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Virtual reality as a distraction technique for pain and anxiety among patients with breast cancer: A randomized control trial

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Original Article

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Abstract

Objective. The goal of this study was to assess the effectiveness of immersive virtual reality (VR) distraction technology in reducing pain and anxiety among female patients with breast cancer.

Method. A randomized control trial design was used with a sample of 80 female patients with breast cancer at a specialized cancer center in Jordan. Participants were randomly assigned into intervention and comparison groups.

Result. The study findings showed that one session of the immersive VR plus morphine made a significant reduction in pain and anxiety self-reported scores, compared with morphine alone, in breast cancer patients.

Significance of results. Immersive VR is an effective distraction intervention for managing pain and anxiety among breast cancer patients. Using immersive VR as an adjuvant intervention is more effective than morphine alone in relieving pain and anxiety; furthermore, VR is a safe intervention more than pharmacological treatment.

Introduction

Breast cancer is the most common cancer among females worldwide (McGuire et al., 2015; Siegel et al., 2016). Cancer patients suffer from a large number of intense physical and psychological symptoms, including pain and anxiety, which are accompanied by declines in physical and psychological health regardless of the stage of the disease (Sivabalan & Upasani, 2016). In about 50% of cancer patients who are in pain, few of the available painkillers achieve adequate pain relief (Wiederhold et al., 2014).

Inadequate treatment for pain among adult patients with cancer leads to health deterioration and difficult cancer treatment (Ahmad et al., 2010). Unfortunately, according to the Jordan Initiative for Pain Management in 2010, about 50% of patients with cancer complained of constant pain. Ovayolu et al. (2013) showed that cancer pain is complex and has multidimensional behavioral, emotional, cognitive, and sensory components. Recently, pain management research started to give more attention to nonpharmacological interventions (Ahmad et al., 2015; Shahrbanian et al., 2009).

Cancer pain management includes pharmacological and nonpharmacological methods (Portenoy, 2011). First, pharmacological pain management involves the use of medications, either alone or in combination with other types of therapy. Three main classes of medication include nonopioid, adjuvant analgesics, and opioid. Opioid types include morphine, which is the most commonly used medication for moderate and severe cancer pain; at the same time, moderate to severe pain is the most common among cancer patients, and about 70–80% of patients with advanced disease are affected by moderate to severe pain (Caraceni et al., 2012). Other opioids used include pethidine, fentanyl, codeine, oxycodone, hydromorphone, methadone, and tramadol. The side effects of opioids include constipation, which is the most common, nausea and vomiting, dry mouth, respiratory depression, sedation, hallucination, drowsiness, urticaria, pruritus, and myoclonic jerking (Ferrell et al., 2015). Second, nonpharmacological interventions have two classifications. The first is the peripheral therapies that have physical agents such as hot-cold treatment, transcutaneous electrical nerve stimulation, acupuncture, acupressure, massage, hydrotherapy, and exercise. The second classification is cognitive-behavioral therapies such as relaxation, meditation, praying, yoga, hypnosis, biofeedback, and distraction (Demir, 2012). Furthermore, it is important that analgesics should be given on a regular basis and according to the World Health Organization ladder. The World Health Organization introduced the analgesic ladder in 1986, and it includes a three-step methodology for the use of pharmacological agents corresponding with the pain's severity as described by the patients as mild, moderate and sever pain (World Health Organization, 2017).

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According to Merriam-Webster (2017), distraction is something that entertains a person and makes it hard for that person to pay attention or think about problems or pains. Furthermore, distraction is a simple nonpharmacological technique that does not need any specific training and can be implemented by nurses (Buratt et al., 2015). Additionally, distraction reduces the perception of pain by altering the nociceptive responses (Haraldstad et al., 2011).

Anxiety is an emotion characterized by subjectively unpleasant feelings of worries over anticipated events or future threats, such as the feeling of imminent death (Davison & Gerald, 2008). In 2015, Ferrell et al. defined anxiety as "a vague, subjective feeling of apprehension, tension, insecurity, and uneasiness, usually without a known, specific cause identifiable by the individual" (p. 394). Anxiety is classified into state anxiety, which is related to a temporary condition, and trait anxiety, which has a long-standing quality (Spielberger, 2012). Anxiety among cancer patients could arise from different reasons such as a reaction to cancer diagnosis, severe pain, long-term treatments, treatment's side effects, and feeling of burden or dependence on others (Arrieta et al., 2013; Lim et al., 2011). Furthermore, anxiety results from failure to control the adverse effects of cancer treatments that are available in Jordan, and among patients who had little or no control over their health (Omran et al., 2012). Anxiety has negative effects on the treatment of cancer patients (Beikmoradi et al., 2015), which leads to delay in patients' healing. For that, anxiety relief for cancer patients should be started immediately after cancer diagnosis and continued until the end of the treatment, with follow-up to support treatment progression (Khan et al., 2010). Spencer et al. (2010) found that anxiety relief among cancer patients can improve their interaction with family, caregivers, and friends, with improvement in their social, cognitive, and emotional functions.

Anxiety treatment of cancer patients can use pharmacological and nonpharmacological methods, however (Ferrell et al., 2015). The use of benzodiazepine drugs to treat anxiety has side effects, including the potential to create tolerance, dependence, and drug interactions. For that reason, nonpharmacological interventions for anxiety treatment were deemed safer (Platt et al., 2016).

Nonpharmacological anxiety-relieving methods include exercising, deep breathing, imagery, and relaxation techniques (Ferrell et al., 2015). The use of distraction was effective in reducing anxiety (Hudson et al., 2015). According to Cherry and Jacob (2016), new clinical treatments emphasize the use of nonpharmacological approach with nursing care to support healing through improving cancer patients' social, cognitive, and emotional functions.

Virtual reality (VR) technology is a form of distraction defined as a noninvasive simulation technology with the three dimensions of width, height, and depth that were generated digitally in a computer-generated environment that allows a user to interact with it (Moskaliuk et al., 2010). VR systems are categorized into two types, the immersive and nonimmersive (Chirico et al., 2016). Immersive VR is characterized by full immersion, which is reached by a head-mounted display, and distracts the patient by presenting them with a view of a computer-generated world instead of the real world (Chirico et al., 2016). In 2008, Jennett et al. defined immersion as a "lack of awareness of time, a loss of. The nonimmersive type is characterized by computer screen where the user can communicate with the external world at the same time he is connected to the virtual world (Chirico et al., 2016)."

VR was helpful in drawing patients' attention away from mental processing and to decrease the amount of pain (Wiederhold et al., 2014). VR as a distraction technique was effective in decreasing pain and anxiety among burn injury patients undergoing wound dressing changes and physiotherapy management (Morris et al., 2009). Virtual reality is also used during chemotherapy infusion to relieve cancer discomfort (Chirico et al., 2016). The immersive VR technology acts as a nonpharmacologic type of analgesia throughout a collection of emotional-affective, emotion-based cognitive, and attentional processes in the body-involved pain modulation system (Li et al., 2011).

The purposes of this study were as follows. (1) compare the pain score between patients receiving standard care, which includes pharmacological interventions (oral or intravenous morphine) alone, with patients receiving standard care plus VR technology among females who are diagnosed with breast cancer with chronic pain. (2) Compare anxiety level between patients receiving standard care, which includes pharmacological interventions (oral or intravenous morphine) alone, with patients receiving standard care plus VR technology among females who are diagnosed with breast cancer with chronic pain.

Methods

Design and setting

A randomized control trial design was used in this study. Participants were recruited from specialized cancer center in Jordan in the medical and surgical wards. The setting is a comprehensive cancer center and a model for palliative care and pain relief in the Middle East.

Sample

The sample size was calculated using the G. Power program for the independent sample *t* test (Faul et al., 2007). Based on a significance level of 0.05, medium effect size 0.5, and power of 0.80, a minimum of 34 participants per group was needed.

This study included 80 female patients (40 in each group) with breast cancer. Four patients refused to participate for reasons such as having no time and not interested; thus, the response rate was 95%. Random assignment was done based on flipping coin; if heads, then the first participant would be placed in the intervention group. The rest of the participants were placed in the study groups by the order of meeting the eligibility criteria.

Instruments

Pain measurement

A visual analog scale (VAS) was used to measure pain; it was a 10-cm scale considered to evaluate the patients' pain intensity, with the anchors from no pain (0) to the worst possible pain (10) (Gagnon et al., 2013). The VAS is a valid and reliable measurement of pain intensity among patients with cancer (Jensen, 2003).

Anxiety measurement

The State Anxiety Inventory (SAI) is a valid and commonly used measure for anxiety (Balsamo et al., 2013). Patients' anxiety levels were measured using the SAI for adults (Spielberger et al., 1983). The SAI includes 20 items; each item is scored on a 4-point Likert scale (1 = almost never, 2 = occasionally, 3 = most

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of the time, and 4 = almost always). The SAI range of total scores is between 20 and 80, with the higher score indicating more anxiety (Beikmoradi et al., 2015). The State Anxiety Scale, rather than trait anxiety, was used in this study because it evaluates the current feeling of anxiety by using items that measure subjective feelings of apprehension, tension, nervousness, worry, and activation/arousal of the autonomic nervous system (Julian, 2011).

The cognitive function was assessed by the principal investigator (PI) using the Mini-Mental State Examination (MMSE). The Arabic version of the MMSE was validated in a study that screened for cognitive impairment among hospitalized adults (Wrobel & Farrag, 2012). The MMSE takes only 5 to 10 minutes to use and includes 11 questions. The maximum score is 30; a score of ≤23 means there is a cognitive impairment (Kurlowicz & Wallace, 1990).

Data collection procedure

Data collection was expanded over 4 months. The inclusion criteria were: being a female patient diagnosed with breast cancer, age between 18 and 70 years, having chronic pain, able to read and write, having no clinical evidence of primary or metastatic disease to the brain or history of seizure, no history of motion sickness, on intravenous morphine or oral analgesics, no significant hearing or visual impairments, and cognitively able to participate. The eligibility criteria were explained to the head nurses in the study setting, which helped in referring patients to the PI of the study.

Before starting data collection, the PI visited the cancer center to determine the most common type of painkiller used with cancer patients, which was morphine; then, the peak time of the effects of this painkiller was used to determine the time-point for anxiety and pain reassessment. Based on the literature, the peak effect for oral morphine occurs within 30 minutes and the peak effect for intravenous morphine occurs within 20 minutes (Trescot et al., 2008).

The study was then explained to the participants by providing information about VR for the intervention group only. When the approached patients agreed to participate, patients' cognitive function was assessed by the PI using the MMSE. Furthermore, to determine the patients in pain, different readings from the patient's profile were taken to expect the time of pain starting for patients with chronic pain. The majority of the participants ($n = 61$, 76%) were in the second and third stages of cancer.

The intervention group chose from two scenarios on a CD-ROM, which included deep sea diving "Ocean Rift," or sitting on the beach with the "Happy Place" track (Chirico et al., 2016). The scenarios were assessed in a pilot study to determine if they were comfortable and clear. Then, the patients wore a head-mounted display with headphones. The PI remained near the participants during the VR session. The VR exposure session was ended at the peak time of painkiller efficacy. The reason for selecting the peak time was to standardize the time of reassessing pain and anxiety level.

The data were collected by the PI using the VAS to determine pain level and the SAI to assess anxiety level. For more accuracy, pain and anxiety ratings were assessed at two points of time for each group as follows: For the intervention group, exactly before giving the morphine and after finishing the VR session (which started exactly at the peak time effect for 15 minutes), which means that the reassessment was done 15 minutes from the peak time effect. The assessment for the comparison group was done just before giving the morphine and at 15 minutes after the peak time effect.

Ethical considerations

Approvals from the ethics committees and the relevant hospitals were obtained. A consent form was signed by each participant. Permission was sought from the participants to obtain access to the data in their medical records, which included information about the cancer type, stage, time since diagnosis, and painkiller type and route. Furthermore, the participants in the control group were given the opportunity to use VR after they completed their role in the study.

Results

The Statistical Package for the Social Sciences 21 program (IBM Corporation, 2012) was used to manage the data. Fifty-five participants (68.8%) were receiving intravenous painkillers, whereas the rest had oral painkillers. The mean for painkiller dose in the intravenous route was 4.24 mg ($SD = 2.42$), ranging from 1 to 10 mg; the mean for pain killer dose in the oral route was 22.6 mg ($SD = 9.70$), ranging from 5 to 30 mg.

Patients' characteristics

The participants' mean age was 51.99 years ($SD = 10.34$), with a range from 30 to 70 years. There was no significant difference in the time since diagnosis ($p = 0.34$), morphine dose ($p = 0.11$), treatment type ($p = 0.06$), marital status ($p = 0.15$), educational level ($p = 0.16$), and cancer stage ($p = 0.64$) between the intervention and comparison groups. There was no significant difference in pain score and anxiety score preintervention between the two groups (Table 1).

The independent sample t test showed a significant difference postintervention between the two groups' pain scores. The intervention group mean was 0.33 ($SD = 0.82$), and the control group mean was 4.84 ($SD = 2.57$) ($t = -9.19$, $p < 0.001$). The paired sample t test also showed a significant difference in the means of pain scores at the pre- and posttest in intervention group and the control group (Table 2).

Regarding the anxiety testing, the independent sample t test showed a significant difference postintervention between the two groups. The intervention group mean was 37.68 ($SD = 3.80$); the control group mean was 50.13 ($SD = 9.32$) ($t = -7.83$, $p < 0.001$). The paired sample t test for testing anxiety levels showed a significant difference in the mean scores at the pre- and posttest in intervention group and the control group (Table 3).

Although we could not pinpoint the exact reason VR brought about pain relief, we assumed that it was that patients' attention was focused on the game, and that the game brought about feelings of joy.

Discussion

Although the benefits of VR are well recognized in the literature, there is limited knowledge at national and international levels on the effects of VR technology on pain and anxiety among female patients with breast cancer. We agree with Chirico et al. (2016) in their argument that VR worked because pain requires conscious attention. Being transferred into another world with VR draws the patient's attention, leaving less attention available to process pain signals. We assume that the patient's attention in our study was focused on the chosen scenario track, which brought feelings of joy. This is important in the Arab world

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Table 1. Comparison of patients' characteristics according to group membership

Item	Category	Intervention group, frequency	Comparison group, frequency	Statistical test	*p* value
Monthly income	≤500 JD	25	33	Chi-square	0.08
	>500 JD	15	7		
Employment status	Not employed	31	34	Chi-square	0.57
	Employed	9	6		
Painkiller route	Intravenous	30	25	Chi-square	0.23
	Oral	10	15		
Marital status	Single	7	2	Fisher's exact	0.15
	Married	33	38		
Treatment type	Chemotherapy	5	0	Fisher's exact	0.06
	Surgery	8	12		
	>1 type	27	28		
Education level	Elementary	13	19	Fisher's exact	0.16
	High school	9	12		
	Diploma	8	6		
	Bachelors	9	2		
	Postgraduate education	1	1		
Cancer stage	I	4	5	Fisher's exact	0.64
	II	15	17		
	III	14	15		
	IV	7	3		
		M (SD)	M (SD)	*T*	
Pain score preintervention		7.32 (2.20)	7.33 (2.45)		0.99
Anxiety score preintervention		64.98 (5.39)	63.30 (7.26)		0.25

JD, Jordanian dinar ($US1.4).

Table 2. Paired sample *t* test for the mean differences in the pain scores for the study groups

Study group	Mean pretest	Mean posttest	DF	*t* test	*p* value
Intervention	7.32	0.33	39	25.57	<0.001
Comparison	7.33	4.84	39	8.20	<0.001

DF, degrees of freedom.

Table 3. Paired sample *t* test for mean differences in the anxiety scores for the study groups

Study group	Mean pretest	Mean posttest	DF	*t* test	*p* value
Intervention	64.98	37.68	39	26.84	<0.001
Comparison	63.30	50.13	39	9.93	<0.001

DF, degrees of freedom.

because no studies had yet examined the effectiveness of immersive VR technology on patients with breast cancer in Jordan or any other Arab country (Ahmad & Dardas, 2016). In addition, the current study is important because it could be the first to test the effectiveness of immersive VR on relieving pain and anxiety among patients with breast cancer, with a focus on type morphine as a painkiller.

About 63% of the participants' ages were 50 years and above, with a range from 30 to 70 years. This is consistent with the statistics on breast cancer from Jordan Cancer Society, which reported that breast cancer is the most common type among females of this age (JCR, 2013). This study has focused on female patients with breast cancer, unlike other studies that used VR on both genders and with more than one type of cancer (Baños et al., 2013; Schneider et al., 2011).

The response rate of 95% in this study is higher than those reported in other VR studies (Baños et al., 2013). This may indicate that the patients who were invited to participate in this study were in need of such an intervention, and possibly because of inadequate treatment of cancer pain in Jordan (Ahmad et al., 2010; Al Qadire

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et al., 2013). Other factors may have enhanced participation in the current intervention, such as short duration of VR session and being excited for exposure to a new technology. However, only the intervention group was exposed to VR during the study; the participants in the control group who showed interest in VR got the chance to participate after their role in the study was completed.

Immersive VR technology in the current study significantly reduced patients' pain and anxiety levels. The mean of pain score in the intervention group was lower than the comparison group after the intervention. This findings support the work of other researchers who used VR distraction interventions during painful procedures (Chan & Scharf, 2017; Gromala et al., 2015; Pandya et al., 2017).

In this study, there was a significant difference in pain scores between the pretest and posttest in the intervention group, which is consistent with a previous VR study on noncancer patients (Hoffman et al., 2007). Our findings contradict a previous study by Chan et al. (2007), in which there was no total immersion and involvement, which may resulted from an uncomfortable position, tiredness, and disturbance by the hospital environment.

In the current study, participants in the comparison group had lower pain scores in posttest than pretest. However, when comparing the results with the intervention group, the t statistics increased from $t = 8.2$ in the comparison group to $t = 25.57$ in the intervention group. This means that the use of VR with morphine in the intervention group reduced pain significantly more than pharmacological intervention alone in the control group. This is consistent with the literature that morphine alone can reduce pain level but that the use of VR and morphine together were more effective in pain reduction (Hoffman et al., 2007).

All patients in this study had anxiety; their scores were above the cutoff level of 39 (Knight et al., 1983). Immersive VR was an effective distraction technique in this study for anxiety level, which is consistent with VR studies among other populations (Gromala et al., 2015; Marquess et al., 2017). The effect of VR distraction in the current study was different from other VR studies, which found no effect on anxiety level (Chirico et al., 2016; Morris et al., 2009). This could be explained by the small sample size in other studies. In our study, the Cohen's D effect size was large enough (2.36) for pain score and (1.75) anxiety score, which supports our result of the differences between the two groups. In addition, the VR equipment and software has become more advanced over time in providing better distraction effect.

The participants in both groups had lower anxiety scores in posttest than pretest; however, there was a significant difference in favor of the intervention group in the reduction of anxiety level. This indicates that morphine reduced anxiety, but when VR was added, more benefits in anxiety relief were recorded. This is consistent with the literature; many studies on patients with a diagnosis other than breast cancer demonstrate that the use of VR could relieve anxiety (Baños et al., 2013; Gromala et al., 2015).

This study supports the use of immersive VR as an effective and safe nonpharmacological method for distracting patients from anxiety. Opioids are widely prescribed to reduce patients' pain, but they are also could lead to drug addiction. Other side effects could include nausea, headache, dizziness, constipation, and weakness (Demir, 2012). This means that the use of VR may reduce the side effects of anxiolytic medication as the nonpharmacological treatment was safer than medications for anxiety treatment (Platt et al., 2016).

We think that there were many factors that supported the conduction of this study. The equipment required to implement the intervention was convenient for participants in the intervention group. Furthermore, this technology is useful and easy to use, making it feasible for patient self-use after discharge if they want to continue its use. Moreover, the intervention was noninvasive with no side effects, and if implemented in future interventions, will reduce pharmacological side effects. This is an important point because it may increase the patients' level of acceptance, especially for those who are reluctant to use medication because of its side effects.

Implications and recommendations

Some patients in this study suggested increasing the time of VR session to distract them during hospitalization. This suggestion should be considered in future research, which should measure the effectiveness of VR along with other diagnoses. Research should compare VR with other distraction techniques such as imagination, music, and art therapy. A qualitative study that supports in-depth examination of patients' experiences during VR sessions is also recommended for assessing and improving VR user interface and user interaction. Moreover, qualitative study could explore how the feelings of pain and anxiety change and for how long the effect could extend. Further research is recommended to examine that, if patients have the VR equipment at home, whether it would be feasible to use it frequently without hindering the activities of daily living.

Conclusion

VR is appropriate for nurses because it is not dependent on a doctor's prescription; however, as with other treatments, this intervention should be used with caution because it may cause motion sickness. Clinicians should instruct patients to discontinue VR if any side effects are experienced. Clinicians should assume that the use of VR will decrease cancer-related pain and anxiety symptoms. Immersive VR was a safe nonpharmacological intervention because none of the participants, who were selected based on the eligibility criteria reported any unusual symptoms, such as dizziness, increased nausea, or visual disturbances. Managing pain and anxiety is a key factor in improving patients' health. The findings of this study suggest that immersive VR holds promise as an effective distraction intervention for managing pain and anxiety among breast cancer patients. Using immersive VR as an adjuvant is more effective than morphine alone in relieving pain and anxiety. It is likely that this is the first study to show that immersive VR as feasible, effective, and acceptable in the Arab world. This study had some limitations, such as the cost of the equipment being relatively expensive, and the findings can only be generalized to female breast cancer patients who received morphine as a painkiller.

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