therefore, it is important that these patients avoid inactivity and resume their daily activities as soon as possible, starting the rehabilitation process immediately after diagnosis (Tough et al., 2018).

Exergames can play a fundamental role here, compared to traditional programs, because emerging technologies further encourage patients to get involved in their daily rehabilitation program, promoting a sense of accomplishment and, as they are pleasurable, contributing to treatment adherence (de Oliveira et al., 2020). Lack of motivation and emotional impact are the main limitations of inactivity in cancer patients, highlighting the importance of motivational strategies, such as exergames (Peyrachon and Rebillard, 2023). From what is observed here, pain is one of the parameters that is improved with an intervention program such as the one presented here, with efficacy in the postoperative period.

As for anxiety and depression or fatigue, the intervention, in order to prove effective, may have to be implemented well beyond the moment of hospitalization, whether in the pre-operative or even postoperative period. And that is one of the advantages of the Wii - its portability, low cost, ease of use, and space saving make it more accessible for continuous home use. For this reason, Wii Fit has been so well received in rehabilitation programs in clinical contexts and being adopted by several health professionals (Tripette et al., 2017). Still, it would be interesting to explore further.

4.1. Limitations

Despite the study's strengths, this is a pilot study with certain limitations. ,including the sample size and the variability of certain pathologies, predominantly intestinal or gastric malignancies. The duration and follow-up of the study should also be considered with caution, as a short-term study might not capture the long-term efficacy of sustained benefits or progression during the rehabilitation process or in the transition to the outpatient unit or community care. Additionally, utilizing the Nintendo Wii® platform rather than an exergame specifically designed for this purpose is a noteworthy limitation.

5. Conclusion

The current study indicated that a rehabilitation program with exergames improved postoperative pain in patients undergoing major abdominal surgery. There were no statistically significant efficacy for anxiety and depression. Our data provide evidence that an exergame rehabilitation program may be a better approach to preventing pain, and perhaps fatigue, in the postoperative period.

CRediT authorship contribution statement

Isabel Alves: Writing – original draft, Methodology, Conceptualization. **Ana Paula Moreira:** Writing – original draft, Methodology, Data curation. **Teresa Sousa:** Writing – original draft, Methodology, Data curation. **Paulo Teles:** Writing – review & editing, Formal analysis. **Carla Sílvia Fernandes:** Writing – review & editing, Supervision, Conceptualization. **Filipe Goncalves:** Writing – review & editing, Writing – original draft, Methodology. **Bruno Magalhães:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We express our sincere gratitude to all the participants and facility nursing staff, during the process of this study.

References

Al Maqbali, M., Al Sinani, M., Al Naamani, Z., Al Badi, K., Tanash, M.I., 2021. Prevalence of fatigue in patients with cancer: a systematic review and meta-analysis. J. Pain Symptom Manag. 61, 167–189 e114.

Alves, B.A., 2017. Validação da Fatigue Assessment Scale para a população portuguesa, EPCV - Escola de Psicologia e Ciências da Vida. Universidade Lusófona de Humanidades e Tecnologias, Lisboa.

Araya, K., Fukuda, M., Mihara, T., Goto, T., Akase, T., 2022. Association between anxiety and depressive symptoms during prehospitalization waiting period and quality of recovery at postoperative day 3 in perioperative cancer patients. J Perianesth Nurs 37, 654–661.

Berger, A.M., Mooney, K., Alvarez-Perez, A., Breitbart, W.S., Carpenter, K.M., Cella, D., Cleeland, C., Dotan, E., Eisenberger, M.A., Escalante, C.P., Jacobsen, P.B., Jankowski, C., LeBlanc, T., Ligibel, J.A., Loggers, E.T., Mandrell, B., Murphy, B.A., Palesh, O., Pirl, W.F., Plaxe, S.C., Riba, M.B., Rugo, H.S., Salvador, C., Wagner, L.I., Wagner-Johnston, N.D., Zachariah, F.J., Bergman, M.A., Smith, C., 2015. Cancer-related fatigue, version 2.2015. J. Natl. Compr. Cancer Netw. 13, 1012–1039.

Boehmer, U., Ozonoff, A., Winter, M., Berklein, F., Potter, J., Ceballos, R.M., Clark, M.A., 2022. Anxiety and depression in colorectal cancer survivors: are there differences by sexual orientation? Psycho Oncol. 31, 521–531.

Breivik, H., Borchgrevink, P.C., Allen, S.M., Rosseland, L.A., Romundstad, L., Breivik Hals, E.K., Kvarstein, G., Stubhaug, A., 2008. Assessment of pain. Br. J. Anaesth. 101, 17–24.

Busweiler, L.A., Henneman, D., Dikken, J.L., Fiocco, M., van Berge Henegouwen, M.I., Wijnhoven, B.P., van Hillegersberg, R., Rosman, C., Wouters, M.W., van Sandick, J. W., Dutch Upper, G.I.C.A.g., 2017. Failure-to-rescue in patients undergoing surgery for esophageal or gastric cancer. Eur. J. Surg. Oncol. 43, 1962–1969.

Chandler, D., Mosieri, C., Kallurkar, A., Pham, A.D., Okada, L.K., Kaye, R.J., Cornett, E. M., Fox, C.J., Urman, R.D., Kaye, A.D., 2020. Perioperative strategies for the reduction of postoperative pulmonary complications. Best Pract. Res. Clin. Anaesthesiol. 34, 153–166.

Codima, A., das Neves Silva, W., de Souza Borges, A.P., de Castro Jr., G., 2021. Exercise prescription for symptoms and quality of life improvements in lung cancer patients: a systematic review. Support. Care Cancer 29, 445–457.

Cramp, F., Byron-Daniel, J., 2012. Exercise for the management of cancer-related fatigue in adults. Cochrane Database Syst. Rev. 11, CD006145.

da Silva Alves, R., Iunes, D.H., Pereira, I.C., Borges, J.B.C., Nogueira, D.A., Silva, A.M., Lobato, D.F.M., Carvalho, L.C., 2017. Influence of exergaming on the perception of cancer-related fatigue. Game. Health J. 6, 119–126.

de Almeida, E.P.M., de Almeida, J.P., Landoni, G., Galas, F., Fukushima, J.T., Fominskiy, E., de Brito, C.M.M., Cavichio, L.B.L., de Almeida, L.A.A., Ribeiro Jr., U., Osawa, E.A., Diz, M.P., Cecatto, R.B., Battistella, L.R., Hajjar, L.A., 2017. Early

mobilization programme improves functional capacity after major abdominal cancer surgery: a randomized controlled trial. Br. J. Anaesth. 119, 900–907.
de Klerk, M., van Dalen, D.H., Nahar-van Venrooij, L.M.W., Meijerink, W., Verdaasdonk, E.G.G., 2021. A multimodal prehabilitation program in high-risk patients undergoing elective resection for colorectal cancer: a retrospective cohort study. Eur. J. Surg. Oncol. 47, 2849–2856.
de Oliveira, P.F., Alves, R.D.S., Iunes, D.H., de Carvalho, J.M., Borges, J.B.C., Menezes, F. D.S., Carvalho, L.C., 2020. Effect of exergaming on muscle strength, pain, and functionality of shoulders in cancer patients. Game. Health J. 9, 297–303.
Eldridge, S.M., Chan, C.L., Campbell, M.J., Bond, C.M., Hopewell, S., Thabane, L., Lancaster, G.A., group, P.c., 2016. CONSORT 2010 statement: extension to randomised pilot and feasibility trials. Br. Med. J. 355, i5239.
Fabi, A., Bhargava, R., Fatigoni, S., Guglielmo, M., Horneber, M., Roila, F., Weis, J., Jordan, K., Ripamonti, C.I., , E.G.C.E.a., 2020. Cancer-related fatigue: ESMO clinical practice guidelines for diagnosis and treatment. Ann. Oncol. 31, 713–723. clinicalguidelines@esmo.org.
Fernandes, C.S., Baldaia, C., Ferreira, L.M., 2022. Impact of exergames in women with breast cancer after surgery: a systematic review. SN Comprehensive Clinical Medicine 5, 5.
Fransgaard, T., Caspar Thygesen, L., Gogenur, I., 2021. The impact of postoperative complications and delay of adjuvant chemotherapy on oncological outcomes in patients with colorectal cancer. Colorectal Dis. 23, 1132–1140.
Frick, M.A., Vachani, C.C., Hampshire, M.K., Bach, C., Arnold-Korzeniowski, K., Metz, J. M., Hill-Kayser, C.E., 2017. Survivorship after lower gastrointestinal cancer: patient-reported outcomes and planning for care. Cancer 123, 1860–1868.
Gan, T.J., Habib, A.S., Miller, T.E., White, W., Apfelbaum, J.L., 2014. Incidence, patient satisfaction, and perceptions of post-surgical pain: results from a US national survey. Curr. Med. Res. Opin. 30, 149–160.
Gustafsson, U.O., Scott, M.J., Schwenk, W., Demartines, N., Roulin, D., Francis, N., McNaught, C.E., Macfie, J., Liberman, A.S., Soop, M., Hill, A., Kennedy, R.H., Lobo, D.N., Fearon, K., Ljungqvist, O., Enhanced Recovery After Surgery Society, f.P. C., European Society for Clinical, N., Metabolism, International Association for Surgical, M., Nutrition, 2013. Guidelines for perioperative care in elective colonic surgery: enhanced Recovery after Surgery (ERAS((R))) Society recommendations. World J. Surg. 37, 259–284.
Harris, J.P., Kashyap, M., Humphreys, J.N., Chang, D.T., Pollom, E.L., 2021. Longitudinal analysis of mental disorder burden among elderly patients with gastrointestinal malignancies. J. Natl. Compr. Cancer Netw. 19, 163–171.
Harris, J.P., Kashyap, M., Humphreys, J.N., Pollom, E.L., Chang, D.T., 2020. The clinical and financial cost of mental disorders among elderly patients with gastrointestinal malignancies. Cancer Med. 9, 8912–8922.
Jones, J.M., Olson, K., Catton, P., Catton, C.N., Fleshner, N.E., Krzyzanowska, M.K., McCready, D.R., Wong, R.K., Jiang, H., Howell, D., 2016. Cancer-related fatigue and associated disability in post-treatment cancer survivors. J Cancer Surviv 10, 51–61.
Karthikeyan, G., Jumnani, D., Prabhu, R., Manoor, U.K., Supe, S.S., 2012. Prevalence of fatigue among cancer patients receiving various anticancer therapies and its impact on quality of life: a cross-sectional study. Indian J. Palliat. Care 18, 165–175.
Keshner, E.A., Weiss, P.T., Geifman, D., Raban, D., 2019. Tracking the evolution of virtual reality applications to rehabilitation as a field of study. J. NeuroEng. Rehabil. 16, 76.
Kulpa, M., Kosowicz, M., Stypuła-Ciuba, B.J., Kazalska, D., 2014. Anxiety and depression, cognitive coping strategies, and health locus of control in patients with digestive system cancer. Przegląd Gastroenterol. 9, 329–335.
Lancaster, G.A., Dodd, S., Williamson, P.R., 2004. Design and analysis of pilot studies: recommendations for good practice. J. Eval. Clin. Pract. 10, 307–312.
Liu, P., Wang, Z., 2022. Postoperative anxiety and depression in surgical gastric cancer patients: their longitudinal change, risk factors, and correlation with survival. Medicine 101.
Martos-Benitez, F.D., Gutierrez-Noyola, A., Echevarria-Victores, A., 2016. Postoperative complications and clinical outcomes among patients undergoing thoracic and gastrointestinal cancer surgery: a prospective cohort study. Rev Bras Ter Intensiva 28, 40–48.
Matsushita, T., Matsushima, E., Maruyama, M., 2005. Anxiety and depression of patients with digestive cancer. Psychiatr. Clin. Neurosci. 59, 576–583.
McHenry, J., Carrier, N., Hull, E., Kabbaj, M., 2014. Sex differences in anxiety and depression: role of testosterone. Front. Neuroendocrinol. 35, 42–57.
Muthanna, F.M.S., Hassan, B.A.R., Karuppannan, M., Ibrahim, H.K., Mohammed, A.H., Abdulrahman, E., 2023. Prevalence and impact of fatigue on quality of life (qol) of cancer patients undergoing chemotherapy: a systematic review and meta-analysis. Asian Pac. J. Cancer Prev. 24, 769–781.
O'Higgins, C.M., Brady, B., O'Connor, B., Walsh, D., Reilly, R.B., 2018. The pathophysiology of cancer-related fatigue: current controversies. Support. Care Cancer 26, 3353–3364.
Oliveira, P.F., Iunes, D.H., Alves, R.S., Carvalho, J.M., Menezes, F.S., Carvalho, L.C., 2018. Effects of exergaming in cancer related fatigue in the quality of life and electromyography of the middle deltoid of people with cancer in treatment: a controlled trial. Asian Pac. J. Cancer Prev. 19, 2591–2597.
Pais-Ribeiro, J., Silva, I., Ferreira, T., Martins, A., Meneses, R., Baltar, M., 2007. Validation study of a Portuguese version of the hospital anxiety and depression scale. Psychol. Health Med. 12, 225–235 quiz 235-227.
Peyrachon, R., Rebillard, A., 2023. Effects of active video games in patients with cancer: systematic review. JMIR Cancer 9, e45037.
Santa Mina, D., van Rooijen, S.J., Minnella, E.M., Alibhai, S.M.H., Brahmbhatt, P., Dalton, S.O., Gillis, C., Grocott, M.P.W., Howell, D., Randall, I.M., Sabiston, C.M., Silver, J.K., Slooter, G., West, M., Jack, S., Carli, F., 2020. Multiphasic prehabilitation across the cancer continuum: a narrative review and conceptual framework. Front. Oncol. 10, 598425.
Scherer, S., Jansen, L., Boakye, D., Hoffmeister, M., Brenner, H., 2021. Changes in health-related outcomes among colorectal cancer patients undergoing inpatient rehabilitation therapy: a systematic review of observational and interventional studies. Acta Oncol. 60, 124–134.
Shimada, H., Fukagawa, T., Haga, Y., Okazumi, S.I., Oba, K., 2021. Clinical TNM staging for esophageal, gastric, and colorectal cancers in the era of neoadjuvant therapy: a systematic review of the literature. Ann Gastroenterol Surg 5, 404–418.
Skivington, K., Matthews, L., Simpson, S.A., Craig, P., Baird, J., Blazeby, J.M., Boyd, K.A., Craig, N., French, D.P., McIntosh, E., Petticrew, M., Rycroft-Malone, J., White, M., Moore, L., 2024. A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. Int. J. Nurs. Stud. 154, 104705.
Sun, X., Wei, Q., Fu, C., Zhang, Q., Liang, Z., Peng, L., Chen, L., He, C., Wei, Q., 2021. Effects of abdominal binders on postoperative pain and functional recovery: a systematic review and meta-analysis. Pain Med. 22, 2174–2184.
Tough, D., Robinson, J., Gowling, S., Raby, P., Dixon, J., Harrison, S.L., 2018. The feasibility, acceptability and outcomes of exergaming among individuals with cancer: a systematic review. BMC Cancer 18, 1151.
Tripette, J., Murakami, H., Ryan, K.R., Ohta, Y., Miyachi, M., 2017. The contribution of Nintendo Wii Fit series in the field of health: a systematic review and meta-analysis. PeerJ 5, e3600.
van der Hulst, H.C., Bastiaannet, E., Portielje, J.E.A., van der Bol, J.M., Dekker, J.W.T., 2021. Can physical prehabilitation prevent complications after colorectal cancer surgery in frail older patients? Eur. J. Surg. Oncol. 47, 2830–2840.
van Kooten, R.T., Bahadoer, R.R., Peeters, K., Hoeksema, J.H.L., Steyerberg, E.W., Hartgrink, H.H., van de Velde, C.J.H., Wouters, M., Tollenaar, R., 2021. Preoperative risk factors for major postoperative complications after complex gastrointestinal cancer surgery: a systematic review. Eur. J. Surg. Oncol. 47, 3049–3058.
Visioni, A., Shah, R., Gabriel, E., Attwood, K., Kukar, M., Nurkin, S., 2018. Enhanced recovery after surgery for noncolorectal surgery?: a systematic review and meta-analysis of major abdominal surgery. Ann. Surg. 267, 57–65.
Voorn, M.J.J., Driessen, E.J.M., Reinders, R., van Kampen-van den Boogaart, V.E.M., Bongers, B.C., Janssen-Heijnen, M.L.G., 2023. Effects of exercise prehabilitation and/or rehabilitation on health-related quality of life and fatigue in patients with non-small cell lung cancer undergoing surgery: a systematic review. Eur. J. Surg. Oncol. 49, 106909.
Warfield, C.A., Kahn, C.H., 1995. Acute pain management. Programs in U.S. hospitals and experiences and attitudes among U.S. adults. Anesthesiology 83, 1090–1094.
Warps, A.K., Tollenaar, R., Tanis, P.J., Dekker, J.W.T., Dutch ColoRectal, A., 2022. Postoperative complications after colorectal cancer surgery and the association with long-term survival. Eur. J. Surg. Oncol. 48, 873–882.
Whitehead, A.L., Julious, S.A., Cooper, C.L., Campbell, M.J., 2016. Estimating the sample size for a pilot randomised trial to minimise the overall trial sample size for the external pilot and main trial for a continuous outcome variable. Stat. Methods Med. Res. 25, 1057–1073.
Wu, C., Wang, N., Zhou, H., Wang, T., Mao, Q., Zhang, X., Zhao, D., 2020. Effects of neoadjuvant chemotherapy toxicity and postoperative complications on short-term and long-term outcomes after curative resection of gastric cancer. J. Gastrointest. Surg. 24, 1278–1289.
Zamani, M., Alizadeh-Tabari, S., 2021. Anxiety and depression prevalence in digestive cancers: a systematic review and meta-analysis. BMJ Support. Palliat. Care. https://doi.org/10.1136/bmjspcare-2021-003275.