Advances in Radiation Oncology (2024) 9, 101640

advances in radiation oncology

www.advancesradonc.org

Research Letter

Impacts of Intrafraction Virtual Reality-Based Environment Modification on Procedural Anxiety, Heart Rate, and Overall Radiation Therapy Experience During External Beam Radiation Therapy

Conley Kriegler, MD,[a,*] Brock Debenham, MD, FRCPC,[a] Michael Piva, BSc, MRT(T),[b] Michelle Bernardo, BSc, MRT(T),[b] Amanda Bylhouwer, BSc, MRT(T),[b] Tina Karim, BSc, MRT(T),[b] Yiming Michael Zhu, MD,[a] Giselle Tucker Belliveau, BHS, MHS,[c] Benjamin Merrick, BSc, MBDC,[c] and Mustafa Al Balushi, MD, FRCPC[d]

[a]Division of Radiation Oncology, Cross Cancer Institute, University of Alberta, Edmonton, Alberta, Canada; [b]Division of Radiation Therapy, Cross Cancer Institute, University of Alberta, Edmonton, Alberta, Canada; [c]Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Alberta, Canada; and [d]Brigham and Women's Hospital, Dana Farber Cancer Institute, Harvard Medical School, Boston, Massachusetts

Received 6 January 2024; accepted 9 September 2024

Purpose: Procedural anxiety of cancer treatments may negatively impact patients and treatments. Mindfulness-promoting environment modification with virtual reality (VR) is increasingly used across medicine to minimize procedural anxiety. We aimed to assess the impacts of intrafraction mindfulness-promoting VR use during external beam radiation therapy (EBRT) on radiation therapy experience and physiological measures of distress.

Methods and Materials: Adult patients receiving EBRT between May and October 2023 at our institution without contraindications to wearing VR were eligible. Participants had heart rates recorded before and after EBRT and completed a post-EBRT survey for 1 treatment without intervention, and 1 using VR. Participants completed the Radiotherapy Experience Questionnaire and additional questions regarding VR. Quantitative data were compared between conditions using paired samples *t* test.

Results: Fifty-two participants completed the project. Between pre- and post-EBRT, a significant decrease in heart rate with VR was noted (80.35 bpm vs 71.79 bpm; $P < .0001$*), but not in the control condition (78.90 bpm vs 78.10 bpm; $P = .44$). Post-EBRT heart rate was significantly lower with VR than without (71.79 bpm vs 78.10 bpm; $P < .01$*). Radiotherapy Experience Questionnaire responses showed participants had significantly lower situational unease (1.46 vs 2.02; $P < .001$*), a more beneficial situational response (1.55 vs 2.12; $P < .01$*), and improved environment acceptance (1.30 vs 1.60; $P < .01$*) when using VR. Most endorsed VR as comfortable (94%), improved treatment experience (86%), and would recommend it to others (86%).

Conclusions: We report the first evidence of the impacts of intrafraction mindfulness-promoting VR use during EBRT. Physiological measures of distress and patient perspectives suggest that VR can minimize procedural anxiety, is well tolerated, and improves the

Sources of support: Work for this project was supported by funding from the CARO-CROF Pamela Catton Summer Studentship Award for employment of a summer student research assistant.

Research data are stored in an institutional repository and will be shared on request to the corresponding author.

*Corresponding author: Conley Kriegler, MD; Email: kriegler@ualberta.ca

https://doi.org/10.1016/j.adro.2024.101640

overall treatment experience. Further research should explore modifying this tool for patients unable to wear headsets and determining where the most clinically significant benefits can be found.

Introduction

Anxiety and psychological distress are common for patients undergoing radiation therapy and are experienced before, during, and after treatments.[1,2] These can cause patient suffering, disrupt treatment delivery and adherence, accrue additional costs, impair clinical workflow, and necessitate pharmacological interventions.[3-5] Elsewhere in oncology, mindfulness-promoting virtual reality (VR) has been used to minimize patient procedural anxiety, such as during chemotherapy infusions or procedural interventions.[6,7] For external beam radiation therapy (EBRT), several nonpharmacological approaches have been investigated, including music therapy,[8] relaxation therapy,[9] or even VR-augmented patient education.[10] Criticisms of these approaches have been mixed results of benefits, technical expertise required to offer services, and time required to provide interventions, thus prompting calls for further research and exploration of new interventions for EBRT procedural anxiety.[11] Interestingly, no research has examined the ability of mindfulness-promoting VR, which lacks the aforementioned weaknesses, to improve the patient experience during EBRT.

This project aimed to assess the impacts of using a mindfulness-promoting VR app during EBRT on patient radiotherapy experience and anxiety, as well as using heart rate as a physiological surrogate for anxiety and distress.[12] Although limited in scope, a better understanding of the effects of mindfulness-promoting VR during EBRT is a first step in determining its utility in mediating procedural anxiety and settings for its optimal use.

Methods

This was a cross-sectional study approved by the Health Research Ethics Board of Alberta. At our single institution, patients aged 18 years and older and scheduled to receive EBRT that would not prevent wearing a VR headset were recruited, and informed consent was obtained. An Oculus Go headset and the Guided Meditation VR app were used to create the VR environment. To control potential anticipatory anxiety, participants were exposed to the headset and selected their preferred scene among 22 options prior to treatment. Heart rate was measured using a finger pulse oximeter before and immediately after treatment. Patient-reported data were recorded using the Radiotherapy Experience Questionnaire (RTEQ), a 23-item validated instrument designed to assess patient experiences of EBRT.[13]

The first fraction of treatment was delivered per standard institutional protocol. During the second fraction, heart rate was recorded prior to treatment, and immediately afterward, followed by questionnaire completion. During the third fraction, heart rate was obtained, and then, a VR headset displaying a calming nature scene with accompanying audio was adjusted onto participants and played throughout treatment. Heart rate was then recorded, and the headset was removed. Participants then completed the RTEQ and 5 questions related to VR experience (Appendix E1). Radiation therapist perspectives were obtained through qualitative analysis of semistructured interviews.[14]

Descriptive statistics were generated for quantitative variables and compared with paired samples t test using IBM SPSS Statistics for Windows (Version 27.0. IBM Corp). The results were considered statistically significant at the 5% critical level ($P < .05$).

Results

Fifty-two participants completed the project and were included in the final analysis. Participants received EBRT between May and October 2023. Mean age was 64.25 years, with 29 men and 23 women participating. Overall, heart rate decreased from before EBRT (79.63 bpm) to afterward (74.94 bpm; $t = 5.57$, $P < .0001$*). When using VR, heart rate significantly decreased from before EBRT (80.35 bpm) to afterward (71.79 bpm; $t = 7.82$, $P < .0001$*), but not in the No VR condition (78.90 bpm vs 78.10 bpm; $t = 0.78$, $P = .44$). With VR, post-EBRT heart rate (71.79 bpm) was significantly lower than in the No VR condition (78.10 bpm; $t = 3.02$, $P = .003$*), whereas pre-EBRT heart rate in the No VR and VR conditions was not significantly different (78.90 bpm vs 80.35 bpm; $t = 1.03$, $P = .31$) (Fig. 1).

RTEQ results showed significantly less situational unease (1.46 vs 2.02; $t = 4.54$, $P < .001$*), significantly improved situational response (1.55 vs 2.12; $t = 2.96$, $P = 0.004$*), and significantly improved environment acceptance with VR than No VR (1.30 vs 1.60; $t = 2.78$, $P = .007$*) (Fig. 2). The majority of participants strongly agreed (50%) or moderately agreed (34%) that the VR headset was comfortable (Fig. 3); strongly agreed (58%) or moderately agreed (11%) that VR improved overall treatment experience (Fig. 4); and strongly agreed (62%) or moderately agreed (11%) that they would recommend

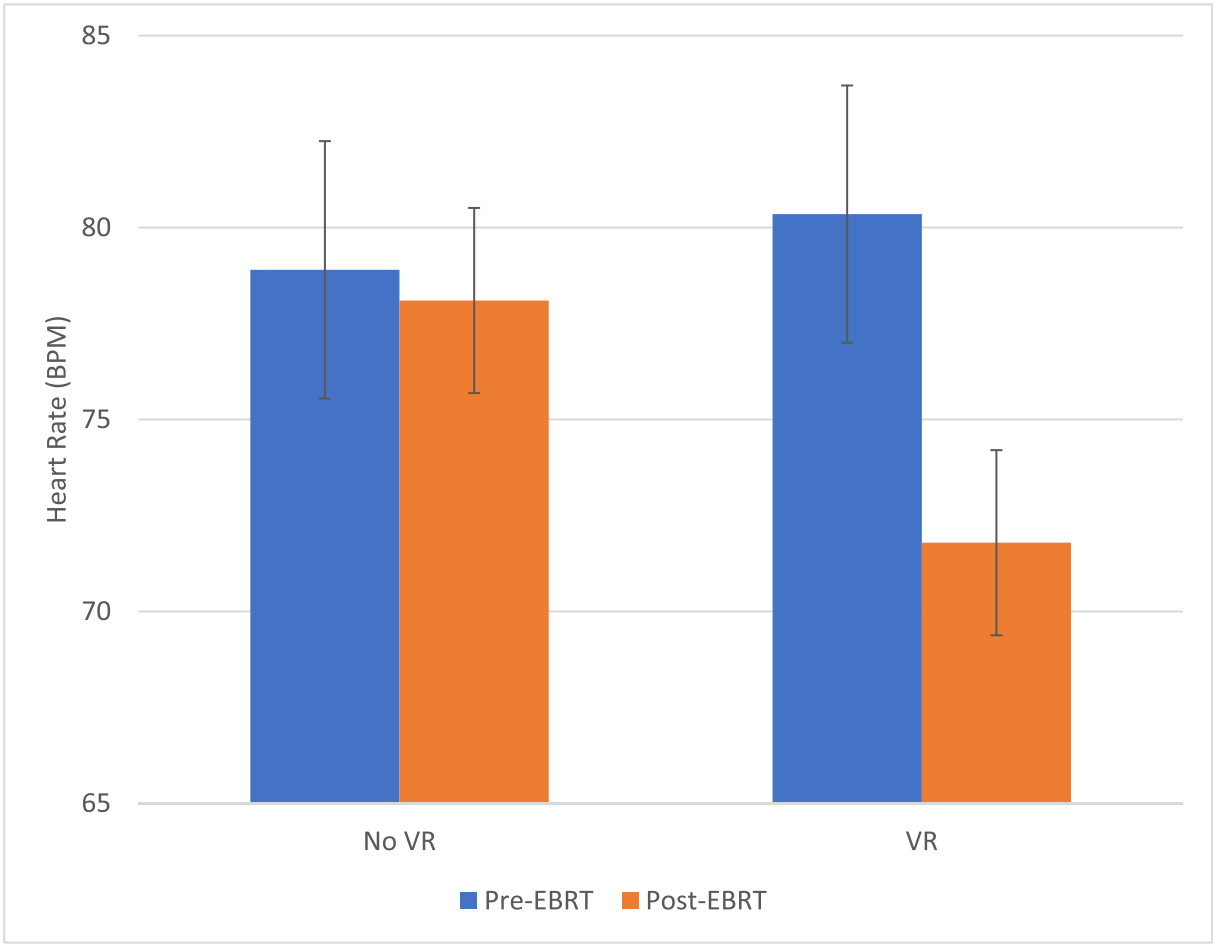

Figure 1 Heart rate pre-external beam radiation therapy and postexternal beam radiation therapy in virtual reality and no virtual reality conditions. Error bars represent standard error of the mean × 2.

using the VR headset to others (Fig. 5). Radiation therapists endorsed VR as an effective anxiety intervention tool, that VR did not impair communication with patients, that VR did not prolong treatment set-up, that VR decreased patient movement during treatment, and as there were no unintended movements noted during the study, that VR was a safe tool that they wished to have access to in the future.

Finally, a thematic analysis of participant likes and dislikes of VR was performed, and the proportions of participants endorsing themes were calculated. Positive aspects of VR included: distraction from treatment, relaxing, liking the pictures and sounds displayed, and time passing more quickly. Negative aspects included: fit of headset difficult due to glasses, fit of headset difficult, and impaired awareness of surroundings (Fig. 6).

Discussion

VR technologies are well-suited to mediate procedural anxiety, with significant uptake across medicine and oncology in recent years.[15] However, for EBRT, nonpharmacological interventions to address procedural anxiety are still needed. This is the first study, to our knowledge, to examine the effect of mindfulness-promoting VR during EBRT on patient experience.

Our results suggest that VR can decrease procedural anxiety, improve patient coping, and increase treatment environment tolerance. This is demonstrated by significantly lower situational unease, improved situational response, and greater environment acceptance when using VR. Heart rate may corroborate the patient-reported benefits of VR, as seen by the significant decrease in heart rate from before to after treatment with VR (80.35 bpm and 71.79 bmp), but not in the control condition (78.90 bpm and 78.10 bpm). Furthermore, the lack of statistical difference in pretreatment heart rate between conditions, combined with the significantly different heart rates after treatment suggests that observed differences were due to VR, not an external factor, such as decreasing anxiety through successive treatments or anticipation of VR use. With most participants endorsing that VR improved treatment experience (86%), was comfortable

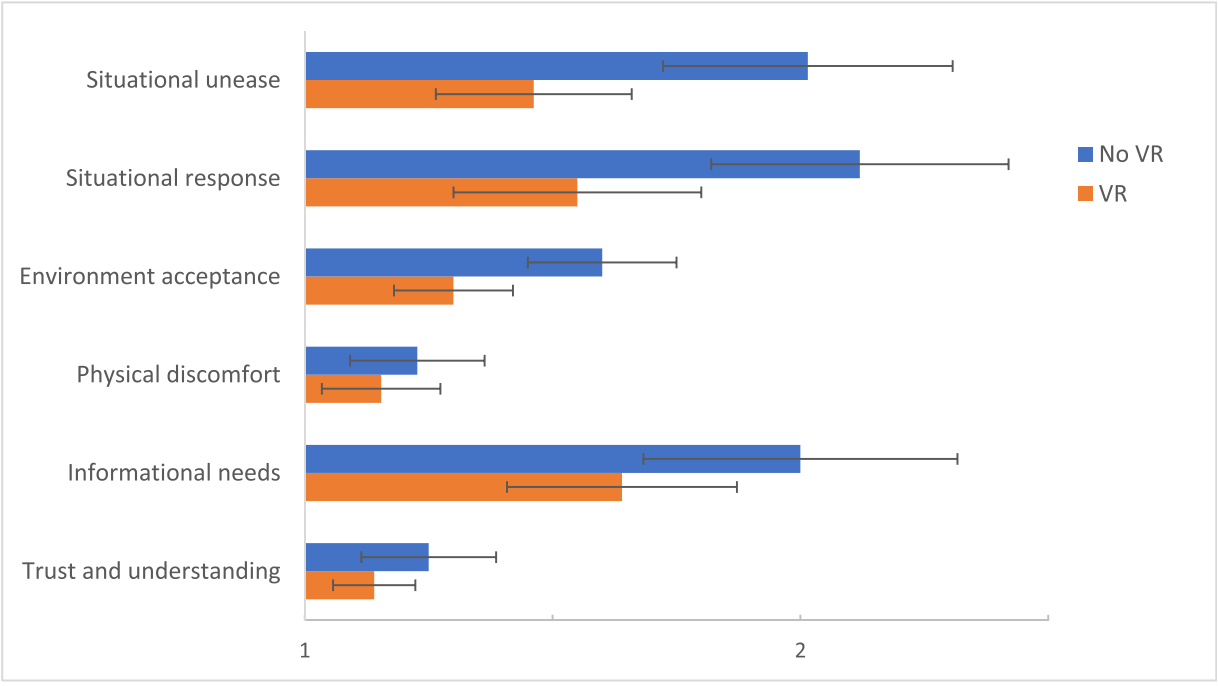

Figure 2 The Radiotherapy Experience Questionnaire responses by theme between virtual reality and no virtual reality conditions. Error bars represent standard error of the mean × 2.

(94%), and would recommend VR to others (86%), it may be inferred that VR could be well tolerated and provide benefit to many patients receiving radiation therapy treatments. Finally, perspectives from therapists support that VR is a safe, efficient, and practical intervention. Thus, compared with other anxiety-mediating interventions, such as music therapy, which may require a trained music therapist, or patient education with VR, which requires creating a custom application with educational graphics, VR could be implemented in centers that lack certain

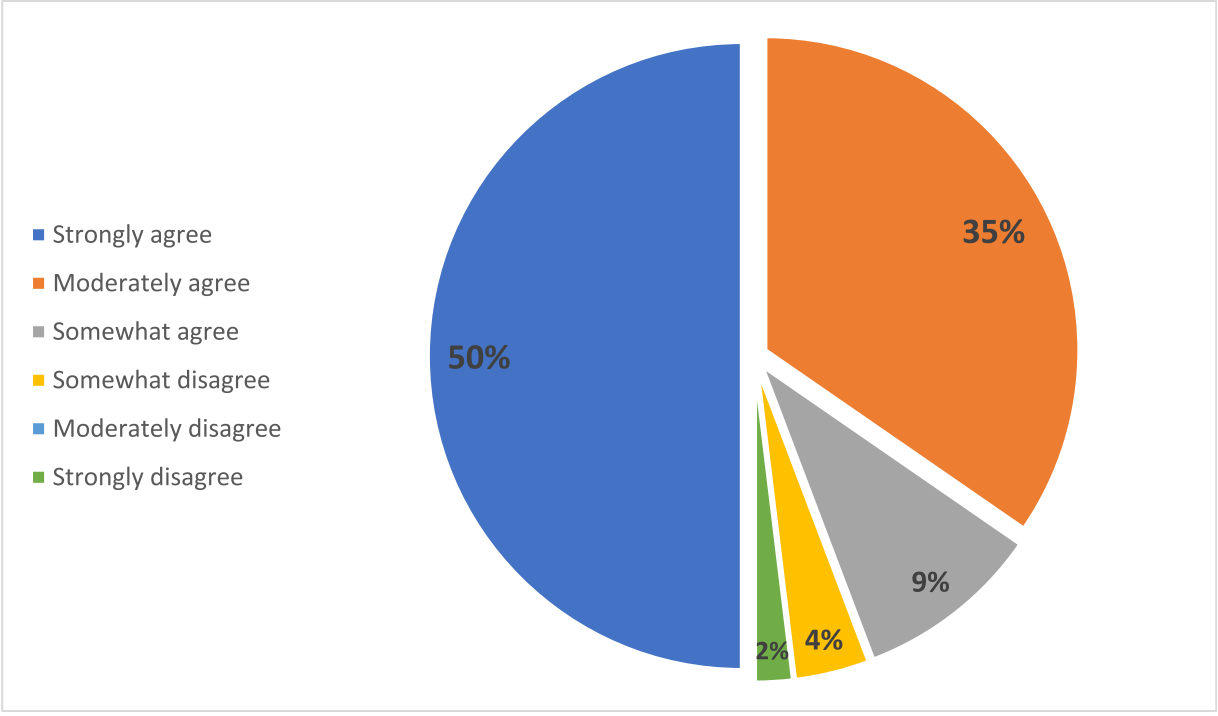

Figure 3 Percentage of responses to question "wearing the virtual reality headset is comfortable."

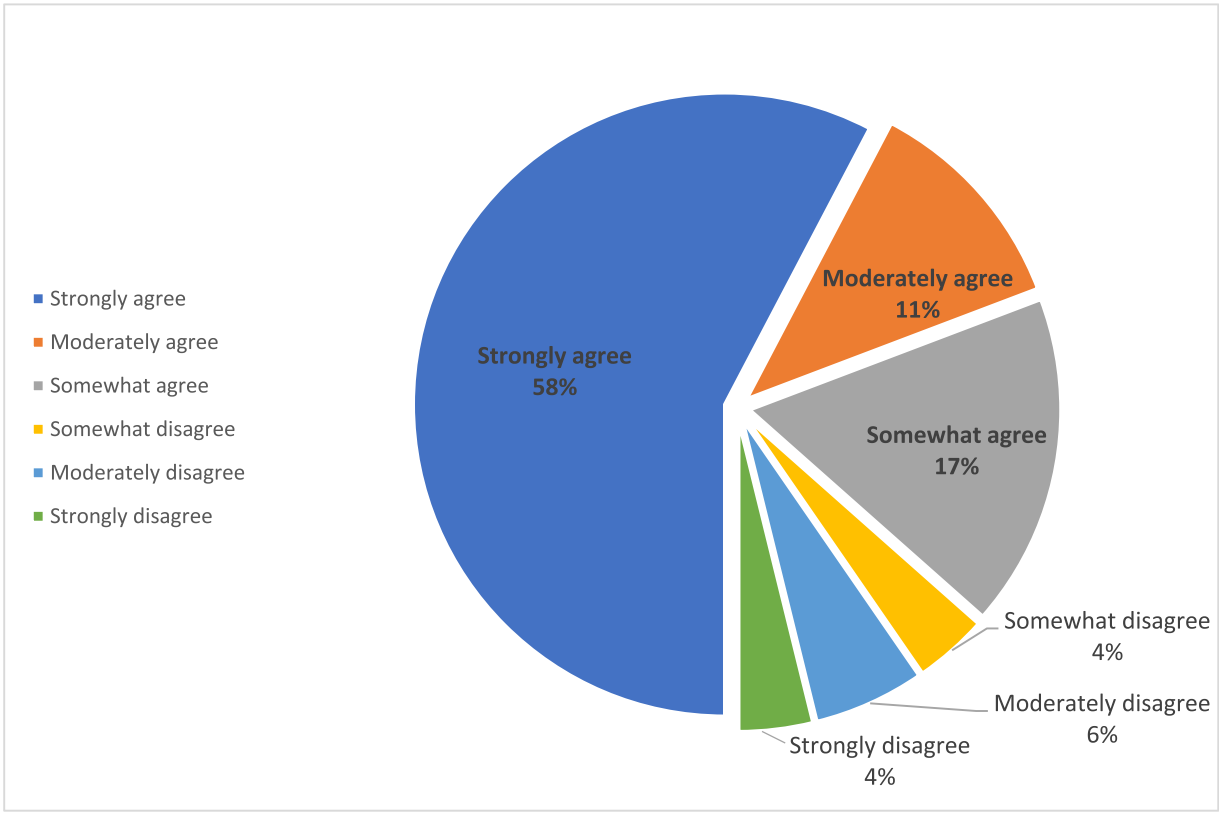

Figure 4 Percentage of responses to question "the virtual reality headset improves the overall radiation therapy experience."

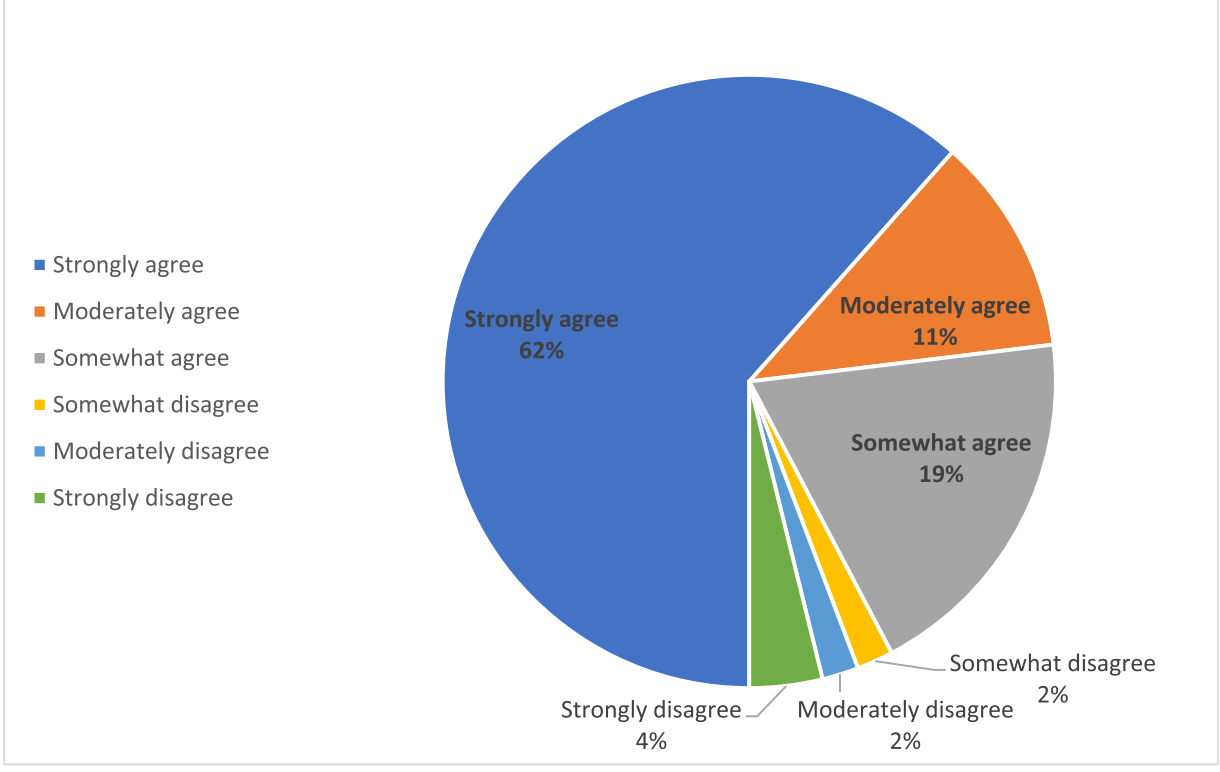

Figure 5 Percentage of responses to question "I would recommend using the virtual reality headset to others."

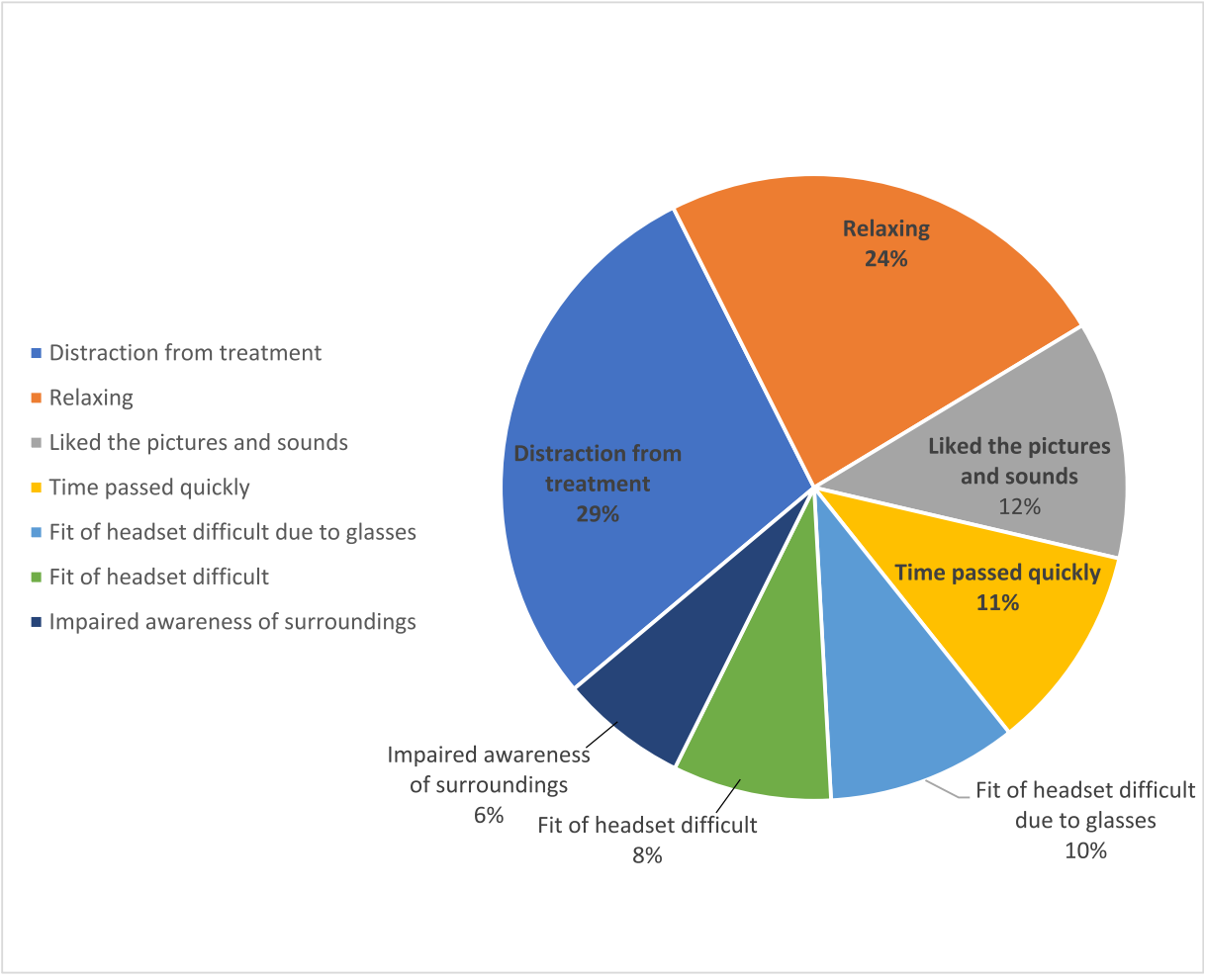

Figure 6 Percentage of positive and negative themes reported by participants.

allied health staff, computer science services, or adequate time for longer interventions.

Conclusions are controlled by several limitations. First, participants used VR after receiving 2 previous treatments. This was done to ensure VR use did not impair clinical workflow and workload, which may be larger when beginning EBRT. Consequently, effects could be attributable to greater EBRT exposure, although unlikely, given the patient perspectives on VR benefit, and that pretreatment heart rate on the day of VR use was higher, although not statistically, than for the previous control treatment. Future research could mediate this potential bias with a crossover design for whether patients receive EBRT with or without VR first. Second, we excluded patients receiving radiation to the head, neck, and brain. As thermoplastic masks used for immobilization in these sites are commonly reported as anxiety-provoking,[16] efforts should be made to determine if and how the beneficial effects of VR can be used by these patients. Patients receiving brachytherapy were also excluded. Finally, the cost of obtaining a VR headset, in our experience several hundred dollars, may be prohibitive. Interestingly, Schulz et al[17] recently had success in using a low-cost cardboard VR headset and smartphone to generate an immersive VR environment. Given these limitations, future research could examine the effect of VR if used not during but immediately prior to EBRT, thus making it compatible with thermoplastic mask use; the effect of VR for patients receiving brachytherapy; and whether the same magnitude of benefit could be seen with a more cost-effective cardboard and smartphone approach for VR immersion.

Conclusions

With increasing useability, sophistication, and affordability of VR technologies, their practicality and indications as nonpharmacological anxiety-reducing tools in medicine are growing. We report the first evidence demonstrating the utility of mindfulness-promoting VR during EBRT to decrease procedural anxiety, improve overall radiation therapy experience, and improve physiological signs of arousal and distress. We also report high patient tolerability with limited risk of detriment to patients.

Further research is needed to translate possible uses of VR to patients at high risk of procedural anxiety, such as patients using thermoplastic masks, and identify who may derive the most clinically meaningful benefits. Although VR uses and indications become further researched, radiation therapy treatment centers wishing to improve patient experience should consider acquiring a VR device or a low-cost cardboard-smartphone alternative and explore avenues for its use in patients at high risk of procedural anxiety and negative treatment experience.

Disclosures

Giselle Tucker Belliveau reports financial support was provided by Canadian Association of Radiation Oncology. The other 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.

Acknowledgments

Conley Kriegler was responsible for statistical analysis.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.adro.2024.101640.

References

1. Stiegelis H, Ranchor A, Sanderman R. Psychological functioning in cancer patients treated with radiotherapy. *Patient Educ Couns*. 2004;52:131-141.
2. Hess CB, Chen AM. Measuring psychosocial functioning in the radiation oncology clinic: a systematic review. *Psychooncology*. 2014;23:841-854.
3. Clover K, Oultram S, Adams C, et al. Disruption to radiation therapy sessions due to anxiety among patients receiving radiation therapy to the head and neck area can be predicted using patient self-report measures. *Psychooncology*. 2011;20:1334-1341.
4. Theofilou P, Panagiotaki H. A literature review to investigate the link between psychosocial characteristics and treatment adherence in cancer patients. *Oncol Rev*. 2012;6:37-44.
5. Bese NS, Hendry J, Jeremic B. Effects of prolongation of overall treatment time due to unplanned interruptions during radiotherapy of different tumor sites and practical methods for compensation. *Int J Radiat Oncol Biol Phys*. 2007;68:654-661.
6. Mohammad E, Ahmad M. Virtual reality as a distraction technique for pain and anxiety among patients with breast cancer: A randomized control trial. *Palliat Support Care*. 2019;17:29-34.
7. Chirico A, Lucidi F, De Laurentiis M, Milanese C, Napoli A, Giordano A. Virtual reality in health system: beyond entertainment. a mini-review on the efficacy of VR during cancer treatment. *Cell Physiol*. 2016;231:275-287.
8. O'Steen L, Lockney NA, Morris CG, Johnson-Mallard V, Pereira D, Amdur RJ. A Prospective Randomized Trial of the Influence of Music on Anxiety in Patients Starting Radiation Therapy for Cancer. *Int J Radiat Oncol Biol Phys*. 2021;109:670-674.
9. Decker TW, Cline-Elsen J, Gallagher M. Relaxation therapy as an adjunct in radiation oncology. *J Clin Psychol*. 1992;48:388-393.
10. Marquess M, Johnston SP, Williams NL, et al. A pilot study to determine if the use of a virtual reality education module reduces anxiety and increases comprehension in patients receiving radiation therapy. *J Radiat Oncol*. 2017;6:317-322.
11. Forbes E, Baker AL, Britton B, et al. A systematic review of nonpharmacological interventions to reduce procedural anxiety among patients undergoing radiation therapy for cancer. *Cancer Med*. 2023;12:20396-20422.
12. Schneider SM, Ellis M, Coombs WT, Shonkwiler EL, Folsom LC. Virtual reality intervention for older women with breast cancer. *Cyberpsychol Behav*. 2003;6:301-307.
13. Olausson K, Hansson A, Zackrisson B, Edvardsson D, Östlund U, Nyholm T. Development and psychometric testing of an instrument to measure the patient's experience of external radiotherapy: The Radiotherapy Experience Questionnaire (RTEQ). *Tech Innov Patient Support Radiat Oncol*. 2017;3-4:7-12.
14. Indovina P, Barone D, Gallo L, Chirico A, De Pietro G, Giordano A. Virtual reality as a distraction intervention to relieve pain and distress during medical procedures: A comprehensive literature review. *Clin J Pain*. 2018;34:858-877.
15. Dicicco-Bloom B, Crabtree BF. The qualitative research interview. *Med Educ*. 2006;40:314-321.
16. Nixon JL, Cartmill B, Turner J, et al. Exploring the prevalence and experience of mask anxiety for the person with head and neck cancer undergoing radiotherapy. *J Med Radiat Sci*. 2018;65:282-290.
17. Schulz JB, Dubrowski P, Blomain E, et al. An affordable platform for virtual reality-based patient education in radiation therapy. *Pract Radiat Oncol*. 2023;13:e475-e483.