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Virtual Reality–Based Biofeedback and Guided Meditation in Rheumatology: A Pilot Study

R. Swamy Venuturupalli,[1] Timothy Chu,[2] Marcus Vicari,[2] Amit Kumar,[2] Natalie Fortune,[2] and Ben Spielberg[3]

Objective. As technology continues to improve, it plays an increasingly vital role in the practice of medicine. This study aimed to assess the feasibility of the implementation of virtual reality (VR) in a rheumatology clinic as a platform to administer guided meditation and biofeedback as a means of reducing chronic pain.

Methods. Twenty participants were recruited from a rheumatology clinic. These participants included adults with physician-diagnosed autoimmune disorders who were on a stable regimen of medication and had a score of at least 5 on the pain Visual Analog Scale (VAS) for a minimum of 4 days during the prior 30 days. VAS, part of most composite outcome measurements in rheumatology, is an instrument used to assess pain that consists of a straight line with the endpoints ranging from "no pain at all" and "pain as bad as it could be." Patients were randomized into two groups that differed in the order in which they experienced the two VR modules. One module consisted of a guided meditation (GM) environment, whereas the other module consisted of a respiratory biofeedback (BFD) environment. Data on pain and anxiety levels were gathered before, during, and after the two modules.

Results. The three most common diagnoses among participants were rheumatoid arthiritis (RA), lupus, and fibromyalgia. There was a significant reduction in VAS scores after BFD and GM (*P* values = 0.01 and 0.04, respectively). There was a significant reduction in Facial Anxiety Scale after the GM compared with the BFD (*P* values = 0.02 and 0.08, respectively).

Conclusion. This novel study demonstrated that VR could be a feasible solution for the management of pain and anxiety in rheumatology patients. Further trials with varying treatment exposures and durations are required to solidify the viability of VR as a treatment option in rheumatology clinics.

INTRODUCTION

Patients with chronic autoimmune conditions such as rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), spondyloarthropathy, and vasculitis often suffer from chronic and debilitating pain. RA is a systemic inflammatory disease of unknown etiology. It is characterized by chronic, symmetric polyarthritis and erosive synovitis (1). SLE is a multi-organ systemic autoimmune disease that is characterized by chronic inflammation with clinical and serological heterogeneity (2).

Physical and psychological stress have been postulated to be a possible component involved in the development of autoimmune diseases (3), and multiple studies have demonstrated that stress worsens disease activity in patients with RA, SLE, spondyloarthropathy, and vasculitis (4–8). Often patients suffering from chronic pain due to these conditions are prescribed highly addictive opioids for pain management. Because of the nature of opioids, patients are continually prescribed higher doses of medication due to a buildup of tolerance, which can eventually lead to addiction and in certain cases death (9). In February 2018, The International Association for the Study of Pain (IASP) recognized that longer-term use, tolerance, dependence, and other neuroadaptations of opioids compromise both efficacy and safety (10).

An analysis of national Medicare data from 2014 revealed that 41% of older patients with RA were regular users of opioids (11). Chronic pain co-occurring with addiction has been linked to anxiety, depression, financial problems, functional disability, cognitive disturbances, sleep disturbances, family, and social problems (12). The current opioid crisis in the United States (13) has highlighted the importance of alternative strategies for pain management (14).

An alternative option for pain management may lie within the field of virtual reality (VR). VR has emerged as a promising and

[1]R. Swamy Venuturupalli, MD: University of California at Los Angeles, Cedars Sinai Medical Center, Los Angeles, California, and Attune Health Research, Beverly Hills, California; [2]Timothy Chu, BS, Marcus Vicari, BS, Amit Kumar, BS, Natalie Fortune, MS, RDN: Attune Health, Beverly Hills, California; [3]Ben Spielberg, MS, TMS & Brain Health, Santa Monica, California

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Address correspondence to Natalie Fortune, MS, RDN, Attune Health, 8750 Wilshire Boulevard, Suite #350, Beverly Hills, CA 90211. E-mail: natalie@attunehealth.com.

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evidence-based treatment modality for musculoskeletal pain (15). A clinical trial comparing VR with the effects of opioids used functional magnetic resonance imaging (fMRI) to assess brain activities related to thermal pain stimulation revealed that opioids and VR both significantly reduced pain-related brain activity in the insula and thalamus (16). By stimulating the visual cortex while engaging other senses, VR modulates the user's processing of nociceptive stimuli (17). A review of VR literature found that VR interventions appeared to alter how the brain processes pain and produces analgesia (18).

Meditation is a practice where an individual uses different techniques, including mindfulness, to cultivate a mentally clear and emotionally stable sense of being. The term "meditation" is now commonly used to refer to several different techniques including contemplation, concentration, use of nature sounds such as the ocean, guided meditation, meditative movement exercises such as yoga and tai chi, qigong, breathing exercises, and mantra (19). These techniques work to influence the senses, mind, intellect, and emotions (19). Systematic reviews have found that mindfulness meditation has an effect on psychological aspects on living with chronic pain and is associated with improving depression and quality of life (20). Recently there have been developments in VR technology, creating new platforms for the distribution and implementation of meditation modules. There is reasonable evidence suggesting that VR is a viable way to practice mindfulness meditation (21).

Biofeedback interventions have been shown to diminish stress-related symptoms in patients with RA (22). Biofeedback is a process that enables patients to control otherwise autonomic processes by providing visual and/or auditory cues whenever a physiological target has been met (22). Biofeedback is a self-regulation technique through which patients learn how to control nonconscious body processes, such as heart rate and respiration rate. This technique requires specialized equipment to convert physiological signals into meaningful visual and auditory cues. Biofeedback allows patients to acknowledge the processes inside their bodies and use the feedback to adjust their physiology in a desired direction (23). For example, if one were using a temperature biofeedback device, a patient would place his or her hand onto a device and attempt to control breathing and heart rate to increase the skin temperature. When the skin temperature increases (thus representing an increase in parasympathetic activation), they may hear a high-pitched tone. Technology involving the use of visual biofeedback has been shown to improve quality of life, pain level, and physical function in patients with RA and SLE (24,25).

VR represents an important advance in biofeedback technologies by providing immersive and realistic multisensory experiences that can help alleviate symptomology by allowing patients to learn stress reduction and pain management skills (26). Previously, VR has been studied in a range of disease states, including obesity (27–29), anxiety disorders (30–32), acute pain management (26,33–36), oncology (37), and neurorehabilitation (38,39). Concurrent improvements in software and hardware design, as well as associated cost reductions, have made VR promising for more widespread accessibility in health care (40). These recent advances in VR technology thus offer a compelling opportunity to both address biopsychosocial distress and reduce chronic pain (17). For instance, Cedars-Sinai medical center in Los Angeles, California, has conducted VR studies in which they assessed the eligibility, usability, and acceptability of VR for pain symptoms in a diverse cohort of patients among an urban community medical center (41).

In this study, we recruited 20 patients with active, physician-diagnosed rheumatic diseases such as RA, SLE, ankylosing spondylitis, psoriatic arthritis, myositis, and vasculitis. Secondary fibromyalgia was prevalent in a small group of patients. Patients with active pain symptoms indicated by the study investigators were offered the opportunity to undergo biofeedback training using a portable VR unit in the clinic. The primary aim of this study was to evaluate the feasibility of a VR-based biofeedback intervention for outpatients within a rheumatology clinic. Secondly, we aimed to explore whether VR-based biofeedback and guided meditation could help decrease chronic pain and anxiety in a short period of time. Finally, we aimed to qualitatively observe the experience of a VR intervention from the perspective of the patients.

METHODS

Participants. Participants (n = 20) were recruited from Attune Health, a private practice rheumatology clinic in Los Angeles, California. Inclusion criteria included adult patients with physician-diagnosed chronic autoimmune disorders who were on a stable medication regimen. Additionally, all participants had a score of at least 5 on the Visual Analog Scale (VAS) for a minimum of 4 days within the prior 30 days (42). The VAS is an instrument used to assess pain that consists of a straight line with the endpoints ranging from "no pain at all" and "pain as bad as it could be" (43). Physicians approached adult patients to ask if they would be interested in taking part in a study in which they could experience and provide feedback on VR. We excluded patients (n = 3) with symptoms of active nausea or vomiting, history of current chronic vertigo or dizziness that might have made them susceptible to motion sickness, and those who were unable to use the VR headset for any reason. Patients with epilepsy were excluded because of an estimated 0.025% risk of inducing seizures (26).

VR hardware and software. We used Samsung Gear VR goggles with a Samsung Galaxy S7 mobile phone to deliver a 3D environment. The sound was transmitted through Nubwo N2 headphones, which were also equipped with a microphone used for breath tracking. The equipment was provided for study use by AppliedVR.

We selected two VR environments for participants based on AppliedVR's EaseVR chronic pain platform. One module consisted of a guided meditation (GM) environment, whereas the other module consisted of a respiratory biofeedback (BFD) environment. Both modules contained immersive experiences with 360° views of sim-

Figure 1. Two-dimensional still from the biofeedback environment. In this scene, purple rings move radially inward and outward to represent inhalation and exhalation, respectively. [Color figure can be viewed at wileyonlinelibrary.com]

ilar nature environments. The BFD contained a virtual guide who instructed participants to breathe along with an oscillating pacer at six breaths per minute. Exhales were visualized by outward-moving blue particles, which increased in size as the participant's respiratory rate more closely synchronized with the rate of the pacer. Guided audio prompts acknowledged effort while including reminders for slow and controlled breathing periodically. These audio prompts adjusted when participants had increased or decreased respiratory rates. Figure 1 shows an example of the environment.

The GM placed participants in the same natural enlivened environment. Participants were led in a meditation by a virtual guide who asked them to shift their focus onto different parts of the body while maintaining awareness of breath control without any audio or visual feedback. Breathing data were collected but neither interacted with nor affected the experience. Similarly, neither a pacer nor breathing particles were presented. The frequency of guided instruction and the duration of the session was fixed, regardless of data.

The two VR modules, GM and BFD, occurred right after one another. Participants were randomly assigned to either receive GM first followed by BFD or BFD first followed by GM. Both modules lasted around 10-15 minutes each, which totaled around 30 minutes of VR. Figure 2 demonstrates how participants were randomized using a random number generator in a 1:1 ratio to either the BFD first or the GM first groups. Both groups received only one 30-minute VR session that consisted of the BFD and GM modules that were administered back to back.

Pre-VR assessments. Prior to beginning the VR session, participants filled out three questionnaires from the Patient-Reported Outcomes Measurement Information System (PROMIS): Emotional Distress/Anxiety (Short Form 8a v.1.0), Emotional Distress/Anger (Short Form 5a v.1.1), and the Global Health Scale (v.1.2). PROMIS surveys were administered prior to patients' receiving VR therapy, allowing for the quantification of both their global health and emotional distress. Within these questionnaires, patients were tasked with responding to the questions and statements posed with a number from 1 to 5, with higher numbers generally corresponding to better health. The global health survey inquired about patients' overall health, quality of life, and mental health. With regard to emotional distress, patients were asked to specify their anger and anxiety levels using a scale identical to the one utilized in the global health questionnaire. Participants then individually completed semistructured face-to-face interviews with a trained research assistant regarding prior conceptions of VR, disease history, pain history, and past treatments. It has been found that patients with musculoskeletal disease are able to accurately recall and rate the severity of pain for a period of three months (44). During this interview, a VAS from 0 to 10 was administered to assess pain, followed by the five-level Facial Anxiety Scale (FAS) to assess anxiety.

Post-VR assessments. Questions about general impressions were asked between the two VR sessions. Participants were also asked to recall what their pain and anxiety levels were during the session using the VAS and FAS before continuing on to the second VR environment. After the second VR environment, participants were once again asked to record current pain and anxiety

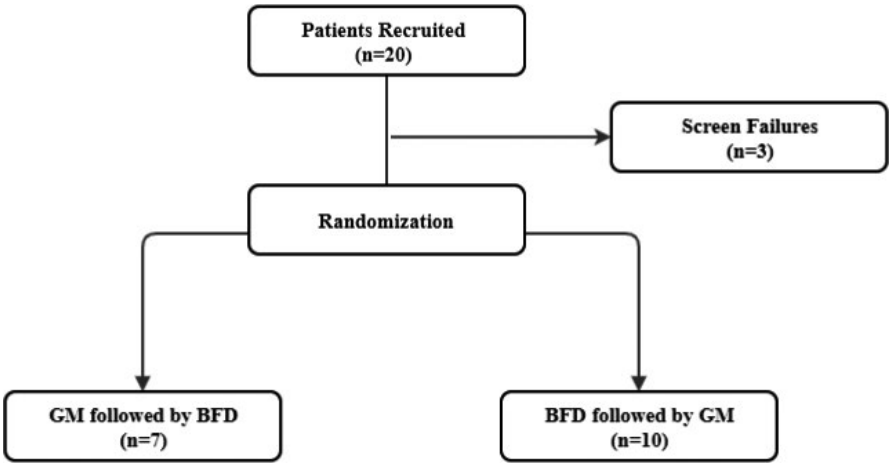

Figure 2. Patient randomization schema. Abbreviation: GM, guided meditation; BFD, biofeedback.

levels using the VAS and FAS as well as to recall pain and anxiety levels during the second VR experience. After the final session, we continued an extensive semistructured interview to evaluate patient opinions on the equipment used, comparisons between sessions, and perceived benefits and harms. We also asked for patient feedback on potential avenues of improvement for the VR experiences. Medical charts were reviewed for age, sex, ethnicity, race, diagnoses, disease activity status, and treatment history.

Analysis. *Qualitative analysis*. We carefully analyzed transcripts of the qualitative patient interviews conducted before, after, and during their respective VR experiences. This analysis was observational and was conducted by an independent coder reading through each transcript. Any common sentiments were recorded, and we kept particular track of prior attempted interventions for pain management, including both pharmacological and behavioral techniques. We also paid particular attention to the reported effect of pain on mood, comments on the comfort level of the device, and which intervention each participant preferred more.

Quantitative analysis. Analyses were conducted in R software and Microsoft Excel. All relevant assumptions, including sphericity, were examined and corrected prior to further analyses. Data were then analyzed using 2-way, 1-way repeated measure ANOVAs with three levels (baseline, after GM, and after BFD) to examine FAS and VAS scores, respectively. Any significant findings were then examined using post hoc pairwise *t* tests. We also completed pairwise *t* tests to determine if there was a difference in reduction in pain or anxiety based on which intervention, GM or BFD, was administered first.

Table 1. Demographics

	GM Followed by BFD (n = 7)		BFD Followed by GM (n = 10)	
	Mean	SD	Mean	SD
Age	53.71	15.94	51.9	17.87
	n	**(%)**	**n**	**(%)**
Sex				
Female	6	85.71%	9	90.00%
Male	1	14.26%	1	10.00%
Race				
White	6	85.71%	8	80.00%
Black	0	0.00%	2	20.00%
Asian	1	14.29%	0	0.00%
Ethnicity				
Non-Hispanic	6	85.71%	9	90.00%
Hispanic	1	14.29%	1	10.00%
Medication[a]				
Anticonvulsant drug	2	16.67%	0	0.00%
Biologic	1	8.33%	1	6.67%
DMARD	3	25.00%	6	46.67%
Marijuana	1	8.33%	1	6.67%
Opioid	2	16.67%	2	13.33%
Over the counter	1	8.33%	1	6.67%
Steroid	1	8.33%	2	13.33%
NSAID	1	8.33%	1	6.67%
Other	0	0.00%	1	6.67%

Abbreviation: BFD, biofeedback; DMARD, disease-modifying antirheumatic drug; GM, guided meditation; NSAID, nonsteroidal anti-inflammatory drug.
[a]There is a greater number of medications than the number of participants as some individuals were on multiple medications.

RESULTS

Demographics. The average age of participants was 52.65 (Standard Deviation [SD] = 16.1) years old. The study population was predominantly Caucasian female, with 88.24% (n = 15) of the participants identifying as female and 76.47% (n = 14) of the participants identifying as Caucasian. The most common diagnosis among participants was RA at 64.71% (n = 11), followed by SLE and fibromyalgia at 23.53% (n = 4) and 17.65% (n = 3), respectively. Average PROMIS scores for physical health and mental health were 10.94 (SD = 2.61, T-Score [T] = 37.4, Standard Error [SE] = 4.10) and 12.41 (SD = 3.30, T = 43.50, SE = 3.60), respectively. Average PROMIS scores for anger were 12 (SD = 3.34, T = 52.7, SE = 3.20) and average PROMIS scores for anxiety were 18.29 (SD = 4.86, T = 75.4, SE = 2.70). These PROMIS scores indicate that our patient sample had higher anxiety scores than the normal population. See Table 1 for demographic information.

Qualitative analysis: acceptance and utility of VR intervention. The actual VR device seemed to be well tolerated by participants, as 100% of participants in the study reported that they would participate in a similar study again. All participants also reported that they use, or have used, oral medications for pain management but are currently seeking other options for various reasons, including chemical dependence, unpalatable side effects, or failure to increase long-term pain symptoms. VR was not necessarily a new concept for most participants, as 88.24% (n = 15) reported that they had heard of VR prior to engaging in the study. The majority of participants reported positive responses to at least one of the VR interventions, with 64.71% (n = 11) spontaneously mentioning, without being prompted, increased relaxation and/or calmness during their respective interviews. These positive responses were often dramatic, with one participant saying in regard to BFD that, "I was able to relax my body. I was able to lower the pain levels by breathing, almost like wiping it away." Another participant, in reference to GM, reported, "When [the guide] was talking about my back… I released my breath [and] it's like everything just melted [away]."

Qualitative analysis: barriers to VR use. Most participants reported that they visually enjoyed the experience, as reported in Table 2. Within the BFD Followed by GM Group, 60.00% of individuals reported enjoying the visuals, while 42.86% of the GM followed by BFD reported enjoying the experience. Finally, only one participant reported the device to be uncomfortable, whereas 44% mentioned that the device felt heavy and/or bulky toward the end

Table 2. VR experience and acceptability

Acceptability of VR	GM Followed by BFD (n = 7) n	(%)	BFD Followed by GM (n = 10) n	(%)
Familiar with VR prior to study				
Yes	6	85.71%	1	10.00%
No	1	14.29%	9	90.00%
Comfort of headset				
Comfortable	2	28.57%	4	40.00%
Slight discomfort	4	57.15%	6	60.00%
No response	1	14.29%	0	0.00%
Liked visuals				
Yes	3	42.86%	6	60.00%
Would prefer more realistic	3	42.86%	3	30.00%
No response	1	14.29%	1	10.00%
Reported relaxation				
Yes	5	71.43%	6	60.00%
No	2	28.57%	4	40.00%

of the session. As participants wore the device for two consecutive VR sessions, this finding may not be relevant, as most people may complete one individual session at a time.

VAS: Pain. First, we conducted Mauchly tests on the pain scores at baseline, after Tree (GM), and after Body Scan to determine whether the sphericity assumption was met, W = 0.93, $\chi^2(2) = 1.12$, $P = 0.57$. Then, we conducted a 1-way ANOVA with repeated measures to examine the effect of all interventions on VAS scores (F (2, 32) = 3.96, $P = 0.03$, $P < 0.05$; see Table 4). There was a significant difference between VAS scores at baseline, after BFD, and after GM at the 95% confidence level. Then, we conducted a post hoc analysis using pairwise *t* tests to determine which interventions most decreased VAS scores (see Table 3). We found a reduction in VAS scores after BFD, with a mean reduction of 1.07, $t = 2.83$, Cohen's d = 0.50, $P = 0.01$, $P < 0.05$. We also found a reduction in VAS scores after GM, with a mean reduction of 1.09, $t = 2.29$, Cohen's d = 0.52, $P = 0.04$, $P < 0.05$. These results suggest that both BFD and GM may decrease pain acutely after a VR environment.

FAS: Anxiety. We conducted Mauchly tests on anxiety scores at baseline, after BFD, and after GM and found that the sphericity assumption was not met, W = 0.49, $\chi^2(2) = 10.71$, $P < 0.05$. Then, we used the Greenhouse-Geisser correction ($\varepsilon = 0.66$) and conducted a 1-way ANOVA with repeated measures to examine the effect of GM and BFD on baseline FAS scores (F (1.32, 21.19) = 5.27, $P < 0.05$, see Table 4). There was a significant difference between FAS scores at baseline, after BFD, and after GM at the 95% confidence level. Then, we conducted a post hoc analysis using pairwise *t* tests to determine which intervention most decreased FAS scores (see Table 3). We found that the greatest reduction in anxiety scores were recorded after the GM intervention, with a mean reduction of 0.59, $t = 2.28$, Cohen's d = 0.91, $P < 0.05$. We also found that there was a significant difference between GM and BFD, with a mean reduction of 0.24, $t = 2.22$, Cohen's d = 0.41, $P = 0.04$, $P < 0.05$. These results suggest that GM, but not BFD, may decrease anxiety acutely in a VR environment.

Order of intervention. We conducted pairwise *t* tests to determine which order of intervention, GM or BFD first, decreased FAS and VAS scores (see Table 5). We found that there was no significant reduction in VAS scores regardless of the order of intervention, with GM followed by BFD ($t = 1.96$, $P = 0.097$) or BFD followed by GM ($t = 1.81$, $P = 0.1032$). We found that there was no significant reduction in FAS scores regardless of the order of intervention; however, GM followed by BFD ($t = 2.34$, $P = 0.582$) was closer to being significant compared with BFD followed by GM ($t = 0.89$, $P = 0.397$).

DISCUSSION

VR is an emerging technology for which researchers are finding novel uses in a variety of different disorders. VR has

Table 3. Descriptive table of post hoc pairwise *t* tests for pain scores (represented by VAS; top four rows) and anxiety scores (represented by FAS; bottom four rows)

Condition	Preintervention Score	Postintervention Score	M Difference	*t* Test	*P* Value	95% CI LL	95% CI UL	Cohen's d
VAS								
Baseline X BFD*	5.47	4.40	1.07	2.83	0.01	0.27	1.87	0.50
Baseline X GM*	5.47	4.38	1.09	2.29	0.04	0.08	2.10	0.52
BFD X GM	4.40	4.38	0.02	0.04	0.97	−0.97	1.01	0
FAS								
Baseline X BFD	1.82	1.47	0.35	1.85	0.08	−0.05	0.76	0.54
Baseline X GM*	1.82	1.23	0.59	2.58	0.02	0.11	1.07	0.91
BFD X GM*	1.47	1.23	0.24	2.22	0.04	0.01	0.46	0.41

Abbreviation: BFD, biofeedback; GM, guided meditation; FAS, Facial Anxiety Scale; LL, lower limit; UL, upper limit; VAS, Visual Analog Scale.
*$P < 0.05$.

Table 4. ANOVA table for VAS scores (top) and FAS scores (bottom)

ANOVA (VAS)					
Sources	SS	df	MS	F	*P* value
Subjects	178.80	16	11.18	6.71	0.000
Groups	13.21	2	6.60	3.96	0.029
Error	53.32	32	1.67		
Total	245.33	50			
ANOVA (FAS)					
Sources	SS	df	MS	F	*P* value
Subjects	9.75	16	0.61	2.16	0.03
Groups	2.98	1.32	2.25	5.29	0.024
Error	9.02	21.19	0.43		
Total	21.75	38.51			

Abbreviation: FAS, Facial Anxiety Scale; MS, mean square; SS, sum of squares; VAS, Visual Analog Scale.

shown promise in traumatic brain injury rehabilitation for both cognitive and gait-related difficulties (45–47). VR has shown to be useful in psychiatric settings, especially for those with anxiety-related disorders (48), such as social anxiety disorder. It has also show to be effective for posttraumatic stress disorder (49). Over the past decade, VR has also been associated with an improvement in acute pain symptoms (26,35,50–52). To the best of our knowledge, no studies to this date have examined the feasibility or effectiveness of VR in an outpatient rheumatology setting. The purpose of this study was to examine the feasibility of a novel VR intervention within an outpatient rheumatology setting.

Our qualitative interview determined that the majority of participants reported a positive—if not profound—experience. These results are consistent with the VR studies done for musculoskeletal pain management (15). Possible modalities for this reduction in pain may be due to a reduction in pain-related brain activity in the insula and thalamus, ie, how the brain processes pain and produces analgesia (18). Technology involving the use of visual biofeedback has been shown to improve quality of life, pain level, and physical function in patients with RA and SLE (26,27). Additionally, all participants reported that they would participate in a similar study again if given the opportunity. In terms of the VR experience, we found that the VR device itself was mostly comfortable, which is integral for any intervention involving a population of individuals suffering from chronic diseases. However, many participants (44%) noted that they would prefer a less heavy or bulky device in the future. A small but notable subset of participants (n = 6) remarked that they would have preferred more "realistic" VR environments, although it is unclear whether that change would provide clinical benefit. Overall, the findings in our study suggest that VR interventions are feasible to use in outpatient rheumatology clinics and are well tolerated and often enjoyable for participants.

It is important to note that this is a pilot study with a small sample size (n = 17) and therefore is underpowered to make definite conclusions about efficacy. These results suggest possible benefits from the intervention, though there is a need for a higher-powered study to solidify findings. Our patients were administered two separate treatment conditions, GM and BFD, and we found that pain was significantly reduced immediately following both conditions with moderate effect sizes, and we did not find a significant difference between those two conditions. Other studies and reviews have found similar trends in immediate reduction of acute and chronic pain post-VR experience (53–56).

Table 5. Descriptive table of paired *t* tests for pain scores and anxiety scores by order of intervention

Condition	Preintervention Score	Postintervention Score	*t* Test	*P* Value	95% CI LL	95% CI UL
VAS						
Guided Meditation First						
Baseline X after both VR sessions	5.14	3.83	1.96	0.0971	−0.351	3.2081
Biofeedback First						
Baseline X after both VR sessions	5.7	4.58	1.81	0.1032	−0.2649	2.4049
FAS						
Guided Meditation First						
Baseline X after both VR sessions	1.71	1	2.34	0.0582	−0.0341	1.4626
Biofeedback First						
Baseline X after both VR sessions	1.9	1.65	0.89	0.3974	−0.3865	0.8865

Abbreviation: CI, confidence interval; FAS, Facial Anxiety Scale; LL, lower limit; UL, upper limit; VAS, Visual Analog Scale; VR, virtual reality.

Anxiety was significantly reduced immediately following an immersive GM environment with a large effect size. However, anxiety wasn't reduced after respiratory BFD. This was inconsistent with results from previous studies (24) and may be a result of the small sample size.

Taken together, these findings suggest that virtual reality may be an efficacious intervention for acute pain relief and anxiety reduction. Specifically, our study suggests that acute pain relief occurs after immersive respiratory biofeedback and, to a lesser extent, immersive GM. On the other hand, our study demonstrated acute anxiety reduction only after GM and not after respiratory BFD. The order of intervention did not have a significant effect on pain or anxiety.

There are a number of limitations in this study. First, interpretation of the results using within-subject methods can be flawed, as it creates more room for the placebo effect than in a randomized controlled trial. Secondly, as this is only a feasibility study, the sample size is too small to generalize our findings to a larger clinical population. Finally, we elected to use a participant group that is more representative of a real-life clinic setting than a laboratory. As such, participants had multiple diagnoses, ages, backgrounds, and treatment trials.

Future research should look to replicate these findings with a larger sample size, ideally in a randomized controlled trial. A significant portion of patients in rheumatology clinics suffer from chronic pain so future studies need to demonstrate sustained benefit in this patient population. Hence, longer trials with varying dose exposures to VR therapy would be helpful in determining the optimal length, intertreatment gaps, and duration of treatment in rheumatology patients. Another next step would involve alternative types of biofeedback, including heart rate variability biofeedback, temperature biofeedback, or electromyogram biofeedback. Lastly, future researchers could use more thorough pain and anxiety scales to tease out which dimensions most benefit from these novel experiences.

CONCLUSION

This is the first study to investigate the tolerability and acceptance of VR by patients in a general Rheumatology clinic. The patients had a mix of conditions seen in typical rheumatology clinics, including RA, SLE, osteoarthritis, and fibromyalgia. In this study, rheumatology patients tolerated the VR-based BFD and GM and experienced a short-term reduction in pain and anxiety. Our results demonstrate that VR could be a feasible nonpharmacological solution for the management of pain and anxiety in rheumatology patients. Further trials that are larger, of greater duration, and with varying treatment exposures are required to solidify the use of VR as a viable treatment option in the rheumatology clinic. As the technology and user experience of VR-based interventions improves, VR technology has the potential to greatly reduce the pain and suffering of rheumatology patients.

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AUTHOR CONTRIBUTIONS

All listed authors have contributed sufficiently to this project to take public responsibility for the content, including participation in the concept, design, analysis, writing, and/or revision of the manuscript. As primary investigator, Dr. Venuturupalli takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. Venuturupalli, Vicari.

Acquisition of data. Chu, Vicari, Kumar.

Analysis and interpretation of data. Fortune, Spielberg.

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Revising the manuscrupt. Venuturupalli, Fortune, Chu, Kumar, Vicari, Spielberg.

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