Master Thesis:

The Effectiveness of Virtual Reality Distraction Interventions on Pain and Anxiety Reduction in Patients with Burn Injuries: A Systematic Literature Review

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August, 2020

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Subject: Positive Psychology & Technology (10EC)

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Abstract

Virtual reality (VR) has been increasingly used as a distraction intervention during painful medical procedures. However, there is a gap of recent systematic reviews in the scientific literature about the effectiveness of VR distraction on pain and anxiety reduction in burn patients. Therefore, the goal of this systematic literature review was to gain insight about the most recent findings about the effectiveness and clinical relevance of active and passive VR distraction for pain and anxiety reduction in burn injured patients. Another aim of this review was to detect differences in the pain and anxiety reducing effect of VR between younger and older burn victims. First, it was hypothesized that VR interventions would effectively reduce pain and anxiety in burn wound patients. Second, it was hypothesized that the VR treatment would show a greater pain and anxiety relieving effect on child and adolescent patients than on adult patients. The databases PubMed, PsychINFO and Scopus have been searched for studies containing information about the effectiveness of VR interventions on managing pain, anxiety or both in burn injured patients reported separately for child and adolescent patients and adult patients. Of the 13 studies included in this review relevant data was extracted, effect sizes generated and summarized. Ten articles found a pain relieving effect of VR distraction. Three articles indicated an anxiety reducing effect of VR distraction and an additional study indicated a reducing effect on negative emotions including fear. Effect sizes of six articles did not reveal a difference in the pain reducing effect of VR distraction between child and adolescent patients and adult patients. Finally, the effect sizes of three studies indicated VR interventions to more effectively reduce anxiety in child and adolescent patients than in adult patients. The results highlight the benefit of VR distraction interventions for pain and anxiety management in the clinical setting. However, the small number of effect sizes that could be generated from the articles limits the representativeness of the results. Future research should continue to examine possible differences of the pain and anxiety reducing effect of VR treatments between younger and older patients, since children have fewer understanding and coping strategies to deal with medical procedures than adults, which makes the exploration of effective interventions for young patients especially important.

Keywords: virtual reality, distraction, pain, anxiety, systematic review

Introduction

Besides causing mental and physical distress following the original trauma, burn injured patients also suffer intense pain from regular procedures such as everyday physiotherapy and wound dressing (Abdi, & Zhou, 2002). Additionally, the burn victim's expectation of experiencing these painful processes may increase their anxiety which in turn can cause muscle tension that near the injury intensify the perceived pain (Abdi, & Zhou, 2002; Ashburn, 1995; Chapman, & Turner, 1986). Anxiety can be defined as a person's individual perception of fear, tension, restlessness and worry combined with an arousal of the neural system (Spielberger, 2010). Appropriate support in mastering pain and anxiety is an important element in developing trust between patient and health professionals (De Jong, Middelkoop, Faber, & Van Loey, 2007; Latarjet, 2002). In that sense, everyone professionally working with children has an obligation to offer scientifically proven interventions to guarantee the best possible healing process (e.g. Hornsby, Blom, & Sengoelge, 2019). However, this statement should be applicable not for children only but for patients of any age.

While analgesic medication builds part of the basis of each burn pain treatment, their efficacy for intense pain is restricted and commonly insufficient in lowering pain (Ashburn, 1995; Hoffman, Patterson, Carrougher, & Sharar, 2001). Furthermore, analgesic medication may have different side-effects, which reduce their benefit, comprising, among others, extreme sedation, nausea, constipation, cognitive dysfunction and the danger of a drug addiction (Hoffman, Patterson, Carrougher, & Sharar, 2001). On the contrary, analgesic methods not based on medication, such as distraction via Virtual Reality (VR), are usually less damaging and yield only minor and short-term side-effects (Hoffmann et al. 2006; Hoffmann et al. 2004). Thus, it is necessary to apply such low-invasive analgesic techniques as they may constitute important assistance next to traditional medical analgesics (Hoffmann et al. 2006; Hoffmann et al. 2004).

Distraction through VR technology is a comparatively new intervention method applied during medical procedures that might demonstrate more efficiency in reducing pain and anxiety than commonly used distraction techniques (Eijlers et al., 2019) such as the application of movies (Landolt, Marti, Widmer, & Meuli, 2002; Mifflin, Hackmann, & Chorney, 2012) and music (Aitken, Wilson, Coury, & Moursi, 2002; Whitehead-Pleaux, Baryza, & Sheridan, 2006). VR enables interaction and orientation in a computer-generated, three-dimensional environment (Eijlers et al., 2019; Malloy & Milling, 2010). Advanced head-mounted displays (HMDs), containing systems for motion tracking and a

wide field of vision project a simulated environment before the eyes of the user (Malloy & Milling, 2010). VR can involve active participation in the virtual environment or passive observing and listening (e.g. Furness et al., (2019). Even though the mechanism of the pain relieving effect of VR distraction is not yet completely understood (Al-Ghamdi et al., 2020), it has been assumed that VR occupies the patient's attention and by that reduces the remaining attention ability of the brain to process the pain stimulus from the burn wound (e.g. Hoffman et al., 1998; Hoffman et al., 2000; Birnie et al., 2017). Another VR intervention technique to reduce pain and anxiety besides VR distraction is VR exposure (e.g. Eijlers et al., 2019). VR exposure has been used, for example, as a prevention to help patients to feel comfortable and to become familiar with medical environments and procedures (Bekelis et al., 2017; Eijlers et al., 2017). As there is more research needed on VR exposure as a prevention method to alleviate pain and anxiety during medical procedures to draw conclusions on its effectiveness (Eijlers et al., 2019), this review focuses on the effectiveness of VR distraction to reduce pain and anxiety, including both, active as well as passive VR distraction.

Users of VR can get fully immersed, that means feel actually present in the simulation (Malloy & Milling, 2010; Wismeijer, & Vingerhoets, 2005). It is important to point out that greater immersion is associated with greater reduction of pain, as fewer attention can be provided for the perception of pain signals (Gutierrez-Martinez, Gutierrez-Maldonado, Cabas-Hoyos, & Loreto, 2010; Hoffman et al., 2004) and anxiety (Hoffman et al., 1998; Hoffman et al., 2000). Thus, the application of VR distraction seems particularly appealing for children, because they frequently become completely immersed in games of imagination (Lillard, 1993). Moreover, younger age appears to be related to higher levels of anxiety during medical procedures (Davidson et al., 2006). Past research revealed that greater pain perception is associated with more fear, anxiety and a lack of mechanisms to cope (Marshall, Shabrun, & Knox, 2017; Dodo & Hashimoto, 2017). Younger patients are usually more influenced by these aspects than adults as they had fewer experience and time to acquire strong coping mechanisms such as distracting themselves or rationalising (National Scientific Council on the Developing Child, 2015), which could make VR distraction especially effective in pain and anxiety reduction for younger than for older patients.

There is promising scientific literature on the effectiveness of VR distraction on pain reduction in burn injured patients (e.g. Morris, Louw, & Grimmer-Somers, 2009; Indovina et al., 2018; Luo, Cao, Zhong, Chen, & Cen, 2019; Scapin et al., 2018). However,

these publications did not take into account the most recent research of the last five years. Moreover, clear evidence for the effectiveness of VR distraction on the reduction of anxiety in burn victims still needs further investigation (Luo, Cao, Zhong, Chen, & Cen, 2019). While VR distraction demonstrates promising effectiveness during painful medical procedures of burn injured child as well as adult patients (e.g. Das et al., 2005; Hoffman et al., 2000; Morris, Louw, & Grimmer-Somers, 2009), this is the first systematic review to particularly compare the effectiveness of VR distraction in pain and anxiety reduction between child and adolescent burn victims and adult burn wound patients.

Therefore, this review aimed to examine recent scientific literature on the effectiveness of active and passive VR distraction on the reduction of pain and anxiety in burn wound patients. Firstly, it was hypothesized that the application of VR active and passive distraction during medical procedures would effectively reduce pain in burn victims. Secondly, it was hypothesized that the application of active and passive VR distraction during medical procedures would effectively reduce anxiety in burn victims. Thirdly, it was hypothesized that VR active and passive distraction would demonstrate significantly more effectiveness in reducing pain in child and adolescent than in adult burn wound patients. Fourthly, it was hypothesized that active and passive VR distraction would demonstrate significantly more effectiveness in reducing anxiety in child and adolescent compared to adult burn wound patients.

Method

Literature Search

The current study will be executed according to the procedure for a systematic literature review (Cuijpers, 2016). For the analysis three electronic databases were exhaustively searched: PubMed, PsychINFO and Scopus. The search was performed in April 2020. For this study only articles in English were used. The main search terms applied in the search were "anxiety*", "burn*", "child*", "effect*", "pain" and "virtual reality". To combine these search terms the operator "AND" was used, either combining all main search terms or all possible combinations of the main search terms. Related search terms were "adolescent*", "adult*", "fear", "intervention*" and "VR". To combine these search terms with the main search terms the operator "OR" was used. Table 1 displays an overview of the search terms and the combinations. The search strings used for the literature search can be found in the Appendix.

Table 1

Search Terms

Main search terms combined with AND	Other search terms combined with OR
Virtual reality	VR, user-computer interface*
Effect*	Efficacy*
burn	
pain	analgesi* OR anxiety OR intervention* OR management* OR treat* OR therapy

Selection Criteria

To evaluate whether the articles are eligible inclusion and exclusion criteria have been determined. These criteria can be found in Table 2.

Table 2

Inclusion and Exclusion Criteria

	Inclusion Criteria	Exclusion Criteria
Study Types	Quantitative, qualitative, mixed-methods	Review, meta-analysis, books
Language	English	All other languages
Constructs	Study reports effectiveness of VR intervention in reducing pain or anxiety in burn injured individuals	Study investigates other constructs not related to the research questions of this review
VR Intervention	Active or passive VR distraction	VR exposure
Age of Participants (only for hypotheses 3 and 4)	Age should be distinguishable to differentiate between child and adolescent patients and adult patients	
Date	From January 2014 until April 2020	Records before January 2014

Note. VR = virtual reality.

The study selection was conducted in five steps. At first, titles were determined via searching of the databases and additional sources. Second, duplicates were removed. In the third step, titles were screened and studies were excluded that did not meet the inclusion criteria. Fourth, abstracts were read and articles were excluded that did not meet the inclusion criteria as well as articles that met the exclusion criteria. Fifth, the full article texts were viewed.

Data Extraction

The articles were successively read and relevant data was collected. Data that was extracted contained the following information for each article: name of the authors, year and location of publication, participant descriptive data, study description, design, the intervention that was used and key results.

To compare the VR intervention effect between child and adolescent burn injured patients and adult burn wound patients effect sizes (*d*) as standardized mean difference between VR distraction and standard care condition divided by the pooled standard deviation have been calculated for pain and anxiety respectively using an online calculator. Mean and standard deviation scores of the VR treatment condition and standard care condition for pain and anxiety were obtained from the articles. The website of the Effect Size Calculator used can be retrieved at https://memory.psych.mun.ca/models/stats/effect_size.shtml.

Results

Search Results and Study Descriptives

The flowchart in Figure 1 illustrates the steps of the systematic search process and exclusion of articles according to the inclusion and exclusion criteria. In total, the number of studies included into this literature review was 13. To give an overview of the included articles, their characteristics are displayed in Table 3, including authors, publication year, country, sample size and objectives of the articles. The studies were published during the past five years and came from six different countries of three continents: North America, South America and Asia. While eight of the articles were conducted in the United States, one article was conducted in Brazil, Canada, China, Saudi Arabia and South Korea respectively. The participants of the studies varied in nationality and cultural background and covered children as well as adults. The age of the participants ranged from two months to 73 years. Ten studies investigated the effectiveness of VR interventions on pain and anxiety management. Three articles focused on the feasibility of VR treatments for burn

injured patients, but were included in this review as they assessed the effect of VR distraction on anxiety, pain or both.

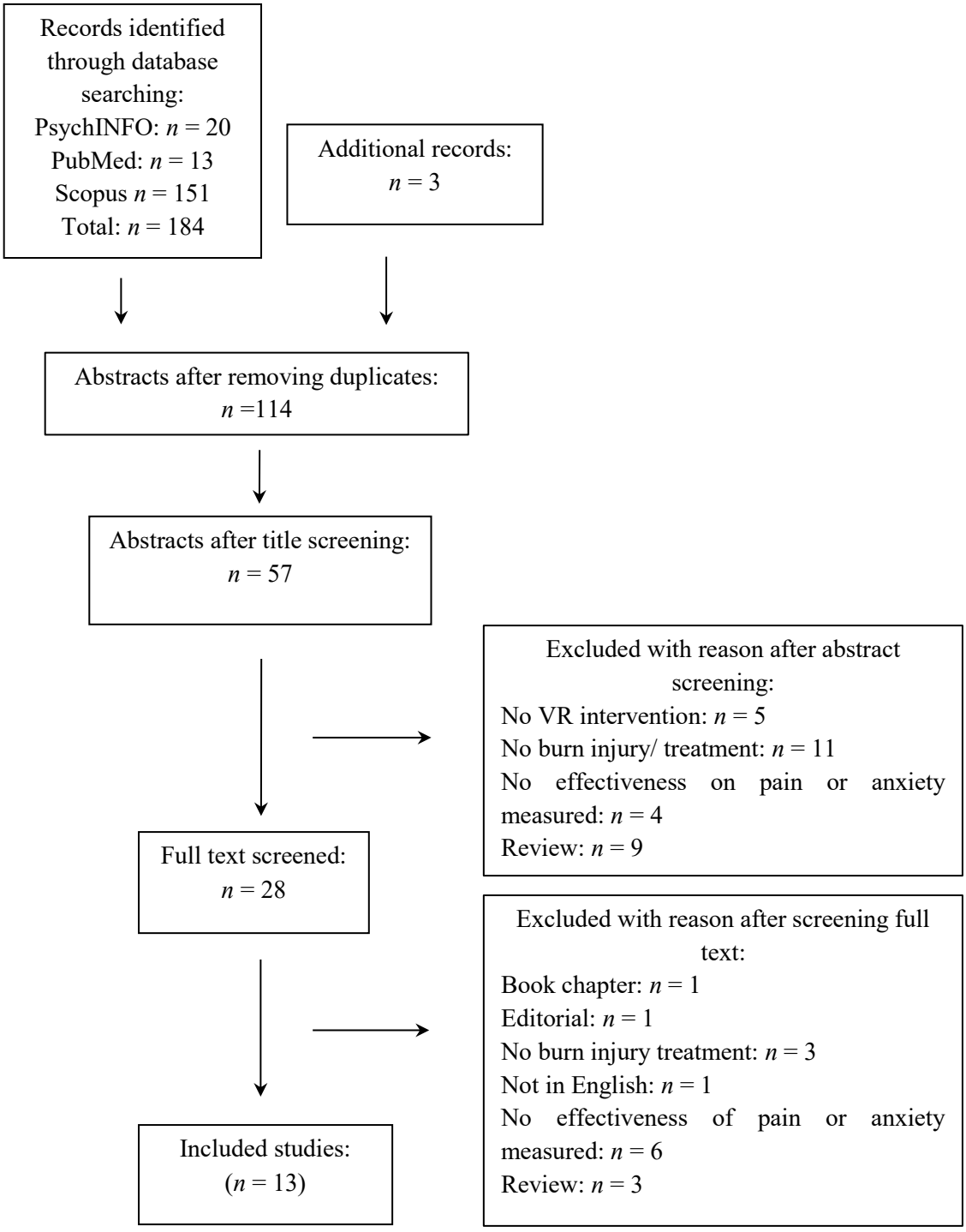

Figure 1. Flowchart of the Literature Search. VR = virtual reality.

Table 3

Study Characteristics

	Authors	Year	Location	Sample Size (*N*)	Objective
Effectiveness Studies	Al-Ghamdi et al.	2020	Saudi Arabia	48	Comparing the effectiveness of interactive eye-tracking VR with passive VR without eye-tracking on pain reduction
	Ford et al.	2018	United States	65	Assessing feasibility, acceptability and effectiveness of low-cost VR in burn care
	Furness et al.	2019	United States	5	Testing perception of burn patients and staff on effectiveness, usability, acceptability of active and passive VR in reducing pain and anxiety
	Hoffman et al.	2019	United States	48	Testing effectiveness of VR on reducing pain in burn injured children
	Hua et al.	2017	China	65	Testing the effectiveness of VR on pain and anxiety reduction during dressing changes in children
	Jeffs et al.	2014	United States	28	Comparing effect of VR and passive distraction on pain and anxiety
	Joo et al.	2020	South Korea	57	Comparing effectiveness of VR and standard rehabilitation on burned hands
	McSherry et al.	2018	United States	18	Evaluating effectiveness of VR during wound care to reduce analgesia required for pain and anxiety management in adults
	Phelan et al.	2019	United States	15	Testing acceptability and effectiveness of active and passive VR scenarios in managing pain
	Scapin et al.	2017	Brazil	2	Testing effectiveness of VR on pain intensity for the treatment of burned children
Feasibility Studies Including Effectiveness Measures	Gomez et al.	2017	United States	1	Testing feasibility and clinical potential of VR on reducing negative emotions and increasing positive emotions
	Hoffman et al.	2014	United States	1	Testing feasibility of inexpensive VR on pain reduction in burn patients
	Khadra et al.	2018	Canada	15	Assessing feasibility and acceptability of VR in managing pain and anxiety in young burn injured children

Note. VR = virtual reality.

VR Intervention Characteristics

In order to have an overview of the VR interventions, their characteristics, such as VR content, equipment and number and length of the sessions are summarized in Table 4. All 13 studies included in this review used distraction through VR as a treatment, either next to analgesia, reduced analgesia or alone. Eleven studies tested VR in addition to analgesia, while two of the studies tested the effect of VR without analgesia under experimental conditions. Regarding the VR hardware, eight of the studies used VR goggles, one a VR helmet, one a projector-based VR dome, two used VR goggles mounted to an articulated arm and one an interactive VR desktop with an exoskeleton glove. With regard to the VR software, five studies used SnowWorld as VR intervention, three studies used two to eight different scenarios between which participants could chose, one study used Ice Age 2: The Meltdown game, one visualized hand movements made with an exoskeleton glove, one used a pseudo-3D game to generate bubbles, one tested four VR scenarios on each participant and one study used two different VR scenarios.

The studies varied in number and duration of VR sessions, while the length of the session was not indicated in some of the articles. The indicated VR session duration ranged from five up to 100 minutes. Nine studies had one VR session only (Ford et al. 2018; Hoffman et al., 2014; Hoffman et al., 2019; Hua et al., 2015; Jeffs et al., 2014; Khardra et al., 2018; McSherry et al., 2017; Phelan et al., 2018; Scarpin et al. 2017), two studies had two VR sessions comparing interactive VR with non-interactive VR (Al-Ghamdi et al., 2018; Furness et al., 2019), one study had four sessions testing varying mindfulness exercises (Gomez et al., 2017) and one article included 20 VR sessions, arguing that repeated training improved effectiveness of VR hand-training for recovery (Joo et al., 2020).

In addition to that, the participant characteristics vary widely. Six of the studies included child and adolescent participants with an age range of two months up to 17 years. The other seven studies included adults with an age ranging from 18 until 73 years. Eleven of the studies had participants with burn wounds, while two tested VR on healthy patients with a pain stimulus (Al-Ghamdi et al., 2018; Phelan, 2018).

Table 4

VR Intervention Characteristics

Article	VR Equipment and Content	Treatment Condition	Number and Duration of VR Sessions
Al-Ghamdi et al. (2018)	VR helmet, eye-tracking system, SnowCanyon	VR distraction	2 VR sessions, length unknown
Ford et al. (2018)	VR goggles, one of eight environments: Amsterdam, soccer, motocross, reindeer race, roller coaster, scuba diving, swinging through a city, Table Mountain sunset	VR distraction	1 VR session; *M* = 8.30 min *SD* = 7.02
Furness et al. (2019)	VR goggles, active VR scenarios: herding sheep or basketball shots, passive VR scenarios: exploring space station, seeing the world from the perspective of an eagle, swimming with dolphins	VR distraction	2 VR sessions, dressing changes between 12-70 min, most between 25-40min
Gomez et al. (2017)	VR goggles, computer-generated river	VR distraction	4 VR sessions in four weeks, 10 min observing visuals, 10 min observing sound
Hoffman et al. (2019)	VR goggles, SnowWorld or snowy canyon	VR distraction	Switching between VR and no VR every 5 min, at least 1 day up to 10 days
Hoffman et al. (2014)	VR goggles mounted to articulated arm, SnowWorld	VR distraction	1 VR session: 20 min per treatment
Hua et al. (2015)	VR goggles, Ice Age 2: The Meltdown game, Chinese version	VR distraction	1 VR session, *M* = 22.3 min *SD* = 7.85
Jeffs et al. (2014)	Desktop VR mounted to articulated arm, SnowWorld	VR distraction	1 VR session: VR used between 5 -100 min

Joo et al. (2020)	Exoskeleton type glove and VR goggles, virtual hands	VR distraction	20 VR sessions of 60 min: 30min standard analgesia, 30 min with VR
Khardra et al. (2018)	VR dome: 150° curved screen, generate bubbles via mouse	VR distraction	1 VR session, length unknown
McSherry et al. (2017)	VR goggles, SnowWorld	VR distraction	1 VR session, *M* = 29.9 min
Phelan et al. (2018)	VR goggles and PC, two passive scenarios: hedgehog birthday celebration, individual with visual disability; two active scenarios: herding sheep, basketball shots	VR distraction	4 VR scenarios for 5 min
Scapin et al. (2017)	VR goggles, roller coaster simulation and marine environment	VR distraction	1 VR session, length unknown

Note. VR = virtual reality.

Study Design

The study design and key findings are displayed in Tables 5 and 6. Ten of the articles used a quantitative, two a mixed-methods (Ford et al., 2018; Phelan et al., 2018) and one a qualitative study design (Furness et al., 2019). This means that the ten quantitative studies used some form of a scale to measure the effects of the VR intervention, the mixed-method studies used a scale as well as a (semi-)structured interview and the qualitative study used interviews and a focus group.

The quantitative studies used a wide range of measurement instruments. The most often used measurement tool to measure pain was Graphic Rating Scales (GRS) which was applied in three studies (Al-Ghamdi et al., 2018; Hoffman et al. 2019; Hoffman et al. 2014). Moreover, the studies comprised varying sample sizes ranging from $N = 1$ (Gomez et al., 2017; Hoffman et al., 2014) up to $N = 65$ (Hua et al., 2015). Two of the articles were pilot studies using a within-subject design, which tested the effectiveness of interactive VR with eye-tracking system compared to passive VR without eye-tracking on reducing pain (Al-Ghamdi et al., 2018) and the effectiveness of VR on pain reduction in young children (Hoffman et al. 2019). There was one more within-subject design study (MySherry et al., 2017), testing the effectiveness of VR to reduce the amount of analgesia needed for pain

management during wound care. Three of the studies used randomized controlled trials (RCT), testing the effectiveness of VR on pain reduction in children (Hua et al., 2015), the effect of VR compared to passive distraction on pain (Jeffs et al., 2014) and the effectiveness of VR rehabilitation compared to standard rehabilitation on burned hands (Joo et al., 2020). Three of the articles were case studies, testing the effectiveness of VR to reduce negative emotions and increase positive emotions (Gomez et al., 2017), the effectiveness of VR to reduce pain in burn patients (Hoffman et al., 2014) and the effect of VR on pain intensity in burned children (Scapin et al., 2017).

The mixed-methods studies tested acceptability, effectiveness VR in burn care (Ford et al., 2018) and the effectiveness of active and passive VR to manage pain (Phelan et al. 2019). One quasi-experimental study tested the effectiveness of VR in pain and anxiety management in burn injured children (Khadra et al, 2018) and one small-scale qualitative usability design study also tested the perceived effectiveness of active and passive VR on reducing pain and anxiety (Furness et al., 2019). Eight studies compared a VR condition with a non-VR condition (Al-Ghamdi et al., 2018; Furness et al., 2019; Hoffman et al. 2019; Hoffman et al., 2014; Hua et al., 2015; Jeffs et al., 2014; Joo et al., 2020; Khadra et al, 2018; MySherry et al., 2017; Scapin et al., 2017). One study measured changes in emotion intensity only and not in pain perception (Gomez et al., 2017).

Effectiveness of VR on Pain Reduction

It was first hypothesized that applying active and passive VR distraction during medical processes would effectively alleviate pain in burn injured patients. The study findings about the effects of VR treatment on pain are displayed in Table 5. Concerning the main results of the articles, ten studies reported VR distraction to effectively reduce pain. Of these studies, three compared an active to a passive VR distraction condition (Al-Ghamdi et al., 2018; Furness et al., 2019; Phelan et al. 2019), six compared a VR distraction condition to a No-VR condition (Hoffmann et al., 2019; Hoffmann et al., 2014; Joo et al., 2020; Khadra, 2018; McSherry et al., 2017; Scapin et al., 2017) and one study only took self- and observer-reported pain measures during the VR treatment (Ford et al., 2018). One study did not find a difference in pain levels between the VR and the No-VR condition (MySherry et al., 2017). However, 75% of the participants of this study reported to find VR helpful. Another study did not find a difference in pain levels before, after or during the VR intervention (Khadra et al, 2018). For six of the 12 studies an effect size was generated as the mean difference between the standard care condition and the VR treatment condition divided by the pooled standard deviation. Effect sizes were not

calculated for Ford et al. (2018), Khardra et al. (2018) and Phelan et al. (2018) because these studies did not include a control standard care condition. Moreover, effect sizes were not calculated for Furness et al. (2019), Hoffman (2014), Sacpin et al. (2017) because complete descriptive data with for example means and standard deviations were not introduced. According to Cohen (1988) effect sizes of .20 are classified as small, .50 as medium and .80 as large. Four of the studies fall under the large range (Al Ghamdi et al., 2018; Hoffman et al., 2019; Hua et al., 2015; Joo et al. 2020), indicating a significant clinical benefit. One of the studies falls under the medium range (Jeffs et al., 2014) and one under the small range (McSherry et al., 2017). While two of the studies pointed out that more research is needed to examine the generalizability of the results to a clinical setting (Al-Ghamdi et al., 2018; Phelan et al., 2018), eight of the studies indicated that VR interventions can be effectively applied in the clinical environment to support pain relief (Ford et al., 2018, Furness et al., 2019; Hoffmann et al., 2019; Hua et al., 2015; Jeffs et al., 2014; Joo et al., 2020; Phalen et al., 2018). Thus, the results supported the first hypotheses that active and passive VR treatment is effective in reducing pain in burn victims, while simultaneously indicating its relevance for burn care in the clinical setting.

Table 5

Main Results of the Included Studies Reporting the Effect of VR Intervention on Pain

Article Author (year)	Participants *N*	Age	Study Design	Measurement Instruments	Statistical Relevance	Cohen's d	Clinical Relevance
Al-Ghamdi et al. (2018)	48	18-30	Within-subject crossover design, no analgesia, healthy subjects received two thermal pain stimuli, once with eye-tracked VR, once with passive VR Additional 24 participants received No VR in pilot test	GRS	Eye-tracking VR significantly more effective than passive VR in reducing pain $p < .001$ 24 participants of No VR condition reported no differences in pain levels.	1.683	More research needed to see generalizability to clinical settings. First subject reported unusually large pain reduction with eye-tracking VR compared to no VR.
Ford et al. (2018)	10	39-65	Mixed-methods, Participants chose one of eight environments and could switch environment	Survey developed for study; Semi-structured interview	90% experienced distraction through VR application and 60% attained meaningful associated pain reduction.	Not available	Outpatient sample indicated effectiveness of VR on pain reduction during burn care in clinical settings.
Furness et al.	5	19-68	Qualitative usability study, three observed	Two patient interviews after	VR reduced perceived pain. Results suggest	Not available	Reports of patients and nurses indicated

(2019)			dressing changes in different orders: no VR, active and passive VR	VR dressing changes and one interview after study completion Post-study interview with staff focus group of three nurses	active VR to be more effective in reducing pain than passive VR.		effectiveness, acceptability and applicability of VR for pain reduction in clinical setting
Hoffman et al. (2019)	48	6-17	Within-subject pilot design, randomized treatment: playing SnowWorld, snowy canyon, no VR and analgesia only	GRS	Significant pain reduction	1.03	Results indicate effectiveness and applicability of VR for pain reduction in clinical setting
Hoffmann et al. (2014	1	11	Case study, three sessions: analgesia only, VR and analgesia, analgesia only	GRS	Reduced pain intensity and pain unpleasantness.	Not available	Results suggest effectiveness of inexpensive VR for pain reduction treatment
Hua et al. (2015)	65	4-16	RCT parallel group: *N*= 32 standard distraction without VR, *N*=33 VR distraction	FACES; VAS; pulse rate and oxygen saturation in 2min intervals; FLACC score by nurses	VR distraction significantly reduced pain levels before, during and after dressing changes compared to standard distraction.	.891	Results suggest efficiency of VR in clinical setting by reducing time for dressing changes
Jeffs et al. (2014)	28	10-17	RCT parallel group, experimental design, three conditions: standard care, passive distraction watching a movie, VR	APPT; word GRS; Open- and closed items in Pre-Procedure and Post-Procedure Questionnaire	VR condition significantly reduced pain compared to passive distraction condition. Participants reported less but statistically insignificant pain in VR compared to standard condition.	.558	Results suggest VR can be valuable adjuvant to standard pain treatment for healthcare professionals to promote pain reduction and lower analgesia needed
Joo et al. (2020)	57	VR group: *M* = 48.07(8.14); control: *M* = 41.69(14.05)	RCT, randomly assigned to VR (*N* = 28) or control group (*N* = 29)	MHQ	Significant improvement in pain in VR condition	.785	Results indicate VR to be clinically useful for pain reduction in patients with burned hands
Khardra et al. (2018)	15	2 months-10 years	Within-subject quasi-experimental design, two conditions: VR and no VR condition	FLACC scale; Comfort Level; Level of sedation	No difference in pain levels before, during or after procedure	Not available	Results indicate acceptability and feasibility of VR for treatment of burn injured children in clinical setting
McSherry et	18	20-73	Within-subject design, two different wound	Verbal numeric scale ; Yes/no	No differences in pain between VR and no	.036	Results suggest VR to be beneficial in

al. (2017)			dressing changes: VR and analgesia and analgesia only, randomized treatment order	questions	VR condition, but amount of opioid analgesics needed significantly reduced in VR condition; over 75% of participants reported to find VR helpful		reducing analgesia needed during burn care and should be used as non-analgesic method for pain reduction
Phelan et al. (2018)	15	18-49	Mixed-methods design, four VR scenarios	Short interview after each scenario Rate maximum pain on pain scale	Significant extent in pain threshold and tolerance in active scenarios compared to passive scenarios. Active scenarios reduced pain awareness.	Not available	Results indicate that active scenarios could effectively reduce pain in clinical settings, but more research is needed
Scapin et al. (2017)	2	8-9	Case study, four measurement moments: just before dressing change, during dressing change no VR, during dressing change with VR, after closing dressing no VR	Facial pain scale	Relevant effect in pain reduction	Not available	VR can improve dressing changes, reduce stress in healthcare team and improve collaboration with children

Note. APPT = Adolescent Pediatric Pain Tool; FACES = Wong-Baker Faces; FLACC scale = Face, Legs, Activity, Cry, Consolability scale; GRS = Graphic Rating Scales; MHQ = Michigan Hand Outcomes Questionnaire; RCT = randomized controlled trial; VAS = Visual Analogue Scale; VR = virtual reality.

Effectiveness of VR on Reducing Anxiety

The second hypothesis was that applying active and passive VR distraction during burn care would effectively reduce anxiety of burn injured patients. Table 6 shows the effects of the VR intervention on anxiety. Three of these studies reported an anxiety reducing effect during the VR treatment (Furness et al., 2019; Hua et al., 2015; Jeffs et al., 2014). One article reported a decrease of negative emotions including fear after the VR treatment on days the participant experienced negative emotions (Gomez et al., 2017). One article did not find any difference in anxiety levels between the VR and the No-VR condition and explained that the verbal numeric scale applied as a measurement tool for anxiety may not have been sufficiently sensitive to be able to notice changes in anxiety levels (MySherry et al., 2017). An effect size was generated for three of the six studies as the mean difference between the standard care and the VR treatment condition divided by the pooled standard deviation. Effect sizes were not calculated for Khardra et al. (2018)

because it did not comprise a standard care condition and for Furness et al. (2019) and Gomez et al. (2017) because these studies did not display complete descriptive data. Two of the studies fall under the small range (Jeffs et al., 2014; McSherry et al., 2017) according to the effect size classification of Cohen (1988). One study falls under the large range (Hua et al., 2015) pointing to its relevance in the clinical environment. One study pointed out the desirability of VR interventions in the clinical setting (Furness et al., 2019) and another study recommended the use of VR for anxiety reduction in a clinical setting (McSherry et al., 2017). The remaining four studies did not directly point out the clinical relevance of VR to reduce anxiety. Thus, the results revealed a tendency of active and passive VR distraction to effectively reduce anxiety during burn care, while some studies indicated its relevance in the clinical setting. Hence, the second hypothesis was supported by the results.

Table 6

Main Results of the Included Studies Reporting the Effect of VR Intervention on Anxiety

Article Author (year)	Participants N	Age	Study Design	Measurement Instruments	Statistical Relevance	Cohen's d	Clinical Relevance
Furness et al. (2019)	5	19-68	Qualitative usability study, three observed dressing changes in different orders: no VR, active and passive VR	Patient interviews; Post-study interview with staff focus group	Active VR seems more effective in reducing anxiety than passive VR	Not available	Results indicated perceived effectiveness, acceptability and applicability of VR in clinical setting for anxiety treatment
Hua et al. (2015)	65	4-16	RCT parallel group: *N*=32 distraction without VR, *N*=33 VR distraction during dressing changes	FACES; VAS; FLACC score by nurses	Nurses report significantly reduced anxiety levels during and after dressing changes in VR distraction condition compared to standard distraction	.986	Results suggest efficiency of VR in clinical setting by reducing time for dressing changes
Jeffs et al. (2014)	28	10-17	RCT parallel group, experimental design, three conditions: standard care, passive distraction watching a movie, VR	Spielberger State-Trait Anxiety Inventory for Children; Pre-Procedure and Post-Procedure Questionnaire	STAIC Trait Anxiety and procedural pain correlated negatively with distraction engagement	.080	VR can be valuable adjuvant to standard pain treatment for healthcare professionals
Khadra et al. (2018)	15	2 months -10 years	Within-subject quasi-experimental design, two conditions: VR and no VR condition	Modified Smith Scale for baseline anxiety; PBCL for procedural anxiety and distress; Comfort Level	Assessing anxiety not feasible	Not available	Results indicate acceptability and feasibility of VR for treatment of burn injured children in clinical setting
Gomez et al. (2017)	1	21	Case study	Diary cards	Reduced fear on days participant experienced negative emotions	Not available	Findings indicate clinical potential of using VR mindfulness in burn wound care
McSherry et al. (2017)	18 73	20-	Within-subject design, two conditions: VR and analgesia and analgesia only, randomized treatment order	Verbal numeric scale; Yes/no questions	No differences in levels of anxiety between VR and no VR condition were found	-.247	VR should be used as non-analgesic method to minimize patient anxiety

Note. APPT = Adolescent Pediatric Pain Tool; FACES = Wong-Baker Faces; FLACC scale = Face, Legs, Activity, Cry, Consolability scale; Procedure Behavior Check List = PBCL; RCT = randomized controlled trial; VAS = Visual Analogue Scale; VR = virtual reality.

Pain Reduction Differences between Younger and Older Patients

The third hypothesis was that active and passive VR distraction would prove significantly more effective in pain reduction in child and adolescent burn patients than in adult burn victims. Effect sizes for pain are displayed in Tables 5 and graphically illustrated in Figure 2. For studies including adult participants two studies fall under the large range (Al Ghamdi et al., 2018; Joo et al. 2020) and one study falls under the small range (McSherry et al., 2017). Of the studies with child and adolescent participants two studies fall under the large (Hoffman et al., 2019; Hua et al., 2015) and one under the medium range (Jeffs et al., 2014). As can be seen in Figure 2 the results do not reveal a difference in effectiveness of active and passive VR distraction between child and adolescent patients and adult patients. Therefore, the third hypothesis was not supported by the results.

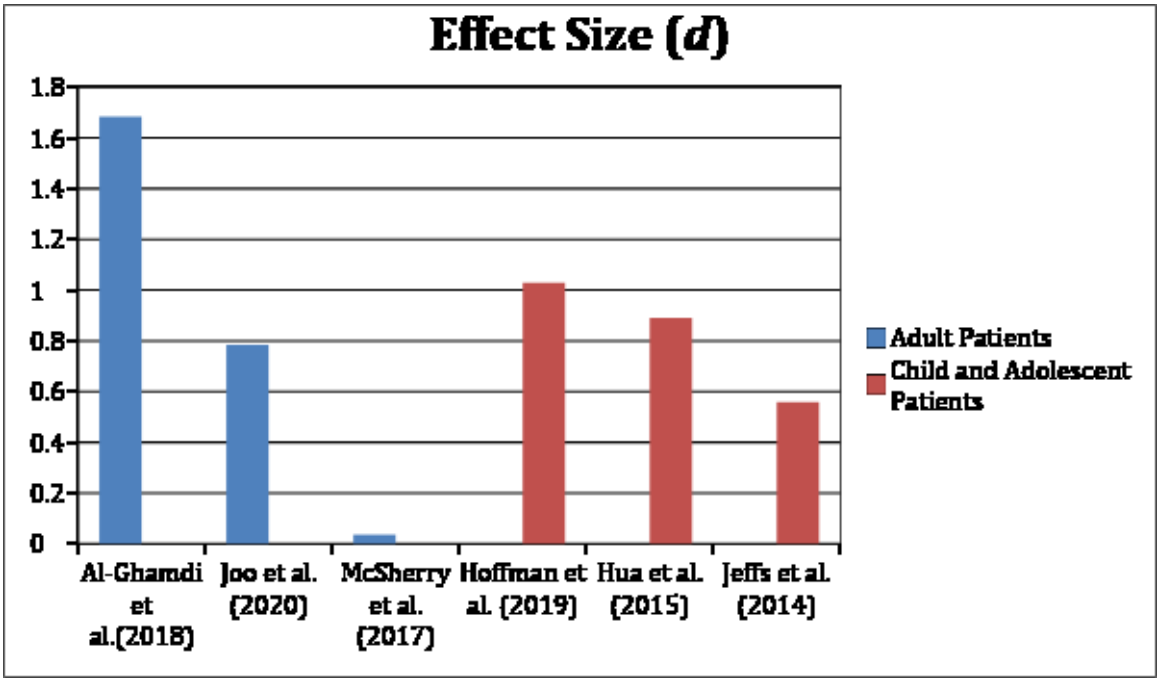

Figure 2. Effect Sizes (*d*) for Pain Reduction as the Mean Differences of the VR Treatment Condition and the Standard Care Condition.

Anxiety Reduction Differences between Younger and Older Patients

It was fourthly hypothesized that active and passive VR distraction would indicate significantly more effectiveness in alleviating anxiety in child and adolescent burn patients than in adult burn victims. Effect sizes for anxiety are presented in Table 6 and Figure 3. The study including adult participants falls under the small range (McSherry et al., 2017) according to the effect size classification of Cohen (1988). Among the studies including

child and adolescent participants one study falls under the large (Hua et al., 2015) and one under the small range (Jeffs et al., 2014). Even though the results reveal a tendency of active and passive VR distraction to be more effective in anxiety reduction for child and adolescent burn patients than for adult patients, the small number of effect sizes available does not yield sufficient evidence to support the fourth hypothesis.

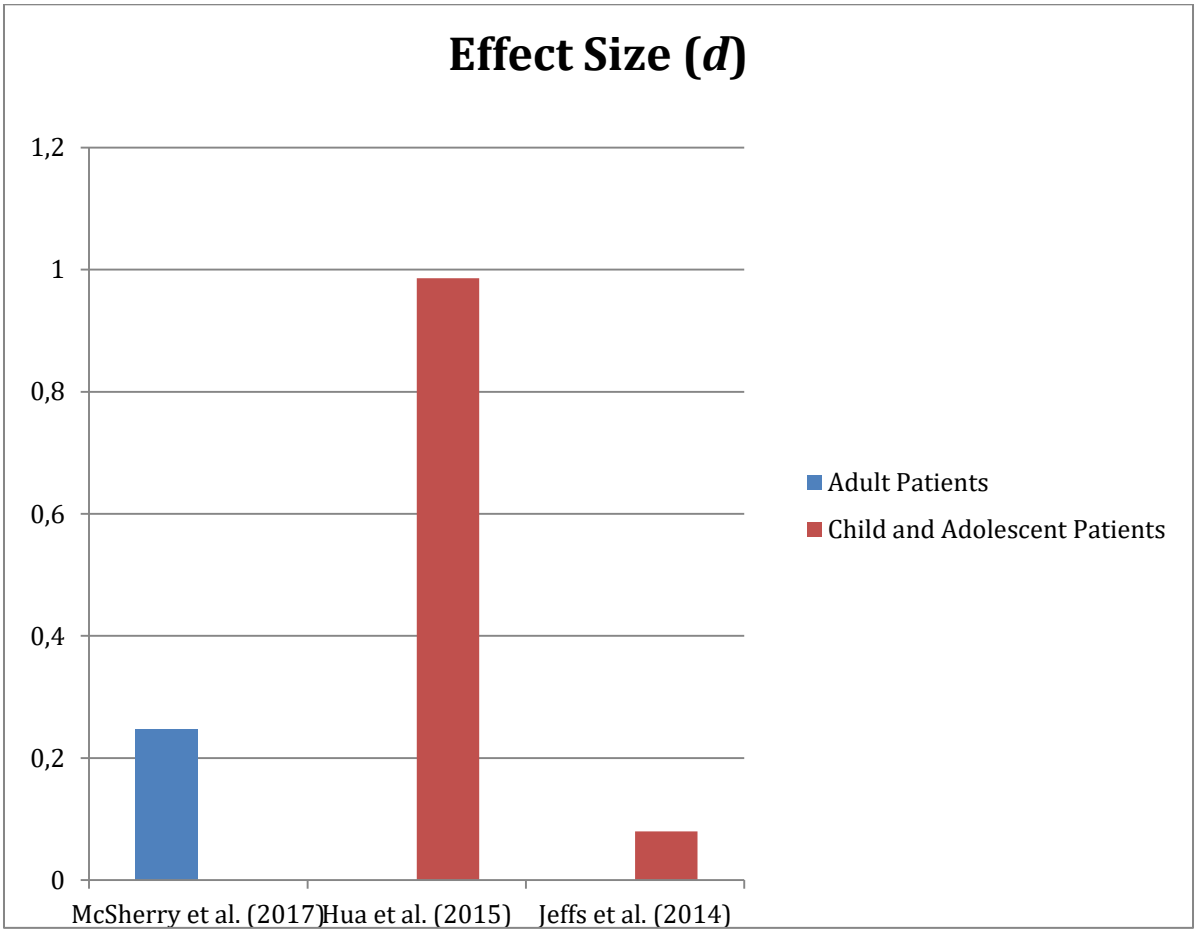

Figure 3. Effect Sizes (*d*) for Anxiety Reduction as the Mean Differences of the VR Treatment Condition and the Standard Care Condition.

Discussion

The aim of this systematic literature review was to examine the effectiveness of active and passive VR distraction interventions in four areas: 1) whether VR distraction is an effective intervention to reduce pain levels in burn injured patients, 2) whether VR distraction interventions are effective in reducing anxiety levels in burn injured patients, 3) whether VR distraction more effectively reduces pain in child and adolescent burn wound patients than in adult burn patients and 4) whether VR distraction reduces anxiety more effectively in child and adolescent burn patients than in adult burn patients.

The first hypothesis was accepted. Most studies found active and passive VR distraction to have a pain reducing effect on burn injured patients. These findings are in line with previous research indicating that pain can be reduced through distraction (e.g. Campbell et al., 2010; Miron, Duncan, & Bushnell, 1989). One explanation for this effect is that VR distraction draws so much attention that the patient's brain has fewer attention capacities left to perceive pain signals from the burn injury (e.g. Hoffman et al., 1998; Hoffman et al., 2000; Birnie et al., 2017). This is in line with a study by Bantick et al. (2002) who found changes in pain-related brain areas due to the application of distraction methods using functional magnetic resonance imagining (fMRI). The two studies that did not find a pain relieving effect of the VR intervention could be explained by the study design. In one study, the mean age of the participants was 2.2 (*SD* = 2.1) and thus, the measurement tools used were largely observational (Khadra et al., 2017). Behaviours pointing to distress, pain or fear have a substantial overlap, which is making it complicated to differentiate between distress that can or cannot be associated with pain (Blount & Loiselle, 2009; Kohut & Riddell, 2009). The other study had a high frequency of drug abusers among the participants, who might have a different pain perception than non-drug abusers (McSherry et al., 2017). These results indicate that active and passive VR distraction is a desirable intervention to support pain reduction in burn patients in the clinical setting, which was also pointed out by most of the articles.

Further, the second hypothesis was supported. Most studies reported active and passive VR distraction interventions to have effectively reduced anxiety levels in burn wound patients. This is in line with earlier studies indicating that distraction has an effect on anxiety reduction (e.g. Canbulat, Inal, & Sönmezer, 2014; Klassen, Liang, Tjosvold, Klassen, & Hartling, 2008; Sahiner & Bal, 2016). The results of the article by McSherry et al. (2007) that found no effect of VR on anxiety in burn injured patients, could have been caused by the measurement instrument that may not have been precise enough to identify changes in anxiety levels. Despite their study outcomes, they recommended the use of VR distraction in the clinical setting. These outcomes indicate that active and passive VR distraction appears to be a valuable tool to reduce anxiety for burn patients in the clinical environment.

The third hypothesis was rejected. Contrary to the expectation that active and passive VR distraction would show more effectiveness in reducing pain in younger burn patients than in adults, the results revealed a similar distribution of the pain reducing effect of the VR distraction intervention between child and adolescent burn victims and adult

burn wound patients. A possible explanation for these results is that the level of VR immersion among adolescents is less intense and more similar to the immersion level of adults than of children. This is in line with previous research suggesting that stronger immersion is associated with stronger pain reduction and that younger children become more immersed into VR interventions than older children (Eijlers et al., 2019; Gutierrez-Martinez, Gutierrez-Maldonado, Cabas-Hoyos, & Loreto, 2010; Hoffman et al., 2004). Another explanation for the results is that only the effect sizes of six articles could be calculated, which is why possible differences of the VR intervention effect between younger and older patients could not reliably be detected. Future studies could examine possible differences in the pain reducing effect of active and passive VR distraction between child and adult burn patients to make recommendations for the clinical setting.

Finally, the fourth hypothesis was not supported by the results. As only three effect sizes for anxiety reduction could be generated from the articles the results were not conclusive about a difference in the effectiveness of active and passive VR distraction between child and adolescent patients and adult burn injured patients. Therefore, more research is needed to investigate a difference in the anxiety reducing effect of active and passive VR distraction between younger and older burn patients.

Strengths and Limitations

For the improvement of future research some strengths and limitations of the present review are taken into account. That three databases have been searched to ensure a thorough overview of the most recent available literature about an increasingly important subject is a strong point of this review considering the fast technological progress and its increasing relevance in the clinical context (e.g. Bhavnani, Narula, & Sengupta, 2016).

One limitation of this review is that it was not possible to perform a meta-analysis to gain even more meaningful results, due to time limitations, the small number of articles available as well as not comparable measurement instruments. Nevertheless, this review contributes valuable insight about the most recent findings about the effectiveness of active and passive VR distraction on pain and anxiety reduction. In addition to that, this is the first review to compare differences of the effectiveness on pain and anxiety reduction of active and passive VR distraction interventions between younger and older burn victims and to encourage future research to investigate that new area further.

A further limitation of this study is the small sample sizes of some of the included articles, which reduces the generalizability of the results to patients with different burn wounds, pain and anxiety severity and ages. Nonetheless, the findings point out that active

and passive VR distraction was beneficial and found to be helpful by most patients, so that future investigations can take this as a motivation to include larger participant groups in their studies.

That the articles used different VR intervention softwares could be seen as another limitation, as this could have impacted the degree of immersion and effectiveness. However, the results of this review show a pain and anxiety reducing effect of the VR intervention despite varying softwares used in the studies. Moreover, the influence of VR software could also be insignificant, as the meta-analysis of Kenney and Milling (2016) did not detect any differences between commercial VR games and particularly developed VR distraction.

Practical Implications and Future Research

On the basis of these outcomes, this review exposes some implications for future research. Active and passive VR distraction can be viewed as a desirable intervention during the treatment of burn patients as it can effectively be applied for the reduction of pain and anxiety. To yield more representative results in the future, studies with larger sample sizes should be conducted. To improve interventions especially for younger patients with fewer coping strategies during medical procedures, this review revealed the need for more research in order to determine possible differences between child and adult patients of the effect of VR interventions on pain and anxiety reduction. In addition to that, the impact of other variables on the effectiveness of VR interventions on pain and anxiety reduction, such as variations in space and depth of the burn wounds, are still unclear and should be investigated in future research. Moreover, the pain and anxiety reducing effect of VR exposure as a preparation for medical procedures is rarely explored (Eijlers et al., 2019) and should be examined in further research.

Conclusion

This review examined the pain and anxiety reducing effects of active and passive VR distraction on pain and anxiety and compared differences in the pain and anxiety reducing effect of active and passive VR distraction between child and adolescent burn victims and adult burn wound patents. In general, VR distraction effectively supported the reduction of pain and anxiety in burn injured patients. The findings of this review suggest that the implementation of active and passive VR distraction during medical procedures may be beneficial for burn injured patients, as it can decrease pain and anxiety perception. The findings did not reveal a difference in the pain and anxiety relieving effect of VR distraction between child and adolescent patients and adult patients and exposed the need

for more research in this area since effective interventions that facilitate medical procedures for younger patients are especially desirable as they have fewer coping abilities than adults. Overall, the results indicate that VR interventions appear to be a valuable tool in the clinical setting and should be a matter of further research to improve its application and effectiveness.

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Appendix

Search Strings

PsycINFO

1 TI (“virtual reality” OR VR OR “user-computer interface*”)

2 TI (burn*)

3 TI (effect* OR efficacy)

4 TI (analgesi* OR pain OR anxiety OR intervention* OR management* OR treat* OR therapy)

1 AND 2 AND 3
1 AND 2 AND 4

PubMed

1 (“virtual reality”[Title] OR VR[Title] OR “user-computer interface*”[Title])

2 AND (burn*[Title])

3 AND (effect*[Title] OR efficacy[Title])

4 AND (analgesi*[Title] OR pain[Title] OR anxiety[Title] OR intervention*[Title] OR management*[Title] OR treat*[Title] therapy[Title])

1 AND 2 AND 3
1 AND 2 AND 4

Scopus

1 TITLE-ABS-KEY(“virtual reality” OR VR OR “user-computer interface*”)

2 AND TITLE-ABS-KEY(burn*)

3 AND TITLE-ABS-KEY(effect* OR efficacy)

4 AND TITLE-ABS-KEY(analgesi* OR pain OR anxiety OR intervention* OR management* OR treat* OR therapy)

1 AND 2 AND 3

1 AND 2 AND 4