PILOT STUDY

Preliminary Study of Virtual-reality-guided Meditation for Veterans with Stress and Chronic Pain

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ABSTRACT

Context • Studies have found evidence for meditation's positive effects on health and well-being, but the difficulty of learning and engaging in meditation practice has been identified as a major barrier. Virtual reality (VR) technology may facilitate meditation practice by immersing users in a distraction-free and calming virtual environment, although this theory has yet to be rigorously tested.

Objective • This study intended to examine the efficacy of VR-guided meditation in a population of US veterans as a tool to facilitate meditation and relaxation practice for reduction of stress and chronic pain as well as to elicit participants' feedback regarding their perceptions of VR-guided meditation.

Design • The research team designed a preliminary study to identify the scope of future investigations.

Setting • The study was conducted at an outpatient polytrauma clinic in a Veterans Affairs (VA) Palo Alto Health Care System, located in Palo Alto, California.

Participants • Participants were a convenience sample of 31 veterans, with an average age of 55.2 years, who were patients at the polytrauma clinic and who had conditions with varying levels of stress and chronic pain.

Intervention • All participants completed a 10-minute, VR-guided-meditation session based on the Zen form of meditation.

Outcome Measures • At baseline immediately before and postintervention immediately after the VR meditation session, self-report ratings of pain and stress, physiological measures testing heart rate (HR) and blood pressure (BP), and participants' survey responses that assessed their experiences with, attitudes toward, and concerns about VR for clinical therapy were obtained.

Results • Participants showed statistically significant reductions in self-reported pain and stress, HR, and systolic and diastolic BP. Participants reported high satisfaction with VR-guided meditation, and few reported negative side-effects.

Conclusions • The study provided evidence for the usefulness of VR technology as a facilitator of meditation practice for reduction of stress and chronic pain. Future studies are needed to examine the long-term effects of repeated VR-guided-meditation sessions for patients with stress and chronic pain. (*Altern Ther Health Med.* 2023;29(6):42-49).

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Virtual reality (VR) describes technology, such as wearable headsets, that provide the user with a simulated virtual environment with varying levels of immersion, ranging from looking around an environment to moving around in and interacting with it. VR has gained much attention in healthcare; in the medical field, VR is most often used for acute pain, medical training, and education for providers.[1-3]

VR has also been effective in reducing procedural pain, such as for individuals with burn injuries undergoing wound care and physical therapy.[4-7] Studies have also suggested that VR may not only effectively distract patients from pain but also reduce anxiety and depressive symptoms.[8] Past studies have examined the use of VR technology with veterans and active-duty service members as an aid during exposure therapy and combat stress-management training or even as a way to create online virtual worlds that foster community and aid in reintegration into civilian life.[9-11]

Meditation has long been used as a means to alleviate stress, anxiety, and other negative emotions.[12] Both Western academia and the general public have recently demonstrated a growing interest in the therapeutic effects of meditation. Increasing experimental evidence has shown that interventions incorporating meditation can produce positive health outcomes, such as reducing anxiety and depression,[13-19] anger,[20] stress,[13,21-23] and the risk of cognitive decline.[24]

A randomized controlled trial using Mindfulness-Based Stress Reduction (MBSR) with chronic-pain patients showed statistically significant reductions in perceived pain and in pain-related inhibition of activity, drug use, and psychological symptomatology, such as anxiety and depression.[25] Some studies have examined the effects of mindfulness-meditation programs and found significant improvements in chronic-pain acceptance, activity engagement, physical function, and stress in comparison to control groups.[26,27]

Although meditation is an effective intervention, it can appear challenging to new practitioners. For example, one study found that the most commonly cited concern regarding meditation training was the difficulty in learning how to meditate.[28] Participants in that study noted that it was difficult to concentrate and it was easy to become distracted during the meditation session. Other researchers have found that distractions from the physical environment, such as noise or other people, are common challenges when engaging in meditation or mindfulness practice.[29]

VR offers a promising approach to help facilitate meditation practice by limiting real-world distractions and increasing a sense of presence through a virtual environment. A study of a sample of mindfulness experts found that VR, by focusing a user's attention and limiting real-world distractions, facilitated meditation practice leading to increases in state mindfulness.[30]

A study of chronic-pain patients found that VR paired with an MBSR-training audio track was superior in short-term reduction of pain compared to the same audio track alone.[31] VR-guided meditation has also been found to be effective in increasing state mindfulness and positive emotions.[32] Some studies have also found meditation within a virtual environment to be superior in promoting relaxation compared to meditation using imaginary techniques or nonimmersive videos.[33,34]

Given the effectiveness of meditation to aid with stress and pain, it's important to specifically examine the challenges that veterans face with meditation and how VR can address those challenges. One study found that the use of in-person group sessions and negative reactions to meditation instructors were the primary reasons that veterans chose not to engage in MBSR, a concern that might be mitigated by use of VR-guided individual sessions.[35] The same study found that difficulty in understanding mindfulness practices was a major barrier for veterans, mirroring the findings that difficulty learning to meditate is the most commonly cited concern in attempting meditation.[28,35]

Some research has demonstrated that engagement in meditation practice lowered the levels of posttraumatic stress disorder (PTSD) and depression symptoms for veterans.[36] Given the unique challenges found in implementing meditation-based interventions with this population, increasing an individual's ability to engage in meditation has been found to be key in promoting the effectiveness of mindfulness, meditation-based interventions and establishes the need for research on potential facilitators of meditation for veterans, such as VR technology.[35,37]

The objective of the current study was to examine the efficacy of VR-guided meditation in a population of US veterans as a tool to facilitate meditation and relaxation practice for reduction of stress and chronic pain as well as to elicit participants' feedback regarding their perceptions of VR-guided meditation.

METHODS

The research team designed a preliminary study to identify the scope of future investigations.

Participants

The study occurred at the Department of Veterans Affairs (VA) at the Polytrauma Headache Center of Excellence (HCoE) in the VA Palo Alto Health Care System, located in Palo Alto, California. Potential participants were outpatients at the HCoE clinic or at the physical medicine and rehabilitation recruited between June and September of 2019. Study staff approached patients in the waiting room of the clinic and informed the participants of the study, and flyers detailing the study were also posted in clinic areas.

Potential participants were included if they: (1) were aged over 18 years and (2) were currently being seen for pain-related complaints. The inclusion criteria were intentionally broad to identify any potential issues with implementing VR in a veteran population.

Potential participants were excluded if they had a history: (1) of severe vertigo, recent seizures or epilepsy, active nausea, or emesis or (2) of prior adverse reactions to

similar modalities, such as 3D-film, iMAX, or other VR devices, although the specific VR modules didn't require the patient to move his or her head. Patients with visual concerns were provided with a bifocal alternative, if appropriate. Notably, only one potential participant was not included due to a recent history of seizures.

All participants were informed by the research team about the details of the study prior to providing their written consents. Ethical approval for the study was sought from and granted for all research procedures by the Stanford/VA Institutional Review Board.

Procedures

Participants. The research team selected a convenience sample of participants recruited from the waiting room or through flyers.

Intervention. The research team observed outpatients using VR-guided meditation, and participants took part in one VR session. All VR meditation sessions were conducted using a portable and Wifi-enabled Oculus Go headset and controller (Facebook Technologies, Irvine, CA, USA). The Guided Meditation VR application was created by a third party, Cubicle Ninjas (Glen Ellyn, IL, USA), due to requirements that the application have a customizable nature and a simple interface. Research staff instructed participants on the operation of the headset, possible adverse side effects, and indications that required them to abort the session.

Outcome measures. Participants completed a baseline survey that collected information about demographics, health conditions, and prior familiarity with VR technology. That survey also asked about their pain types, such as musculoskeletal pain, nerve pain, or headaches.

At baseline and postintervention, participants reported their current levels of pain and stress using one 11-point numerical rating scales (NRS) for pain and another for stress. Resting-state systolic and diastolic blood pressure (BP) and heart rate (HR) were also collected at baseline and postintervention as physiological markers of stress and anxiety.[38-41]

Participants were administered a postintervention survey to assess their experiences with, attitudes toward, and concerns about VR for clinical therapy.

Table 1. Participants' Demographics and Health Information (N = 31)

Demographics	Mean ± SD
Age	55.2 ± 14.8
	N (%)
Gender, male	93.5
Currently receiving treatment	
Psychological treatment	64.5
Occupational therapy	35.5
Physical therapy	74.2
Speech therapy	22.6
Pain management	54.8
Conditions	
Migraines	35.5
Headaches, unspecified	41.9
Traumatic brain injury	48.4
Post-traumatic stress disorder (PTSD)	67.7
General stress	74.2
Acute or chronic anxiety	51.6
Depression	58.1
Other chronic pain, excluding headaches	80.6
Insomnia	64.5
Current pain type	
Headaches	61.3
Musculoskeletal	87.1
Nerve	41.9
Familiarity with virtual reality (VR) technology	
Know nothing about VR	19.4
Only heard about VR	25.8
Somewhat familiar, never used VR	25.8
Tried VR at least once	19.4
Used VR many times, very familiar	9.7

Intervention

In the application, the meditation modules were 10-minutes long and used the same preselected ambient music and guided meditation script for all participants, which was centered around the Zen form of meditation. The meditation script instructed participants on an effortless-breathing exercise and guided them in establishing a state of nonjudgmental awareness of their thoughts.

This form of meditation was chosen due to its demonstrated effectiveness in pain management.[13] Participants were able to choose one of six modules that differed only in the virtual scenery—mountain, forest, beach, desert, lake, or cave—with the six natural environments being selected due to past studies showing the positive effects of virtual nature settings on mood.[42] The virtual environments were 360-degree panoramic settings that were designed to increase a sense of immersion and presence while limiting real-world distractions.

Outcome Measures

The NRS is an instrument with both high test-retest reliability and high convergent validity for the measurement of both pain and stress.[43-45]

NRS-1. Participants rated the pain they were currently experiencing on an 11-point numerical scale, ranging from 0 to 10. 0 represented no pain, 10 represented the worst pain imaginable, and illustrated faces ranging from happy to crying accompanied each number as a visual representation.

NRS-2. Participants rated the stress they were currently experiencing on an 11-point numerical scale, ranging from 0 to 10. 0 represented no stress, 10 represented the worst stress imaginable, and illustrated faces ranging from happy to crying accompanied each number as a visual representation.

Postintervention survey. The participants rated their opinions on VR using a five-point Likert scale with the following options: strongly agree, agree, neutral, disagree, strongly disagree.

Table 2. Postintervention Survey Responses

Question	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
Overall…					
I enjoyed using virtual reality (VR)	51.6%	25.8%	16.1%	3.2%	3.2%
I enjoyed the specific guided-meditation module	46.7%	23.3%	23.3%	3.3%	3.3%
I was satisfied with the module's length	50.0%	33.3%	13.3%	3.3%	0.0%
I was comfortable using the headset	67.7%	19.4%	6.5%	0.0%	6.5%
I could use this on my own	67.7%	16.1%	6.5%	3.2%	6.5%
I could see myself…					
Using VR for entertainment	58.6%	17.2%	17.2%	3.4%	3.4%
Using VR for therapeutic benefits	67.7%	19.4%	9.7%	0.0%	3.2%
Wanting to use the latest technology	58.1%	19.4%	12.9%	6.5%	3.2%
Wanting to use VR in a clinical setting	33.3%	16.7%	33.3%	10.0%	6.7%
Wanting to use VR at home	66.7%	23.3%	3.3%	3.3%	3.3%
I think VR technology would…					
Improve my mood and emotional well-being	53.3%	23.3%	13.3%	3.3%	6.7%
Improve my pain	37.9%	31.0%	20.7%	0.0%	10.3%
Improve my compliance with health behaviors	37.0%	29.6%	22.2%	3.7%	7.4%
Decrease feelings of fear, anxiety, depression	35.7%	35.7%	17.9%	3.6%	7.1%
Improve my focus	39.3%	35.7%	14.3%	3.6%	7.1%
I am concerned about…					
It worsening my symptoms	6.9%	3.4%	17.2%	10.3%	62.1%
Relying too much on VR	0.0%	3.7%	33.3%	7.4%	55.6%
Experiencing dizziness, nausea, vertigo, etc.	0.0%	6.7%	26.7%	13.3%	53.3%

Statistical Analysis

Descriptive statistics were calculated for each of the outcome measures—reported pain, reported stress, BP, and HR. Paired-sample t-tests were used for paired observations to test significant changes in outcome measures. Cohen's d was calculated to determine effect size of the differences in outcome measures between baseline and postintervention. Significance occurred at $P < .05$.

Interaction effects were examined using hierarchical linear regression with an outcome variables—pain rating, stress rating, BP, or HR—as the dependent variables and a dummy-coded treatment variable, with a value of 0 indicating pre-treatment and 1 indicating post-treatment,—the potential covariate—and a treatment-covariate interaction term as the input variable.

RESULTS

Participants

Participants' characteristics are presented in Table 1. Thirty-one adults, aged between 20 and 81 years with an average age of 55.2 years, consented to and completed the research study. The majority of participants (87.1%) reported that they were currently experiencing migraines (35.5%), headaches (41.9%), or some other form of chronic pain (80.6%). A significant number of participants reported a combination of either two (54.8%) or three (19.4%) pain types, and the most commonly represented type of pain reported by participants at the time of the VR session was musculoskeletal (87.1%).

A majority of participants (83.8%) also reported current concerns related to mental health, such as PTSD (67.7%), general stress (74.2%), acute or chronic anxiety (51.6%), or depression (58.1%). Again, participants reported a combination of conditions.

All veterans were currently receiving some form of treatment from the VA healthcare system, with the most commonly represented services being physical therapy (74.1%), psychological treatment (64.5%), and pain management (54.8%).

Participants' Feedback

Table 2 shows participant's survey responses after the meditation session. The majority of participants thought that VR technology could be used for therapeutic benefits, with more participants reporting that they would want to use VR at home (90%) than in a clinical setting (50%). A significant portion of participants (54.8%) expressed agreement by indicating "agree" or "strongly agree" with all three items related to whether VR technology would improve their mood and emotional well-being, reduce their pain symptoms, and decrease feelings of fear, anxiety, and depression. A minority of participants (16.1%) expressed agreement by indicating "agree" or "strongly agree" with concerns related to VR worsening their symptoms, over-reliance on VR, and experiencing dizziness, nausea, or vertigo.

Pain and Stress NRS

Perceived pain was significantly reduced immediately postintervention (Table 3). Participants' mean pain rating at baseline was 5.28 compared to a rating postintervention of 4.20 (Figure 1), representing a small-to-medium effect size (Cohen's d = 0.42).

Perceived stress was also significantly reduced immediately postintervention. The mean stress rating at baseline was 5.27 compared to the rating postintervention of 3.72 (Figure 2), representing a medium effect size (Cohen's d = 0.53).

Blood Pressure and Heart Rate

Both systolic and diastolic BP were significantly reduced between baseline and immediately postintervention. The mean systolic BP at baseline was 125.63 mmHg compared to that postintervention of 118.93 mmHg (Figure 3), representing a small-medium effect size (Cohen's d = 0.40). The mean diastolic BP at baseline was 78.67 mmHg compared to that postintervention of 75.03 mmHg (Figure 4), representing a small effect size (Cohen's d = 0.36).

HR was significantly reduced between baseline and immediately postintervention. The mean HR at baseline was 73.6 bpm compared to that postintervention of 69.1 bpm (Figure 5), representing a small effect size (Cohen's d = 0.34).

Interaction Effects

No significant interaction effects were found between treatment and age, pain type, or VR familiarity on any of the outcome variables ($P > .05$).

DISCUSSION

Pain, Stress, BP, and HR

The current study's first main findings were statistically significant drops in subjective pain and stress ratings following the meditation session, which was further supported by statistically significant reductions in BP and HR, indicating that the session promoted relaxation. This is consistent with prior studies that have shown that meditation, both facilitated by VR technology and through more traditional means, is associated with increased relaxation and decreased pain.[12,15,16,20,22,26,31,32]

Based both on the results of the current study's postintervention survey and qualitative feedback, these positive results may be explained by participants' high enjoyment of the VR experience and openness to using new technology, exposure to VR's natural environments, and the VR technology's unique ability to facilitate participants' sense of being there or immersion in a place, which is consistent with other studies of VR-assisted mindfulness practice.[32,42,46,47]

It's likely that VR environments, by creating a pleasant experience and limiting distractions from the physical environment, allow users to easily engage in meditation practice, such as being aware of and paying attention to the present moment. Other studies using VR-guided meditation have explored additional features such as biofeedback or movement, which may optimize the effectiveness of VR-guided meditation in reducing pain.[31] Future work is needed to identify how different aspects and features of VR-guided meditation impact its effectiveness.

Table 3. Summary of Outcome Measures

	Baseline	Postintervention	Mean Change	Cohen's d
Pain rating	5.28	4.2	1.08[a]	0.42
Stress rating	5.27	3.72	1.55	0.53
Systolic blood pressure	125.63	118.93	6.7[a]	0.40
Diastolic blood pressure	78.67	75.03	3.6[a]	0.36
Heart rate	73.6	69.1	4.5[a]	0.34

[a]Indicates significant change at $P < .05$.

Figure 1. Pain ratings: Baseline Compared to Postintervention. The diamond indicates the average.

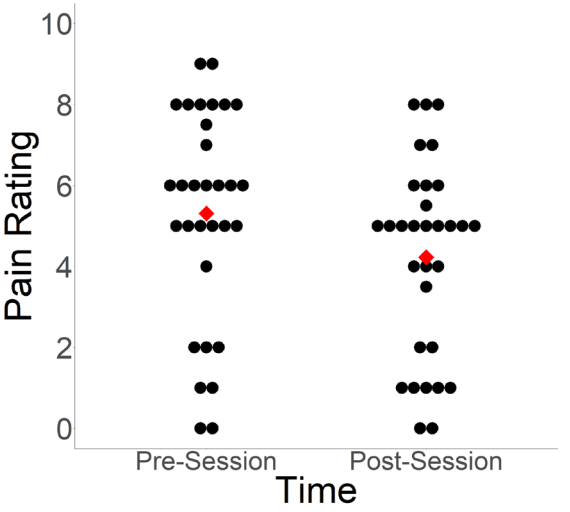
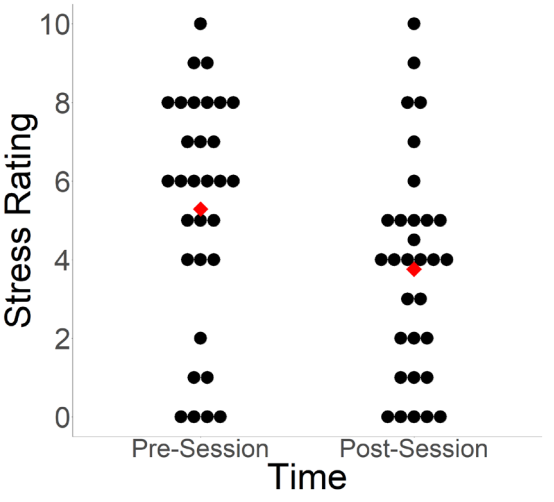


Figure 2. Stress Ratings: Baseline Compared to Postintervention. The diamond indicates the average.



Postintervention Survey

The current study's second main finding was that most participants enjoyed the VR-guided meditation experience and didn't experience negative side-effects. Most participants also agreed that VR technology might improve their moods, compliance with health behaviors, and focus, and decrease pain symptoms and feelings of fear, anxiety, or depression.

Figure 3. Systolic Blood Pressure (mmHg): Baseline Compared to Postintervention. The diamond indicates the average.

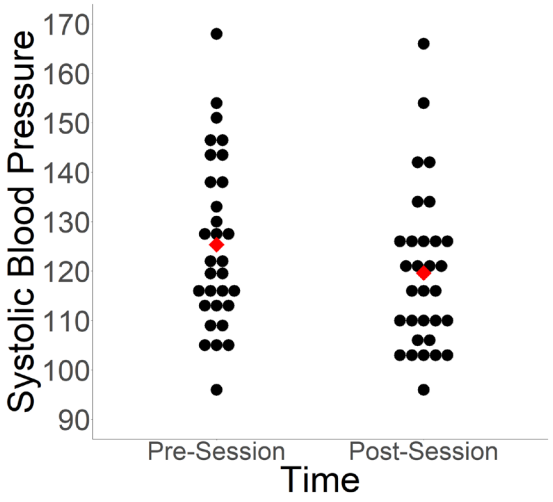


Figure 4. Diastolic Blood Pressure (mmHg): Baseline Compared to Postintervention. The diamond indicates the average.

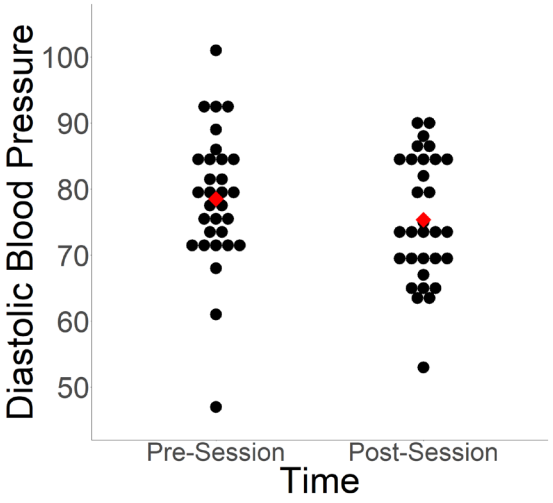
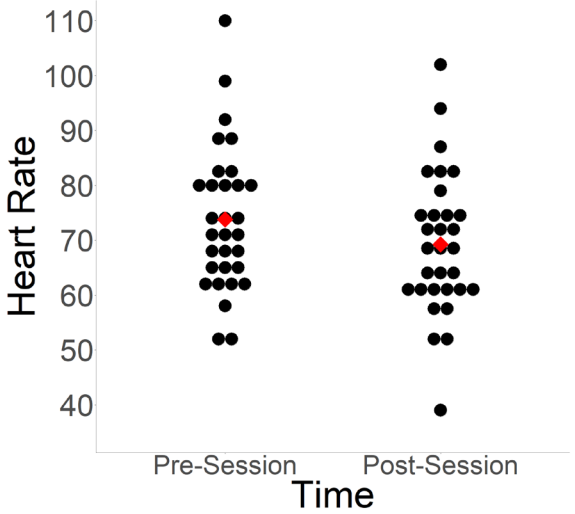


Figure 5. Heart rate (bpm): Baseline Compared to Postintervention. The diamond indicates the average.



VR technology's potential to improve mood and reduce negative emotions is significant in that negative emotions, such as boredom and upsetting thoughts or emotions, often represent a barrier to engaging in meditation or mindfulness practice.[29] Therefore, it's possible that the positive effects of VR on mood and negative emotions may mitigate the barriers to engaging in meditation.

Additionally, although the most common negative side-effect of using VR technology is virtual-reality motion sickness, only 6.5% of participants surveyed were concerned about motion-sickness-like symptoms after experiencing the VR-guided meditation session. Although the current study's VR meditation application included the ability to look around the environment, participants didn't move through it, which may explain the low incidence of motion-sickness.[48] Still, it's important for future studies to examine the risks and benefits of VR experiences that include or don't include movement as part of meditation.

Finally, although the VR-guided meditation session was conducted in a clinical setting, most participants indicated that they didn't want to use VR in such a setting, but 90% of participants wanted to use VR at home. This suggests that future studies might examine how participants engage with VR-guided meditation in their own homes rather than in clinical settings, which hasn't yet been explored. Given the COVID-19 global pandemic and the resulting difficulty of in-person medical appointments, VR technology may present a promising option for meditation-based interventions for chronic pain or stress reduction.[49]

Interaction Effects

The current study's third main finding was that the effects of the VR-guided meditation session, namely decreases in pain and stress, didn't differ depending on the participant's age, prior familiarity with VR technology, or pain type. This is evidence that VR technology is effective as a facilitator of meditation equally across different ages and pain types and that effectiveness doesn't depend on the user already being familiar or comfortable with VR technology.

This is consistent with previous work showing that virtual reality is effective in enhancing the health and well-being of older adults and young adults.[50,51] It's also consistent with previous research showing that meditation experts who tried a VR-guided meditation session, despite reporting little or no knowledge about VR and 3D images, expressed the high acceptability of VR systems to practice mindfulness and meditation.[30] Future studies might examine other potential factors impacting the effectiveness of VR-guided meditation to determine which patient groups might benefit most from these interventions.

Limitations

Despite the favorable evidence about the usefulness of VR-guided meditation generated by the current study, it's important to consider its limitations. Due to the limited sample size (n = 31), all results should be interpreted with

caution due to lack of statistical power and possibly an inflated false discovery rate. Also, the focus on an outpatient sample prevented inclusion of participants with acute psychiatric or medical conditions requiring inpatient care.

The current study's within-subject experimental design, without a control group, limits the interpretability of results, particularly as to whether decreases in blood pressure and heart rate were due to VR-guided meditation or other factors, such as remaining sitting; it's also unknown how VR-guided meditation's effectiveness compares with the effectiveness of more traditional meditation modalities.

Additionally, it's difficult to distinguish between the effects of meditation and the effects of VR environments on mood.[42,52] This study incorporated only a single session, meaning that it is unknown whether multiple sessions could induce greater therapeutic benefits or reduce effectiveness in subsequent sessions.

Follow-up data wasn't collected about the perseverance of therapeutic benefits, so no conclusions can be made about how long the reductions in pain and stress may have lasted following the session. The lack of follow-up data also limits speculation about whether VR served as a temporary facilitator of meditation or a method by which users could learn meditation practice in the long-term. Future studies could examine the effectiveness of VR-guided meditation using a larger sample, a between-group design, and multiple sessions with follow-up data collection. Studies could also examine other desirable outcomes of VR-guided meditation, such as increases in mindfulness or positive emotion.[32] Other work has also suggested that the addition of game-design elements to VR-guided meditation applications may enhance effectiveness, and the present study didn't incorporate such elements.[53]

The current study provides preliminary evidence for the usefulness of VR-guided meditation as an intervention for the reduction of chronic pain and stress symptoms in the veteran population and polytrauma settings. The study's results support past literature showing that participants who are suffering from conditions such as chronic pain or stress can benefit from meditation. Additionally, VR-guided meditation may serve as an adjunct or alternative to traditional meditation therapy for the portion of the population for whom difficulty associated with learning meditation practices and distractions from the physical environment present a major barrier to seeking to access the therapeutic benefits of meditation.[13,28,29]

In addition, participants in the current study demonstrated a strong interest in using VR-guided meditation at home rather than in a clinical setting. Therefore, VR-guided meditation should be explored as a more accessible alternative to interventions for chronic pain and stress that require in-person visits. Future studies are planned to compare the effects of VR-guided meditation against other meditation modalities, such as audio-guided or group meditation, using longitudinal studies with control groups.

CONCLUSIONS

The study provided evidence for the usefulness of VR technology as a facilitator of meditation practice for reduction of stress and chronic pain. Future studies are needed to examine the long-term effects of repeated VR-guided-meditation sessions for patients with stress and chronic pain.

AUTHORS DISCLOSURE STATEMENT

The authors declare that they have no relevant or material financial interests that relate to the research described in this paper.

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