



Research article

Patients perceptions of virtual reality therapy in the management of chronic cancer pain

Bernard M. Garrett^{a,*}, Gordon Tao^b, Tarnia Taverner^a, Elliott Cordingley^c, Crystal Sun^a^a School of Nursing, University of British Columbia, BC, Canada^b Graduate Programs in Rehabilitation Science, Faculty of Medicine, University of British Columbia, BC, Canada^c Faculty of Science, University of British Columbia, BC, Canada

ARTICLE INFO

Keywords:

Nursing
Health technology
Clinical psychology
Well-being
Digital media
Virtual reality
Pain
Cancer pain

ABSTRACT

The management of chronic cancer pain remains challenging and complex, with the process often involving a variety of pharmacological and non-pharmacological approaches. Recent studies have shown virtual reality (VR) therapy to be successful in the management of acute pain. However, it remains unclear whether VR-based applications are effective as an adjunctive therapy for cancer patients with chronic pain. Moreover, there exists a gap in the current research landscape that address patient's perceptions of virtual reality therapy. This qualitative study enrolled patients from a larger ongoing randomized controlled clinical trial in two focus groups covering topics including patients experience with and perspectives on using VR for chronic pain control, both generally, and specific to their own circumstances. Five major thematic categories and 23 sub-categories emerged in the analysis process reflecting the participants' narrative. Similar to other research, this study found mixed results in the use of adjunctive VR therapy to manage chronic cancer pain, although a majority of respondents found it to be beneficial. This study confirms that pain management is a highly complex and individualized process. For maximum efficacy, it is recommended that future designs of VR interventions engage pain patients in the design process to ensure maximum efficacy of experiences to with individuals' preferences.

1. Introduction

Cancer survivors often live with comorbidities including chronic pain, depression, or other associated chronic conditions [1, 2]. With increasing aging and growing populations, the incidence of cancer is growing worldwide [3, 4]. Furthermore, cancer survivorship and related life expectancy has also improved over the last decade due to advancements in diagnosis and treatment. However, with these improvements comes an increased prevalence of cancer survivors living with chronic pain such as neuropathy, post-surgical pain, osteoradionecrosis, or arthralgias [1].

Chronic pain is defined as persistent pain lasting at least three months beyond the period of normal healing following trauma and/or injury [5, 6, 7]. The management of chronic pain remains a challenging and complex process involving pharmacologic, physical, occupational, and psychological factors [1]. Therefore, chronic pain management relies on a multidisciplinary approach using different modalities that focus on both comfort and function [1].

Typically, pharmaceutical interventions such as acetaminophen and NSAIDs, as well as opioids, are used to enhance comfort in cancer-related

chronic pain [1, 2, 5]. Beyond medication, rehabilitation approaches, including physical and occupational therapy, and psychological approaches are used to improve function, overcome activity limitations, and help manage chronic pain. Technology-augmented approaches to engage patients in such interventions seems a promising new field [8, 9, 10].

In particular, virtual reality (VR) has been recently researched for pain management applications [8, 9]. The purpose of VR technology is to provide users with sense of presence within a simulated environment—they feel like they are there. This is typically accomplished using computer-simulated environments, binocular headsets, and motion tracking to produce an immersive experience.

VR approaches may be considered as an additional psychological strategy and has been used successfully in the treatment of acute pain [8, 11, 12, 13, 14] and more recently has also been studied as an adjunctive measure in the management of chronic pain [15, 16]. However, it remains unclear which aspects of VR-based adjunctive pain therapy work and don't work for chronic pain in this population. As a rapidly developing field, understanding how VR health interventions fit within such

* Corresponding author.

E-mail address: bernie.garrett@ubc.ca (B.M. Garrett).

complex care contexts is required to ensure the effective adoption of VR into pain management programs.

Cognitive distraction is a common strategy for controlling pain and relies on competing cognitive resources, i.e. attention, to reduce the perception of pain [17, 18]. Therefore, immersive VR interventions using stereoscopic 3D headsets have been proposed as powerful distractors that require visual, audio, cognitive, and emotional engagement from the user [19, 20, 21]. However, such usage of VR for pain control have typically focused on acute pain; the effectiveness of VR interventions for chronic pain remains unclear [9].

Another approach valued by some patients is mindfulness meditation for chronic pain management. Mindfulness meditation is a psychological technique that requires intentional and non-judgmental awareness of pain and conscious relaxation to support its acceptance and help reduce its impact [22, 23]. Reported effect sizes for this technique have been typically mild to moderate [10, 24]. Moreover, adherence to mindfulness meditation may be challenging in self-directed contexts [10]. Within this context, combining mindfulness meditation within a VR intervention may help support acceptance and adherence to the practice while having a synergistic effect on pain reduction through immersive VR distraction [25, 26].

However, greater specificity is required in identifying the nature of any therapeutic effects, the usability characteristics of the hardware and software, and optimal design characteristics of VR interventions for supporting chronic pain patients in pain management. Our early pilot work has demonstrated some indications of efficacy with this approach [15, 16] and we are currently conducting a randomized controlled trial (RCT) to explore the efficacy of daily adjunctive VR as a therapeutic tool in cancer chronic pain (clinicaltrials.gov: NCT 02995434). However, the effectiveness of providing cancer patients experiencing chronic pain with VR-based adjunctive therapy relies on more than just the reported analgesic effects. Effectiveness of such technological strategies is contingent on users' personal acceptance and sustained adoption of them. This can be challenging, particularly in older adult populations where technology usage may be low [27, 28]. As with technology products generally, a satisfying, or at least non-frustrating, user experience is therefore crucial for sustained usage of VR interventions in health. User experience, as a construct, broadly encompasses aspects such as usability, utility, accessibility, and value [29, 30]. For the particular approach of using VR for chronic pain management in cancer patients, it remains unclear what elements of the physical system and digital content support or detract from these aspects of users' personal experiences. Moreover, as pain management is highly individualized, we expect some heterogeneity in user experiences. We may consider that people use health technologies in different ways, hold different values, and experience pain differently. Therefore, there is a need to understand "what works for different people" in this population.

To address this gap, we conducted a qualitative study using focus groups with participants who had chronic pain associated with a cancer diagnosis and were participants from an ongoing randomized controlled trial (clinicaltrials.gov: NCT 02995434), to better understand their experiences and help inform future design. Therefore, the purpose of this research was to:

- 1) explore the experiences of individuals with chronic pain associated with a cancer diagnosis in using a daily VR-based self-administered home therapy for one month as an adjunctive measure to help manage pain,
- 2) determine their perceptions of the value of such VR therapy, and
- 3) evaluate the effects of VR interventions based upon either cognitive problem-solving or mindfulness and relaxation in providing relief from pain as well as the aspects that supported or detracted from pain management.

2. Methods

This study was conducted in Vancouver, British Columbia, Canada as one element of a larger RCT study (clinicaltrials.gov, NCT 02995434) to investigate the efficacy of VR interventions as a practical therapeutic intervention in the self-management of the chronic pain associated with cancer. The trial is two-armed and participant-blinded, using the term "immersive multimedia" to obfuscate group assignment. Participants are randomly assigned to either a VR experimental group or a non-VR (laptop with 2-dimensional display) control group to engage with a randomized series of four interventions: two based on cognitive engagement and two based on mindfulness meditation. Each intervention requires 30 min of activity per day for six days, totalling four weeks of participation. Outcome measures for the RCT include daily pain scores using the Visual Analogue Scale [31], weekly neuropathic pain and health quality scores, using the McGill Pain Questionnaire [32] and the Health Survey Short Form (SF-12) [33], and also sleep quality using the Pittsburgh Sleep Quality Index [34]. This currently ongoing work will inform further clinical studies and future research into the potential uses of VR in the treatment of cancer associated pain. For the focus group, purposeful convenience sampling was used to recruit participants following their VR experiences.

2.1. Materials

Two of the VR interventions that the participants were exposed to as a part of the RCT used contemplative mindfulness-based environments, whilst the other two used cognitive problem-solving environments. The interventions used are described in Table 1.

The order of the experiences was randomized per participant to avoid any cumulative sequencing effects, and participants experienced the VR for 45 min in their home through an HTC Vive stereoscopic headset running from a personal computer designed to support a high-quality VR experience.

2.2. Approach

This study used a qualitative inductive approach using the interpretative description (ID) method to explore experiences of participants who had used VR interventions as a part of the larger RCT. The purpose of ID is to generate new knowledge and understanding of clinical phenomena by exploring patients' personal experiences [35]. Under this method, sampling is informed by the phenomenon of interest, the state of the science underpinning the area of study, and the level of theoretical development. Therefore, the ID method is particularly suited for addressing the goals of understanding chronic pain cancer patients' experiences with novel VR-based pain interventions. This study used focus group interviews as the importance of the group interview method of data collection is clearly understood and valued within the context of ID. ID uses an inductive constant-comparative approach to analysing data, going from data collection, analysis, and back to data collection to elicit a rich understanding of the personal impact of the clinical phenomena being explored.

2.3. Sample

Following ethical approval from the University of British Columbia (UBC) Behavioural Research Ethics Board, participants who completed the VR arm of the RCT study were sent an initial letter inviting them to participate in one of two one-hour focus groups. Eligibility criteria for the RCT included:

- over age 16, past or current diagnosis of cancer

Table 1. VR interventions used.

Contemplative/ Mindfulness	Virtual Meditative Walk	The Participant walks through a forest with relaxing music and audio cues to assist personal contemplation, and relaxation. This was a custom designed environment produced by Dr. Diane Gromala's Interactive Media Laboratory at Simon Fraser University.
	WildFlowers	Developed by Mobio Interactive Inc in Toronto as a patient centred VR relaxation application. It involves the participant flying as a butterfly through a virtual environment and completing meditations.
Cognitive	Carpe Lucem	Developed by Hammer Labs. The participant completes 3D puzzles in a relaxing environment.
	Obduction	A sci-fi adventure game developed by Cyan. The participant explores an alien world and completes puzzles to move forward in the storyline.

- past or current treatment with standard care cancer therapies
- experiencing chronic pain (ongoing daily pain ≥ 3 months with Neuropathic Pain Rating Scale ≥ 4)
- able to understand the English language (read and write)
- normal stereoscopic vision
- readily able to move head up, down, left, and right, and able to wear a headset
- have fine motor control in one hand sufficient to use a game controller
- have space at home for a computer and monitor

A total of 23 participants were invited, with 12 completing the focus group. The study complied with all the required ethical regulations and informed consent was obtained before proceeding to interview the participants. Table 2 summarizes the sample characteristics of the 12 participants.

2.4. Focus groups

Two mini focus groups addressing the topics of participants' experiences and perceptions of the use of VR conducted on August 14, 2018 (n = 6) and March 26, 2019 (n = 7). Both focus groups were facilitated by

the Principal Investigator Dr. Bernie Garrett, an experienced professor and researcher at the University of British Columbia with the support of two graduate research assistants, conducted in English, and lasting approximately 60 min each. Focus groups were selected as they support social interaction and interchange between participants and the co-construction of meaning of a shared experience. This was seen as a highly-desirable aspect of the method, to help establish the nature of the experience in meaningful personal terms [53, 54]. The first group was conducted in person at the University, whilst the second group was video conferenced as a majority of the participants were widely dispersed. As all of the participants were chronic cancer pain patients, many had mobility issues and hence an online format was used for those who could not travel. Both were recorded using GoToMeeting videoconferencing software (V. 8.45.2, LogMeIn Inc., Boston, USA). Online focus groups are now well-established and validated as social-research tools [55, 56]. However, it was recognized that the different medium used between the two groups may have influenced the data collection and results. Therefore, steps were taken to ensure that the interviews across the two groups were as identical as possible. In the online focus group all participants could see and hear each other and the researchers on their screens in order to maximize non-verbal interaction. The interview was led by Dr Bernie Garrett. Basic demographic information such as age, gender,

Table 2. Sample characteristics of participants.

Demographic	Focus Group 1	Focus Group 2
No. of participants	5	7
Male/Female/Undisclosed	3/1	3/3/1
Age in years, median (range)	59 (37–62)	58 (45–73)
Average pain score in VAS, median (range)	4 (3–7)	6 (2.5–8)
Experience with VR		
None	4	4
Once	1	3
Experience with Gaming		
None	1	2
Little	1	3
Some	2	1
Extensive	1	1
Pain Characteristics		
Neuropathy	3	3
Fibromyalgia	2	-
Pain in Surgical Area	-	2
Non-specific/general	-	2
Type of Cancer		
Abdominal	1	-
Breast	2	-
Bone	-	1
Colon	-	2
Kidney	-	1
Lung	-	2
Non-Hodgkin's Lymphoma	1	-
Throat	1	1

Table 3. Guide questions.

	Category	Guide Questions
1	General Experience with VR	<ul style="list-style-type: none"> • Tell me about your experience with using VR. • Are there any other points you would like to discuss about your experience using VR?
2	Pain Control	<ul style="list-style-type: none"> • How useful did you find the VR experiences in managing your pain? If yes, how so? • Which of the VR environments did you find most useful/worked best for your pain? • Which of the VR environments did you find the least useful/worked least for your pain?
3	Other Benefits	<ul style="list-style-type: none"> • What sort of benefits did you get out of using VR? • Did the VR help with your sleep in any way? • Did the VR help with your mobility in any way?
4	Adverse Effects	<ul style="list-style-type: none"> • Did you experience any physical problems from using the VR? (probe: headache, nausea)
5	Support Required	<ul style="list-style-type: none"> • What would you put off using VR in the future? • What would encourage you to using VR in the future? • What sort of support did you need to use the VR environments effectively? • Was there sufficient help for you to use the VR environments?

gaming experience, chronic pain status, and cancer diagnosis status were initially recorded, and a semi-structured interview guide was used, covering topics including participants’ experiences with and perspectives on using VR for chronic pain control, both generally, and specific to their own circumstances (Table 3). The interview followed this sequence of structured questions with group discussion of each, until no new information was being elicited. The focus groups were transcribed verbatim by two graduate research assistants following the recording.

2.5. Analysis

The ID approach involved concurrent data collection, and constant comparative analysis of the material as it was transcribed to interpret it. The analysis of focus group data involves balancing individual voices with group dynamics, and listening carefully to group consensus vs. augmentative interactions, comparing inter-group and intra-group differences [53, 54, 55]. Hence, a detailed iterative content analysis of the focus group transcripts and videos was also undertaken using established guidelines [36]. Transcripts from both focus groups (including memos from the researchers) were entered into Nvivo 12 qualitative data analysis software which was then distributed to four researchers for independent analysis. The content was then read, and notes were made on the general themes arising from the data. This process is known as *decontextualization* of the data to create meaningful units of content and code them with identifiers [38].

The transcript was then examined again by the researchers who constructed as many codes as necessary to describe all aspects of the content (open coding) using annotations in Nvivo to describe their meaning. At this point the different codings were sent back to the

primary researcher, who then amalgamated the codes into a single file. It was evident at this point that the number of codes arising from the data reflected a range of similar and differing thematic elements and conceptualizations. Two of the researchers then went back through the transcript in a second stage of *recontextualization* to condense relevant content, recode and merge duplicate items. They excluded irrelevant and unusable material or “dross” acknowledging that as part of the ID process [37, 38]. It is the researchers who ultimately decide on the relevance of the material [39]. Each code and associated text was then examined again by the primary researcher two more times, continuing until the transcript had been completely re-examined and coding refined. In this penultimate *categorization* phase, a cataloguing of emerging themes, conceptualizations relationships their and associated codes was created, condensing meaning units together into a single framework. This was then reviewed by the three other researchers who provided further feedback and revisions in a final *compilation* phase, resulting in the final hierarchical framework. Their commentary and revisions were used to create the final consensus of codes, relationships, and meanings to reflect both the actual words of the participants and the underlying meanings of them. The facilitator’s separate questions and comments were not coded to eliminate contamination of the data and minimize risk of bias.

3. Results

Five major thematic categories and 23 sub-categories emerged in the analysis process reflecting the participants’ narrative (Table 4). A supplemental file of the full data in Nvivo V.11 format (VR Focus Group Data.nvp) is available from the journal website. The results are presented according to the most significant content areas in terms of frequency of

Table 4. Overview of major themes and sub-themes identified.

Major Thematic Category	Subtheme (positive)	Subtheme (negative)
Activities (99)	<ul style="list-style-type: none"> • Contemplative (47) • Cognitive Challenge (26) • Design (7) 	<ul style="list-style-type: none"> • Contemplative (2) • Cognitive Challenge (8) • Design (6)
Usability (90)	<ul style="list-style-type: none"> • Accessibility (13) 	<ul style="list-style-type: none"> • Practical Limitations (77)
Effects (84)	<ul style="list-style-type: none"> • Decreased Pain (20) • Emotional response (17) • Sleep (3) • Effects Over time (3) • Mobility (2) 	<ul style="list-style-type: none"> • Cybersickness (13) • Emotional response (13) • Increased Pain (6) • Eye Strain (3) • Sleep (1)
Mode of Action (44)	<ul style="list-style-type: none"> • Relaxation (17) • Distraction (16) • Immersion (5) • Presence (3) 	<ul style="list-style-type: none"> • Immersion (1)
Technical Aspects (22)	<ul style="list-style-type: none"> • Technical Support (7) • Visual (6) • Audio (4) 	<ul style="list-style-type: none"> • Technical Support (3)

Numbers in brackets indicate frequency count for comments reflecting the theme (Note: sub themes may not add up to the total as some comments were neutral).

responses, and overall positive or negative characteristics identified in the context of the a priori study aims.

Details of the thematic categories are described and quotes are accompanied by a code to indicate the focus group and respondent. For example, FG1-2 is participant number two from focus group one.

3.1. VR activities

Discussion of participants' experiences with each VR intervention represented the most dominant theme. This theme encompassed the four interventions representing two approaches of pain management: cognitive engagement and mindfulness meditation. Most participants (8 of 12) expressed positive responses to the two meditation interventions (Wildflowers and the VMW), with Wildflowers being the most popular of the two:

FG1-3

In the Wildflowers, there was the one meditation though that told you to pay attention to where your pain was at that moment, or where there wasn't some pain, pay attention to that and feel what it was like, and then go to the other place where there was pain – I found that really useful.

FG2-5

But I would actually come in and put that Meditative Walk on in the day, just to help. That's how much I enjoyed that.

The two cognitive engagement interventions were also positively received, but by fewer participants (7 of 12). Overall, they were less popular than the contemplative interventions, and of these, Carpe Lucem (the 3D light puzzle) was more popular than Obduction:

FG1-4

I mean, for me, obviously with what we've been chatting about, Carpe Lucem was on the top of my list for pain control.

Several comments (7) also reflected that participants found these interventions frustrating, particularly the problem-solving escape game (Obduction) as it was seen as overly complex:

FG2-5

Then the pipe one [Carpe Lucem] was... unless I cheated, it was... It was pretty hard on the brain!

FG2-2

I found that the game portion was very frustrating, because, particularly in Obduction, you have to follow, or try to follow the rules or try to find a way to get to the next part... and I think it gave me more pain when I just couldn't do it.

FG2-3

So it would be better if it was an uplifting story, with beautiful scenery instead of this like deserted, empty, scary... That doesn't really add to the cancer experience, to have to go through an activity that is dealing with stuff like that. It would be better if the story was something uplifting or whatever.

However, two other participants liked the complex and detailed rendering of the other worldly environment in that experience:

FG2-5

You can look around and just... Obduction is so beautiful but hard to do.

Some participants emphasised the value of those interventions that had an open environment that they could go and explore, rather than being restricted to one location or path. The different personal

preferences for design prompted a couple participants to comment on the value of having more choice in their selected experience, for example:

FG2-5

Most of us here I would assume spend a lot of our effort and time in the day trying to escape from pain, and in a variety of ways, so this is a tool that we could use. Especially in the future, you could have thousands of different situations that you could immerse yourself in, for as much time as you want in the day.

3.2. Usability

The next theme that emerged focused on the usability of the VR equipment and interventions. The majority of this discussion (76 comments) focused on ergonomic limitations and limitations of current VR technology. Nearly all of the participants reported physical limitations of the equipment, particularly in terms of seated or standing position discomfort while using the VR equipment, discomfort when using glasses, and discomfort due to the headset weight. Many participants (8) felt that sitting or standing for half an hour was problematic for them, and several reported strategies to make the system more comfortable:

FG1-4

On problem I came across was the seating limitation. It's... at least for my experience, I found that it was very uncomfortable... I actually tried to use a different chair or different cushion. But I found that not being able to stand for long periods of times created this limitation, because I had to be seated.

FG2-6

I just thought it was important to have a comfortable chair to make sure that - because I have leg issues, so you have to start off with a comfortable chair, because after a half an hour, if you're sitting on a stool, the pain can be worse. So I made sure I had a pillow and my heat blanket.

Eight participants commented on the weight of the headset, and three of them noted that a cordless headset would help considerably, whilst seven comments reflected problems wearing eyeglasses inside the headset. This was also reflected in discussion of the negative effects of the VR system:

FG2-4

I found that the headset was really quite heavy, which actually affected my neck.

FG2-4

Because I had to stick my glasses in the VR headset, then put the VR headset on, and so I found that was kind of a functional limitation, a physical limitation.

FG1-4

I found that I had to reposition the towers, they're very sensitive, and I had to recalibrate a few times in order to really get the space down... It's very... right now it's very kind of marshmallowy. If you touch it, it changes.

Lastly, in this theme, several participants commented positively about the accessibility of VR technology for use in primary care settings. However, some felt that the current price of the VR system may prove a barrier:

FG2-4

Yeah, so I didn't have to go anywhere, and sometimes if I was down, or had a really bad day or you know, I could go on there and I could choose, you know? And my brain could check into that instead of into

pain. I really liked that I didn't have to go straight to the hospital to do the project.

3.3. Effects of the VR experience

The effects of the VR experience theme included both effects on pain and effects on other aspects of participants' lives. Overall the results were mixed, although the majority of participants reported positive experiences. The most common effect reported was that VR was beneficial in their pain management, with 20 comments reflecting this:

FG1-2

I also looked forward to my sessions every day. Because I actually would get to the point where I was in the game and I realized I had no pain. And it was like, wow! I'm not only enjoying myself, but I actually have no pain!

FG1-4

Honestly, I could play that for hours and not think about my pain and... I mean, I got to about an hour, and then at that point my body was like, okay, pain centres come back up.

Nevertheless, others (4) found no benefits for their pain management and even reported some experiences exacerbated their pain:

FG2-4

I found that - I'm not sure which one, one of the talking ones - where they got you to focus on your pain [VMW]. I found that that made my pain much worse, and I think part way through I actually stopped doing it and went to a different one to do my 30 min a day, because the pain was just so aggravated by concentrating on it.

An emotional response seemed to be triggered in many participants with a mainly positive effect (17) but also some negative responses (13). The positive responses reflected enjoyment and relaxation, whilst the negative ones focused on frustration (with the cognitive challenge activities), depression, confusion, and fear:

FG1-1

I just found it completely and utterly fascinating, and begged them to leave the equipment with me!

FG2-1

I'm very pleased with the fact that I'm not afraid anymore. I'm not afraid of my pain. That's what I got out of all of this.

FG2-3

The meditation was great, the scenery was beautiful, and the scenery in the other one with the ocean scenes and that, that was relaxing, beautiful. Those were good.

FG1-2

The alien world [Obduction] I found actually kind of disconcerting, and... wasn't as... [useful], very frustrating and disturbing to me.

The next most frequent items reflected the negative effects of motion sickness induced by VR (known as cybersickness). Comments from 13 participants reflected this problem, predominantly in the Wildflowers intervention (as it involved flying). However, all those who reported cybersickness indicated that they developed some tolerance to it; others suggested strategies to avoid it:

FG2-2

The butterfly [Wildflowers], that made me nauseous. I couldn't do it, I couldn't control the butterfly flying around, and it was making me sick.

FG1-3

I had to close my eyes a lot of times to stop... it was the flying one... it was okay once I got used to how to handle moving, but it was getting used to how I was supposed to move and not go so fast.

Finally, the majority of participants did not report any significant effects lasting after the VR experience. However, five comments suggested some short-term effects of the of the experience:

FG1-2

It was about 30 min... that I felt sort of calmer and more relaxed, and just... you'd felt like you'd had a break from the pain.

FG1-4

I felt the analgesic effect last – persisted beyond the virtual reality environment but it didn't last as long as say a medication or like a true analgesic. But I found the effect would last or persist for maybe a half hour or an hour after. So just because it gave me something to refocus my mind and actually put my logic to use and tire my brain out, so that I'm not strictly focused on my pain all the time. And so it gave me an opportunity to dodge it for an hour or two once I was done, and it kept me in that zone. But I didn't find that it lasted 4 h or 5 h, it was more like 30 min to an hour.

Other comments in terms of longer-term results reflected the effects of the VR experience on sleep and mobility. Although the majority did not observe any improvement in their sleep or mobility patterns, with one indicating that the VR possibly disrupted their falling asleep sometimes, four participants reported some effects on these aspects:

FG1-1

...I found I slept much better after when I did VR. And especially those two programs [the relaxation focused interventions]. So I was very thankful for that.

FG1-4

With the slight analgesic effect yes, mobility was increased somewhat... When I'm in pain I'm less mobile, whereas with the VR headset, when I was done the VR, I was thinking about my pain less.

Finally, in this category, three participants indicated they noticed eye strain after about 30–40 min:

FG2-5

For me, half an hour is long enough. In actual fact, I did have eye strain after about 20 min and I needed to remove the glasses from my head and take a break. So it did bother me, with the eyes.

3.4. Mode of action

Another significant topic of discussion explored how the VR experience worked in terms of helping with pain management. Most comments reflected that relaxation (17) and distraction (16) appeared to be the most significant factors:

FG2-1

I found that the meditation part was good, it sort of got me into the relaxation of the body. I found the games more distracting and actually, while I was trying to figure out the games, I forgot about my pain.

FG1-2

But what really surprised me was that I loved the last one! The light beam one. Like that just really... like, I was even more relaxed doing

that than I was with the meditation. And that's the one I went back to again and again.

FG1-5

The problem-solving apps caused me to think about the situation and took my mind off the pain.

In considering what aspects of VR helped achieve this, the topics of immersion (technical aspects of VR designed to present data in a natural encompassing way that promotes engagement with it) and presence (feeling they were actually in the environment) were cited.

FG1-4

You actually felt like you had contact with this virtual environment and could influence that virtual environment.

FG2-4

One of the things that I found too, before I had bone cancer I was very active. I was hiking, I was always into rock climbing, sports, things like that. So, for me to be able to like virtually go to, like... I would just go and check and explore something and watch the water. I really enjoyed that part, it took me to places that I just relate to from my climbing days.

3.5. Technical aspects

The last thematic category reflects comments about the technology and how it impacted the users' experience. Seven comments reflected the need for good technical support. Three participants noted that they had good technical support during the project but five indicated a perceived need for good support when implementing VR interventions at home, which was linked to the current early stage of VR development and complexity of VR equipment:

FG1-1

I just want it to work and I don't know how to fix things like that. So, it's something that I would absolutely educate myself on and want somebody that I could reach out to if I was having problems.

Five comments pertained to issues with the visual aspects of VR that negatively affected the participants sense of immersion at times, and four that the audio was an important part of the experience:

FG1-4

I found that some of the sprites or some of the grass, for example, looked very fake, and it was harder to get into from a technical perspective.

FG1-5

It's that background beat [rhythmic music], that just... fits my brain so well. You know, as he's talking, the... Yeah, it's amazing. I found that so good.

4. Discussion

Similar to other research, this study confirms that some people find benefits from the use of VR as an adjunctive therapy in helping manage their pain, whilst others do not. These mixed effects are consistent with reports using adjunctive therapies for chronic pain management and reflect the complex psychological aspects as well as highly personal nature of different forms of chronic pain [1, 2, 5]. Some participants reported substantial changes in pain during the use of VR, whereas others perceived no effect [15, 24, 40].

Overall, participants appeared split into two categories of preference for type of VR intervention. Most liked either the contemplative meditative environments or the environments that required cognitive

engagement to solve problems. Only two participants reported that they liked both approaches, suggesting a "one size fits all" approach to developing therapeutic VR environments for pain management is unlikely to be productive. To narrow the potential landscape of VR environments, however, other work along with participants' comments in this study suggests that pain patients find meditative and cognitive engagement approaches most valuable [15, 41, 42, 43]. Therefore, the development of VR applications using these two different approaches while including a diversity of environments may be more fruitful.

Design of VR for pain applications also requires careful consideration of patients' values and needs in terms of user experience. Some users found one particular VR experience (the problem-solving game, *Obduction*) depressing and suggested this aggravated their pain. As most current VR applications are designed for the recreational market, many are unsuitable for pain applications, e.g. first-person shooter games or horror survival games that make up the majority of commercial titles. It is important that VR designs for pain management offer a satisfying and non-frustrating experience. Designs that incorporate positive environments, natural elements and soundscapes may be more effective [44, 45, 46]. Visual problems with some designs were also noted by some participants, such as the unrealistic grass movement in the *VMW* detracting from the immersive experience. Applications that offer separate meditative and cognitive engagement experiences may be more appealing. As well, applications that work at room-scale (walking VR), lying down, or in sitting positions would provide flexibility for patients to engage in their most comfortable position. Involving a variety of chronic pain patients in patient-centered design is more likely to result in effective designs that promote user engagement [47]. Many experimental designs exploring VR in pain applications focus upon artificially induced pain in healthy participants [8, 13]. However, involving real-world chronic pain patients as end-users in the design of VR products that account for their experience, needs, and values is essential to maximize the utility of these applications, as their lived experiences of pain are very different from healthy adults.

In terms of quality of life, the reported effects of VR were inconclusive. Some participants indicated an improved sense of mobility and that being able to walk again in VR had psychological benefits potentially extending beyond the therapy. Likewise, some reported sleep benefits, but for most, no changes in these aspects of their lives was evident. The effects on pain were transient and appeared to last from immediately after the VR experience to half an hour later, although one patient reported benefits of several hours' duration. This in itself is not uncommon with adjunctive pain therapies. Moreover, such effects may be highly valuable for chronic pain sufferers, providing a brief respite from constant pain, i.e. a "pain holiday". [48, 49] This may help explain, why even though the effects of VR therapy appeared limited, many participants were very positive about its value in helping them self-manage their ongoing pain, especially given the absence of significant side-effects compared to pharmaceutical interventions. Additionally, there may be some benefits in terms of other health aspects such as sleep and mobility, although in this study the evidence remains unclear.

Participants encountered considerable limitations in the usability of VR technology. The recently updated standard of usability defines usability according to three supporting factors: effectiveness, efficiency, and satisfaction throughout product usage, from learning to infrequent use to maintenance; the update further emphasizes a wider range of goals including personal outcomes: in this case, supporting users' individualized pain management goals [57]. The participants in this study all described poor satisfaction with physical ergonomics, including general discomfort, wired tethers, problems using eye-glasses, and weight of the headset. Moreover, participants felt the technical operation and maintenance of VR equipment was a barrier to access (effectiveness). Despite developments of VR for the consumer market, use of the technology remains relatively complex. Technical support was another factor highlighted by the participants that may affect the usability of VR in practice. Although technical support was reportedly good for this project, this

support involved dedicated resources that would also be required in real-world applications to support effective independent use at home. This is an important consideration when comparing cost-effectiveness with respect to other pain interventions. If a nurse, healthcare, or technical worker needs to support the management of a therapy, then this may decrease its utility. Additionally, economic accessibility was highlighted as a significant barrier, as a good quality VR setup currently costs over a thousand dollars. On the positive satisfaction side, participants found the ability to use the VR therapy at home an important advantage. They also suggested that being able to use VR freely in a clinic would be beneficial. Such an arrangement would help with public access to VR as a pain management tool, as well as provide opportunity for individuals to test the value of this specific therapeutic approach for their own pain issues. As chronic pain is highly individually contextualized, these are important considerations, and these factors will influence adoption and acceptance of the technology, particularly the extent to which end-users can readily use the product in their daily lives.

In terms of adverse events, VR appears a safe and relatively side-effect free adjunctive therapy. Cybersickness remains the main negative effect identified by the participants, with almost all incidents occurring in the flying experience of Wildflowers. However, all of the participants developed some tolerance to this. Moreover, effective VR environment design and control of visual flow can help mitigate this problem [50, 51]. Eye strain was also a reported issue for several people, and this may be more difficult to alleviate as current VR headsets all involve screens placed a few centimeters in front of the eyes. This may limit the practical use of VR to half an hour or so at a time. Other VR implementations using full-size room projectors are currently unwieldy for home use, and techniques attempting retinal image projection currently remain experimental [52].

It is likely that distraction through cognitive engagement or relaxation are the main effects of the VR therapy. Both seem to involve the user in activities that psychologically remove them from their immediate pain experience. Engaging a powerful sense of presence seems an important aspect of the value of VR here, and must be created through seamless immersive technology in order to maximize the benefits for distraction from chronic pain. Future exploration of the value of VR for chronic pain using neurological studies to further identify the mechanisms involved may be useful.

Overall, the effectiveness of these interventions compared to other adjunctive chronic pain therapies such as massage, acupuncture, mindfulness relaxation, music therapy, or even placebo therapeutics remains to be established and well-controlled large randomized clinical trials are necessary to establish the size of any analgesic effect of VR as an adjunctive tool in chronic pain management.

A number of limitations of this study are acknowledged, in that as a qualitative inductive exploration with a small number of participants, varied types of cancer, chronic pain and varied timing of the VR interventions, the results may not be generalizable across wider chronic pain populations. Nevertheless, the nature of chronic pain is a highly personal experience, and as standardization is often unviable in clinical studies of this nature and the response to pain interventions on individuals' experiences of pain also widely vary, it remains a useful area to explore. Additionally, this work only explored the use of cognitive engagement and meditative VR environments used from a static position, and so the outcomes may not necessarily be extrapolated to other types of VR interventions. However, these environments do represent the majority of those currently used in the clinical management of pain.

5. Conclusions

This focus group study clarified users' perceptions of the value of daily self-administered adjunctive VR therapy for helping to manage chronic pain and the aspects that detracted from its success. Overall, users reported mixed results with using VR for chronic pain, although the majority of respondents noted it was beneficial. Our findings also highlight

unique usability considerations of applying VR for long-term pain management. While a minority found no benefit, some found it remarkably effective in providing pain relief for the period of use. Participants tended to prefer either relaxation-based or cognitive-engagement types of VR experiences, but not both, in helping to manage their pain. This reflects the highly personal nature, complexity, and impact of psychological mediation on a person's chronic pain experience. The main mechanism of action appears to be a powerful form of distraction where immersive VR facilitates a strong sense of presence in a novel environment, thereby directing attention away from pain. VR applications for chronic pain management may be best leveraged for maximum efficacy by offering a variety of experiences to mesh with individuals' preferences. Furthermore, there were few and no serious adverse effects of the VR therapy; the main issues were cybersickness with some applications and mild neck and eye ache with prolonged use.

The existing technical and economic limitations of using VR interventions may also present barriers to the uptake of it as a home-based therapeutic intervention for chronic pain. However, the technology and price of these systems is changing rapidly. The hardware and software has already advanced beyond the capabilities of the VR systems used in this study, and more optimal HMDs that are lightweight, wireless, and allow the use of glasses are now becoming available. In addition, the cost of systems is also gradually reducing as commercial uptake expands.

Future designs of VR systems for chronic pain management will need to address these considerations in order to achieve maximum utility in this area, and engaging chronic pain patients early in the design process of VR pain interventions is recommended. Finally, a qualitative study of this nature can only demonstrate the potential value of this technology for chronic pain management. Whilst full clinical trials are extremely difficult to manage in-vivo, further comparative trials of VR with larger and more standardized populations are also needed to establish its value as a therapeutic intervention in chronic pain management. Completion of our wider RCT will take place in 2020, when we will have further data to expand upon this work.

Declarations

Author contribution statement

B. Garrett: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

G. Tao, E. Cordingley and C. Sun: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

T. Taverner: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

This work was supported by the Lotte & John Memorial Hecht Foundation Grant #4110.

Competing interest statement

The authors declare no conflict of interest.

Additional information

Supplementary content related to this article has been published online at <https://doi.org/10.1016/j.heliyon.2020.e03916>

Acknowledgements

The authors thank Dr. Diane Gromala, Interactive Media Laboratory at Simon Fraser University, Mobio Interactive Inc., Hammer Labs and

Cyan Inc., for providing the VR environments used by participants in this study. We thank People In Pain Network (PIP), Pain BC, and BC Cancer Agency, for assisting with participant recruitment, and all of the participants who volunteered for this study.

References

- [1] J.A. Paice, R. Portenoy, C. Lachetti, T. Campbell, A. Cheville, M. Citron, et al., Management of chronic pain in survivors of adult cancers: American society of clinical oncology clinical practice guideline [Internet], *J. Clin. Oncol.* (2016 Sep 20) [cited 2019 Sep 9];34(27):3325–45. Available from:
- [2] J.S. Merlin, K. Patel, N. Thompson, J. Kapo, F. Keefe, J. Liebschutz, et al., Managing chronic pain in cancer survivors prescribed long-term opioid therapy: a national survey of ambulatory palliative care providers [Internet], *J. Pain Symptom Manag.* 57 (1) (2019) 20–27. Available from:
- [3] F. Bray, J. Ferlay, I. Soerjomataram, R.L. Siegel, L.A. Torre, A. Jemal, Global Cancer Statistics 2018: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries [Internet], *CA Cancer J Clin.* 2018 Nov 1 [cited 2019 Sep 9];68(6):394–424. Available from:
- [4] L.A. Torre, F. Bray, R.L. Siegel, J. Ferlay, J. Lortet-Tieulent, A. Jemal, Global cancer statistics, 2012 [Internet], *CA A Cancer J. Clin.* (2015 Mar 1) [cited 2019 Sep 9]; 65(2):87–108. Available from:
- [5] D. Dowell, T.M. Haegerich, R. Chou, CDC Guideline for Prescribing Opioids for Chronic Pain — United States, 2016, *MMWR Recomm Reports* [Internet], 2016. Mar 15 [cited 2019 Aug 20];65(1):1–49. Available from: <http://www.cdc.gov/mmwr/volumes/65/rr/rr6501e1er.htm>.
- [6] S.A. Schug, P. Lavand'homme, A. Barke, B. Korwisi, W. Rief, R.-D. Treede, The IASP classification of chronic pain for ICD-11 [Internet], *Pain* 160 (1) (2019 Jan) 45–52 [cited 2019 Aug 31] Available from: <http://insights.ovid.com/crossref?an=00006396-201901000-00006>.
- [7] M. Von Korff, A.I. Scher, C. Helmick, O. Carter-Pokras, D.W. Dodick, J. Goulet, et al., United States national pain strategy for population research: concepts, definitions, and pilot data [Internet], *J. Pain* 17 (10) (2016 Oct 1) 1068–1080 [cited 2019 Aug 20] Available from: <https://www.sciencedirect.com/science/article/abs/pii/S1526590016301109>.
- [8] B. Garrett, T. Taverner, W. Masinde, D. Gromala, C. Shaw, M. Negraeff, et al., A rapid evidence assessment of immersive virtual reality as an adjunct therapy in acute pain management in clinical practice [Internet], *Clin. J. Pain* 30 (12) (2014) 1–26. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/24535053>.
- [9] N. Ahmadpour, H. Randall, H. Choksi, A. Gao, C. Vaughan, P. Poronnik, Virtual Reality interventions for acute and chronic pain management [Internet], *Int. J. Biochem. Cell Biol.* (2019 Sep 1) [cited 2019 Sep 9];114:105568. Available from: <https://www.sciencedirect.com/science/article/pii/S1357272519301451?via%3Dihub>.
- [10] H.R. Trompetter, E.T. Bohlmeijer, M.M. Veehof, K.M.G. Schreurs, Internet-based guided self-help intervention for chronic pain based on Acceptance and Commitment Therapy: a randomized controlled trial [Internet], *J. Behav. Med.* 38 (1) (2015 Feb 13) 66–80 [cited 2019 Sep 9] Available from: <http://link.springer.com/10.1007/s10865-014-9579-0>.
- [11] H.G. Hoffman, D.R. Patterson, J. Magula, G.J. Carrougher, K. Zeltzer, S. Dagadakis, et al., Virtual reality pain control during burn wound debridement in the hydrotank [Internet], *J. Clin. Psychol.* 24 (2) (2004) 299–304. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/21795888>.
- [12] R. Madelin, Personalizing therapy [Internet], *Cyberpsychol., Behav. Soc. Netw.* 17 (6) (2014 Jun) 333 [cited 2015 Jan 6] Available from: <http://www.ncbi.nlm.nih.gov/pubmed/24892193>.
- [13] N.E. Mahrer, J.I. Gold, The use of virtual reality for pain control: a review [Internet], *Curr. Pain Headache Rep.* 13 (2) (2009 Apr) 100–109. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/19272275>.
- [14] A. Pourmand, S. Davis, D. Lee, S. Barber, N. Sikka, Emerging utility of virtual reality as a multidisciplinary tool in clinical medicine, *Game. Health J.* 6 (5) (2017).
- [15] B. Garrett, T. Taverner, P. McDade, Virtual reality as an adjunct home therapy in chronic pain management: an exploratory study [Internet], *JMIR Med. Inf.* 5 (2) (2017 May 11), e11 [cited 2018 Feb 19] Available from: <http://www.ncbi.nlm.nih.gov/pubmed/28495661>.
- [16] D. Gromala, X. Tong, A. Choo, M. Karamnejad, C.D. Shaw, The virtual meditative walk: virtual reality therapy for chronic pain management, *Proc. ACM CHI'15 Conf. Hum. Factors Comput. Syst.* 1 (2015).
- [17] M.H. Johnson, How does distraction work in the management of pain? [Internet], *Curr. Pain Headache Rep.* 9 (2) (2005 Mar), 90–5. [cited 2019 Sep 9] Available from: <http://link.springer.com/10.1007/s11916-005-0044-1>.
- [18] C. Eccleston, Chronic pain and distraction: an experimental investigation into the role of sustained and shifting attention in the processing of chronic persistent pain [Internet], *Behav. Res. Ther.* 33 (4) (1995 May) 391–405 [cited 2019 Sep 9] Available from: <http://www.ncbi.nlm.nih.gov/pubmed/7538753>.
- [19] J. Dascal, M. Reid, W.W. Ishak, B. Spiegel, J. Recacho, B. Rosen, et al., Virtual reality and medical inpatients: a systematic review of randomized, controlled trials, *Innovat. Clin. Neuro.* 14 (2017).
- [20] A. Li, Chen Montano, J.I. Gold, Virtual reality and pain management: current trends and future directions, *Pain Manag.* 1 (2) (2011) 147–157.
- [21] K.M. Malloy, L.S. Milling, The effectiveness of virtual reality distraction for pain reduction: a systematic review [Internet], *Clin. Psychol. Rev.* 30 (8) (2010 Dec) 1011–1018 [cited 2014 Mar 5];Available from:
- [22] J. Kabat-Zinn, Mindfulness-based interventions in context: past, present, and future, *Clin. Psychol. Sci. Pract.* 10 (2) (2003) 144–156.
- [23] S. Rosenzweig, J.M. Greeson, D.K. Reibel, J.S. Green, S.A. Jasser, D. Beasley, Mindfulness-based stress reduction for chronic pain conditions: variation in treatment outcomes and role of home meditation practice [Internet], *J. Psychosom. Res.* 68 (1) (2010 Jan 1) 29–36 [cited 2019 Sep 9] Available from: <https://www.sciencedirect.com/science/article/abs/pii/S0022399909000944?via%3Dihub>.
- [24] M.M. Veehof, H.R. Trompetter, E.T. Bohlmeijer, K.M.G. Schreurs, Acceptance- and mindfulness-based interventions for the treatment of chronic pain: a meta-analytic review [Internet], *Cognit. Behav. Ther.* 45 (1) (2016 Jan 2) 5–31 [cited 2019 Sep 9] Available from:
- [25] D. Gromala, M. Song, J.-D. Yim, T. Fox, S.J. Barnes, M. Nazemi, et al., Immersive VR: a non-pharmacological analgesic for chronic pain? *Proc. Annu. Conf. Hum. Factors Comput. Syst. (CHI '11)* (2011) 1171–1176.
- [26] W. Jin, A. Choo, D. Gromala, C. Shaw, P. Squire, A virtual reality game for chronic pain management: a randomized, controlled clinical study [Internet], *Stud. Health Technol. Inf.* 220 (2016) 154–160. Available from: <http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emexa&NEWS=N&AN=616614392>.
- [27] T. Heart, E. Kalderon, Older adults: are they ready to adopt health-related ICT? [Internet], *Int. J. Med. Inf.* 82 (11) (2013 Nov 1) e209–e231 [cited 2019 Sep 9]; Available from: <https://www.sciencedirect.com/science/article/abs/pii/S1386505611000682?via%3Dihub>.
- [28] S.T.M. Peek, K.G. Luijckx, M.D. Rijnaard, M.E. Nieboer, C.S. van der Voort, S. Aarts, et al., Older adults' reasons for using technology while aging in place [Internet], *Gerontology* 62 (2) (2016) 226–237 [cited 2019 Sep 9]; Available from: <http://www.ncbi.nlm.nih.gov/pubmed/26044243>.
- [29] M. Hassenzahl, S. Diefenbach, A. Göritz, Needs, affect, and interactive products – facets of user experience [Internet], *Interact. Comput.* 22 (5) (2010 Sep 1) 353–362 [cited 2019 Sep 9]; Available from: <https://academic.oup.com/iwc/article-lookup/doi/10.1016/j.intercom.2010.04.002>.
- [30] C. Lallemand, G. Gronier, V. Koenig, User experience: a concept without consensus? Exploring practitioners' perspectives through an international survey [Internet], *Comput. Hum. Behav.* 43 (2015 Feb 1) 35–48 [cited 2019 Sep 9]; Available from: <https://www.sciencedirect.com/science/article/pii/S0747563214005718?via%3Dihub>.
- [31] A.M. Carlsson, Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale [Internet], *Pain* 16 (1) (1983 May) 87–101 [cited 2019 Sep 9]; Available from: <http://www.ncbi.nlm.nih.gov/pubmed/6602967>.
- [32] R. Melzack, The short-form McGill pain questionnaire, *Pain* 30 (1987) 191–197.
- [33] J.E. Ware, M. Kosinski, S.D. Keller, A 12-item short-form health survey [Internet], *Med. Care* 34 (3) (1996 Mar) 220–233 [cited 2019 Sep 9]; Available from: <http://www.ncbi.nlm.nih.gov/pubmed/8628042>.
- [34] D.J. Buysse, C.F. Reynolds, T.H. Monk, S.R. Berman, D.J. Kupfer, The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research [Internet], *Psychiatr. Res.* 28 (2) (1989 May) 193–213 [cited 2019 Sep 9] Available from: <http://www.ncbi.nlm.nih.gov/pubmed/2748771>.
- [35] S.E. Thorne, Interpretive Description: Qualitative Research for Applied Practice [Internet], Routledge, 2016, p. 336 [cited 2019 Aug 20] Available from: <https://www.routledge.com/Interpretive-Description-Qualitative-Research-for-Applied-Practice-2nd/Thorne/p/book/9781629582993>.
- [36] M. Bengtsson, How to plan and perform a qualitative study using content analysis [Internet], *NursingPlus Open* 2 (2016) 8–14.
- [37] P. Burnard, A method of analysing interview transcripts in qualitative research [Internet], *Nurse Educ. Today* 11 (6) (1991 Dec 1) 461–466 [cited 2019 Jul 18] Available from: <https://www.sciencedirect.com/science/article/abs/pii/026069179190009Y>.
- [38] J.M. Morse, P.-A. Field, *Qualitative Research Methods for Health Professionals*, Sage Publications, 1995, p. 254.
- [39] S. Thorne, M. Sandelowski, *Interpretive Description (Developing Qualitative Inquiry)*, Left Coast Press, 2008.
- [40] J.L. Mosso, G.T. Obrador, B. Wiederhold, M. Wiederhold, V. Lara, A. Santander, *Cybertherapy in Medicine – Experience at the Universidad Panamericana, IMSS and ISSSTE Mexico*, 2012.
- [41] H.G. Hoffman, G.T. Chambers, W.J. Meyer 3rd, L.L. Arceneaux, W.J. Russell, E.J. Seibel, et al., Virtual reality as an adjunctive non-pharmacologic analgesic for acute burn pain during medical procedures, *Ann. Behav. Med.* 41 (2) (2011 Apr) 183–191.
- [42] C. Maani, H.G. Hoffman, P.A. DeSocio, M. Morrow, C. Galin, et al., Pain control during wound care for combat-related burn injuries using custom articulated arm mounted virtual reality goggles [Internet], *J. Cyber. Therapy Rehabil.* 1 (2) (2008) 193–198 [cited 2011 Nov 16] Available from: <http://citeseerx.ist.psu.edu/viewdoc/download?>
- [43] J. Vidyarthi, B.E. Riecke, D. Gromala, Sonic cradle: designing for an immersive experience of meditation by connecting respiration to music, *Proc DIS 2012* (2012) 408–417.
- [44] D. Loreto-Quijada, J. Gutiérrez-Maldonado, R. Nieto, O. Gutiérrez-Martínez, M. Ferrer-García, C. Saldana, et al., Differential effects of two virtual reality interventions: distraction versus pain control, *Cyberpsychology* 17 (6) (2014).
- [45] J.M. Gorman, Virtual reality: a real treatment option [Internet]. 2006, *CNS Spectr.* 11 (1) (2006), 12–3. Available from: http://csaweb105v.csa.com.proxy.lib.wayne.edu/ids70/view_record.php?id=3&recnum=276&log=from_res&SID=nh65ffhjt3jpdet4p1a7pv3.
- [46] B. Garrett, T. Taverner, D. Gromala, G. Tao, E. Cordingley, C. Sun, Virtual reality clinical research: promises and challenges [Internet], *JMIR serious games* 6 (4)

- (2018 Oct 17), e10839 [cited 2019 Jan 17] Available from: <http://games.jmir.org/2018/4/e10839/>.
- 47 S. Triberti, G. Riva, Engaging Users to Design Positive Technologies for Patient Engagement: the Perfect Interaction Model [Internet], 2015 [cited 2019 Sep 9]. Available from: <https://www.degruyter.com/downloadpdf/books/9783110452440/9783110452440-006/9783110452440-006.pdf>.
- [48] D.P. Alford, Opioid prescribing for chronic pain — achieving the right balance through education [Internet]. *N. Engl. J. Med.* 374 (4) (2016 Jan 28) 301–303 [cited 2019 Sep 9] Available from:
- [49] B.K. Wiederhold, K. Gao, C. Sulea, M.D. Wiederhold, Virtual reality as a distraction technique in chronic pain patients [Internet], *Cyberpsychol., Behav. Soc. Netw.* 17 (6) (2014 Jun 3) 346–352 [cited 2019 Sep 9] Available from:
- [50] A. Mazloumi Gavvani, D.M. Hodgson, E. Nalivaiko, Effects of visual flow direction on signs and symptoms of cybersickness [Internet], in: M. Sakakibara (Ed.), *PLoS One* 12 (8) (2017 Aug 4), e0182790 [cited 2019 Sep 9] Available from: <https://plos.org/10.1371/journal.pone.0182790>.
- [51] L. Rebenitsch, C. Owen, Review on cybersickness in applications and visual displays [Internet], *Virtual Real.* 20 (2) (2016 Jun 26) 101–125 [cited 2019 Sep 9] Available from: <http://link.springer.com/10.1007/s10055-016-0285-9>.
- [52] H. Takahashi, S. Hirooka, Stereoscopic see-through retinal projection head-mounted display [cited 2019 Sep 5]. p. 68031N. Available from:, in: A.J. Woods, N.S. Holliman, J.O. Merritt (Eds.), *International Society for Optics and Photonics*, 2008.
- [53] J. Kitzinger, R.S. Barbour, *Developing Focus Group Research: Politics, Theory, and Practice*, SAGE Publications, 1999, p. 225.
- [54] R.S. Barbour, U. Flick, *Doing Focus Groups*, Sage Publications, London, UK, 2007, p. 199.
- [55] L. Litosseliti, *Using Focus Groups in Research*, Continuum, London, UK, 2003.
- [56] E. Brügger, P. Willems, A critical comparison of offline focus groups, online focus groups and E-delphi, *Int. J. Mark. Res.* 51 (3) (2009 Jan 25) 1–15. Available from.
- [57] International Organization for Standardization. ISO 9241-11:2018. Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts. Geneva: ISO; 2018.