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Research Paper

Psychological effects of virtual reality intervention on breast cancer patients with different personalities: A randomized controlled trial

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ABSTRACT

Objectives: To explore the efficacy and safety of virtual reality (VR) in relieving negative emotions in patients with breast cancer with different personalities.
Methods: A randomized controlled trial was conducted. Between April 2023 and October 2023, we enrolled patients with breast cancer treated in the Department of Breast Cancer and Oncology at Sun Yat-Sen Memorial Hospital, Sun Yat-Sen University, Guangdong Province. The patients were randomly divided into an intervention group ($n = 118$) and a control group ($n = 119$) using block randomization. The intervention group received the VR intervention $3 - 5$ times over 5 ± 2 weeks using natural landscapes with music or relaxation guidance, and the duration of each VR intervention was 15 ± 3 min. The control group received routine nursing care, including disease education and psychological counseling. Patients were assessed using the Type D Scale, Positive and Negative Affect Scale, and Distress Thermometer, and adverse events during the intervention were recorded.
Results: Overall, 85 patients completed the study (44 in the intervention group and 41 in the control group). Patients with Type D personalities showed more negative emotions [25.0 (21.5, 27.5) vs. 19.0 (16.0, 24.0), $P = 0.001$] and distressed attitudes [4.0 (2.0, 5.0) vs. 3.0 (1.0, 4.0), $P = 0.020$] with fewer positive emotions (27.2 ± 5.6 vs. 31.0 ± 5.9, $P = 0.014$) than those with non-Type D personalities. Total population analysis revealed no significant differences between the groups. However, in the subgroup analysis, patients with Type D personalities in the intervention group showed greater relief from negative emotions than those in the control group [median difference, −5.0 (−9.0, −2.5) vs. −2.0 (−4.0, 2.0), $P = 0.046$]. No significant differences were found between groups of patients with non-Type D personality traits. The proportion of adverse events was not significantly different between groups ($P = 0.110$).
Conclusions: Breast cancer patients with Type D personalities suffer more severe negative emotions and distress, and more attention should be paid to them. VR intervention significantly and safely reduced negative emotions in patients with Type D personalities.

What is known?

- Breast cancer has become the most common malignant tumor in women worldwide, seriously threatening their health and requiring special attention.
- The mental symptoms of breast cancer patients are often overlooked, and more nursing plans are urgently required to address this issue.
- The ongoing advancement and interdisciplinary integration of virtual reality (VR) technology hold promise for aiding patients in alleviating adverse emotional states.

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What is new?

- More attention should be paid to patients with Type D personalities to reduce their negative emotions and social inhibition.
- VR can effectively reduce negative emotions in patients with breast cancer who have a Type D personality.
- VR potentially improves positive emotions in patients with Type D personalities.

1. Introduction

In 2022, the incidence of female breast cancer was the second highest in the world, after lung cancer, with an estimated 2.3 million new cases, becoming the most common malignant tumor in women worldwide, seriously threatening their health and highlighting their need for special attention [1,2]. International consensus guidelines indicate that the current treatments for breast cancer primarily include chemotherapy, radiation therapy, targeted therapy, immunotherapy, hormone therapy, and surgery [3]. Treatment regimens often involve estrogen deprivation, which can lead to or exacerbate menopausal symptoms in patients, including cognitive impairment, depression, and sleep disturbances, thus significantly affecting their quality of life [4]. In addition, changes in breast appearance resulting from radiation therapy or surgery may contribute to post-treatment depression. Therefore, more systematic nursing interventions are required to address these issues.

At present, many personality classification scales divide people into various groups. This study mainly explores the Type D personality, coined by Professor Denollet, a prevalent clinical personality type known as “sad personality.” It includes two dimensions: negative affectivity (NA) and social inhibition (SI) [5,6]. Patients exhibiting Type D personalities tend to display heightened NA and SI, often leading to increased psychological distress. People with non-type D personalities are more positive, socially active, and better at expressing negative emotions, making them more optimistic in facing difficulties. In individuals with cancer, depressive sentiments become more prominent owing to the challenges associated with diagnosis, treatment, and potential survival concerns, a circumstance often compounded by the prevalence of Type D personalities in this cohort. A previous study showed that the Type D personality was present in up to 56% of patients with ovarian cancer, and symptoms were more severe in patients with Type D personalities [7]. Another study revealed that 21% of men with colorectal cancer exhibit Type D personality traits. This further demonstrates that both the overall Type D personality group and its subgroup characterized by negative emotions experience higher all-cause mortality rates (hazard ratios 1.7 and 2.0, respectively) among men aged more than 70 years [8]. A prospective observational study found that 49.2% of patients with breast cancer have a Type D personality, and individuals with a Type D personality tended to have relatively higher levels of supportive care needs [9]. Although there is a high proportion of patients with breast cancer and Type D personality traits, limited attention has been paid to this population. Currently, there are few supportive cancer rehabilitation services specifically tailored to meet the needs of breast cancer patients with Type D personalities [10].

When focusing on the two major characteristics of Type D personality, stronger NA and SI, it is evident that methods to enhance SI and reduce negative emotions in these patients are urgently needed. One widely used approach is psychoeducation, which provides patients with information about their disease, treatment processes, and coping strategies to alleviate fear and uncertainty [11]. Cognitive behavioral therapy is another effective method that focuses on reshaping negative thoughts and unhealthy behaviors to reduce anxiety and depression [12]. Mindfulness-based therapies, such as meditation and body scans, help patients concentrate on the present moment and promote relaxation and emotional well-being [13]. For many, a comprehensive approach that combines these methods proves to be the most effective, holistically addressing emotional needs and empowering patients to navigate their journey with resilience. However, all these measures require group assistance and may not be effective for individuals with Type D personalities.

Virtual reality (VR) is an interactive system that combines visual, auditory, pressure sensing, and other senses and constructs virtual scenes through interactive technology to allow users an immersive experience [14]. In recent years, the continuous advancement of VR technology has led to its application in psychological interventions. VR offers highly realistic and engaging interactive scenarios that can increase patients’ motivation for SI and potentially enhance their social engagement. Additionally, VR can simulate social activities to alleviate social fears, which may be helpful for patients with Type D personalities experiencing SI. Researchers have attempted to apply VR to the rehabilitation of patients with clinical mental illnesses [15]. In children with autism spectrum disorder, combining VR with conventional rehabilitation training improves cognitive and social development, supporting the goal of improving the rehabilitation effect [16]. Similarly, in stroke patients, VR training may provide additional rehabilitative interventions for recovery. It not only aids in recovery but also helps improve patients’ self-efficacy and ability to perform activities of daily living effectively [17,18].

Patients undergoing antitumor treatment often experience emotional distress, and opportunities to access outside scenic spots and travel are limited owing to their physical condition. Thus, VR and travel may be a promising combination. Recent research has shown that exposure to natural stimuli in any form can reduce symptoms related to psychophysiological stress and irritability [19]. Combining visual and auditory stimulation in VR can create an immersive experience that can easily reduce perceived pain and negative effects and induce relaxation and positive impact. Many websites offer impressive views, such as AirPano, dedicated to capturing and presenting stunning panoramic images and videos worldwide, covering the most fascinating natural landscapes and human landmarks on Earth. AirPano allows users to freely rotate the angle of view through a simple mouse operation or mobile phone touch, as if they were in the scene, feeling the full range of visual impact. Therefore, realistic and beautiful natural scenery may reduce negative emotions in patients with breast cancer.

VR has made promising achievements in many mental health studies and has been shown to produce similar or even more effective results than traditional treatments for certain mental illnesses, including agoraphobia and social anxiety [20]. A VR program for people with post-traumatic stress disorder, complicated grief, or adjustment disorders showed that confronting emotionally charged VR objects significantly improved relaxation and negative emotions compared with traditional cognitive behavioral therapy [21]. Another study on patients with breast cancer undergoing adjuvant radiation therapy found that immersive VR used during radiotherapy reduced their anxiety during radiation therapy planning [22].

VR physical and mental relaxation training primarily involves simulating various scenes, such as natural landscapes (such as glaciers, mountains, grasslands, and beaches), animated VR stories with a plot, and a variety of relaxing VR games. However, the wide variety of available VR materials poses a challenge because the specific types of VR content used in interventions are often

insufficiently detailed or standardized. To address this gap, this study focused on exploring the effects of VR experiences featuring natural landscapes on the psychological wellbeing of patients with breast cancer and different personality types.

2. Methods

2.1. Study design and participants

This was a parallel, unblinded, single-center, randomized controlled trial that included women with breast cancer in a hospital and reported according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines. The trial was registered under the number ChiCTR2300076765.

An objective sampling method was used to select patients with breast cancer at a hospital between April 2023 and October 2023. The inclusion criteria were as follows: a) diagnosis of breast cancer according to breast cancer treatment guidelines; b) females aged 18–70 years, including both ends of the age spectrum; and c) provision of informed consent and voluntary participation in the study. The exclusion criteria were as follows: a) unsuitability for VR use, such as claustrophobia, fear of heights, vertigo, or mental disorders; b) language expression disorders or language barriers; c) consistent responses in the pre-intervention questionnaire indicating potential irregularity; d) conditions that impede VR use, including but not limited to visual or hearing impairments affecting VR material perception or facial injuries hindering the safe use of VR glasses; and e) any other circumstances deemed inappropriate for participation by the researchers.

PASS software (version 15.0) was used to determine the sample size. Before calculating the sample size, we determined the study design, outcomes, test level α, test efficacy $1-\beta$, and baseline mean based on pre-trials or literature. This was a randomized controlled trial. The experimental group was the VR intervention group, and the control group was the standard care group. Psychological distress was the primary outcome measure. Based on relevant literature, the baseline mean psychological distress score was 4 points in cancer patients [23–25]. Thus, we set the expected baseline score of the control group at 4 ± 1.3 points. We anticipated that the intervention group would experience a decrease of 1 point in their psychological distress score, with bilateral $\alpha = 0.05$ and $1-\beta = 0.9$. Based on this calculation, the minimum sample size for each group was 37, requiring 74 patients. Assuming a dropout rate of 15%, the required sample size was 88 patients.

2.2. Randomization and allocation concealment

Block randomization was adopted [26], and patients were randomly grouped according to a 1:1 ratio into permuted blocks of two or four. The random sequence was generated using the R programming language by a faculty member from the Medical Design Department who was not directly involved in the experiment. The envelope method was used to conceal the groups. After the random sequences were generated, they were placed in sealed opaque envelopes. The participants were put into groups according to the order of the envelope numbers when informed consent was obtained.

2.3. Interventions

2.3.1. Intervention group

Before the intervention, we established an intervention team that included medical staff, psychologists, and engineers to determine the content and steps of the intervention. All the researchers underwent uniform training to familiarise themselves with the research plan and implementation steps. VR technologists focused on developing VR hardware and software. The aim was to provide users with immersive VR experiences, create new connections, expand their life experiences, and unleash unlimited potential. There were many VR materials for VR content, including natural landscapes, game sports, and animated movies. For consistency and considering that most breast cancer patients are women, natural landscapes may be more suitable; therefore, we chose landscapes as the VR intervention for patients in the intervention group. VR technology includes a mind-body interactive training system incorporating Attention Recovery Theory and Stress Reduction Theory to generate system programs. The content of the VR scenarios mainly included a natural environment with a visual focus: plants such as trees, flowers, mountains, and meadows; water such as beaches, lakes, and streams; blue sky; white clouds; and sunsets (Appendix A). The patients were provided with music, relaxation training, and breathing exercises to enhance the effects of relaxation. The patients were scheduled to watch different natural scenes each time.

Before VR training, the participants were introduced to the training time, content, and process. Patients' vital signs, including blood pressure (if a sphygmomanometer was available) and pulse, were assessed by trained healthcare professionals within 10 min before VR viewing. If the patients experienced no discomfort, they were assisted in wearing a disposable eye mask and the VR equipment. Patients with myopia were allowed to wear glasses. The researchers guided the patients during the training and monitored their pulse rates (Appendix B). If dizziness or any other discomfort occurred during VR training, the session was promptly halted, and appropriate treatment and psychological counseling were provided. Previous studies had varied intervention frequencies, with some intervening only once and others intervening several times [27–29]. In our study, each VR intervention lasted 15 ± 3 min, with 3–5 interventions over 5 ± 2 weeks. We referred to clinical drug trials, and the visit time of patients was set as a time window because patients also have various conditions. In addition, it was difficult for some patients to return to the hospital specifically for this project; usually, they had to return to the hospital for treatment, prescription of drugs, and examinations, and thus, they presented in their spare time for intervention.

2.3.2. Control group

The control group received standard psychological care on the first day of enrolment, including disease education, information about common psychological development processes, and coping measures. Targeted education was provided based on the patient's current treatment stages. For example, for chemotherapy patients, we focused on observing, monitoring, and treating adverse reactions. For patients undergoing surgery, we paid more attention to postoperative care and limb function exercises. For radiotherapy patients, we targeted skin care and radiation dermatitis care. In addition, we conducted targeted psychological counseling based on the results of the patient's psychological evaluation. Additionally, patients underwent telephone follow-ups, which included further disease education, psychological counseling, and other relevant support. Subsequently, they were asked to complete a re-evaluation questionnaire.

2.4. Measurements

VR intervention may relieve patients' negative emotions [20], and the questionnaire completion was not burdensome; therefore, we chose the Positive Affect and Negative Affect Scale (PANAS) and Distress Thermometer (DT) scores as our primary outcomes.

2.4.1. Baseline variables

Demographic characteristics and general data were collected using a self-administered questionnaire that included basic information on age, education level, height, weight, alcohol consumption, smoking status, and other diseases. Personality information was collected using 14 items of the Type D Scale (DS14), and patients were classified into Type D and non-Type D personality groups [5]. DS14 consists of seven items for each of the NA and SI dimensions. Each entry was scored on a five-point Likert scale from 0 to 4. Participants can be classified as having Type D personalities when their scores on both the NA and SI dimensions are $\geq$10 [6]. DS14 was suitable for Chinese patients; the Cronbach's α coefficients for the NA and SI subscales were 0.9 and 0.85, respectively [30].

2.4.2. Primary outcomes

2.4.2.1. Positive and negative emotions. The PANAS comprises 20 adjectives to assess emotions and encompasses positive and negative affect factors [31]. Each positive and negative emotion consisted of ten corresponding adjectives rated on a five-point Likert scale (1–5). The participants chose according to their actual situation. A high total positive emotion score indicates an individual's emotional state of high energy, concentration, and happiness. A high total negative emotion score indicated subjective feelings of confusion, anxiety, and hostility. The scale has been verified to have good reliability and validity [32,33] and is suitable for the psychological investigation of patients with breast cancer patients. The Cronbach's α coefficients of the positive and negative affect scales were 0.937 and 0.919, respectively [34]. Data were collected before and after all interventions.

2.4.2.2. Psychological distress. The National Comprehensive Cancer Network recommends DT as a screening tool for the rapid identification of psychological distress, and it is widely used in cancer clinics worldwide [35]. The DT is on a scale of 0 (no distress) to 10 (extreme distress). Patients were asked to mark a number corresponding to their average level of distress, reflecting the psychological distress of cancer patients. Data were collected before and after all interventions.

2.4.3. Secondary outcome-adverse events

Safety was assessed based on all adverse events during the VR intervention, including dizziness, palpitations, and any other discomfort experienced by the participants. Patients were asked open-ended questions like "How did you feel?" and "Did you experience any discomfort during the intervention?" Any symptoms that emerged during the VR intervention session were documented and assessed by experienced healthcare professionals to determine whether the VR intervention should be continued. The secondary outcomes were evaluated after each intervention.

2.4.4. Exploratory outcome-pulse rate

Pulse rate data were obtained by trained healthcare professionals using a sphygmomanometer or finger pulse oximeter. The patient's pulse rate during the first VR intervention was measured within 10 min before the VR intervention, after 2 ± 1 min, after 5 ± 1 min, after 10 ± 1 min, and at the end of the VR intervention.

2.5. Data collection

Before the intervention, both groups were required to provide basic information, such as personality, psychological state, and other assessments. We provided patients with a paper or electronic version of the questionnaire, and it took about 20 min to complete. If a patient was unable to recall specific medical history information, they could leave those sections blank, and we would later retrieve the necessary details from the medical record system. Researchers assisted patients in filling out the questionnaire and monitored the completion rate to ensure all sections were filled out properly. Patients were continuously followed up during the study period. Patients were initially contacted via a short message service or WeChat; if there was no response, two additional attempts were made through phone calls. Failure to respond after these attempts led to the patient being lost to follow-up. Patients in both groups received similar medications, and the medical staff involved in the intervention was the same. After all the interventions, we collected the scores of patients' positive and negative emotions, as well as psychological distress again. This study used a per-protocol analysis to include only patients who had participated in 3–5 VR interventions and completed a post-intervention evaluation.

2.6. Ethical consideration

This study was conducted on the ethical principles of the Declaration of Helsinki and has been approved by the ethics committee of Sun Yat-Sen Memorial Hospital, Sun Yat-Sen University (No. SYSKY-2023-303-02). All the participants had signed informed consent forms before participating.

2.7. Data analysis

Statistical software (SPSS version 20.0) was used for the data analysis. The Shapiro–Wilk test was used to assess the normal distribution of the data. Basic characteristics were represented by *Mean* ± *SD* or *Median* (P_{25}, P_{75}). Categorical variables were tested using the chi-squared test or Fisher's exact test. The paired-sample *t*-test and Wilcoxon test were used for intragroup comparisons, and the two-independent sample *t*-test or Mann–Whitney *U* test was employed for intergroup comparisons. Repeated measures analysis of variance was used to determine the effect of VR intervention on pulse rate. Statistical significance was set at $P < 0.05$.

3. Results

3.1. Study participation

Initially, 326 patients were enrolled, and 89 unqualified patients were excluded. The remaining 237 participants provided written informed consent, completed the baseline questionnaire, and were randomly assigned to one of the two groups. Finally, 85 patients completed all interventions, and re-evaluations were included in the analysis (Appendix C). The number of excluded patients was slightly higher because we required 3–5 interventions to be completed within 5 ± 2 weeks, and many patients did not return to the hospital as scheduled to participate in the intervention, resulting in overdue data and were excluded. Some patients returned to the hospital but did not have time to participate in the intervention after chemotherapy on the same day. When the patient returned to the hospital the next time, they exceeded the visit window and were excluded.

3.2. Baseline information

A total of 85 female patients with a mean age of 46.4 ± 10.6 years were included in the study. Because this study involved only patients who engaged in at least three VR interventions and completed the post-intervention evaluation, older patients may have felt more uncomfortable wearing VR glasses and refused further follow-up interventions, potentially leading to age-related

differences between the groups. However, there were no significant differences in the distributions of other basic characteristics, mental states, or Type D personality traits. Before the intervention, the two groups were comparable except for age. Most patients underwent chemotherapy (Appendix D).

3.3. Comparing the mental states of individuals with and without type D personalities before the intervention

The Type D personality group's positive and negative emotion scores before intervention were 27.2 ± 5.6 and 25.0 (21.5, 27.5), respectively, with a median DT score of 4.0 (2.0, 5.0). The non-Type D personality group showed a more positive attitude, with a mean score of 31.0 ± 5.9, and a less negative attitude, with a median score of 19.0 (16.0, 24.0) and a median DT score of 3.0 (1.0, 4.0). The P values for mental status between the two personality groups were < 0.05, indicating that individuals with Type D personalities may be more prone to anxiety, depression, and stress, while individuals with non-type D personalities may confront challenges more actively and handle stress more effectively (Table 1).

3.4. Comparison between the two groups after the intervention

Intragroup comparisons showed that negative emotions and psychological distress were significantly reduced in the VR group after intervention ($P < 0.05$), while psychological distress improved in the control group after the intervention ($P = 0.024$) when compared with the baseline scores. However, the two groups had no significant differences after the interventions (Table 2).

3.5. Comparison between the two groups with different personalities

In the group of patients with breast cancer and Type D personalities, positive and negative emotions and psychological distress significantly improved after the intervention in the VR group ($P < 0.05$). No improvement was observed in the control group. The negative emotions of breast cancer patients with Type D personalities decreased by 5.0 points after the VR intervention. The difference in negative emotions between the groups was statistically significant ($P = 0.046$).

In the group of patients with breast cancer and non-type D personalities, psychological distress in the VR group significantly improved after the intervention ($P < 0.001$), whereas no improvement was noted in the control group. However, no significant differences were observed between groups (Appendix E).

3.6. Adverse events

Only minor adverse events were observed. In the first VR group, 104 patients received the VR intervention, and only three (2.9%) patients experienced vertigo symptoms and discontinued the trial. In the control group, 112 patients participated in routine nursing interventions, and no adverse events occurred. The two groups had no statistically significant difference (Fisher's exact test, $P = 0.110$).

3.7. Pulse rate changes during the first VR intervention

The patients' pulse rates within 10 min before VR intervention and after 2, 5, 10 min (time window was ±1 min) and the end of intervention were 79.9 ± 14.1, 79.2 ± 13.9, 79.6 ± 14.5, 79.4 ± 13.2, and 80.0 ± 13.9 times/min, respectively. There was no significant difference in the pulse rates at different times during the intervention (correction using the Greenhouse–Geisser method, F [2.661, 95.814] = 0.279, $P = 0.817$).

4. Discussion

We found that negative emotions and psychological distress were higher in patients with breast cancer and Type D personality traits than those with non-type D personality traits. No significant differences were observed after intervention between the groups in the total population. However, the subgroup analysis showed that the VR intervention significantly improved the negative emotions of patients with breast cancer and Type D personalities. A few adverse events (3 out of 104 patients) were observed during the trial, indicating the safety of the VR intervention. Breast cancer is the most common malignant tumor in women worldwide, and its physical and mental problems require attention. Our findings are consistent with those of other cancer patients [8]. Combined with the real-world clinical situation and with the high prevalence of breast cancer leading to a large patient population, the workload would be very large if all patients underwent psychological intervention. Our study suggests that more attention should be paid to improving negative emotions in individuals with a Type D personality.

The relationship between mental health and breast cancer is intricate, as they may influence each other causally, presenting challenges in identification compared with conventional risk factors. Patients with cancer undergoing cytotoxic therapy are at an increased risk of depression [36]. Participation in VR immersive experiences may help alleviate SI for patients with Type D personalities, enabling them to engage more openly with medical staff and other patients. By integrating natural elements such as mountains, rivers, blue skies, and white clouds with immersive VR experiences, patients can redirect their focus away from their disease and find relief for their bodies and minds. Another potential mechanism (the psycho-evolutionary theory) states that exposure to natural environments through VR simulations can quickly restore positive emotions and reduce stress-related physiological activation [37]. Being in nature can also positively affect social behavior, emotional regulation, and pro-environmental behavior [38,39]. VR has demonstrated superior efficacy compared to alternative intervention measures in ameliorating anxiety, depression, and fatigue in patients undergoing chemotherapy [40]. The VR material provided in this trial had beautiful scenery, most foreign, such as snowy mountains, rivers, and beaches. Therefore, integrating restorative environmental materials into VR technology brought new

Table 1
Comparing the mental states of individuals with and without Type D personalities before the intervention

Mental status	Personality type		t/Z	P
	Type D personality ($n = 24$)	Non-type D personality ($n = 61$)		
Positive emotion	27.2 ± 5.6	31.0 ± 5.9	2.525	0.014[a]
Negative emotion	25.0 (21.5, 27.5)	19.0 (16.0, 24.0)	−3.176	0.001[b]
Psychological distress	4.0 (2.0, 5.0)	3.0 (1.0, 4.0)	−2.319	0.020[b]

Note: Data are *Mean* ± *SD* or *Median* (P_{25}, P_{75}). [a] Independent-Samples t test; [b] Mann-Whitney U test.

Table 2
Comparison between the two groups after intervention.

Variables	Intervention group ($n = 44$)					Control group ($n = 41$)					Z	P_2
	Pre	Post	Difference	Z	P_1	Pre	Post	Difference	Z	P_1		
Positive emotion	30.0 (26.0, 32.3)	31.0 (27.0, 35.8)	2.0 (−3.3, 6.0)	−1.487	0.137[a]	31.5 (26.0, 34.0)	30.0 (26.5, 34.0)	0 (−3.8, 3.0)	−0.184	0.854[a]	−1.192	0.233[b]
Negative emotion	21.5 (18.0, 25.0)	20.0 (16.3, 22.0)	−2.0 (−5.3, 1.3)	−2.766	0.006[a]	20.5 (16.0, 26.0)	19.0 (15.0, 23.5)	−0.5 (−4.8, 4.0)	−0.540	0.589[a]	−1.180	0.238[b]
Psychological distress	3.0 (2.0, 5.0)	1.0 (0.3, 2.0)	−1.0 (−3.0, 0)	−4.229	<0.001[a]	2.0 (1.0, 4.0)	2.0 (0, 2.5)	0 (−2.0, 0.5)	−2.265	0.024[a]	−1.543	0.123[b]

Note: Data are *Mean* ± *SD* or *Median* (P_{25}, P_{75}). P_1: Intra-group comparison before and after intervention; P_2: Inter-group comparison of difference between group.
[a] Wilcoxon Test. [b] Mann-Whitney *U* test.

experiences and was an effective psychological intervention method for long-term and repeatedly hospitalized patients.

Cancer diagnosis represents a significant emotional challenge that affects not only individuals but also their families. Patients naturally experience sadness and distress, and negative emotions are common. Once negative emotions are alleviated to a certain extent, patients can find peace of mind and accept their illness courageously. This acceptance can lead to positive feedback and stimulation of positive emotions. Previous studies suggested immersive VR experiences improve psychological distress and negative emotions by distracting people from negative thoughts and stimuli [41]. In our study, after the VR intervention, the positive emotion scores of the Type D personality group increased, and the *P* value of the comparison between the groups was 0.081, which was very close to 0.05. This indicated that the VR intervention also had a potential improvement effect on the positive emotions of patients with breast cancer and Type D personalities, and if the sample size were increased, it would likely produce statistical significance.

For patients with non-Type D personalities, there was no difference between the groups; they may exhibit positivity, optimism, and extroversion and possess strong emotional regulation skills and adeptness in problem-solving through communication. Consequently, they may not have perceived the VR intervention as having a significant psychological impact.

In this study, we have not yet found that the VR intervention can significantly reduce patients' psychological distress, and there was no statistically significant difference between the two groups. Because the DT scale involves more problems, in addition to emotions, there were many physiological problems, such as constipation, rapid heartbeat, numbness of hands and feet, stomach pain, etc, that may have been associated with higher scores. VR interventions may not significantly improve physical symptoms, and the symptoms of physical discomfort are more dependent on medication. In addition, this may be due to the high rejection rate of patients in this study and the small sample size.

Regarding secondary outcomes, only three (2.9%) patients experienced vertigo symptoms, showing that the VR intervention had few side effects and could be extended to other types of clinical research. Similarly, previous research has demonstrated the efficacy and safety of incorporating VR or other media interventions into patient care, such as cardiovascular and diabetes care, often resulting in more favorable outcomes than conventional care methods [42,43].

Regarding the exploratory outcome, there was no significant difference in pulse rates at different times during the intervention, and no signs of physical arousal were observed during the session. A previous study [27] on VR-assisted anesthesia during upper gastrointestinal endoscopy found no significant differences in patient pulses before, during, and after the VR intervention. Contrary to the results of our study, VR can reduce heart rate and blood pressure during tooth extraction in patients with hypertension without increasing adverse events [29]. However, the effects of VR therapy on vital signs and other clinical indicators remain unclear. More objective variables are required to explore different potential directions of VR therapy. Hormonal imbalance is characterized by decreased estrogen levels and elevated levels of pro-inflammatory cytokines, such as interleukin-1 and interleukin-6, which play significant roles in their manifestation [44]. Further studies are required to establish a complete body of evidence.

Although our study has made significant progress, the adoption of VR in therapeutic interventions is limited because of multiple theoretical and practical barriers. In theory, the efficacy of VR relies on its ability to replicate real-world conditions, which are complex and require significant progress in scene design, immersion quality, and consistency with treatment goals. However, the VR content ecosystem has not exploded because of hardware facility limitations [45]. Moreover, VR has ethical concerns regarding potential risks, especially in older patients [46]. The low acceptance of new psychological intervention techniques also led to age differences in our study. Addressing these challenges requires a targeted investment in VR research, a stronger regulatory framework, and collaboration between healthcare professionals and technologists to bridge the gap between VR's theoretical potential and practical implementation.

5. Limitations

This was a single-center, non-blinded study with a small sample size, and the number of patient interventions was limited to only 3–5 sessions. Therefore, our conclusions are not sufficiently representative and fail to capture the long-term effects of the VR intervention. Another limitation is the implementation of quarantine measures during the pandemic, and the number of excluded participants exceeded our initial projections. For various reasons, some patients did not return to the hospital on time for the next intervention, excluding patients beyond the specified study period. Future studies should conduct continuous, long-term interventions to explore the use of VR materials.

6. Conclusion

In patients with breast cancer and Type D personalities, VR intervention can significantly improve negative emotions and have a potential effect on positive emotions. Natural VR landscapes are safe and feasible for breast cancer patients.

CRediT authorship contribution statement

Shanshan Wu: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original

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Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Declaration of competing interest

The authors declare that there are no conflicts of interest regarding the publication of this paper. We confirm that we do not have any financial or personal relationships with other people or organizations that could inappropriately influence (bias) our work presented in this manuscript.

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Appendices. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2025.02.008.

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