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The Impact of Virtual Reality on Chronic Pain

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THE IMPACT OF VIRTUAL REALITY ON CHRONIC PAIN

by

ALEXIS E. WHITEHEAD

A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Nursing
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ABSTRACT

Chronic pain remains a prevalent problem across the United States. Chronic pain does not seem to have a function and relief of this symptom remains elusive for many sufferers. Virtual reality has been used as an adjunct therapy to decrease acute pain with promising results, but there is little research on whether virtual reality could be used as a successful intervention for those with chronic pain. Virtual reality has few side effects, so it warrants consideration for the treatment of chronic pain. There is growing evidence that there is potential for virtual reality to produce desired results with patients having chronic pain, but without more research this intervention cannot be confidently recommended (Garrett, Taverner, & McDade 2017). This thesis reviewed published research on the use of virtual reality in those with chronic pain. A total of seven studies that addressed virtual reality and chronic pain were analyzed and integrated into this literature review. All studies used virtual reality as a distraction to improve chronic pain. Three studies included patients with chronic back pain, one study included patients with chronic neck pain, and the remaining three studies addressed other types of chronic pain including chronic postoperative breast cancer pain, chronic neuropathic pain, and chronic generalized pain. All studies reviewed reported improvement of chronic pain symptoms. This literature review provides evidence to support the use of virtual reality for those with chronic pain. More rigorous research with larger sample sizes is needed to increase the generalizability of results to help people suffering with chronic pain from a variety of causes. This literature review used the search terms “chronic pain” and “virtual reality” and the following databases: EBSCOhost, Medline, CINAHL Plus with Full Text, PsycINFO, Academic Search Premiere, and Applied Science & Technology Source.

DEDICATIONS

I would like to thank my mom for motivating me, my dad for supporting me, and Sam for encouraging me.

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INTRODUCTION

Many people of all ages suffer from chronic pain due to an ineffective pain management regimen or a lack of consistent treatment (Jones, Skadberg, & Moore, 2018). Clinical management of chronic pain can be complicated and generally does not rely only on pharmacological substances such as opioids (Wilson, Ramesh, Carruthers, & O'Connor, 2018). Patients who are routinely taking prescription medications are at a higher risk for addiction, physical dependence, overdose and substance use disorder (Lewei, Bohnert, Jannausch, Goesling, & Ilgen, 2018). However, chronic pain still needs to be managed as efficiently and effectively as possible.

Virtual reality has been used in those with multiple medical diagnoses focusing on physical, neurocognitive, and affective conditions (Trost & Parsons, 2014). It can be used alone or in combination with other treatments not only for acute pain, but for chronic pain conditions as well (Keefe et al., 2012). Virtual reality has also been reported to help with patient adherence to their therapies because of the entertainment value of the programs (Wilson et al., 2018). The “gate theory” of attention is the best model to date describing the impact of virtual reality on pain. This theory suggests that virtual reality decreases a patient’s perception of pain by distracting their attention away from it (Jones, Moore, & Choo, 2016). Even though virtual reality in regard to chronic pain is still at the beginning stages of research, the use of deeply engaging virtual experiences holds a sizable amount of hope for future patients (Trost & Parsons, 2014).

BACKGROUND

Chronic Pain

Pain occurs when something hurts, causing an unpleasant sensation (Cleveland Clinic, 2017). Chronic pain is when the unpleasant sensation lasts for longer than six months. This type of pain can persist even after the initial injury or illness that caused it has healed. Chronic pain can also occur when there is no past injury or illness, but has been linked to conditions such as headache, arthritis, cancer, nerve pain, back pain, and fibromyalgia pain (Cleveland Clinic, 2017).

Chronic pain is one of the most common reasons adults seek out medical care (Dahlhamer et al., 2018). In 2016, an estimated 20% of United States adults had chronic pain with the highest prevalence being among adults living in poverty, adults with less than a high school education, and adults with public health insurance (Dahlhamer et al., 2018). In 2010, the estimated total financial cost of pain to society ranged from 560-635 billion dollars (Gaskin & Richard, 2011). This estimation combined the health care cost estimates as well as three productivity estimates which included days of work missed, hours of work lost, and lower wages (Gaskin & Richard, 2011). Even though there are many medical interventions currently being implemented for chronic pain, the problem still persists. Due to this, we should be looking for non-pharmacological interventions that could improve quality of life for those patients currently coping with chronic pain.

Virtual Reality

Virtual reality can be defined as an artificial environment which is experienced through sensory stimuli provided by a computer (Merriam-Webster, 2019). The history of virtual reality

dates back to the 1960s when it was initially created. In the 1980s, the first commercial virtual reality tools were developed (Cipresso, Giglioli, Raya, & Riva1, 2018). Since then, researchers have been exploring the processes, effects, and applications of virtual reality technology. The study of virtual reality was originally designed for use in the field of computer graphics but has since been opened to several different disciplines. In the last few years, investors as well as the general public, have been attracted to virtual reality (Cipresso et al., 2018).

Medical applications of virtual reality technology have been continuing to develop in areas including diagnosis, preoperative planning, education/training systems, and image guided surgery, but this is only the beginning of the potential virtual reality holds (Székely & Satava, 1999). Virtual reality offers immersive programs that can not only help a physician, but the patients being treated as well. Over the years, many programs have been tested for both physical and mental rehabilitation in patients. Virtual reality has also been used for supporting mental health therapy by exposing patients to experiences or illusions that are needed for the therapy being provided (Székely & Satava, 1999).

Pain associated with many different medical procedures, in some cases, has been managed by virtual reality (Li, Montañó, Chen, & Gold, 2011). The exact neurobiological mechanism of virtual reality is still unknown; however, it is hypothesized that virtual reality assumes the form of a non-pharmacological analgesic by projecting a variety of emotional affective, emotion-based cognitive, and attentional processes on the body's complex pain modulation system. Patients immersed in virtual reality in clinical settings as well as in experimental studies have shown reduced pain levels and a desire to use the programs again during painful medical procedures. There has been a considerable amount of research supporting the use of virtual reality in cases of acute pain, but the investigation of using virtual reality for

chronic pain management is still at the beginning. Since virtual reality has been so successful in the management of acute pain, more research should be done to see if virtual reality is a viable option for those dealing with chronic pain management (Li et al., 2011).

PURPOSE

The purpose of this literature review is to critically analyze published research related to the use of virtual reality and chronic pain.

METHODS

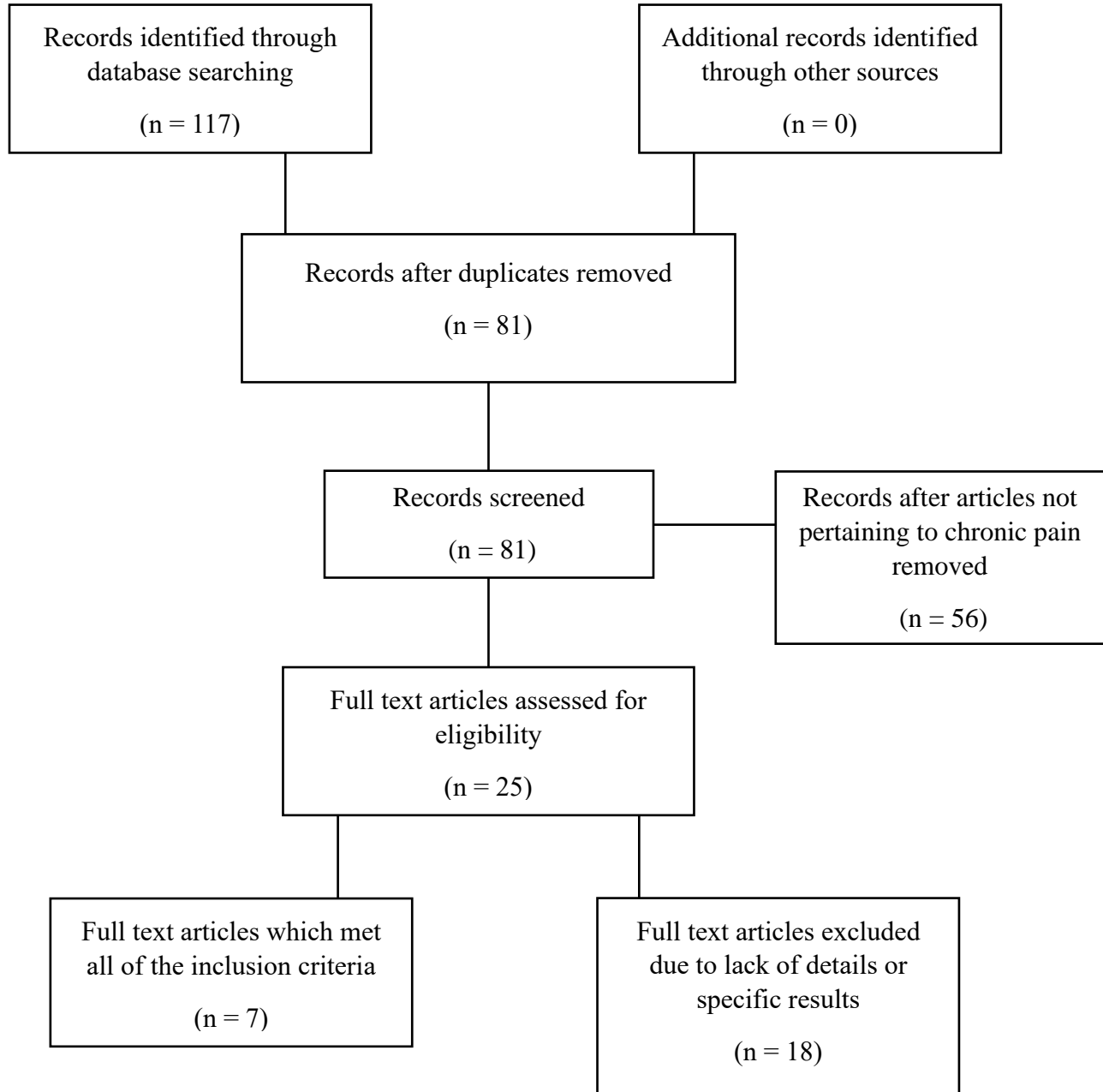
A literature review was completed by searching articles that study virtual reality in patients with chronic pain. The databases that were used for this search included Medline, CINAHL Plus with Full Text, PsycINFO, Academic Search Premiere, and Applied Science & Technology Source. The key search term utilized were “virtual reality AND chronic or persistent or long-term AND pain NOT systematic review or meta-analysis or physical therapy”. The results were limited to peer reviewed/scholarly journals that were published between 2015 and 2019. Additional inclusion criteria included articles written in English. Articles were excluded if they did not relate to chronic pain, virtual reality, and pain management.

The first search of the key word phrases yielded a total of one-hundred and seventeen articles. Once duplicate articles were removed, eighty-one remained. After carefully reviewing the eighty-one articles, fifty-six were removed since they did not pertain to chronic pain leaving a total of twenty-five. An additional eighteen articles were removed from the twenty-five due to lack of details or specific results. A total of seven articles were included in this literature review.

Figure 1: Prism Flow Diagram

Key Search Terms: virtual reality, chronic or persistent or long-term, AND pain.

Limiters: NOT systematic review or meta-analysis or physical therapy, English language, peer-reviewed and scholarly journals published between 2015-2019.



FINDINGS

Seven studies pertaining to the effects of virtual reality in regard to chronic pain were reviewed and analyzed, and although they did not contain the same systems, types of pain or study methodologies, they had similar findings. While virtual reality showed positive results in regard to chronic pain, the duration of the results varied among patients. In addition, pain was measured using different scales, treatment durations varied among different studies, and in some studies other effects were being measured in addition to chronic pain.

House et al. (2016) conducted a pilot study that explored the effects of virtual reality in twelve women with chronic postsurgical breast cancer pain. The researchers were trying to investigate the feasibility of the BrightArm Duo therapy for coping with post-surgical chronic pain and associated disability in breast cancer survivors. The BrightArm Duo Rehabilitation System monitors arm position and grasping strength while patients play integrative rehabilitation games. The system included low-friction robotic rehabilitation table, computerized forearm supports, a display, a laptop computer, a remote clinical server, and a library of integrative rehabilitation games. Nine custom games were developed to train shoulder abduction/adduction, shoulder flexion/extension, working memory, focusing, short-term visual and auditory memory, motor control, and grasp strength. The treatment consisted of two weekly BrightArm Duo Rehabilitation System sessions ranging from 20-50 minutes for a total of eight weeks. This study used a numeric rating scale of 0-10 to measure pain intensity. There was a 20% downward pain trend which equated to a downward slope of 1.1 during the eight-week protocol. Only the results of one patient proved to be statistically significant. However, the results were excluded since the patient had also reported lower back pain due to an unrelated injury.

Tsai et al. (2018) conducted a pilot study to investigate the immediate effects of virtual reality on nine patients with lower back pain. The study used Cardboard[®] which is virtual reality system glasses. Every patient participated in two types of interventions while suffering from their lower back pain. The first intervention had the participants use the virtual reality glasses to watch therapeutic exercise videos while they sat and imagined they were doing the exercises they were watching. The second intervention had the participants use virtual reality glasses to watch therapeutic exercise videos, but while sitting and resting during the video clip. A Virtual Analogue Scale (VAS) was used to measure pain before and after the interventions. The results of the study showed that there were statistically significant differences between the patients who imagined they were participating in the exercises versus those who remained at rest. Those in the first intervention had lower post-assessment VAS scores of 1.330 ± 1.414 versus those in the second intervention who had post-assessment VAS scores of 2.670 ± 1.581 . The study did not include data on the VAS scores of patients prior to beginning the exercises.

Alemanno et al. (2019) conducted a proof-of-concept study on the effect of virtual reality on twenty patients with chronic low back pain. The purpose of this study was to investigate if virtual reality can contribute to restoring correct body image, improving quality of life, reducing pain sensations, acting positively on mood, and recovering sensorimotor abilities. The study used a Virtual Reality Rehabilitation System (VRRS) by the Khymeia group that included a computer workstation, a high-resolution LCD displaying the virtual scenarios on a large screen, and a software processing the motion data. Using the VRRS, the researchers would have the participants perform specific motor tasks such as trunk rotation and flexion. The VRRS would then provide immediate visual and auditory feedback as well as measure the patient's motions. Patients participated in twelve one-hour sessions over a four to six-week period. An eleven-point

numeric rating scale was used to track the intensity of pain reported by the patients. After six weeks of treatment, there was a significant decrease in all pain scale scores going from an average of 7.5 to an average of 3.0.

Rezaei et al. (2019) conducted a randomized control study to investigate the effect of virtual reality training (VRT) versus conventional proprioceptive training (CPT) on forty-five patients with chronic neck pain. The patients were randomized and split into either a CPT or VRT group. Both studies involved two training sessions per week for four weeks. Each session lasted 21 minutes in both groups. The CPT groups training consisted of exercises including eye-follow, gaze stability, eye-head coordination, and position/movement sense practice. The VRT groups training included a video game known as Cervigame[®], a reflective marker, a head mouse extreme, and a computer. The game is made up of fifty stages divided into unidirectional and two-directional stages ordered from easy to hard. The purpose of the game is to have the patient move their head and neck in order to progress to the next level of the game. Each level had a unique invisible movement pattern for the patient. Neck pain intensity was measured using a Visual Analogue Scale from 0–100 mm anchored with “no pain” at one end and “worst pain imaginable” at the other end. There was a mean Visual Analogue Scale score improvement of 36.36 mm in the virtual reality training, but only a 19.32 mm improvement in the conventional proprioceptive training. At the 5-week follow-up appointment, the improvements were 37.54 mm and 18.78 mm, respectively. In this study, the use of Cervigame[®] significantly improved pain in patients with chronic neck pain immediately after and 5 weeks after the intervention.

Thomas et al. (2016) conducted a proof-of-concept study to investigate using virtual reality to reduce pain associated with movement and reaching tasks in fifty-two patients with chronic low back pain. The patients were randomized into either a game group or a control

group. The study used a virtual reality dodgeball intervention created on Vizard software, Samsung 3D shutter glasses, and a high definition 3D television. Patients participated in daily fifteen-minute virtual dodgeball games over a three-day span. Pain was measured using a Visual Analog Scale rating, Present Pain Intensity, and Pain Rating Index. Overall, a decrease in lower back pain was shown through all three of these pain measurement tools by the final visit of the study. Researchers found a significant reduction in pain ratings from the baseline to post-test in both groups with an average Visual Analog Score reduction of -6.7, standard deviation 7.1, and a Present Pain Intensity score average reduction of -0.4, standard deviation 0.5. However, the study also noted that the findings did not result in significant changes outside of the game environment due to the limited exposure to the intervention.

Jones, Moore, & Choo (2016) conducted a randomized control study that investigated the effects of virtual reality on thirty patients with various chronic pain conditions in an attempt to find effective adjunct or alternatives to opioid analgesics. The study used a virtual reality application called COOL! which is an interactive journey through a fully immersive 360° virtual reality fantasy landscape. Patients can control their speed, music, and interact with different aspects of the landscape as they travel through the experience. Patients participated in one five-minute session. A 0-10 visual analog scale was used to rate pain in this study. Patients were asked about their pain before the virtual reality session, during the session, and immediately after the session. The average pain rating decreased from a pre-session rating of 5.7 to a post-session rating of 4.1 resulting in a 33% decrease in pain. Additionally, the average pain rating decreased from a pre-session rating of 5.7 to during-session rating of 2.6 resulting in a 60% decrease. Researchers utilized a paired T test which found the resulting change is significant at the $p < .001$ level. Participants were additionally asked to report and rate side effects such as dizziness,

nausea, and headaches. There were no resultant effects of dizziness or headache, however, one participant with a previous history of nausea with videogames did have a minor reaction of 3/10 to the virtual reality experience.

Jones, Skadberg, & Moore (2018) conducted a pilot study to try and help guide future research in how virtual reality may positively affect chronic pain. The study included ten patients with specific types of chronic neuropathic pain including chronic regional pain syndrome, small fiber neuropathy, peripheral neuropathy, trigeminal neuralgia, and phantom limb syndrome. The study also used the virtual reality system called COOL!. Similar to the study by Jones, Moore, & Choo (2016), the COOL! system was used as a virtual reality intervention tool. In this study they used three twenty minute sessions of virtual reality offered on three consecutive weeks. The researchers measured pain, engagement, and side effects. Pain intensity was measured with a 0-10 numerical rating scale. The average pain rating decreased from a pre-session rating of 5.1 to a during-session rating of 1.8 resulting in a 65% decrease in pain. Additionally, the average pain rating decreased from a pre-session rating of 5.1 to post-session rating of 2.8 resulting in a 45% decrease. According to the researchers, there was no statistically significant data, however, there was a downward trend. Two different questions rated on a scale of 0-10 were asked regarding the participants' immersion. The results were 8.3 and 6.5 respectively indicating achieved immersion within the COOL! application. Three different questions rated on a scale of 0-10 were asked regarding side effects including nausea, dizziness, and headache. The average ratings were 0.3, 0.1 and 0.4 respectively. Patients on average felt the analgesic effects from the session for thirty hours after gameplay.

DISCUSSION

Even though the criteria for eligibility within the studies varied, all studies used patients who had some form of chronic pain. Almost all studies required the patients to have previous documentation of chronic pain. Patients in these studies participated in either therapeutic exercise videos or interactive video games in their virtual reality sessions for varying amounts of time. Virtual reality systems included Cardboard[®], COOL!, Cervigame[®], and a dodgeball program developed on Vizard. The patients were all monitored before, during, and after the virtual reality intervention.

The seven studies used a variety of methods in their research. Some used interactive videos for patients to watch while others had interactive games for patients to play. Of the research studies that utilized interactive games, there was a large variation in which gaming program was used. For example, in the Jones, Moore, & Choo (2016) and the Jones, Skadberg, & Moore (2018) studies, the researchers used the COOL! gaming system which appeared to be more interactive than the Cervigame[®] gaming system which was used in the study by Rezaei et al. (2019).

Pain was measured differently in the various studies, mostly based on the researcher's preference. While most of the studies used the Visual Analogue Scale with a range of 0-10, Rezaei et al. (2019) utilized a 0-100 range instead. Thomas et al. (2016), however, used the Present Pain Intensity Scale and the Pain Rating Index in addition to the Visual Analogue Scale. Additionally, House et al. (2016) had occupational therapists assess pain verbally at the beginning of the study while most other studies appeared to collect the data via written form.

Patients with lower back pain appeared to respond most favorably in the studies reviewed, both during and immediately post treatment. Although the studies did not include

directly comparable information to determine which of the three was the most successful, patients utilizing the dodgeball intervention created on Vizard, Cardboard[®], and VRRS showed the most statistically significant results of the seven studies reviewed. Both of the COOL! studies were also successful but were used on patients with different pain types and final results varied. The study utilizing Cervigame[®] was not directly comparable as it used a 100-point pain scale. However, it was the only study that included data that showed successful results 5 weeks after the conclusion of the treatment.

The seven research studies included a large array of sample sizes, ranging from nine patients up to as many as sixty-five patients which did not provide a lot of consistency when comparing results. The duration of treatment varied in all the studies, ranging from five minutes to an hour, which made it difficult to draw a clear conclusion as to which time frame would provide the best results for patients. In another one of the research studies, eight sessions were completed over four weeks. However, this study used a different virtual reality intervention and even though they achieve a reduction in pain, the results were not as significant as results achieved using other intervention methods making it difficult to assess whether the time period or the tool is the more important criteria. The different articles reviewed had many limitations and few commonalities. Even though the researchers analyzed pain levels using different pain scales and varying methodologies, all the studies showed a decrease in the patient's chronic pain. In addition, none of the studies showed any negative effects of virtual reality on the patient's chronic pain levels indicating that this may be successfully used as an adjunct therapy option in the future.

The research studies did not show any negative long-term effects from the use of virtual reality in the treatment of chronic pain. However, there have not been many long-term studies in

this emerging area. With more research, the efficacy of using virtual reality in managing chronic pain for patients long-term may be further explored. Although there is not enough evidence to conclude that virtual reality will definitely offer a reduction in chronic pain for all patients, I would recommend further research to explore its potential. At this early stage of research, I would not be able to recommend its usage to patients without further studies. I'm optimistic and am hopeful that researchers will have additional long-term positive outcomes for patients with chronic pain in the future.

LIMITATIONS

Despite the positive effects virtual reality has on chronic pain, there were limitations in this review of literature. To start, there were very few studies pertaining to virtual reality regarding chronic pain. This is an emerging field with researchers just now branching out to see how this can affect chronic pain, so there are very few articles that have consistent methodology, group sizes, virtual reality methods, pain measurements, and treatment. Only seven articles were reviewed and included in this review.

The researchers did not use the same virtual reality methods in their studies. Some virtual reality systems such as Cardboard[®] used therapeutic exercise videos while others had a variety of different interactive games for patients to play such as COOL!, Cervigame[®], and Vizard. Additionally, even the interactive games had a lot of variation in the types of games offered to patients. Using the same method, video, or game program would more accurately assess the effectiveness of virtual reality regarding chronic pain.

There were a number of other variations in the studies that included a variety in the duration of treatment, dissimilar sample sizes, and differences in the measurement of pain and the use of the pain scales. To better compare the effectiveness of the pain relief obtained within these studies, a similar timeframe should be considered. Having a consistent pain scale would be better for determining an average in reduction of chronic pain during these studies. Lastly, studies with larger sample sizes may find impacts that the current studies may have missed.

Despite all of these limitations, the research has shown great results in the reduction of chronic pain in patients. The consistent decrease in pain within all of these studies confirms that virtual reality is beneficial to patients in chronic pain.

NURSING IMPLICATIONS

One of a nurse's primary roles is to provide proper education and potential options to their patients. As a result, nurses should be educated on the different virtual reality programs and chronic pain management tools offered. This may also include at home options, in addition to formal programs, once more research has been completed to determine the effectiveness of available devices. Currently, nurses may only have exposure to these programs if they are supporting one of the research programs in this emerging area. Any formal training opportunities and education would be through exposure to those studies. However, outside of these studies, if a nurse wanted to examine this area further, nurses would need to do their own individual exploration or contact researchers in order to investigate potential adjunct therapy possibilities

Knowledgeable nurses can properly educate their patients on different options that may be available to their patients, including this emerging technology. If a nurse is working with one of the virtual reality systems, they would also have the responsibility of learning how to use the programs correctly as well as being able to ask the proper follow up questions to confirm a patients' understanding of the virtual reality tools. As one of the studies indicated, the way the patients use certain virtual reality programs can directly effect the results of the program.

Although most patients had no negative side effects in these studies, some patients did experience motion sickness including nausea, dizziness, and headache. Nurses need to also be familiar with the potential side effects from virtual reality programs and treatment options for patients, pre- and post-session. This will allow them to recommend a program that is less likely to cause side effects to a patient who is prone to them as well as to treat the patient in the event that side effects occur. For example, if treating a patient who is prone to motion sickness, a nurse

may recommend a slower pace virtual reality program such as COOL! which provides the patient with a fully immersive 360° virtual reality fantasy landscape in which the pace could be adjusted.

RESEARCH IMPLICATIONS

Even though within these studies virtual reality has shown positive effects in reducing chronic pain, more rigorous research needs to be completed to increase confidence of use in larger patient populations. Some of the applications used have shown positive results and should be explored in more depth, with larger sample sizes, increased duration, and perhaps a variation in chronic pain types to determine if the applications that have been developed can in fact be successful in the treatment of chronic pain. It may also be that more specific research needs to be completed in order to confidently recommend virtual reality to different types of chronic pain. Regardless, it would be beneficial for virtual reality interventions to offer more than just an analgesic effect. For example, implementation of a specific skill training to the type of chronic pain the system is addressing could make a difference and increase a nurse's confidence in recommending virtual reality as an intervention for patients in chronic pain.

In new research studies, another opportunity would be to determine optimal session times to achieve ideal results. This may vary by chronic pain type and by type of virtual reality program used. Once those variables have been established, researchers should vary the length of the treatment sessions, the number of sessions and the frequency of sessions to determine how to produce the most statistically significant long-term reduction of chronic pain for the virtual reality program used. These studies should then be repeated in multiple groups to ensure that the results are repeatable.

Future research studies could implement at home sessions of virtual reality to track usage over longer periods of time. With that being said, the tools used in some of the current studies are not practical for home use due to expense. Instead, researchers could have patients use home base virtual reality tools such as Google Daydream which interacts with a patient's smartphone

via a headset. Perhaps repeated daily virtual reality sessions could provide analgesic effects for patients which would provide a continued benefit for chronic pain management. The research on management of chronic pain using virtual reality is still at the very beginning. To truly unlock its potential for use, future meticulous research should be completed that is detailed, consistent, and controlled.

CONCLUSION

Many patients suffer from chronic pain due to an ineffective pain management regimen or a lack of consistent treatment (Jones, Skadberg, & Moore, 2018). Pharmacological use on its own is not currently effectively managing patients' chronic pain. Virtual reality has the potential to help a multitude of patients in chronic pain. Via the research studies in this literature review, results have shown positive effects in chronic pain reduction. Since virtual reality in regard to chronic pain is still at its infancy, more rigorous research needs to be completed to be able to confidently recommend it for further use in chronic pain management.

APPENDIX: TABLES

Table 1: Table of Evidence

Articles	Participants and Study Design	Intervention Detail	Outcome Measures	Results (Key Findings)	Nursing Implications
<p>House, G., Burdea, G., Grampurohit, N., Polistico, K., Roll, D., Damiani, F., Hundal, J., & Demesmin, D. (2016). A feasibility study to determine the benefits of upper extremity virtual rehabilitation therapy for coping with chronic pain post-cancer surgery. <i>British Journal of Pain</i>, 10(4), 186 –197.</p>	<p>Participants: Twelve female subjects with breast cancer postsurgical chronic pain, who were out-patients at the University Pain Medicine Center (Somerset, NJ), volunteered and signed an informed consent. Six of the twelve did not complete the study. Data presented here was generated by the remaining six subjects who completed the experiment. The participants had to be age 22 and up, minimal to severe depression, on regular pain medication and presenting with UE impairments.</p>	<p>The intervention was the BrightArm Duo Rehabilitation System which included a low-friction robotic rehabilitation table, computerized forearm supports, a display, a laptop computer for the therapist station, a remote clinical server and a library of custom integrative rehabilitation games. Therapy sessions progressed from 20 to 50 minutes of training over a period of 8 weeks, with two sessions every week.</p>	<p>The study used an ABAA protocol, with data being collected pre-training (A), during training (B), post training (A) and at 8-week follow-up (A). Therapy session data (B) consisted of supported arm reach baseline on the BrightArm Duo table, power grasp strength baseline, heart rate and blood pressure, number of active movements and grasp repetitions for each arm during a session collected during play. Pain was assessed using the NRS administered verbally by the attending OT. 20 At</p>	<p>In this study, the pain intensity measured using the NRS showed a 20% downward trend ($p = 0.1$).</p> <p>Immersion in VR two times a week for an 8-week protocol reduced depression an average of 8.3 points in this study ($p = 0.04$) as measured by the BDI-II.</p>	<p>This study provides evidence that virtual reality therapy can be used as an adjunct treatment to help with chronic pain management.</p>

	Pilot study with convenient sample. Quantitative.		the end of weeks 4 and 8 of VR training, the subjects rated their experience on a custom paper-based subjective evaluation questionnaire.		
Jones, T., Skadberg, R., & Moore, T. (2018). A pilot study of the impact of repeated sessions of virtual reality on chronic neuropathic pain. <i>The International Journal of Virtual Reality</i> , 18(01), 19-34.	A total of ten subjects comprised the study sample. Participants had to be at least 18 years old, must not be visually or hearing impaired, had to be an active patient at the pain practice, had to have had an initial psychological assessment, and had to have been assessed at the initial psychological assessment as having sufficient cognitive faculties to give informed consent. They also needed to have a primary diagnosis involving a	The study used three 20-minute sessions of VR using the application COOL! as the intervention. These were offered on three consecutive weeks.	Data was gathered about the subject's pain after each of these sessions and one week after the third VR session. These data gathering points were termed "Time 1," "Time 2," "Time 3," and "Time 4." A packet of psychology assessments was administered before the first VR session (Time 1) and one week after the third VR session (Time 4).	Analysis of the data here finds that the subjects reported significant analgesia during and immediately after the VR session. The average decrease in pain during the session was 65% and the average decrease in pain immediately after the session was 45%.	Evidence from this article proves that virtual reality can cause analgesic effects on those with chronic pain both while actively participating and in some cases after the session is over up to 30 hours.

	<p>neuropathic pain condition.</p> <p>Pilot study with convenient sample. Quantitative.</p>				
<p>Tsai, Y.W., Hsu, H.H., Hou, Y.R., Chiu, Y.L., & Sung, W.H. (2018). Immediate effects of virtual reality mental practice in subjects with low back pain: A pilot study. <i>Abstracts / Annals of Physical and Rehabilitation Medicine</i> 61S, 435–557.</p>	<p>Nine subjects suffered from LBP were recruited. Two males and seven females, age = 33.670 ± 16.560</p> <p>Pilot study with convenient sample. Quantitative.</p>	<p>Each subject had two types of intervention while suffering from pain, one was using VR glasses (Cardboard®) to watch LBP therapeutic exercise video while sitting and asked them to imagine they were doing the exercise shown in the video (VRMP); the other type asked patients to rest as the video clip played (Rest). The sequence of two types of intervention was assigned randomly.</p>	<p>Before and after intervention, Visual Analogue Scale (VAS), range of motion (ROM), Oswestry disability index (ODI) and Fear avoidance beliefs questionnaire (FABQ) were assessed. The data was analyzed by paired t-test and statistical significance was set as $\alpha < 0.05$.</p>	<p>Before interventions, all assessments had no significant differences between VRMP and Rest. After VRMP intervention, VAS, FABQ, ODI and ROM (extension and side bending) showed significant improvements, but there were no significant differences found in Rest. However, in post-assessments, only VAS (VRMP 1.330 ± 1.414 vs. Rest</p>	<p>Results from this study showed that virtual reality had immediate effects on pain relief with those who suffer from low back pain.</p>

				2.670±1.581, P=0.042) and FABQ (VRMP 26.000±17.270 vs. Rest 32.670±11.916, P=0.029) had significant differences between two types of intervention.	
Alemanno, F., Houdayer, E., Emedoli, D., Locatelli, M., Mortini, P., Mandelli, C., Raggi, A., & Iannaccone, S. (2019). Efficacy of virtual reality to reduce chronic low back pain: Proof-of-concept of a nonpharmacological approach on pain, quality of life, neuropsychological and functional outcome. <i>PLoS ONE</i> 14(5). doi: 10.1371/journal.pone.0216858	Twenty patients were included in this study. Exclusion criteria were: (1) systemic metabolic disorder, (2) neurological or muscular degenerative disorder, (3) systemic infection, (4) cardiopulmonary or pulmonary disorder with contraindication to physical exercise, (5) recent spinal surgery (<12 months), (6) spinal pathologies such as stenosis or	Patients participated in twelve sessions of 1 hour each, over a period of 4 to 6 weeks. Treatments consisted in virtual reality-based sensorimotor rehabilitation provided by the Virtual Reality Rehabilitation System (VRRS) of the Khymeia group.	Pre and post values of all the pain ratings, neuropsychological and functional assessments were compared using either Student's t-test for paired values or Wilcoxon test, depending on the normality of data distribution, as evaluated by the Shapiro-Wilk test. Correlations between improvements in pain and/or neuropsychological and functional	After six weeks of treatment, significant decreases were observed for all pain scores. This decreased pain sensation was also accompanied by improvements in QoL, in some cognitive functions and sensorimotor output.	In this study, there is evidence on the fact that virtual reality can be efficient in reducing pain sensation and improving their quality of life.

	<p>spondylolisthesis or fracture, (7) acute radiculopathy or compromised nerve root, (8) pregnancy.</p> <p>Single-armed study/proof of concept study. Quantitative.</p>		<p>scores (measured as differences between pre and post values) were tested using Pearson and Spearman correlations, depending on the data distribution. Data were considered significant when $p < 0.05$. The commercially available software IBM SPSS Statistics v.23 (IBM Corp.) was used for all statistical tests.</p>		
<p>Rezaei, I., Razeghi, M., Ebrahimi, S., Kayedi, S., & Rezaeian-Zadeh, A., (2019). A novel virtual reality technique (Cervigame®) compared to conventional proprioceptive training to treat neck pain: A randomized controlled trial. <i>J Biomed Phys Eng</i>, 9(3), 355-366.</p>	<p>Forty-four patients were included in this study. A history of nontraumatic NP for more than three months and age between twenty and fifty-five years. They needed to score a ≥ 15 and ≤ 9 (out of possible 50) on Neck Disability Index (NDI), history of cervical and</p>	<p>Patients participated in a novel videogame called Cervigame® designed for virtual reality therapy. It is comprised of 50 stages divided into unidirectional and bi-directional stages ordered from easy to hard.</p>	<p>Visual analogue scale score, neck disability index and Y-balance test results were recorded at baseline, immediately after and 5 weeks post-intervention. Mixed repeated measure ANOVA was used to analyze differences between</p>	<p>There were significant improvements in all variables in both groups immediately after and 5 weeks after the intervention. Greater improvements were observed in the visual analogue scale</p>	<p>The evidence from this study shows that virtual reality is not only an effective method of pain management, but also more effective than conventional proprioceptive training in regard</p>

	<p>thoracic trauma within the 6 months before examination, neurological signs and symptoms in the upper extremities, nerve injury, spinal cord compression, cervical spine pathology or surgery and cancer.</p> <p>Randomized control study. Quantitative.</p>	<p>CPT consisted of eye-follow, gaze stability, eye-head coordination and position and movement sense training. Both groups completed 8 training sessions over 4 weeks.</p>	<p>mean values for each variable at an alpha level of 0.05.</p>	<p>and neck disability index scores in VRT group, and the results for all directions in Y-balance test were similar in both groups. Improvements in neck pain and disability were greater in VRT than CPT group.</p>	<p>to chronic neck pain.</p>
<p>Thomas, J., France, C., Applegate, M., Leitkam, S., & Walkowski, S., (2016). Feasibility and safety of a virtual reality dodgeball intervention for chronic low back pain: A randomized clinical trial. <i>J Pain</i>. 17(12), 1302–1317. doi:10.1016/j.jpain.2016.08.011.</p>	<p>Fifty-two participants with chronic low back pain and high fear of movement were included in this study. They were randomized to either a game group (n=26) or a control group (n=26). All participants completed a pregame baseline and a follow up assessment (4–6 days later) of lumbar spine motion and</p>	<p>For three consecutive days, participants in the game group completed 15 minutes of virtual dodgeball between baseline and follow up.</p>	<p>Movement of light-reflective marker clusters attached to the head, upper arms, forearms, hands, trunk, pelvis, thighs, shanks, and feet were tracked using a 10 camera Vicon Bonita system sampled at 100Hz using TheMotion-Monitor software (Innovative Sports Training, Inc., Chicago, IL).</p>	<p>The virtual dodgeball was effective at increasing lumbar flexion within and across gameplay sessions. Participants reported strong positive endorsement of the game, no increases in medication use, pain, or disability, and no adverse events.</p>	<p>The results of this study demonstrate that virtual dodgeball is safe and feasible. The program was also capable of shaping changes in lumbar spine flexion during gameplay which in extended sessions could make a positive change for other patients with</p>

	<p>expectations of pain and harm during standardized reaches to high (easier), middle, and low (hardest to reach) targets.</p> <p>Proof of concept study. Quantitative.</p>				chronic low back pain.
<p>Hua, Y., Qui, R., Yao, W., Zhang, Q., & Chen, X, (2015). The effect of virtual reality distraction on pain relief during dressing changes in children with chronic wounds on lower limbs. <i>Pain Management Nursing</i>, 16(5), 685-691. doi: https://doi.org/10.1016/j.pmn.2015.03.001</p>	<p>Sixty-five children from ages 4-16 with chronic wounds on their lower limbs participated in this study.</p> <p>Prospective randomized study. Quantitative.</p>	<p>On a Lenovo-Y430p laptop, a Chinese version of Ice Age 2: The Meltdown game was used to achieve virtual distraction during dressing changes.</p>	<p>Using the Wong-Baker Faces picture scale, visual analogue scale, and behavior scale, pain and anxiety scores were measured during dressing changes.</p>	<p>The results of the study showed that the virtual reality distraction device significantly alleviated pain experience of the participants before, during, and after dressing changes as compared to standard distraction methods. In addition, the amount of time it took for dressing changes was reduced in the</p>	<p>In this study, the use of virtual reality as a distraction tool offered better pain reduction to the participants as compared to standard distraction methods. This shows that virtual reality can potentially improve clinical efficiency by reducing pain and time of dressing changes.</p>

				virtual reality distraction group.	
Jones, T., Moore, T., & Choo, J. (2016). The impact of virtual reality on chronic pain. <i>PLoS ONE</i> , 11(12), 1-10. doi:10.1371/journal.pone.0167523	<p>Participation in the study was voluntary and had no bearing on the patient's pain treatment. To qualify for the study, participants had to be at least 18 years old, must not be visually or hearing impaired, had to be an active patient at the pain practice, had to have had an initial psychological assessment, and assessed at the initial psychological assessment as having sufficient cognitive faculties to give informed consent. Thirty participants were included in this study.</p> <p>Randomized control study. Quantitative.</p>	The VR application used in this study is called COOL!. COOL! is an interactive journey through a fully immersive 360° VR fantasy landscape. Participants were taken along a route through a virtual landscape.	Participants were asked about their pain using a 0–10 visual analog scale rating before the VR session, during the session and immediately after the session.	Pain was reduced from pre-session to post-session by 33%. Pain was reduced from pre-session during the VR session by 60%. Three participants (10%) reported no change between pre and post pain ratings. Ten participants (33%) reported complete pain relief while doing the virtual reality session. All participants (100%) reported a decrease in pain to some degree between pre-session pain and during-session pain.	The results from this study confirms that virtual reality seems to have promise as a non-opioid treatment for chronic pain.

REFERENCES

- Alemanno, F., Houdayer, E., Emedoli, D., Locatelli, M., Mortini, P., Mandelli, C., Raggi, A., & Iannaccone, S. (2019). Efficacy of virtual reality to reduce chronic low back pain: Proof-of-concept of a nonpharmacological approach on pain, quality of life, neuropsychological and functional outcome. *PLoS ONE* 14(5). doi: 10.1371/journal.pone.0216858
- Chen, K., Sesto, M., Ponto, K., Leonard, J., Mason, A., Vanderheiden, G., Williams, J., & Radwin, R., (2017). Use of virtual reality feedback for patients with chronic neck pain and kinesiophobia. *IEEE Transactions on Neural Systems and Rehabilitation Engineering* 25(8), 1240-1248.
- Cipresso, P., Giglioli, I. A. C., Raya, A., & Riva, G. (2018). The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. *Frontiers in Psychology* 9, 2086. doi: 10.3389/fpsyg.2018.02086
- Cleveland Clinic. (2017). *Acute vs. chronic pain*. Retrieved July 4th, 2019, from <https://my.clevelandclinic.org/health/articles/12051-acute-vs-chronic-pain>
- Dahlhamer, J., Lucas, J., Zeleya, C., Nahin, R., Mackey, S., DeBar, L., Kerns, R., Von Korff, M., Porter, L., & Helmick, C. (2018). Prevalence of chronic pain and high-impact chronic pain among adults – United States, 2016. *Morbidity and Mortality Weekly Report*, 67(36), 1001-1006. doi: <http://dx.doi.org/10.15585/mmwr.mm6736a2>
- House, G., Burdea, G., Grampurohit, N., Polistico, K., Roll, D., Damiani, F., Hundal, J., & Demesmin, D. (2016). A feasibility study to determine the benefits of upper extremity virtual rehabilitation therapy for coping with chronic pain post-cancer surgery. *British Journal of Pain*, 10(4), 186–197.

- Hua, Y., Qui, R., Yao, W., Zhang, Q., & Chen, X., (2015). The effect of virtual reality distraction on pain relief during dressing changes in children with chronic wounds on lower limbs. *Pain Management Nursing*, 16(5), 685-691. doi: <https://doi.org/10.1016/j.pmn.2015.03.001>
- Garrett, B., Taverner, T., & McDade, P. (2017). Virtual reality as an adjunct home therapy in chronic pain management: An exploratory study. *JMIR Medical Informatics*, 5(2), 17-28. doi: 10.2196/medinform.7271
- Gaskin, D. & Richard, P. (2011). The economic costs of pain in the United States. In Institute of Medicine (US) Committee on Advancing Pain Research, Care, and Education. *Relieving pain in America: A blueprint for transforming prevention, care, education, and research (301-337)*. Washington (DC): National Academies Press (US).
- Jones, T., Moore, T., & Choo, J. (2016). The impact of virtual reality on chronic pain. *PLoS ONE*, 11(12), 1-10. doi:10.1371/journal.pone.0167523
- Jones, T., Skadberg, R., & Moore, T. (2018). A pilot study of the impact of repeated sessions of virtual reality on chronic neuropathic pain. *The International Journal of Virtual Reality*, 18(01), 19-34.
- Keefe, F. J., Huling, D. A., Coggins, M. J., Keefe, D. F., Rosenthal, M. Z., Herr, N. R., & Hoffman, H. G. (2012). Virtual reality for persistent pain: A new direction for behavioral pain management. *In Pain*, 153(11), 2163-2166.
- Li, A., Montañó, Z., Chen, V. J., & Gold, J. I. (2011). Virtual reality and pain management: Current trends and future directions. *Pain Management*, 1(2) 147–157. doi: 10.2217/pmt.10.15

- Lewei, L. A., Bohnert, A. S. B., Jannausch, M., Goesling, J., & Ilgen, M. A. (2018). Brief report: Use of non-pharmacological strategies for pain relief in addiction treatment patients with chronic pain. *The American Journal on Addictions, 26*, 564–56. doi: 10.1111/ajad.12600
- Merriam-Webster. (2019). *Virtual reality*. Retrieved July 5th, 2019, from <https://www.merriam-webster.com/dictionary/virtual%20reality>
- Pozeg, P., Pallue, E., Ronchi, R., Solca, M., Al-Khodairy, A., Jordon, X., Kassouha, A., & Blanke, O. (2017). Virtual reality improves embodiment and neuropathic pain caused by spinal cord injury. *Neurology, 89*, 1894-1903. doi: 10.1212/WNL.0000000000004585
- Rezaei, I., Razeghi, M., Ebrahimi, S., Kayedi, S., & Rezaeian-Zadeh, A., (2019). A novel virtual reality technique (Cervigame®) compared to conventional proprioceptive training to treat neck pain: A randomized controlled trial. *J Biomed Phys Eng, 9*(3), 355-366.
- Székely, G. & Satava, R. M. (1999). Virtual reality in medicine. *The BMJ, 319*(7220), 1305. doi: 10.1136/bmj.319.7220.1305
- Thomas, J., France, C., Applegate, M., Leitkama, S., & Walkowski, S., (2016). Feasibility and safety of a virtual reality dodgeball intervention for chronic low back pain: A randomized clinical trial. *J Pain. 17*(12), 1302–1317. doi:10.1016/j.jpain.2016.08.011.
- Trost, Z. & Parsons, T. D. (2014). Beyond distraction: Virtual reality graded exposure therapy as treatment for pain-related fear and disability in chronic pain. *Journal of Applied Biobehavioral Research, 19*(2), 106-126.
- Tsai, Y.W., Hsu, H.H., Hou, Y.R., Chiu, Y.L., & Sung, W.H. (2018). Immediate effects of virtual reality mental practice in subjects with low back pain: A pilot study. *Abstracts / Annals of Physical and Rehabilitation Medicine 61S*, 435–557.

Wilson, A. S., Ramesh, A., Carruthers, D., & O'Connor, J. (2018). A prototype virtual reality rehabilitation game for complex regional pain syndrome. *Proceedings of the European Conference on Games Based Learning*, 745-753.