

SYSTEMATIC REVIEW

The Effectiveness of Virtual Reality in Controlling Pain in Patients with Burns: A Systematic Review

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ABSTRACT

Study Design: Systematic review of the literature. **Objectives:** To determine if virtual reality (VR) with standard analgesics is more effective at improving patients' reports of pain during wound dressing changes, passive stretching, and range of motion (ROM) exercises than standard analgesics alone. **Background:** People with burn injuries experience significant pain during rehabilitation. VR may be a means to enhance pain control during the rehabilitation period. There are no previous systematic reviews of this topic. **Methods and Measures:** The following databases were searched for studies applying VR in the treatment of patients with burns; Ovid Medline, Cinahl, PEDro, and Pubmed. The PEDro¹ scale was used to assess methodological quality of included studies. Included studies were then synthesized for a best-level of evidence using the qualitative scale from Van Tulder.² **Results:** Seven randomized controlled trials and quasi-experimental studies were included in the review. All seven studies were of moderate level quality. Six out of seven articles showed a statistically significant effect of VR on pain scores. Of the statistically significant results, two articles used the Faces Scale and demonstrated a mean reduction in pain from 4.1 to 1.3⁹, and 5.38 to 2.81¹² respectively. Two articles used a Visual Analog Scale and indicated a mean pain reduction from 69.00mm to 28.29mm⁶ and from 36.33mm to 14.67mm.¹⁰ Additionally, one study used a Graphic Rating Scale and showed a mean reduction in pain from 7.6 to 5.1¹¹, and the last study used a Visual Analog Thermometer and showed a mean reduction in pain from 5.52 to 2.83.¹³ Moderate level evidence indicates that VR results in lower pain scores during dressing changes and physical therapy compared to analgesics alone. **Conclusions:** The available data suggests that VR in adjunct with standard pharmacologic analgesics produces lower pain scores during wound dressing changes and physical therapy compared to standard pharmacologic analgesics alone. Further research should address the use and effect of VR in a physical therapy specific setting, as well as the cost-effectiveness of such an intervention.

Background

Burn injuries pose a major challenge to healthcare professionals. Burns can affect people of any age, race, or sex and can cause many health complications including: cardiopulmonary distress, metabolic dysfunctions, integumentary issues and infection.³ More than one million people are burned each year in the United States and approximately 45,000 people are subsequently hospitalized.⁴ Recovery after a burn is dependent on severity, but is almost

always a very long, arduous, and painful process for the patient. A comprehensive medical approach is necessary to ensure the full recovery of the patient. Physical therapists assist the medical team in treating burn patients early in the acute phase of recovery. Their roles include performing wound dressing changes, scar and contracture prevention, range of motion exercises, strength and conditioning training, and training in activities of daily living (ADL).

The patient with burns presents an interesting challenge to rehabilitation as they often suffer complications due to their injuries. Patients with burns are at high risk for developing hypertrophic scars, joint and tissue contractures, and heterotopic ossification.³ These conditions all present a significant threat to the patient's full return to function and independence with ADLs. Patients with burns also present a considerable challenge during rehabilitation due to the pain of their injuries. Wound dressing changes and rehabilitation post burn is commonly known as the most painful process an individual can endure, and current research indicates that burn pain generally remains under treated.⁵ Patients with burns report significantly higher levels of pain during procedures (such as physical therapy) than at rest. Furthermore, patients with burns have been shown to report increasing levels of pain and anxiety as the healing process progresses, and their healing times are often much longer than those of other patients. Subsequently, many patients with burns are non-compliant with exercise programs due to the severe pain and anxiety they experience. Old methods of pain control implement the use of standard analgesics such as acetaminophen, non-steroidal anti-inflammatory drugs, and opiates. These categories of drugs are associated with many unfavorable side effects, the risk of dependence, and have been shown to be only moderately effective in a patient with burns.⁵ Patients with burns undergo an extreme inflammatory response, both systemically and locally, and as such have different responses to pharmacokinetics and pharmacodynamics. These traditional methods of pain management may then prove ineffective in dealing with increasing levels of pain.

Advances in technology have recently provided a new approach to pain relief. The

use of VR as a method of pain relief and distraction has been increasingly studied over the past several years. VR provides pain relief through distracting the conscious attention of the user and leaving less cognitive function available for pain perception.⁶ VR may be more effective than other forms of distraction (hypnosis, biofeedback, or watching a video) because it can simultaneously stimulate the senses of sight, touch, and hearing. Most tested VR systems involve the use of a helmet which presents a variety of images to the user, while subsequently decreasing their visual recognition of the real environment. Several studies have assessed the effectiveness of using VR to modify pain in patients undergoing physical therapy burn care. Thus far, most studies have shown positive results towards reducing pain in patients undergoing burn care. However, currently there are no systematic reviews to summarize and determine the overall usefulness of VR as an adjunct to physical therapy for burn patients. Therefore, the aim of this systematic review is to determine if VR with standard analgesics is more effective at improving patient's reports of pain during wound dressing changes, passive stretching, and range of motion (ROM) exercises than standard analgesics alone.

Methods

Literature Search and Selection Criteria

The following databases were reviewed for research articles pertaining to the review topic: Cinahl, Ovid Medline, PEDro, and Pubmed. Search terms used were "burns", "virtual reality", and the combined term of "burns and virtual reality". The search was limited to human subjects, articles in English, and articles published from 1998 to 2008. The abstracts of each article were subsequently reviewed for inclusion and

exclusion criteria and appropriate articles were selected to include in the review. Articles were excluded from the review if they were case studies or review articles. Included studies consisted of randomized controlled trials and quasi-experimental designs. Included studies also had patients with burns as their subjects, applied VR in adjunct with standard analgesics as the primary intervention, and used pain as the main outcome measure.

Validity Assessment

Methodological quality was assessed by using the PEDro¹ scale (Appendix 1.1). The PEDro scale is a previously validated quality rating scale used to assess randomized controlled trials of physical therapy interventions. Included studies were evaluated independently. Each question was scored as affirmative or negative and was given a point accordingly. Answers that were unclear were automatically given a score of zero on that question. Studies were given a final overall score out of ten possible points. The methodological quality of included studies was then determined out of the total ten points. Total scores above a seven were considered high quality, scores between four and six indicated moderate quality, and scores below four were considered low quality.

Data Extraction and Synthesis

Data was extracted from each study relating to the primary outcome measure of pain score. Pain score was evaluated using a visual analog scale or visual analog thermometer for adult subjects, and a faces pain rating scale for pediatric patients. After validity assessment for each individual study, the data was synthesized using a qualitative scale from Van Tulder (Appendix 1.2).² The scale has five levels which denote the level of evidence of the combined studies. All studies included in

the review were synthesized and collectively assigned a level of evidence based on the scale. The assigned number reflects the application and relevance of the clinical conclusion.

Results

Search Strategy

A total of 55 articles were retrieved using the above databases, terms, and limits. Several duplicate studies were found after searching each database and these duplicates were only reviewed once. The abstracts and full text of relevant articles were reviewed and seven articles were included in the present review. The most common reason for exclusion was a case study research design. A few articles fit all the inclusion criteria but were excluded because one was a summary of three yet to be published studies and presented only preliminary results.⁷ An additional two studies were also excluded because they were merely abstracts presented at the American Burn Conference and have also yet to be published. Figure A presents the results of the electronic search and ensuing assessment of the included studies.

Methodological Quality

Table 1 displays the outcome of the methodological quality of the included studies. Articles with a score above seven were scored as high quality, those with a score between four and six were scored as moderate, and those below a four were scored as low. All of the included studies scored either a five or six and were thus considered moderate quality studies. The author determined methodological quality independently and hence no disputes were encountered.

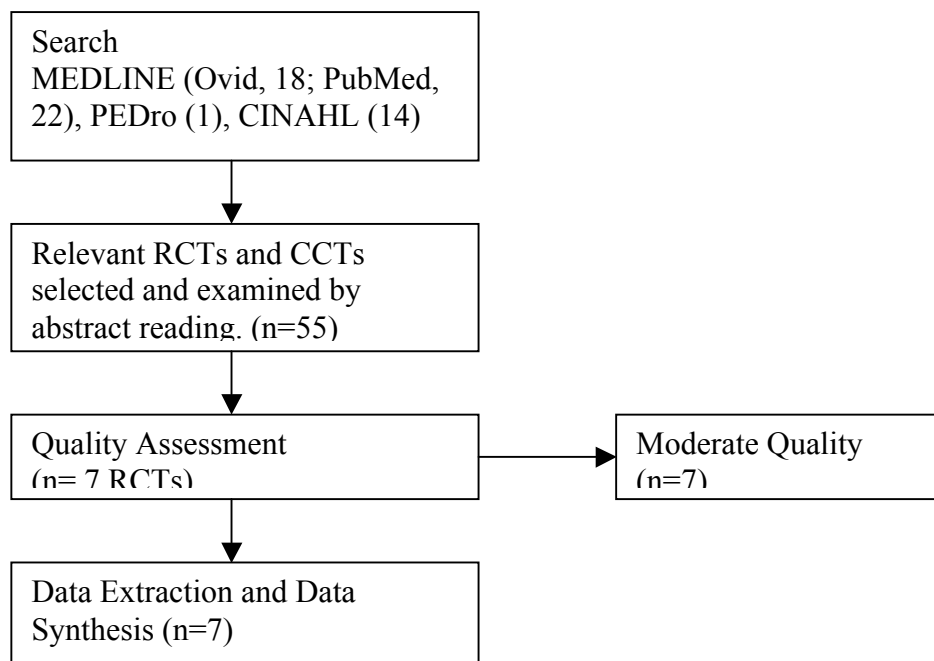


Figure A. Selection process of relevant articles to include in the review.

Outcome Measures

The characteristics of the included studies are presented in Table 2. A total of 108 subjects participated in all seven studies. Only two subjects dropped out which yielded a drop-out rate of 1.85%. A qualitative review was executed using the previously mentioned scale by Van Tulder.² The majority of the studies only used pain as their primary outcome measure, although a few did measure other outcomes such as respiration rate, anxiety, and time of dressing change.^{12,13} Pain is the only outcome measure subsequently addressed as it is the main measure focused on by this review.

All seven studies compared the effectiveness of VR with standard pharmacologic analgesics on pain scores during dressing changes or physical therapy against no VR and standard pharmacologic analgesics

alone. Therefore, the intervention applied in each study was VR, and the control treatment was standard pharmacologic analgesics alone. Five of the included studies^{8,9,11-13} applied the VR setting during wound dressing changes while the remaining two studies^{6,10} applied VR during a physical therapy treatment. The wound dressing change sessions consisted of removing the old dressings and applying new dressings. This process took a variable amount of time depending on the patient, degree of burn, size of burn, and experience of the person doing the dressing change. The physical therapy treatment for one study consisted of active-assisted range of motion exercises performed by an occupational therapist.⁶ The physical therapy treatment in the other study was not specified, but was performed by occupational therapists.¹⁰ Each study measured patient's pain scores before and after treatment for both the intervention and control situation.

Studies	1	2	3	4	5	6	7	8	9	10	11	Total Score*	Quality
Chan et al. ⁸	+	+	-	+	-	-	-	+	+	+	+	6	Mod.
Das et al. ⁹	+	+	-	+	-	-	+	-	-	+	+	5	Mod.
Hoffman et al. ¹⁰	+	+	-	+	-	-	-	+	+	+	+	6	Mod.
Hoffman et al. ⁶	+	+	-	+	-	-	-	+	-	+	+	5	Mod.
Hoffman et al. ¹¹	+	+	-	+	-	-	-	+	+	+	+	6	Mod.
Mott et al. ¹²	+	+	-	+	-	-	-	+	-	+	+	5	Mod.
van Twillert et al. ¹³	+	+	-	+	-	-	-	+	+	+	+	6	Mod.

(Key: +, the criterion was present; -, the criterion was absent or unclear, *,Items 2-11)

Table 1. Quality of the included studies as established by the PEDro¹ Scale.

Outcome Measure	Study	Immediate Term	Data Synthesis
Pain	Chan et al. ⁸	Mean VR: 38.13mm Mean no VR: 53.75mm p > 0.05	Moderate Evidence in favor of virtual reality intervention
	Das et al. ⁹	Mean VR: 1.3 Mean no VR: 4.1 p < 0.01	
	Hoffman et al. ¹⁰	Mean VR: 14.67mm Mean no VR: 36.33mm p = 0.002	
	Hoffman et al. ⁶	Mean VR: 28.29mm Mean no VR: 69.00mm p = 0.020	
	Hoffman et al. ¹¹	Mean VR: 5.1 Mean no VR: 7.6 p = 0.015	
	Mott et al. ¹²	Mean VR: 2.81 Mean no VR: 5.38 p = 0.01	
	van Twillert et al. ¹³	Mean VR: 2.83 Mean no VR: 5.52 p < 0.001	

(Key: mm= millimeters, VR= Virtual Reality)

Table 3. Summary of quantitative results of pain score in experimental and control conditions of each included study with summary of level of evidence synthesized from review.

<u>Studies</u>	<u>Study Design</u>	<u>Age</u>	<u>Inclusion/Exclusion Criteria</u>	<u>Sample Size</u>	<u>Intervention</u>	<u>Dose and Duration</u>	<u>Outcome Measures</u>	<u>Follow-up</u>
Chan et al.8	Within-subject Crossover	Mean: 6.54 yrs	Inpatient pediatric patients with burns from major regional burn facility in Taiwan.	n = 8	Conventional treatment for pain during dressing changes with and without VR (control)	One 15-20 min. dressing change with VR and one without VR. Standard pain management in both trials	Pain (Faces Scale), PQ	Immediate
Das et al.9	Within-subject Crossover	Mean: 10 yrs Range: 5-16yrs	All children admitted to WCH ward, age 5-18, having burns to more than 3% TBSA, and requiring dressing changes. Children with burns to hands, face, or head, past history of epilepsy and reduced intellectual capacity were excluded.	n = 9	Routine pharmacological analgesia with and without VR during dressing change	11 trials of dressing changes	Pain (Faces Scale), Interview with parent/carer and nurses	Immediate
Hoffman et al.10	Within-subject Crossover	Mean: 27.67 yrs Range: 19-47 yrs	Inpatient patients with burns from Harborview Burn Center with prior trouble tolerating pain during physical therapy.	n = 12	Standard pharmacologic analgesia with and without VR during physical therapy	One session of 3 minutes with VR during physical therapy exercise and 3 minutes without	Pain (VAS)	Immediate
Hoffman et al.5	Within-subject Crossover	Mean: 21.9 yrs Range: 9-32 yrs	Inpatient patients with burns hospitalized at a major regional burn facility with previous trouble tolerating pain during physical therapy.	n = 7	Physical therapy exercises with and without VR	As many physical therapy sessions as possible before discharge each lasting a predetermined amount of time	Pain (VAS)	Immediate
Hoffman et al.11	Within-subject Crossover	Mean: 27 yrs Range: 9-40 yrs	Inpatient patients with burns who had excessive pain, despite pharmacologies, during wound care in the hydrotank.	n = 11	Wound Debridement in a hydrotank with and without immersive VR	One, 6 minute section of dressing change with 3 minutes with VR and 3 minutes without	Pain (GRS)	Immediate
Mott et al.12	Randomized Controlled Trial	Range: 3.5-14 yrs	Pediatric patients with burns undergoing outpatient dressing changes. No exclusion for site of burn or intellectual ability.	n = 42	Treatment Group: dressing change with augmented VR and standard analgesics Control Group: dressing change with standard analgesics	One or more dressing changes of varying duration	Pain (Faces Scale, VAS), pulse rate, oxygen saturation, respiratory rate	Immediate
van Twillert et al.13	Within-subject Crossover	Mean: 30 yrs Range: 8-65 yrs	Well-communicating patients of 8 or older, without facial burns or other physical limitations, without any actual psychiatric disorder, and with expected hospital stay of 4 days.	n = 19	VR during daily dressing change, dressing change without VR, or dressing change with other distraction method	Three separate dressing change periods of variable length	Pain (VAT), Anxiety (STAI)	Immediate

Table 2. Characteristics of included studies. (yrs= Years, VR= Virtual Reality, PQ= Patient Questionnaire, VAS= Visual Analog Scale, VAT= Visual Analog Thermometer, STAI= Spielberger State-Trait Anxiety Inventory, GRS= Global Rating Scale)

Pain was measured using an age-appropriate scale in each study. In three pediatric studies^{8,9,12} used a Faces Scale to measure pain, two other studies^{6,10} used a Visual Analog Scale, one study used a Graphic Rating Scale,¹¹ and one study used a Visual Analog Thermometer.¹³ All of the studies reported immediate term effects. A summary of results of each study is included in Table 3. All included studies, except the study by Chan et al., demonstrated a statistically significant effect of VR on pain. The study by Das et al. demonstrated a mean pain score difference of 3.2 on the Faces scale between the control and experimental conditions. Similarly, in the 2000 study by Hoffman et al., participants rated their worst pain on a visual analog scale at 42.00mm without VR and at only 19.92mm with VR. Lastly, in the study by Van Twillert et al., the mean reduction in pain scores among all participants was 39% between the treatment without VR and with VR. These statistics indicate that there is moderate evidence to suggest that VR is effective in reducing pain compared to analgesics alone at immediate follow-up.

Discussion

This review investigated seven studies to determine the effectiveness of VR in reducing pain in patients with burns during wound dressing changes, passive stretching, and range of motion exercises. There is moderate evidence to suggest that VR combined with standard analgesics is more effective at reducing pain than standard analgesics alone. No review has previously been conducted on this topic and as such this review should be updated as more research becomes available.

The studies included in this review all possess several weaknesses which challenge the validity of their results. The sample

sizes of all included studies were quite small, with the largest sample being 42 patients.¹³ Small sample sizes are hard to generalize to a broader population and may favorably skew the results of the study. Additionally, three studies^{8,9,12} used only pediatric patients as their subjects, three^{6,11,13} used pediatric and adult patients, and one study¹⁰ used only adult patients. These studies did not really address the possible differences in pain experience between pediatric and adult patients. It may not be appropriate to compare results from children with those from adults, as a child's understanding and expression of pain may be drastically different from an adult's. None of the included studies used a double blinded design, which further threatens their validity. Although the nature of the intervention makes it difficult to blind the patients and examiners to treatment condition, accomplishing this would greatly strengthen the quality of the studies. Lastly, as previously mentioned, five^{8,9,11-13} of the studies implemented VR during wound dressing changes, and only two^{6,10} applied it during a physical therapy exercise. Although both of these treatments situations are relevant to this review and demonstrated significant results, the effect of VR on pain during these different procedures should be explored separately as more research becomes available.

Despite the above weaknesses, the studies included in this review all had a moderate level of methodological quality. No one study scored significantly higher or lower than the others. Therefore, the results of this review can be interpreted as fair and can be used to guide treatments under the conclusion that a moderate level of evidence exists to support the use of VR in addition to standard analgesics in the reduction of pain in patients with burns.

This review was conducted by only one author and therefore is subject to several biases. Only one person scored each article for methodological quality and no one checked the determined scores. In addition, the author only searched a finite amount of databases and may have overlooked studies that could have been included. Similarly, the author was the only person to review studies for inclusion and exclusion criteria and may have dismissed studies that would not support her point of view.

Although this review shows a favorable outcome in using VR as an adjunctive treatment for patients with burns, future research needs to be done to further substantiate these results. Future research should concentrate on the use of VR alone versus standard analgesics in an effort to further reduce the negative side-effects of pharmacologic interventions for patients with burns. It should also explore the effect of VR on outcome measures such as ROM, function, and disability. Lastly, it is vital that future research address the cost-effectiveness of VR as an intervention. VR is currently being implemented in the U.S., and continues to be researched in countries such as Taiwan, Australia, and the Netherlands. However, to initiate wide-ranging implementation of VR, a cost-benefit analysis should be established taking into account the cost of the VR system, cost of employee training, and potential number of appropriate patients.

Conclusion

There is moderate evidence to indicate that VR in addition to standard analgesics is effective at improving patient's reports of pain during wound dressing changes, passive stretching, and range of motion exercises.

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Appendix 1.1

PEDro Scale

Rating Scale for RCT's, non-RCTs, and Case Series

For each item, please justify scoring (for both YES and NO responses), by at least mentioning page and paragraph numbers.

- | | |
|---|------------|
| 1. eligibility criteria were specified | yes c no c |
| 2. subjects were randomly allocated to interventions (in a crossover study, subjects were randomly allocated an order in which treatments were received) | yes c no c |
| 3. allocation was concealed | yes c no c |
| 4. the intervention groups were similar at baseline regarding the most important prognostic indicators | yes c no c |
| 5. there was blinding of all subjects | yes c no c |
| 6. there was blinding of all therapists who administered the therapy | yes c no c |
| 7. there was blinding of all assessors who measured at least one key outcome | yes c no c |
| 8. measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups | yes c no c |
| 9. all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat" | yes c no c |
| 10. the results of between- intervention group statistical comparisons are reported for at least one key outcome | yes c no c |
| 11. the study provides both point measures and measures of variability for at least one key outcome | yes c no c |

Appendix 1.2

Van Tulder Scale

1. Strong Evidence: provided by generally consistent findings in multiple high-quality RCTs or CCTs (controlled clinical trial).
2. Moderate Evidence: provided by generally consistent findings in 1 high-quality RCT or CCT and 1 or more low-quality RCTs or CCTs, or by generally consistent findings in multiple low quality RCTs or CCTs.
3. Limited Evidence: provided by only 1 RCT or CCT (either high or low quality).
4. Conflicting Evidence: inconsistent findings in multiple RCTs or CCTs (either high or low quality).
5. No Evidence: if there are no published RCTs or CCTs.