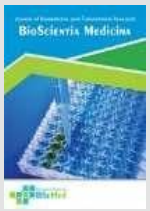
eISSN (Online): 2598-0580



Bioscientia Medicina: Journal of Biomedicine & Translational Research

Journal Homepage: www.bioscmed.com

The Role of Virtual Reality in Cancer Pain Management: A Systematic Literature Review

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ARTICLE INFO

Keywords:
Cancer pain
Pain management
Organ dysfunction
Technology
Virtual reality

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All authors have reviewed and approved the final version of the manuscript.

https://doi.org/10.37275/bsm.v7i1.752

A B S T R A C T

Background: Virtual reality (VR) is a 3D environment-based simulation using computer technology that creates a realistic multi-sensorial experience. VR allows users to simulate real-world scenarios in a safe, attractive virtual space. Immersive VR has been proposed as a non-pharmacologic approach to cancer pain management. This systematic review aimed to explore the role of virtual reality in cancer pain management. **Methods:** The current review was conducted and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This study used PICO consisting of population: adult patients with cancer pain, intervention: virtual reality, comparison: placebo, outcome: reducing cancer pain. **Results:** Four studies of moderate to the high quality that met the inclusion and exclusion criteria were reviewed in this study. Two studies show VR can reduce stress and anxiety and increase relaxation. Two RCTs demonstrated the effectiveness of VR in reducing cancer pain. **Conclusion:** Virtual reality technology can help to reduce cancer pain. In addition to pain severity, other parameters such as fatigue, depression, anxiety, and stress also were decreased. VR also could increase the level of relaxation. Virtual reality's role in reducing pain can have good implications for cancer pain management and increasing patient comfort.

1. Introduction

Cancer pain management remains undertreated due to the complex nature of cancer pain. Cancer pain management generally requires multimodal analgesic treatment. However, the pharmacologic approach in cancer pain management was limited due to patients' comorbidities and analgesic's side effects. Virtual reality (VR) is a 3D environment-based simulation created by computer technology that makes a realistic multi-sensorial experience.[1] VR has been known as an effective and engaging modality to improve physical rehabilitation and pain management in cancer patients. Virtual reality (VR) is an alternative modality that might be used as a non-pharmacologic approach to reducing analgesic requirements and side effects of cancer pain management. VR can divert a patient's attention from sensory pain signals and focus on the virtual experience generated by the VR software.[2-5] VR has previously been known to have a significant role in managing acute and chronic pain. Previous studies have explored the role of VR in the pain management of fibromyalgia, spinal cord injury, phantom limb,

migraines, and psychological disorders such as anxiety disorders and post-traumatic stress disorder.[6-10] VR has also been used to reduce pain and psychological stress during medical procedures such as burn wound dressing.[11] This systematic review aimed to explore the role of VR in cancer pain management.

2. Methods

The current review was conducted and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This study used PICO consisting of population: adult patients with cancer pain, intervention: virtual reality, comparison: placebo, outcome: reducing cancer pain. Searches were conducted through online databases such as Pubmed, ResearchGate, ScienceDirect, and Cochrane from inception to January 20, 2022. Search terms included the following: "Virtual Reality," "cancer," and "pain." The search is carried out using keywords arranged with the boolean operators "AND," "OR", and "NOT," which are adapted to the search format of each data center.

The two independent researchers will double-check all articles obtained through the four central databases to remove duplicate reports. Researchers will conduct a screening based on the title of the research article and abstract to assess whether the research meets the eligibility criteria. Differences between the review authors were settled by discussion, and a third reviewer was consulted if differences persisted. The study authors were contacted to acquire additional information on the data presented if needed. We excluded reviews without outcome summary statistics (effect size with 95%CIs). The articles that meet the inclusion and exclusion criteria will be screened again and selected using key analysis.

The quality of the evidence was rated by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) guideline. Results are divided into high, moderate, low, and very low. The two independent investigators conducted the methodology and evidence quality assessment process. Discrepancies between investigators were resolved by discussion or by a third reviewer in cases when a consensus was not reached. Descriptive analyses were carried out on the methodology and evidence quality of the included systematic review or research articles.

3. Results

A flow diagram of study screening and selection procedures is illustrated in Figure 1. Our electronic search yielded 42 potentially relevant publications. After the double-filtering process, there were seven articles left. However, after reviewing the articles, there are only four, including one pilot study, one cross-over study, and two randomized controlled trials (RCT).

The characteristics of the four studies included are summarized in Table 1. Reynolds et al. studied the acceptability and efficacy of VR interventions in patients with metastatic breast cancer to improve quality of life and reduce pain, depression, anxiety, and stress.[12] The research included 38 women who suffered from metastatic breast cancer and excluded patients with cognitive, auditory, and visual impairments and patients with an English language barrier. In addition, the study also reported the role of VR on fatigue, depression, and stress. Another outcome that was also assessed was the visibility of implementing VR at home operated by patients or their families.

Austin et al. found a significant decrease in cancer pain intensity after applying 3D VR HMD ($p=0.003$) and 2D screen ($p = 0.007$).[13] This study examined 13 palliative patients aged 18 years and over, diagnosed with cancer, hospitalized or received focused palliative care at home, and had experienced cancer pain 24 hours before and at the time of study participation, with a life expectancy of one month. This study studied the feasibility and acceptability of VR for treating cancer pain.

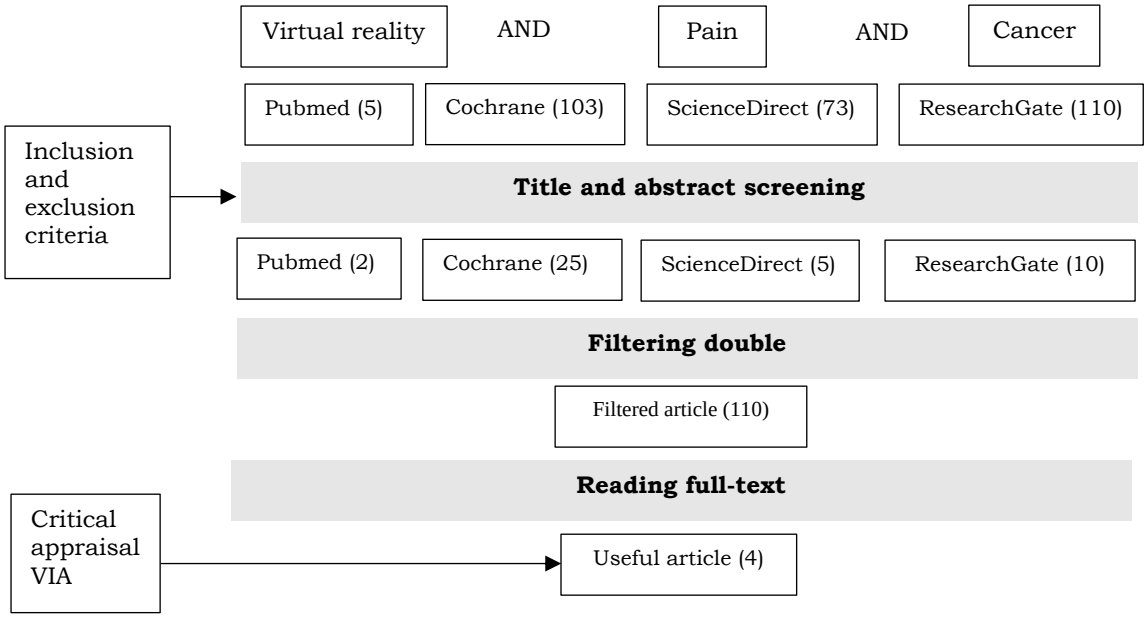

Figure 1. Flow diagram of study screening and selection procedures.

Verzwyvelt et al. studied the role of VR in cancer pain management by comparing the standard intervention group, the VR intervention group, and the green therapy intervention group. Subjects included 33 samples aged 26 to 84 diagnosed with breast, gynecological, gastrointestinal, pancreatic, and prostate cancer. Their study excluded hematological malignancy and or patients with a history of chemotherapy. They assessed the biological impact (heart rate, systolic or diastolic blood pressure, cortisol levels in saliva, pain, or anxiety) between groups. Apart from the primary outcome, this study also found that most participants were interested in exploring how the natural environment could influence wellness.[15]

Kelleher et al. performing pre and post-study of VR intervention within a marine environment (VR Blue).[16] The study included 20 subjects aged 18-85 with at least moderate cancer pain. They excluded patients with a severe mental illness (e.g., schizophrenia) or medical condition (e.g., recent myocardial infarction before the study) that were contraindicated and might be harmful; or visual, auditory, or cognitive impairments that would interfere with engagement of blue VR session. After the VR intervention, they found that 58.93% of pain intensity decreased, 68.40% of stress level decreased, 65.22% anxiety decreased, 37.78% relaxation increased, and 20% improved mood. Changes in pain were significantly correlated with the degree of relaxation ($r = -0.455$, $p < 0.05$). In addition to the primary outcome, this study also studied the acceptability, compliance, completeness, and safety of participants who run VR Blue by assessing dizziness, headaches, and nausea side effects.[15]

4. Discussion

Virtual reality (VR) is an effective tool for managing cancer pain.[16,17] Cancer patients often experience a variety of physical and psychological symptoms, including pain, anxiety, and depression.[18] Traditional pain management techniques, such as medication and physical therapy, may not be sufficient to address all of these symptoms.[18-20] Virtual reality can help by providing a distraction from pain and anxiety. VR technology can create an immersive environment that patients can interact with, taking their minds off their physical discomfort.[21] VR environments can be designed to be calming, soothing, and relaxing, which can help patients feel more at ease. Studies have shown that VR can be an effective tool for managing cancer pain.[22-23]

Table 1. Summary of studies.

Author	Study design	Patients	Intervention	Assessment tools	Primary outcome: cancer pain	Secondary outcome
Reynolds et al. (2022)[12]	RCT	A woman that has a diagnosis of MBC is over 18 years, be able to physically wear and tolerate the VR headset, and has experienced symptoms of fatigue, pain, or anxiety in the week prior to enrolment by study researchers.	Pico Goblin VR headset with Two different VR interventions, "Happy Place" and "Ripple."	EQ-5D-5L, FACIT-Fatigue, DASS-SF	Significant improvements post-intervention and/or 48 h later were demonstrated for quality of life, fatigue, pain, depression, anxiety, and stress. (p: 0,004)	The established benefits of VR on symptoms of pain, depression, and anxiety also extend to fatigue. VR intervention can be a viable and acceptable treatment for MBC patients (at home, patient-operated)
Austin et al. (2020)[13]	RCT	Palliative care inpatient unit patients or patients receiving home-based palliative care, Aged 18 years and older, A diagnosis of cancer, The presence of cancer-related pain over the previous 24 hours and at the time of study participation, the life expectancy of one month and over.	3D head-mounted display (HMD) VR application and 2D screen application	Primary outcome measurement: Pain numerical rating scale (NRS). Secondary outcome: Edmonton Symptom Assessment System (ESAS), Australian-modified Karnofsky Performance Status (AKPS), iGroup Presence Questionnaire (IPQ)	Cancer pain intensity significantly reduced after 3D HMD VR (1.9 ± 1.8, P = 0.003) and 2D screen applications (1.5 ± 1.6, P = 0.007)	The completion rate was high (93%), with significantly higher levels of presence with the 3D HMD VR compared to the 2D screen (60.7 ± SD 12.4 versus 34.3 ± SD 17.1, mean 95% CI: 16.4–40.7, P = 0.001). Increased presence was associated with significantly lower pain intensity (mean 95% CI: −.04–−0.01, P = 0.02).
Verzwyvelt et al., (2021)[14]	case-crossover	33 participants with breast, gynecologic, gastrointestinal, pancreatic, and prostate cancers	Control room, VR room, Green therapy room	Pain scale, distress screening tool, saliva cortisol testing, and additional stress measurement tools (GE Dinamap Procare 400)	No statistical significance in heart rate, systolic or diastolic blood pressure, saliva cortisol, pain, or distress between the control, green therapy, and virtual reality rooms.	44% of patients reported that they were spending more time outside (71.4% reported spending at least 60 min outside). Over 90% of patients reported that they are interested in the effects of nature on their health.
Kelleher, et al. (2022)[15]	Pilot trial	Adult colorectal cancer patients with advanced disease (stage IV) that included: age 18–85, at least moderate pain (≥4 on 0–10 scale) on most days of the month for ≥3 months; English-speaking; and self-reported normal or corrected to normal vision and hearing.	VR blue session	BPI, visual analog scale (VAS), coping strategies questionnaire (CSQ), and chronic pain self-efficacy scale.	From pre- to post-VR Blue, pain decreased by 58.93%., tension decreased by 74.33%, stress decreased by 68.40%. anxiety decreased by 65.22%. Relaxation increased by 37.78%. Mood level improved by 70.20%. Change in pain catastrophizing was significantly correlated with change in relaxation (r = −0.455, p < 0.05)	Acceptability: highly acceptable with a mean satisfaction rating of 3.30 out of 4.0 (SD = 0.41). Adherence and data completion: 100 % (above 80% feasibility benchmark), Safety: All participants (100%) completed the VR Blue session without self-report of significant side effects (e.g., dizziness, headache, and nausea)

From studies obtained, it was found that all articles had almost the same results regarding the effect of VR on reducing the intensity of cancer pain in patients with cancer. From the research obtained, the use of VR has an impact on improving the quality of life of patients. More than fifty percent of women with metastatic breast cancer tend to have a poorer quality of life, which is related to the side effects of treatment and symptoms of cancer. Virtual reality improves the quality of life, enhancing immune function by reducing depression, anxiety, and fear and increasing relaxation. Lower levels of anxiety and fatigue are predicted to extend the time between recurrences and lag times and can ultimately increase patient survival. In the studies obtained, it was also found that VR interventions can be operated by patients and their families and carried out at home so patients can feel more comfortable; this is considered to reduce anxiety levels. Although research by Verswyvelt et al. showed no significant change between VR and cancer pain, surveys and quality of life questionnaires with patients showed positive results in improving quality of life and responses that were also good in reducing anxiety and increasing relaxation.

The thing that needs to be considered from all of these studies is that there are differences between the pain scales used, so that needs to be a concern for researchers who wish to carry out further research on what pain scale and quality of life to use and in accordance with the population to be studied. Overall, virtual reality is a promising tool for managing cancer pain.[24,25] As VR technology continues to evolve and become more widely available, it may become a standard part of cancer pain management programs.

5. Conclusion

Virtual reality technology can help to reduce cancer pain. In addition to pain severity, other parameters such as fatigue, depression, anxiety, and stress also were decreased. VR also could increase the level of relaxation. Virtual reality's role in reducing pain can have good implications for cancer pain management and increasing patient comfort.

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