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Flourishing-Life-Of-Wish Virtual Reality Relaxation Therapy (FLOW-VRT-Relaxation) outperforms traditional relaxation therapy in palliative care: results from a randomized controlled trial

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Introduction: As the global population continues to age, the demand for palliative care is progressively increasing. This growing trend highlights the pressing need for groundbreaking interventions that can effectively manage palliative symptoms and improve the quality of end-of-life care. We present a brief, structured, personalized, and innovative psychological intervention named Flourishing-Life-Of-Wish Virtual Reality Therapy (FLOW-VRT)®, which capitalizes on the distinctiveness of virtual reality (VR) as an advanced technology for symptom management. FLOW-VRT is theoretically based on self-determination theory, stress coping theory, flow theory, and attention restoration theory. With a special focus on relaxation, "FLOW-VRT-Relaxation" is designed to enhance end-of-life coping through personalized VR relaxation. As most studies on the use of VR in palliative care have been feasibility or pilot studies with small sample sizes, there is a need for a randomized controlled trial with sufficient statistical power.

Methods: The current study used a randomized controlled trial (n = 128) to test the efficacy of FLOW-VRT-Relaxation by comparing it to traditional relaxation practice in palliative care.

Results: Our results showed that following a FLOW-VRT-Relaxation session, the symptoms of distress that patients in palliative care have to endure significantly reduced, whether physical or emotional in nature.

Discussions: The current findings provide promising results regarding the therapeutic potential of using FLOW-VRT-Relaxation as a cost-effective, scalable, and personalized VR relaxation for patients in palliative care.

KEYWORDS

virtual reality, palliative care, relaxation, FLOW-VRT, personalized, end-of-life care, symptom management, randomized controlled trial

1 Introduction

Palliative care is considered a basic human right for all patients with chronic and life-threatening illnesses (Ezer et al., 2018). This applies particularly to patients with cancer (Heins et al., 2018)- a leading cause of mortality resulting in 10 million deaths in 2020 (World Health Organization, 2020). The objective of palliative care is to manage symptoms and improve the quality of life of patients in the physical, psychological, spiritual, and psychosocial domains (Khater et al., 2021). Despite the provision of palliative care, several unmet needs remain for patients with advanced illnesses (World Health Organization, 2020). A systematic review finds that psychological, physical, and healthcare information and services are the three most commonly reported domains of unmet needs among Chinese patients with advanced cancer (Wu et al., 2022). Another systematic review (Wang et al., 2018) specifically identifies the unmet care needs of patients with terminal cancer. These needs include the appropriate management of physical pain as an example of an unmet physical need, and perceived reduction in autonomy as an example of unmet psychological need, often expressed as "not being able to do the things I used to do," "I can do less than before," and "experiencing loss of control over my life." Additionally, unmet social needs for companionship include lack of "family and friends' support", not "having one member of hospital staff with whom I can talk to," and "support in coping." These unmet needs have been documented to have a detrimental effect on the progression of illnesses and consequently the quality-of-life of patients with terminal diseases (Spitzer et al., 1995; Katon, 2003; Cohen, 2004; Fink et al., 2004).

Evidence-based medical treatment and non-pharmacological interventions have both been used to manage symptoms in palliative care. Without the side effects of medical treatment, psychological interventions are widely delivered. Relaxation plays a central role in cognitive-behavioral therapy and has been found to be an effective tool for psychological interventions (Barlow et al., 1989; Norton and Price, 2007; Tsitsi et al., 2017). They are cost-effective, practical, and free of side effects (McCallie et al., 2006; Lin et al., 2011). Numerous studies have confirmed the effectiveness of relaxation techniques for managing cancer-related symptoms (Simeit et al., 2004; de Carvalho et al., 2007; Kwekkeboom et al., 2008; Matsuda et al., 2014; Stoerkel et al., 2018; Berkman and Akan, 2019; Dikmen and Terzioglu, 2019). Diaphragmatic breathing is an example of such a technique. It refers to a breathing technique that involves the contraction and relaxation of the diaphragm muscle. Unlike shallow chest breathing, diaphragmatic breathing intentionally expands the abdomen for deeper inhalation and exhalation, resulting in physiological and psychological benefits. It can relax the autonomic nervous system by enhancing parasympathetic activity (Lazarus and Mayne, 1990). It is found to improve attention, reduce negative affect, and alleviate stress responses (Ma et al., 2017).

Despite the abundance of evidence indicating the effectiveness of relaxation for symptom management, most studies concentrate solely on traditional techniques. Only a few studies have integrated advanced technologies, such as virtual reality (VR), with traditional relaxation methods (Chirico et al., 2016). VR is a cutting-edge technology that has the potential to make up for the shortcomings of traditional approaches in palliative care settings. It creates an immersive experience that can generate a sense of presence in a virtual environment (Malloy and Miling, 2010; Cummings and Bailenson, 2016; Berkman and Akan, 2019). It has become increasingly popular in complementary medicine because its unique characteristics can overcome certain limitations of traditional therapy (Stetz et al., 2011; Morina et al., 2015). First, VR offers an immersive environment that blocks patients from seeing their physical surroundings while instead inducing a sense of presence ("being there") in a controlled, virtual environment (Slater, 2009). One of the most important cognitive-behavioral techniques for reducing pain is distraction, as suggested by gate control theory (Melzack and Wall, 1965). The sense of presence within the virtual environment can provide a high level of distraction from reality, which is likely one of the reasons why VR has been shown to be effective in reducing pain (Hoffman et al., 2006). Various studies have provided further evidence that consistently reported on patients' feelings of being distanced from their current suffering during VR experiences (Schneider et al., 2004; Baños et al., 2013; Lloyd and Haraldsdottir, 2019; Niki et al., 2019; Weingarten et al., 2019; Ferguson et al., 2020; Johnson et al., 2020; Brungardt et al., 2021). Given its therapeutic potential in pain and mood management, VR has been further considered a potential substitute for analgesia (Bani Mohammad and Ahmad, 2019; Wittkopf et al., 2020). Second, VR allows a customized selection of virtual environments that can be tailored to meet the individual needs of patients (Perna et al., 2021). This personalized approach allows VR to overcome certain limitations of traditional therapy. For example, it enables patients to select their preferred VR content for relaxation purpose or even fulfill their wishes of traveling, albeit virtually. A case report (Woo and Lee, 2023) reported the therapeutic potential of using freely available videos from the internet as relaxation material to fulfill the participant's last wishes of traveling to Japan to enjoy the blossoming season of *sakura*. Third, VR can induce positive emotions in patients faced with existential challenges. Lloyd and Haraldsdottir's (2019) pilot study reported on patients' positive experiences, such as joy and happiness, while using VR as a means to temporarily escape from their real and current situation. Since VR is able to simulate a wide range of environments and sensory experiences with remarkable accuracy, it allows patients to select the virtual environment that maximizes their positive emotions (Woo and Lee, 2023).

Although the three most recent systematic reviews support the potential use of VR in palliative care (Carmont and McIlfatrick, 2022; Martin et al., 2022; Mo et al., 2022), there remains a significant gap in research and clinical practices. Martin et al. (2022) report that most VR studies are related to feasibility or are pilot studies with a small sample size and thus call for a randomized controlled trial with adequate power. The importance of delivering meaningful VR interventions to participants is also highlighted in this review, noting that VR activities that are meaningful for the patient are associated with better outcomes. Ma et al. (2021) similarly stress the importance of conducting high-quality randomized controlled trials to validate the effectiveness of VR as a modality of treatment. They also emphasize the necessity of standardizing programs and procedures to promote the widespread adoption of VR in palliative care. Carmont and McIlfatrick (2022) advocate for a comparison between VR therapy and complementary therapies within the context of palliative care. Geraets et al. (2021) express a similar viewpoint, stating that well-designed studies are necessary to explore the efficacy, efficiency, and cost-effectiveness of VR interventions in comparison to existing treatments.

Invitation script for study participation	
Original version in Cantonese	您好! 我係心理科胡姑娘，我哋進行緊一項關於鬆弛練習嘅研究。我哋誠意邀請 您參加。 您可能會被邀戴上虛擬實景眼鏡，透過欣賞大自然景色進行約十分鐘鬆馳練習。依個體驗就好似親歷其境嘅。類似研究嘅初步結果顯示唔少參加者喺虛擬實景體驗後都舒服咗同埋放鬆咗。如果您有興趣參加，我會喺同意書上再詳細講解。
Translation in English	Hello, I am Ms. Woo from the Department of Clinical Psychology. We are conducting a research study on relaxation. You may be invited to wear a virtual reality headset to enjoy natural scenery and engage in relaxation exercises for about ten minutes. This experience may make you feel as if you are actually there in the natural environment. Preliminary research results show that participants feel comfortable and relaxed after the virtual reality experience. If you are interested in participating, I will explain in detail in the consent form.

FIGURE 1
Invitation script for study participation.

To fill the gap in both clinical practice and research, we developed a novel VR psychological intervention called Flourishing-Life-Of-Wish Virtual Reality Therapy (FLOW-VRT)®. FLOW-VRT is a structured and personalized psychological intervention specially designed for patients in need of palliative care. Its theoretical foundations are based on flow theory (Csikszentmihalyi, 1975), which proposes the psychological state of flow "in which an individual is completely absorbed in activity without reflective self-consciousness but with a deep sense of control" (Engeser et al., 2021, p.2); self-determination theory, which promotes autonomy and sense of control (Deci and Ryan, 2000); stress coping theory, which advocates the employment of various cognitive and behavioral strategies to adapt to stressful conditions (Lazarus and Folkman, 1984); and attention restoration theory, which posits that an exposure to natural environments helps replenish cognitive resources and enhance wellbeing (Kaplan, 1995; Kaplan, 2001). The primary objective of FLOW-VRT is to address patients' palliative needs by alleviating physical and emotional distress as well as enhancing the quality of end-of-life. "FLOW-VRT-Relaxation" refers to a specialized version of our FLOW-VRT intervention that focuses on relaxation. It allows patients to choose their preferred VR relaxation experience. In a recent case report (Woo and Lee, 2023), we found initial evidence supporting its feasibility and therapeutic potential. Using a randomized controlled trial, the current study compares FLOW-VRT-Relaxation with traditional relaxation practice. We aim to test the efficacy of FLOW-VRT-Relaxation in effective symptom control, i.e., improved emotional and physical symptoms, when compared with traditional relaxation practice.

2 Methods

2.1 Study design

This was a single-centered, prospective, randomized, single-blind, controlled trial conducted in Hong Kong. The present trial was pre-registered on 6th June 2022 with the Open Science Framework (OSF) registry. The pre-registration can be accessed through https://doi.org/10.17605/OSF.IO/4FJUP. The trial was approved by the Departmental Research Ethics Committee, Department of Psychology, the University of Hong Kong and the Joint CUHK-NTEC CREC (Reference Number: 2022.435-T).

2.2 Participants

A total of 128 patients with terminal cancer from an adult palliative care ward of Shatin Hospital, a public hospital in Hong Kong, were recruited. Eligible participants were all adults aged 18 or over, Cantonese-speaking, able to give informed consent, and diagnosed with cancer. Exclusion criteria were visual and hearing impairment, severe cognitive impairment, diagnosed epilepsy or having had a seizure in the past 6 weeks, hypersensitivity to motion, active nausea or vomiting, physical disability such as neck injury, a clinically depressed or unstable mood, delirium symptoms, or a history of dissociative disorders. Exclusion criteria are set to minimize the potential physical and psychological risks as delineated in the article of Woo and Lee (2023). A neutral script was used to introduce the study, which is included in Figure 1. Eligible participants who gave informed consent were randomly assigned following simple randomization procedures in a 1:1 ratio to the experimental or control group, using computer-generated randomization (https://www.randomizer.org). The randomization process was concealed until allocation. The sample size calculation was based on efficacy analysis. In order to achieve 80% power in detecting a medium effect size estimate of 0.25 between the two groups at a significance level of 5%, a sample size of 128 was estimated.

2.3 Interventions

In the FLOW-VRT-Relaxation treatment group, a need assessment was first conducted by the primary investigator, who

TABLE 1 List of the most popular relaxation content and its selected VR video from YouTube VR app.

Relaxation Content	Selected video from YouTube VR
Beach	Highway Forty Productions. "Malibu Beach—VR 360—4K Video—Soothing Surround Beach Sounds—ASMR CaliScapes." Video, 31:56, September 28, 2023. https://youtu.be/bW9VYhytk-c?si=fx-gwd9jqCYA9Kcl.
Underwater	3D VR 360 VIDEOS. "(360 Video) The Ocean—Underwater World in VR." Video, 8:15, September 28, 2023. https://www.youtube.com/watch?v=bzZEKGRoZwc
Waterfall	Escape TV. "Virtual Nature 360°—5K—Relaxation—Nature Meditation—Immersive Natural Waterfall & Bushwalk." Video, 9:45, September 28, 2023. https://youtu.be/yGlgldn5orU?si=BZq0R-2oqY_P8gvD
Snow mountain	4K Relaxation Channel. "Virtual Nature Relaxation—VR 360° 5K Video—Chief Mountain, BC, Canada." Video, 1:57:44, September 28, 2023. https://youtu.be/__kQAlOJhfQ?si=ZqyKWVbE7vroXp74
Japan Onsen	ma mi. "つつし゛亭 露天風呂 うららの湯】草津温泉 湯めぐりVR." Video, 6:00, September 28, 2023. https://youtu.be/IPgsomPcdBI?si=3xEhJpcTWj9QPjMn
Japan Sakura	TokyoStreetView-Japan The Beautiful. "[360 5K] The Cherry blossoms of Shakujii Kawa—Tokyo—石神井川." Video, 8:26, September 28, 2023. https://youtu.be/Awz-wNJ_bk0?si=oQiyClWEMjYnR8L2
Forest	AirPano VR. "Four Seasons. Forest Relaxation 360 video in 8K." Video, 7:00, September 28, 2023. https://youtu.be/pXfUhkK_QRQ?si=cnyYSDQvoDrB2dqk
Clouds/ Sky	Team Brainspiro. "4K 360 VR * 7 Minutes * Relaxing clouds flying—Sunrise and Sunset within 7 minutes." Video, 7:00, September 28, 2023. https://youtu.be/mfQb_b_au2w?si=rCYDI7Xivm9_GCDd

is both a registered clinical psychologist and a certified thanatologist, using a need assessment schedule specifically developed for the purpose of this study. The primary investigator presented the participants with a list of the most popular VR relaxation content (see Table 1), which was compiled based on the results of a survey conducted among patients in palliative care. The 360° VR videos were located in the YouTube VR app. YouTube VR is a free VR application that utilizes 360-degree video playback and spatial audio technologies to provide an immersive viewing experience, allowing users to navigate YouTube content in a virtual environment using VR headsets. The eight YouTube 360° VR videos were selected based on the following criteria:

1. VR content that promotes relaxation through serene environments, comforting sounds, and calming visuals;
2. VR content filmed with steady or stationary cameras to minimize sudden motions that can induce cybersickness;
3. VR content with a lower intensity of visual disturbances, such as minimal use of rapid transitions;
4. VR content that allows patients to focus on a fixed point or provides a stationary viewing experience.

After showing the list of VR content, the participants were asked to select their preferred relaxation video. The primary investigator then assisted in a 10-min session using the chosen relaxation VR video and the Meta Quest 2 VR headset. The Meta Quest 2 is a standalone VR headset with high-quality graphics through a resolution of 1832 × 1920 pixels per eye, providing an immersive viewing experience. During the VR experience, the primary investigator coached on diaphragmatic breathing by inviting the participant to inhale slowly by expanding the belly while focusing on the breathing process, then exhale slowly. Most of the participants spontaneously expressed their feelings and thoughts upon VR exposure. Sufficient time (around 1–2 min) was then provided for their adaptation to the virtual environment and verbal expressions before relaxation coaching. To standardize the procedure, FLOW-VRT-Relaxation was implemented following treatment procedures developed as part of the study and specified in a manual.

In the treatment-as-usual group, a need assessment was first conducted to assess participants' need for relaxation. In this group, patients received 10-min coaching on diaphragmatic breathing by the primary investigator, as is usual practice in relaxation-based palliative care. Using the same approach as in the treatment group, diaphragmatic breathing was coached by inviting the participant to inhale slowly by expanding the belly while focusing on the breathing, then exhaling slowly. Pre-selected soothing music was played during relaxation.

2.4 Outcome measures

The outcome measure of the current study is the Chinese version of the Edmonton Symptom Assessment System (CESAS) (Bruera et al., 1991; Dong et al., 2015). It is a questionnaire used to rate the intensity of nine common symptoms experienced by patients diagnosed with cancer. Research has demonstrated the reliability of using it as a tool to assess symptoms in patients undergoing palliative care (Watanabe et al., 2012). The CESAS demonstrated acceptable internal consistency with a Cronbach's alpha 0.72, strong test-retest reliability with Pearson correlation coefficients ranging from 0.47 to 0.92 between baseline and after 2 h, and good concurrent validity with Spearman correlation ranging from 0.66 to 0.96 between CESAS and the Chinese version of the M. D. Anderson Symptom Inventory (Dong et al., 2015). Demographic and clinical variables such as age, sex, education, medical diagnosis, and current treatment were collected by retrieving information from the medical records with informed consent from the participants.

Upon recruitment, one of our research assistants blinded to study group allocation administered the pre-test measurement, after which another assistant performed the computer-generated

randomization and notified the principal investigator of the group allocations. The principal investigator was not blinded to the group allocation due to the nature of the study; however, participants were blinded to study group allocation during the intervention. The research assistant, who was blinded to the study group allocation, administered the post-test measurement.

2.5 Data analysis

A comparison between the FLOW-VRT-Relaxation and Treatment-as-Usual groups was performed using Analysis of Covariance (ANCOVA). Pre-test measurements were included as covariates in the ANOVA model to control for their effects on the dependent variable. Statistical analysis was performed using the statistical analysis software Jamovi (The Jamovi Project, 2023), choosing $p < 0.05$ as indicating statistical significance. The statistical analysis was conducted on an intention-to-treat basis, including all participants irrespective of whether they completed the entire intervention or not (Gupta, 2011). The assumption check of the ANCOVA was assessed using Shapiro-Wilk tests for the normality and Levene's test for the homogeneity of variances.

3 Results

Eligible participants from a palliative care unit in a public hospital were recruited from November 2022 to September 2023. During the recruitment period, 140 patients were eligible and approached for the study, with 128 (91%) agreeing to participate. Through randomization, 64 were assigned to the experimental group, and 64 were assigned to the control group. The overall completion rate is 93%, with 59 [92.2%] participants from the experimental group and 60 [93.8%] participants from the control group completing the session. Reasons for incomplete sessions include lack of interest in continuing VR intervention, unfavorable physical conditions such as coughing and tiredness, interruptions such as family visits and early discharge, and needs assessed to be null for VR intervention. The mean and standard deviation ages of the 128 randomized participants are 66.6 and 11.5 years, respectively. 90 of 128 recruited participants [70%] are female, while 38 [30%] are male. The majority of participants completed at least primary education (120 participants [93.8%]). There are no significant differences between groups in terms of age [$t(126) = 0.183$, $p = 0.855$], education [$\chi2(4) = 1.24$, $p = 0.871$], gender [$\chi2$ (1) = 0.599, $p = 0.439$] and medical treatment [$\chi2$ (4) = 7.43, $p = 0.115$]. Similarly, there are no significant differences between

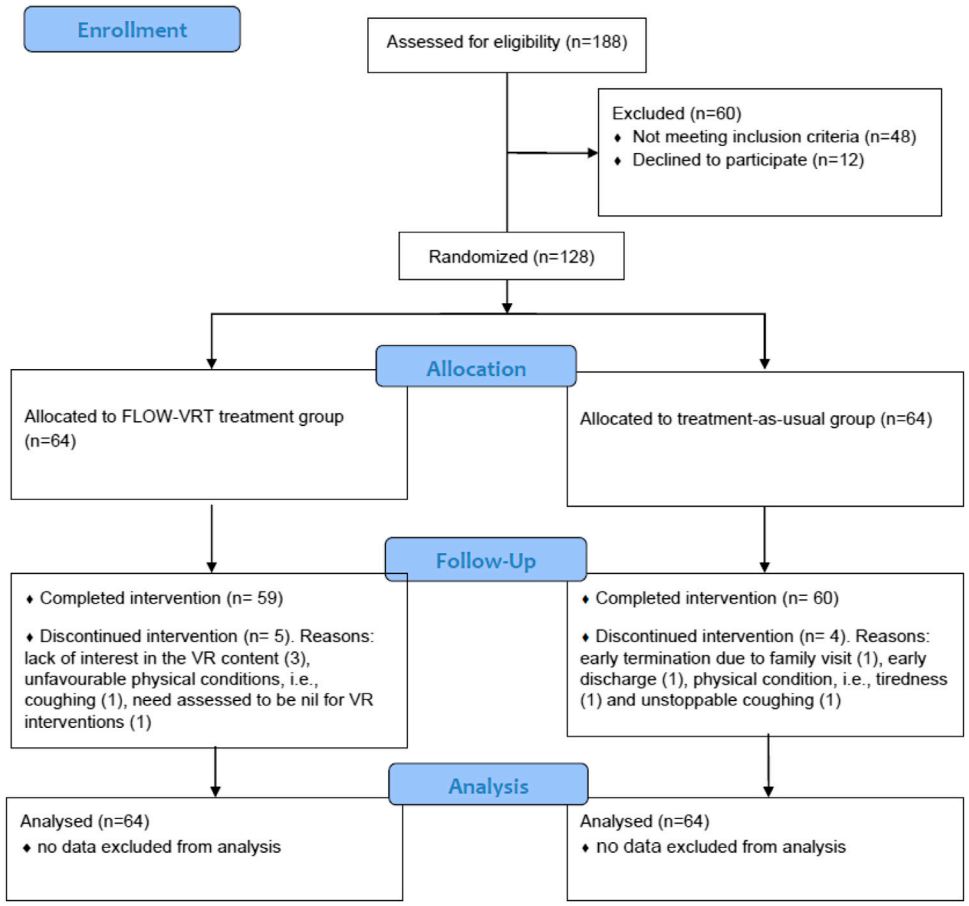

FIGURE 2
CONSORT flow diagram.

TABLE 2 Baseline demographic and clinical characteristics of participants.

	Control group (n = 64)	Treatment group (n = 64)
Mean age (years)	66.8	66.4
Sex		
Male	17 (13%)	21 (16%)
Female	47 (37%)	43 (34%)
Education		
Illiterate	3 (2%)	2 (2%)
Kindergarten	2 (2%)	1 (1%)
Primary	34 (27%)	33 (26%)
Secondary	20 (16%)	20 (16%)
Tertiary	5 (4%)	8 (6%)
Medical diagnosis		
Lung cancer	21 (16%)	24 (19%)
Breast cancer	9 (7%)	12 (9%)
Rectum cancer	3 (2%)	4 (3%)
Prostate cancer	3 (2%)	4 (3%)
Others	28 (22%)	20 (16%)
Medical treatment		
Radiotherapy	19 (15%)	11 (9%)
Chemotherapy	23 (18%)	28 (22%)
Medication	21 (16%)	18 (14%)
Others	0 (0%)	1 (1%)
None	1 (1%)	6 (5%)

groups at baseline in CESAS-Total score [$t(117) = 0.695$, $p = 0.488$], CESAS-Physical Subscale score [$t(117) = 0.401$, $p = 0.689$], and CESAS-Emotional Subscale score [$t(117) = 0.324$, $p = 0.746$]. Please refer to Figure 2 for the CONSORT study flow diagram and Table 2 for the baseline characteristics of participants. ANCOVA with the baseline assessment as covariates was conducted to determine if FLOW-VRT-Relaxation would bring about more symptom reduction when compared with a traditional relaxation practice. The ANOVA assumptions were assessed for the total score, physical subscale score, and emotional subscale score. The results of Shapiro-Wilk tests show that the total score ($p = 0.112$) and physical subscale score ($p = 0.182$) are normally distributed, but not the emotional subscale score ($p < 0.05$). Kruskal-Wallis test, as a non-parametric test, was then conducted to analyze the emotional subscale score. The assumption of homogeneity of variances was examined using Levene's test, which indicates no significant differences for the total score [$F(1, 117) = 0.634$, $p = 0.427$], emotional subscale score [$F(1, 117) = 0.007$, $p = 0.934$], and physical subscale score [$F(1, 117) = 1.88$, $p = 0.173$].

The ANCOVA results show significant differences between the experimental and control groups on the total score [$F(1, 116) = 11.3$, $p = 0.001$, $\eta p^2 = 0.09$] and physical subscale score, [$F(1, 116) = 5.42$, $p = 0.022$, $\eta p^2 = 0.05$] (see Figure 3). *Post hoc* tests report a significantly lower total score (MD = 4.54, $p = 0.001$, $d = 0.618$), and the physical subscale score (MD = 2.18, $p = 0.02$, $d = 0.427$) for the experimental group. The Kruskal-Wallis test results show a significant difference in the emotional subscale score [H(1) = 8.94, $p = 0.003$, $\epsilon^2 = 0.03$]. Please refer to Table 3 for the baseline and post-test results of each group and Table 4 for the results of ANCOVA or Kruskal-Wallis test following assumption check.

4 Discussions

The current study compares the efficacy of FLOW-VRT-Relaxation with respect to traditional relaxation practice in a palliative care setting. FLOW-VRT-Relaxation shows a significant difference in the reduction of the total score [$F(1, 116) = 11.3$, $p = 0.001$, $\eta p^2 = 0.09$], physical subscale score [$F(1, 116) = 5.42$, $p = 0.022$, $\eta p^2 = 0.05$], and emotional subscale score [H(1) = 8.94, $p = 0.003$, $\epsilon^2 = 0.03$] with respect to traditional relaxation administered in a clinical setting. Significant pre-post treatment effect sizes between the two groups are medium ($\eta p^2 = 0.09$) for the total score and small for both the physical ($\eta p^2 = 0.05$) and emotional subscale score ($\epsilon^2 = 0.03$) (Cohen, 1988), reflecting a substantial superiority of FLOW-VRT-Relaxation especially with regard to total symptom improvement. The result appears consistent with the data

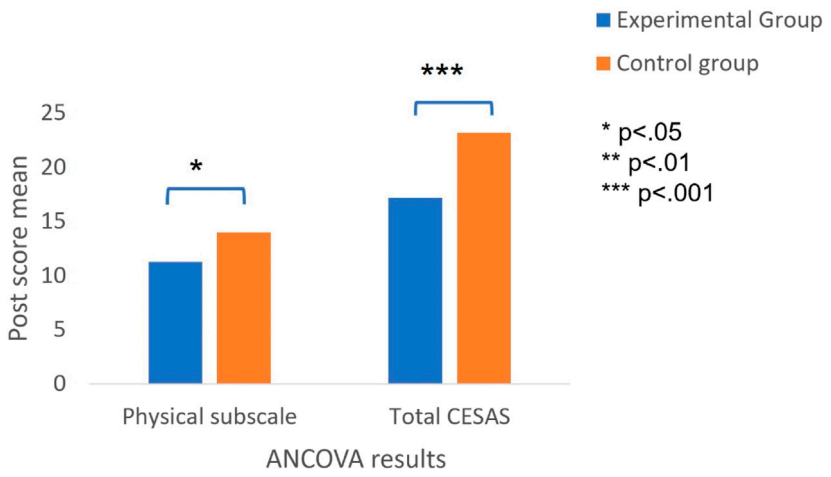

FIGURE 3
ANOVA results under the between-group comparisons on physical subscale score and total score.

TABLE 3 Baseline and post-test results of each group.

	FLOW-VRT-Relaxation group		Control group	
	Pre-test [mean (SD)]	Post-test [mean (SD)]	Pre-test [mean (SD)]	Post-test [mean (SD)]
Physical subscale	15.4 (8.8)	11.3 (8.9)	16.1 (9.6)	14.0 (9.0)
Emotional subscale	4.75 (6.0)	2.5 (4.6)	5.1 (6.5)	4.1 (5.6)
Total CESAS	25.2 (14.2)	17.2 (13.2)	27.2 (16.0)	23.2 (14.9)

TABLE 4 ANCOVA with *post hoc* comparisons or Kruskal-Wallis test results, following results from Levene's test and Shapiro-Wilk W test.

	Levene test		Shapiro-Wilk W test		ANCOVA			ANCOVA *post hoc* comparison			Kruskal-Wallis test	
Scores	*F*	*p*	*W*	*p*	*F*	*p*	*ηp2*	*MD*̂	*SE*	*d*	*H*	*p*
Physical	1.88	0.17	0.98	0.18	5.42	0.02*	0.05	2.18	0.94	0.43	—	—
Emotional	0.007	0.93	0.86	<0.01*	—	—	—	—	—	—	8.94	0.003*
Total	0.63	0.43	0.98	0.11	11.3	0.001*	0.09	4.54	1.35	0.618	—	—

*$p < 0.05$.
̂*MD* = mean difference (control-experimental).

pooled across 8 studies in a recent systematic review conducted by Mo et al. (2022) which demonstrates the significant differences in symptom improvement led by the VR group; however, six out of these eight studies have no comparative arm in their research design. The randomized controlled trial design of our study provides a sound methodological apparatus capable of demonstrating the advantages of complementing traditional relaxation techniques with an immersive VR experience.

The therapeutic elements of FLOW-VRT-Relaxation that are particularly useful in reducing the emotional and physical symptoms among patients with terminal illnesses may relate to its theoretical frameworks. First, FLOW-VRT-Relaxation may have the potential to enhance patients' self-determination, which requires future investigations to establish the potential relationship. Self-determination theory is "centrally concerned with the social conditions that facilitate or hinder human flourishing" (Ryan and Deci, 2017, p. 6). It is a psychological theory that appraises behavior as a function of motives, taking the form of desires, values, and goals (Deci and Ryan, 2000). Research shows that autonomy-supportive interactions are effective in motivating individuals to adopt healthier behaviors, in contrast to methods that aim to control or regulate the person (Ryan et al., 2008; Ryan et al., 2011). The therapeutic benefits of FLOW-VRT may relate to customization, allowing patients to choose the content used during the experience according to their desires and values. The findings of a systematic review by Martin et al.

(2022) resonate with the current study, revealing the therapeutic potential of customized content. Specifically, the review highlights a pattern across the statistical results in which significant somatic and psychological symptom improvement was observed when the VR experience was personally meaningful. Second, FLOW-VRT-Relaxation incorporates VR technology, which has been shown to be flow-inducing (Gaggioli et al., 2003). Although limited studies are exploring the direct effect of flow experiences induced by VR on symptom control in palliative care, it is known that flow is associated with both physical and psychological wellbeing (Persson, 1996; Heo et al., 2010; Hirao et al., 2012; Heo et al., 2013). Future research is, therefore, recommended to substantiate the role of flow in symptom management among patients with terminal illnesses. Lastly, FLOW-VRT-Relaxation may offer opportunities for patients to explore and cultivate adaptive stress coping. The stress coping theory posits the existence of two coping strategies: problem-focused coping, which refers to a coping style concentrating on the management of stressful situations by operating on the stressor, and emotion-focused coping, which aims to manage one's emotions when facing that stressor (Lazarus and Folkman, 1984). FLOW-VRT-Relaxation allows patients to experience positive emotions derived from the virtual experience, which is clinically meaningful when the stressful condition of being terminally ill may not allow room for problem-focused coping. Such emotion-focused coping is further supported by the findings of Carmont and McIlfatrick's (2022) systematic integrative review. Their study highlights the potential of VR to foster emotional connection, particularly in the context of patients dealing with terminal illnesses and the accompanying physical and emotional decline.

4.1 Study limitations

A possible limitation of the current study is that only the immediate effect of FLOW-VRT-Relaxation is measured. Since a follow-up assessment, such as in one-day or one-week time, is not conducted, the maintenance of the treatment effect of relaxation is not ascertained. Given the fact that the death of patients in palliative care can be imminent, i.e., within a few hours or days (General Medical Council of the United Kingdom, 2010), the short-term therapeutic effect of FLOW-VRT-Relaxation on patients is regarded as clinically meaningful, not to mention the virtual fulfillment of their last wishes. Although the current study investigates only the immediate effects, long-term benefits are worthy of further investigation and research. Another limitation refers to the fact that all the VR videos are drawn from pre-existing online sources, limiting the degree of personalization. As meaningful VR for patients is important, as highlighted in the systematic review of Martin et al. (2022), future research that focuses on the advancement of personalized and meaningful VR content for the needs of patients in palliative care is recommended. The participation of various stakeholders, such as patients, families, ward staff, and therapists, in the curation process would be favorable. Lastly, since FLOW-VRT-Relaxation is carried out by one registered clinical psychologist who is also a certified thanatologist with years of clinical experience of VR delivery in palliative care settings, results may not reflect the skills of other VR therapists or facilitators. Appropriate training may be needed for the VR therapists-to-be to ensure quality delivery of VR interventions in palliative care.

4.2 Clinical implications and future study directions

Based on our clinical experience in administering VR-based interventions in a palliative care setting, we suggest taking a few precautions to minimize potential adverse effects associated with the use of this technology. First, patients' needs, values, and preferences should be respected at all times, following the ethical principle of patient *autonomy* (Beauchamp and Childress, 2001). One of the participants who withdrew from our research shared that he wished to watch war-related VR content instead of what the therapist had selected as relaxing, while another participant rejected VR exposure due to a lack of interest. Encouraging patients to try such a novel technology further may impose unnecessary stress or psychological pressure. Second, exclusion criteria should be crafted with care in preparation for future clinical or research applications. Given the physical and emotional vulnerability of the target users, patients with symptoms of depression or suffering from low morale may be susceptible to psychological distress. Indeed, engaging in virtual travel involving (virtual) physical activities may backfire as it can increase awareness of one's actual physical limitations. The patient may experience a sense of loss regarding their physical abilities or their past identity, such as being an energetic hiker or scuba diver. This heightened awareness of limitations can lead to emotional disturbances and potentially pose psychological risks. Therefore, it is essential to screen a patient's mood at all times, including their readiness to enter the virtual and ideal world. Lastly, our study shows a high female-to-male ratio (70%–30%) in the recruited participants. We observe that males show higher rates of rejection towards research participation and are more often physically unable to join the VR research, i.e., males are observed to be more tired, more often with life-supporting devices, and more often sleeping upon approach when compared with females. Based on the clinical sensitivity and experiences of VR therapists or researchers, it is important to decide whether or not to proceed with recruitment to avoid unnecessary pressure or burden on patients who are either psychologically or physically unready for VR.

Our results show that following a FLOW-VRT-Relaxation session, the symptoms of distress that patients in palliative care have to endure significantly reduce, whether physical or emotional in nature. The novel and distinctive features of FLOW-VRT-Relaxation include prior assessment of individual needs for VR relaxation, customized VR relaxation content, and live coaching of relaxation techniques by a clinical psychologist during VR. Instead of being limited to coaching diaphragmatic breathing, as is the case in traditional clinical settings, FLOW-VRT-Relaxation includes an immersive virtual experience using "relaxation content" previously selected by the patients themselves. Their improvement in mood and physical symptoms may be explained by the capacity of this innovative technology to address not only the physical symptoms (e.g., through relaxation induced by a powerful and distracting immersive experience) but also the psychological needs (e.g., through virtual fulfillment of wishes, sense of control). Addressing these physical and psychological needs is particularly important for patients with terminal illnesses who often suffer from their physical constraints (e.g., bedbound conditions, unfavorable ward environments, unresolved

pain, negative side-effects of medications) and emotional fragility (e.g., unfulfilled wishes of traveling to a comfortable place, barriers to escape from current suffering). FLOW-VRT-Relaxation appears to be a superior form of relaxation than the traditional approach, as the former potentially addresses the high prevalence of palliative symptoms and further improves the quality of end-of-life care. In future follow-up studies, we will explore whether FLOW-VRT can lead to greater senses of presence, flow, and, restoration that contribute to symptom control, which hopefully provides further evidence to support our claims about the positive effects of our intervention on adaptive stress-coping.

5 Conclusion

The current study tested the efficacy of FLOW-VRT-Relaxation by comparing it to traditional relaxation practice in palliative care. Our results show that following a FLOW-VRT-Relaxation session, the symptoms of distress that patients in palliative care typically report significantly reduce, whether physical or emotional in nature. It provides promising evidence that the newly developed FLOW-VRT-Relaxation is preferable as a novel relaxation practice in palliative care. It is hitherto the first personalized VR relaxation intervention guided by theories and clinical considerations on the purpose and content of VR, how VR is to be delivered, and by whom it is delivered. It is also the first VR relaxation intervention empirically tested in a randomized controlled trial with an adequate sample size and compared with traditional relaxation practice in a palliative care setting. The encouraging result of the current research may shed light on the potential application of FLOW-VRT-Relaxation in wider adoption, such as elderly homes and rehabilitation centers. With its optimal use, FLOW-VRT-Relaxation hopefully serve as a complementary therapeutic tool that effectively improves end-of-life care in face of the mounting need of palliative care.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the Departmental Research Ethics Committee, Department of Psychology, the University of Hong Kong and the Joint CUHK-NTEC CREC (Reference Number: 2022.435-T). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

OW: Conceptualization, Data curation, Formal Analysis, Investigation, Writing–original draft. AL: Conceptualization, Investigation, Supervision, Writing–review and editing. RN: Writing–review and editing. DE: Writing–review and editing. RL: Writing–review and editing. AC: Funding acquisition, Writing–review and editing, Validation, Resources.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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