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IMMERSIVE VIRTUAL REALITY IN PAIN RELIEF IN PATIENTS WITH BURNS: SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Objective: Evaluating the use of immersive virtual reality as a non-pharmacological intervention for pain relief and opioid consumption during dressing changes in patients with burn injuries. **Methods:** This review considered study designs, randomized clinical trials, non-randomized controlled trials, without restriction on the year of publication. An extensive search in six electronic databases (PubMed; EMBASE, Web of Science, CINAHL, Cochrane Library, Clinicaltrial.gov) was performed. RevMan version 5 software was used to carry out a meta-analysis. The certainty of the evidence was analyzed using GRADE. **Results:** Included 10 articles, total of 514 patients, aging 5 to 80 years old. In a combined analysis of pain variables, time thinking about pain from eight studies, the result favored the use of immersive virtual reality compared to control, the Standardized Mean Difference (SMD -0.86; 95% CI -1.22 - 0.49 N = 772 I2 = 82%). **Conclusion:** The evidence compiled in this review supports the use of immersive virtual reality to reduce pain.

DESCRIPTORS: Immersive Virtual reality. Burns. Pain. Anxiety. Adults. Children

REALIDADE VIRTUAL IMERSIVA NO ALÍVIO DA DOR EM PACIENTES COM QUEIMADURAS: REVISÃO SISTEMÁTICA E METANÁLISE

RESUMO

Objetivos: Avaliar o uso da realidade virtual imersiva como intervenção não farmacológica no alívio da dor e no consumo de opioides durante a troca de curativo em pacientes com lesões por queimaduras. **Métodos:** Esta revisão considerou desenhos de estudos, ensaios clínicos randomizados, ensaios controlados não randomizados. Foi realizada busca extensa em seis bases de dados eletrônicas, (PubMed; EMBASE, Web of Science, CINAHL, Cochrane Library, Clinicaltrial.gov). Para metanálise foi utilizado o software RevMan versão 5. A certeza da evidência foi analisada por meio do GRADE, sem limite de ano de publicação. **Resultados:** Incluídos 10 artigos, total de 514 pacientes, idades de 5 a 80 anos. Em uma análise combinada das variáveis de dor, de oito estudos e o tempo pensando na dor de dois estudos, o resultado favoreceu o uso de realidade virtual imersiva em comparação ao controle, a Diferença da Média Padronizada (DMP -0,86; IC 95% -1,22 – 0,49 N = 772 I2 = 82%). **Conclusão:** As evidências reunidas nessa revisão apoiam o uso realidade virtual imersiva para reduzir a dor.

DESCRITORES: Realidade virtual imersiva. Queimaduras. Dor. Ansiedade. Adulto. Criança.

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REALIDAD VIRTUAL INMERSIVA EN EL ALÍVIO DEL DOLOR EN PACIENTES CON QUEMADURAS: REVISIÓN SISTEMÁTICA Y METANÁLISIS

RESUMEN

Objetivos: Evaluar el uso de la realidad virtual inmersiva como intervención no farmacológica en el alívio del dolor y el consumo de opioides durante el cambio de apósitos en pacientes con lesiones por quemadura. **Métodos:** Esta revisión consideró los diseños de estudio ensayos clínicos aleatorizados, ensayos controlados no aleatorizados, sin límite en el año de publicación. Se realizó una búsqueda exhaustiva en seis bases de datos electrónicas (PubMed; EMBASE, Web of Science, CINAHL, Cochrane Library, Clinicaltrial.gov). Para el metanálisis se utilizó el software RevMan versión 5. La certeza de la evidencia se analizó mediante GRADE. **Resultados:** Se incluyeron 10 artículos, con un total de 514 pacientes de edades comprendidas entre los 5 y los 80 años. En un análisis combinado de variables de dolor, tiempo pensando en el dolor de ocho estudios, el resultado favoreció el uso de realidad virtual inmersiva en comparación con el control, la Diferencia de medias estandarizada (DME -0,86; IC del 95%: -1,22 - 0,49 N = 772 I2 = 82%). **Conclusión:** Las pruebas reunidas en esta revisión apoyan el uso de la realidad virtual inmersiva para reducir el dolor.

DESCRIPTORES: Realidad Virtual Inmersiva. Quemaduras. Dolor. Ansiedade. Adultos. Niños.

INTRODUCTION

Burns are caused by thermal, chemical, electrical or radioactive agents and are defined as traumatic wounds. These agents act directly on the skin, causing partial or total destruction of tissues and their attachments. They can reach deeper layers, such as subcutaneous cellular tissues, muscles, tendons and bones. Burns are classified according to depth and size and can be measured by the percentage of body surface affected[1,2]. According to data from the American Burn Association (ABA), in 2014, 450,000 burn events were recorded in the United States of America (USA), with 3,275 deaths related to burns due to smoke inhalation[1]. According to the 2016 report by the Agency for Healthcare Research and Quality, in 2010, US$1.5 billion was spent treating burn patients, with US$5 billion in costs associated with lost work. The vast majority of these injuries were preventable[1].

In Brazil, data from the Ministry of Health indicate that around one million Brazilians suffer burns per year, and only one hundred thousand seek medical care, with 2,500 deaths directly or indirectly related to burn injuries2. The most prevalent burns in the country are second-degree burns[2]. 20,864 hospitalizations of children between 0 and 14 years old suffering from burns were recorded in 2017. In 2016, 209 children in this same age group died from burns[2,3]. However, adults between 20 and 39 years old are those most at risk, as are those at the extremes of age, that is, individuals under 10 and over 60 years old[2,3]. In the pediatric population, the majority of burns occur at home, and around 80% occur in the kitchen. The primary damaging agent is superheated liquids, which cause scalds[2].

Pain is frequently reported among burn patients and can be a limiting factor in activities such as physiotherapy, eating, sleeping and resting, among others. A study on the management of burn injuries that analyzed the meaning attributed to pain based on the interpretation of reports from victims and the nursing team revealed that pain causes stress in the care team, especially during bathing and dressing and is perceived as something terrible for victims during hospitalization[4].

Pain management in burn treatment is still a significant challenge. The characteristics of the pain are vigorous intensity, and several factors contribute to the worsening of pain and prolonged suffering of the burn patient. The trauma caused by the burn itself causes anxiety, aggression, agitation and hyperactivity, which are behavioral responses of individuals with burns[5].

The painful sensation caused by the burn is directly related to nociceptive mechanisms such as extension, duration and location. The affective dimension is related to unpleasant feelings and is closely related to psycho-social-cultural factors, such as culture, social influences, behavioral and personality factors. The cognitive dimension comprises a set of pain modulation factors such as attention-distraction, including the person's meaning and interpretation related to the painful moment. Therefore, it is essential to highlight that the experience is subjective and individual since the

dimensions involved may be stimulated differently, just as the stimulus may be interpreted differently. Therefore, pain assessment and management must be individualized to meet the needs of each patient[5,6].

Pain relief with common analgesics or opioids is essential, as they have a central or peripheral action in pain treatment. They can be administered preventively before applying the dressing intravenously in small bolus with monitoring of vital signs or orally, in case of minor burns[7].

Cognitive distraction has been studied to alleviate pain in different situations, aiming to change how the patient perceives pain. In this context, the use of new technologies has been explored as a non-pharmacological intervention to assist health professionals in pain management. Immersive Virtual Reality (IVR) is an advanced user interface model that allows the visualization, manipulation and interaction of content similar to those in the physical world. Considered a technological tool, IVR provides multisensory information, which enables a three-dimensional vision in a virtual environment. Thus, the user gets involved and interacts in real-time through movement and visualization. This interaction is done through glasses, allowing the individual to have sensations of being, acting and living within the virtual environment. The IVR system provides the user with a distraction of their senses from the real environment. Thus, participants divert their attention from painful procedures, which can change their perception of pain itself.[6,7].

IVR can become an alternative to distraction and consequently reduce pain during care for burn injuries. Knowing that its operation includes the processing of pain signals that affect the conscious attention of the user undergoing treatment and that this attention can be diverted, being focused on images and sounds provided by the IVR, its use has the potential to facilitate the realization of nursing procedures[8].

Therefore, what is the effect of virtual reality compared to usual care in relieving pain and reducing opioid consumption during dressing changes in burn patients?

This review aims to evaluate the use of immersive virtual reality as a non-pharmacological intervention to relieve pain and reduce opioid consumption when changing dressings in patients with burn injuries. In addition to verifying the satisfaction of patients who used virtual reality to relieve pain during dressing changes.

METHOD

This systematic review was done according to the Joanna Briggs Institute (JBI) effect review guidelines9,10.

Intervention

In this review, primary studies that used IVR of any intensity or duration were included to reduce the intensity of pain, anxiety, fear and/or reducing opioid consumption. These interventions can be used with or without pharmacological support. Non-immersive virtual reality interventions were excluded. The interventions of interest were distraction with IVR compared to no distraction, virtual reality distraction compared to non-virtual distraction or analgesic administration alone.

Control

The control was the standard care (usual care) described in primary research or any other intervention that did not have the character of IVR, such as toys, watching TV, or games.

Outcomes/Results

Primary outcomes: Pain intensity during the procedure, measured through self-report, observer report, and caregiver report; behavioral measures also assessed through observer report, post-procedure (up to one hour) and after the procedure measured by medium: self-report and observer report.

Secondary results: Satisfaction, anxiety and reduction in opioid consumption among patients who used IVR. Time that patients spent thinking about the pain and time spent changing the dressing.

Type of Study

In the current research, studies with a randomized clinical trial (RCT) design were included, comparing IVR distraction with no distraction and non-IVR distraction, associated or not with other interventions.

Search strategy

The search strategy was guided by a librarian and carried out in three stages following guidelines from the Joanna Briggs Institute (JBI) Review Manual9.

Gray literature was not included in this research because it was not subject to peer review. A primary search was carried out on the following bases: Excerpta Medica dataBASE (EMBASE); National Library of Medicine, National Institutes of Health (NIH, responsible for the PubMed database), Web of Science, Cochrane Library, Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Production Repository from the University of São Paulo, the portal of the Coordination for the Improvement of Higher Education Personnel (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior-CAPES*) and on the American Burn Association website. Next, the title and abstract were read, and the descriptors used for each article were analyzed.

A second phase of the search was performed, combining all keywords and index terms across all databases included in the search.

The third phase of the search was carried out by analyzing the reference list of studies that met the inclusion criteria of the present review. Date limits and language restrictions were not applied. The limits were study designs, clinical trials and burns. The initial descriptors used were pain, anxiety, burns, distraction, analgesia, and immersive virtual reality (Appendix I).

Study selection

Two independent reviewers carried out the selection of studies. Studies that met the inclusion criteria were retrieved as full texts. Assessment of inclusion criteria included primary studies with patients aged 4 to 80 years who underwent burn dressing changes and experienced IVR during the procedure. Studies with the neonatal population and articles that used virtual reality for rehabilitation were excluded. Inconsistencies were resolved through discussion with a third reviewer. The research results were presented in the review following the items in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart[10].

Assessment of methodological quality

The studies included in the present review were evaluated by two independent reviewers using a standardized checklist for critical evaluation of studies with randomized clinical trial designs, the JBI Critical Appraisal Checklist for Randomized Controlled Trials11, which consists of 13 questions. Differences between reviewers were resolved by consensus with a third reviewer. The assessment of the certainty of the evidence was carried out using the GRADEpro software (McMaster University, ON, Canada) for all three outcomes analyzed in the meta-analysis[12,13].

Data extraction

Data were extracted using a form structured by the authors with the following study information: country, year, magazine, population (age, sex), type of intervention (if immersive combined with an opioid, opioid only), main results, study design, instruments used to measure results, measured results (pain, anxiety, fear).

Data presentation and statistical analysis

For studies that did not contain sufficient information to include them in the meta-analysis, the results were presented in a descriptive summary.

Data were analyzed using standardized mean difference (SMD), a statistic used in meta-analysis to standardize and combine results from studies that evaluate the same outcome but are measured differently. Studies with similarly measured outcomes and sufficient data reporting (primary studies) were included in the meta-analysis. RevMan 5.4 was used for statistical analysis and meta-analysis.

Heterogeneity was assessed using the I^2 statistic. This measure describes the percentage of total variation between studies due to heterogeneity rather than chance. A value greater than 50% can be considered substantial heterogeneity[14].

The random effect model used in the meta-analysis was selected because it assumes a distribution of effects and not a typical identical effect size. In this model, the condensed effect size estimates the mean distribution of actual effects, not a standard shared effect size equal for all studies[15].

RESULTS

After analyzing the texts by two independent reviewers, 48 articles were included, with only ten articles meeting the eligibility criteria. Two articles, due to the scarcity of data, were considered only for descriptive synthesis and eight for quantitative synthesis. The publication period was from 2005 to 2022 (Fig. 1).

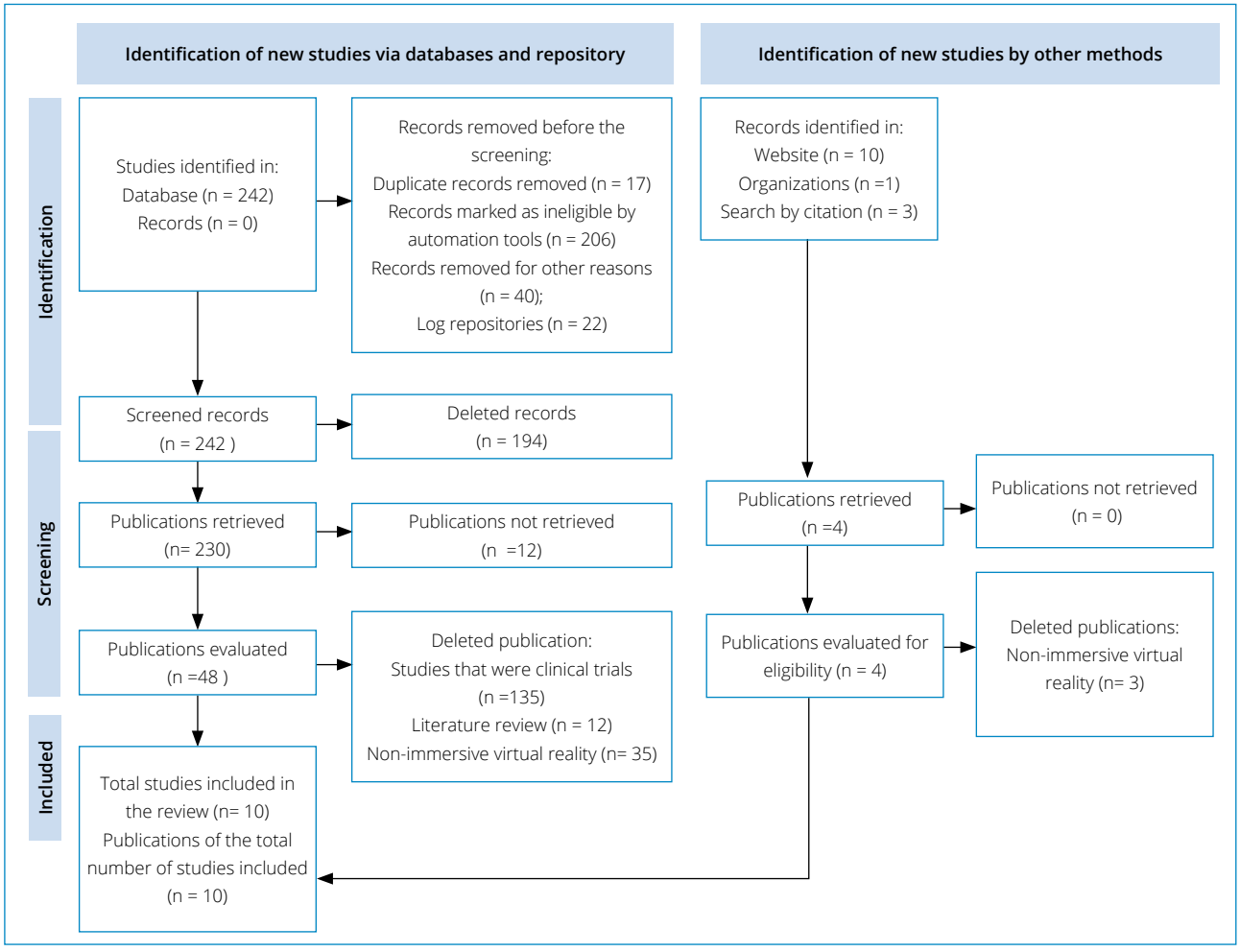

Figure 1. PRISMA flowchart for analysis, selection, inclusion and exclusion of studies. São Paulo (SP), Brazil - 2022.

Source: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020[17,18]

The ten articles included account for 502 patients aged between 5 and 80. We had IVR interventions offered by trained nurses, as well as routine pharmacological interventions associated or not with the intervention. The types of intervention used described in ten studies[5,7,19,20-26] were made up of interactive games such as Virtual River Cruise, SnowWorld, an immersive three-dimensional virtual world program, Ice Age 2 game, Chicken Little, Need for Speed, and Merry Snowballs. In the control group, the main interventions cited by the studies[20,23,26] primary interventions were toys, books, watching TV, music and comfort from caregivers, in addition to routine pharmacological therapy (Table 1).

Table 1. Characteristics of the primary studies included in the review. São Paulo (SP), Brazil – 2022.

Author. Year, Country, Journal	Objective	Study design	Results measured	Population sample
Xiang H, Shen J, Wheeler KK, et al[19] 2021 JAMA Netw Open	Evaluate the effectiveness of a smartphone VR game on dressing change pain in pediatric burn patients	RCT	Anxiety Pain	90 children Age 6 to 17 years 45 Male 45 Female 51 (57%) white; 31 children active intervention group 30 children passive intervention group 29 children control group
	Scales used to measure outcomes	**Degree of burn**	**Intervention**	**Main results**
	Scale Faces, Legs, Activity, Cry, and Consolability-Revised (FLACC-R) Analogic Visual Scale State-Trait Anxiety Inventory for Children (STAI-CH)	The children had burns: First degree 0 (0%) Second grade 81 (90%) Third grade 6 (7%) TBSA was 2.6 (1.8-3.4)	Active IG had the Virtual River Cruise and had interaction. Passive IG were immersed in the same VR environment without interaction CG received distraction tools such as: (iPads, music, books and/or conversations). Equipment used: Apple iPhone 6 and detachable headphones. Outpatient	Participants in the active VR group had lower pain (Visual Analog Scale score 24.9 [95% CI, 12.2-37.6]) compared to the control group (Visual Analog Scale score, 47.1 [95% CI] %, 32.1-62.2]; P = 0.02) Child's expectation: active RV 85.1 (77.0-93-3) vs passive RV 85.5 (78.0-92.9) vs. Control 90.7 (84.7-96.8). Anxiety: Intervention 11.7 (10.7-12.6) vs. Control 12.3 (10.9-13.7) The median days since injury were similar in the 3 groups. Of the 90 patients, 30 (33%) received pain medication six hours before dressing change
Author. Year, Country, Journal	**Objective**	**Study design**	**Results measured**	**Population sample**
Das DA, Grimmer KA, Sparnon AL, McRae SE, Thomas BH[20]. 2005 BMC Pediatrics	Verify the effectiveness of playing a VR game in modulating pain in children with acute burns	RCT random	Pain	9 children Age 10 5-16 years 6 Male 3 Female
	Scales used to measure outcomes	**Degree of burn**	**Intervention**	**Main results**
	Faces Scale *Visual Analog Scales*	TBSA was 5.3% (SD 3.4%). Causes of burns: By motorcycle silencer, hot water bottle, gasoline and hot oil on the barbecue. Everyone suffered burns for the first time. Dressing Type: Acticoat/Silver Oxide Dressing	The control group received routine analgesia. The intervention group experienced VR and standard analgesia—interactive game. The VR equipment consisted of a laptop (Dell Inspiron 5100, Pentium 42.4 GHz CPU with Radeon Mobility 7500 graphics card) with the game software. ICU environment	Pain: Control 4.1 (2.9) vs. Intervention 1.3 (1.8)

Continue...

Table 1. Continuation...

Author. Year, Country, Journal	Objective	Study design	Results measured	Population sample
Hoffman HG, Rodriguez RA, Gonzalez M, et al[7] 2019 Front Hum Neurosci	To test for the first time whether immersive virtual reality (VR) can serve as an adjunctive non-opioid analgesic for children with extensive burns during dressing changes.	RCT	Pain Pain intensity Satisfaction Fun	48 children Age 6 to 17 years 33 Male 15 female Intervention group Group control
	Scales used to measure outcomes	**Degree of burn**	**Intervention**	**Main results**
	Graphic Rating Scales *Visual Analog Scales* *Pain Catastrophizing Scale for Children* (PSC-C)	TBSA 40% 28% 3rd degree burns 77% burns to the hands, 85% to the arms, 44% to the feet, 79% to the legs, 71% to the neck/head, 79% to the torso/ torso and 23% to the groin	Snow World Intervention (interactive game). Control group analgesia only. Equipment: NVIS.com MX90 VR glasses with 90-degree diagonal field of view per eye and 1,280 × 1,024 pixel resolution per eye ICU environment	Pain: Control 8.52 (1.75) vs. Intervention 5.10 (3.27) Fun: Control 4.81 (3.93) vs. Intervention 6.68 (3.86) Satisfaction with treatment: Control 5.22 (3.34) vs. Intervention 8.04(2.33) Time thinking about pain: Control 6.04 (3.41) vs. Intervention 2.47 (3.37) Average dressing change time: 16.56 min Control vs. 12.89 min Intervention
Author. Year, Country, Journal	**Objective**	**Study design**	**Results measured**	**Population sample**
Hua Y, Qiu R, Yao WY, Zhang Q, Chen XL[21] 2015 Pain Manag Nurs	Investigate the effect of VR experience on pain relief during dressing changes in children with chronic wounds in the lower limbs.	RCT	Pain Pulse Oxygen Saturation	65 patients Age 4 to 16 years 31 Male 34 Female 32 patients control group 33 patients intervention group
	Scales used to measure outcomes	**Degree of burn**	**Intervention**	**Main results**
	Visual Analog Scales FLACC *Score* FACES *Pain Score*	The average wound size was 72.6±62.3 cm2 in the CG and in the IG 84.2±57.5 Causes of injury: 29 Traffic injury 17 Injury from falling 13 Mutilated Injury 6 other causes Type of dressing: 24 Silver ions 25 Acid seaweed salt 10 Povidone-iodine 6 other types	The control group received toys, television, books and comfort from parents. The intervention group used the game Ice Age 2. Equipment: an eMagin Z800 3DVISOR head-mounted display. SVGA three-dimensional OLED micro screens, 24-bit colors for more than 16.7 million colors. Wards	Pain: Intervention during dressing: FACES 2.42 (1.85), VAS 4.35 (2.64), FLACC 4.18 (2.97) vs. Control during dressing: FLACC 7.36 (3.47), VAS 6.25 (2.84), FACES 4.19 (2.12). Dressing change time: Control 27.9 (6.83) mins vs. 22.3 (7.85) min p ¼ 0.003 in Intervention Patients had lower pulse rates during dressing change in the Intervention group 98.88 (11.57) vs. Control 106.2 (11.45), p < 0.05
Author. Year, Country, Journal	**Objective**	**Study design**	**Results measured**	**Population sample**
Hoffman HG, Patterson DR, Rodriguez RA, Peña R, Beck W, Meyer WJ[22] 2020 Front Virtual Real.	Compare the effect of adjunctive VR with the effect of standard analgesics during burn cleaning/debridement	RCT random	Fun Pain Time spent thinking about pain	50 children Age 6 to 17 years 84% male 16% female

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Table 1. Continuation...

Author. Year, Country, Journal	Scales used to measure outcomes	Degree of burn	Intervention	Main results
Hoffman HG, Patterson DR, Rodriguez RA, Peña R, Beck W, Meyer WJ[22] 2020 Front Virtual Real.	Graphic Rating Scale Visual Analog Scales	TBSA ranged from 14 to 86% 68% burns on the hands, 76% on the arms, 29% on the feet, 59% on the legs, 63% on the head/neck, 76% on the torso/ torso, and 12% on the groin. Etiologies of burns: flame 66% electric 27% scald 7.3% chemical 2% other 4.9%	Snow World interactive game intervention, in addition to painkillers. Control received oral opioids alone or combined with an oral benzodiazepine. The equipment was model MX90 VR glasses from NVISinc.com with a 90-degree diagonal field of vision per eye. ICU environment	Mean duration of wound treatment on day 1:24.05 min (SD 7.35) Control vs Intervention 20.20 min (SD 7.43) Pain: Control 7.46 (SD 2.93) vs. Intervention 5.54 (SD 3.56) Time spent thinking about pain: Control 6.33 (4.26) vs 4.88 (3.54) min Intervention. Fun: Control 2.97 (3.81) vs Intervention 4.96 (3.97)

Author. Year, Country, Journal	Objective	Study design	Results measured	Population sample
Kipping B, Rodger S, Miller K, Kimble RM[23] 2012 Journal of the International Society for Burn injuries	To evaluate the effect of VR in reducing the intensity of acute pain during the treatment of burns in teenagers	RCT	Pain Pain intensity Heart rate SatO2	41 teenagers Aged 11 to 17 28(68.3%) Male 20 in the intervention group 21 in the control group
	Scales used to measure outcomes	**Degree of burn**	**Intervention**	**Main results**
	*Faces, Legs, Activity, Cry, Consolability (*FLACC*) Visual Analog Scales*	TBSA 4.9 (5.4); 17 (41.5%) superficial burns 15 (36.6%) deep burns Burns etiology: 12(29.3%) scald 4 (9.8%) contact 15 (36.6%) call 10 (24.4%) friction Types of dressings: 35 (85.4%) acticoat 6 (14.6%) petroleum-based	Intervention group: age-appropriate software games. Control group: access to TV, stories, music, support from caregivers or no distractions. Equipment used: head-mounted display (eMagin, Z800 3DVisor with head tracking and 2 high-contrast SVGA resolution 800 × 600, 16.7 million colors), manual joystick control, computer	VAS pain intensity: Control 3.8 (3.6) vs in Intervention 2.33 (3.4) p0.40 FLACC pain intensity: Control 4.7 (2.5) vs Intervention 2.9 (2.4) p0.02 To remove the dressing, both groups had an average time of 8 min. For dressing application Intervention Interquartile range = 4–20 min) vs Control 12 min (IQR = 9–20 min)

Author. Year, Country, Journal	Objective	Study design	Results measured	Population sample
Konstantatos AH, Angliss M, Costello V, Cleland H, Stafrace S[24]. 2009 Journal of the International Society for Burn injuries	To examine whether pre-procedure VR-guided relaxation added to morphine patient-controlled analgesia reduced pain intensity during dressing changes in burn patients	RCT	Pain Anxiety	88 patients Age 18 to 80 years 43 in the intervention group 43 in the control group
	Scales used to measure outcomes	**Degree of burn**	**Intervention**	**Main results**
	Stanford Hypnotic Clinical Scale Visual Analogue Scale	TBSA in the intervention group was 15.5 (14.8), and in the control group, 15.1 (10.7)	Intervention group RV and intravenous morphine. The control group with intravenous morphine only. Equipment: glasses fitted to the head using a circumferential strap and a disposable headset. Nursery	Pain 7.3 Intervention Control 5.3 p(0.003) 95% CI (1.7) (0.6–2.8). Pain intensity after dressing change 3.7 in Control 2.3 (p 0.031) 95% CI 1.0 (0.1–1.9) Intervention. Duration of dressing change was 76.8 (35.4) Intervention vs 77.3 (27.3) Control. There was no significant difference in opioid use

Continue...

Table 1. Continuation...

Author. Year, Country, Journal	Objective	Study design	Results measured	Population sample
McSherry T, Atterbury M, Gartner S, Helmold E, Searles DM, Schulman C[25]. 2018 J Burn Care Res.	To evaluate the effect of distraction therapy on IVR during painful wound care procedures in adults	RCT	Pain, Anxiety Opioid consumption	18 patients Age 20 to 73 years 13 (72%) Male 5 (28%) Female 18 control/intervention
	Scales used to measure outcomes	**Degree of burn**	**Intervention**	**Main results**
	Numeric pain scale	15 (83) partial thickness burn	Intervention group: VR glasses and participation in an interactive computer-generated immersive three-dimensional virtual world program. The control group received only opioids.	Time to change dressings Intervention 29.9 (12.9) vs Control 30.7 (15.1). Anxiety after dressing Intervention 3.5 (3.0) vs Control 3.5 (2.6). Pain Intervention 5.8 (2.9) vs Control 5.7 (2.6). Opioid consumption during dressing changes in the Intervention 17.9 (6.0) vs. Control 29.2 (4.5) group
Author. Year, Country, Journal	**Objective**	**Study design**	**Results measured**	**Population sample**
Kaya M. ÖzlüZK [26] 2022 Burn	Determine the effect of VR on the levels of pain, anxiety and fear experienced by patients during burn dressing changes.	RCT	Pain Fear Anxiety FC SatO2	65 patients Age 7 to 12 years 36 Female 29 Male 33 in the intervention group 32 in the control group
	Scales used to measure outcomes	**Degree of burn**	**Intervention**	**Main results**
	Wong–Baker FACES Pain Rating Scale *Children's fear scale* *State-Trait Anxiety Inventory for children* (STAI-C)	TBSA intervention 5.88±2.8 vs. Control 5.03±2.7 Etiology of burns: 59 hot liquids 6 fire	Two Samsung Gear and Oculus Rift VR headsets equipped with *Merry Snowballs* VR game The control group received paracetamol. Neither group received opioids.	Pain Control 4.25 (1.04) vs Intervention 2.61 (1.97). fear Control was 3.72(0.58) vs Intervention 2.24(1.11). Anxiety Control 53.16 (7.40) vs Intervention 36.45 (8.09). HR Control 129.56 (10.64) vs Intervention 119.60 (8.09). SatO2 Control 96.93(1.29) vs Intervention 97.03 (0.98)
Author. Year, Country, Journal	**Objective**	**Study design**	**Results measured**	**Population sample**
Jeffs D, Dorman D, Brown S, et al(5) 2014 Journal of Burn Care & Research	To Compare the Effect of VR With Passive Distraction and Standard Care on Pain Experienced in the Treatment of Burns in Adolescents	RCT	Pain Anxiety	28 teenagers Age 10 to 17 years 9 Female 19 Male 10 in the control group 8 in the RV group 10 in the passive distraction group
	Scales used to measure outcomes	**Degree of burn**	**Intervention**	**Main results**
	Adolescent Pediatric Pain Tool Word Graphic Rating Scale (WGRS) Spielberger State-Trait Anxiety Inventory	Etiology of burns: 8 (30%) Scald 7 (26%) Hot objects 12 (44%) fire TBSA intervention 7.4 (8.5) vs. control 4.7 (6.9) vs. passive distraction 3.4 (3.3)	Group intervention interactive game Snow World. The control group received only routine analgesia. Game intervention Cloudy with a Chance of Meatballs. Equipment: Kaiser Optics SR80a VR helmet with SXGA resolution (1280-1024) 80-degree field of view Outpatient	Anxiety. Control 34.1 (7.1) vs Intervention 34.6 (5.0)

TBSA: Total body surface area; VR: Virtual reality; RCT: Randomized Clinical Trial; FC: Heart Rate; IG: Intervention group; CG: Control group; SatO2: oxygen saturation. Source: Elaborated by the authors

Assessment of methodological quality

The methodological quality of the included studies ranged from moderate to high, as shown in Table 2.

Table 2. Assessment of the methodological quality of studies with randomized clinical trial design included in the study. São Paulo (SP), Brazil – 2022

Studies	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Xiang H, et al.[19]	S	S	S	S	N	NC	S	S	S	S	S	S	S
Das DA et al.[20]	N	NC	S	N	N	S	S	S	S	S	S	S	S
Hoffman HG et al.[7]	S	NC	S	N	N	NC	S	S	S	S	S	S	S
Hua Y et al.[21]	S	NC	S	N	N	NC	S	S	S	S	S	S	S
Hoffman HG, Patterson DR et al.[22]	S	NC	S	N	N	NC	S	S	S	S	S	S	S
Kipping B et al.[23]	S	S	S	N	N	S	S	S	S	S	S	S	S
Konstantatos AH, et al[24]	S	NC	S	N	N	NC	S	S	S	S	S	S	S
McSherry T et al.[25]	S	S	S	N	S	NC	S	S	S	S	S	S	S
Kaya M et al.[26]	S	NC	S	N	N	NC	S	S	S	S	S	S	S
Jeffs D et al.[5]	S	S	S	N	N	NC	S	S	S	S	S	S	S
Total %	90	40	100	10	10	20	100	100	100	100	100	100	100

Y (YES); N (No); NC (Not Clear). Source: Elaborated by the authors

Q1.Was true randomization used to assign participants to treatment groups? Q2. Was the allocation to treatment groups concealed? Q3. Were the treatment groups similar at baseline? Q4. Were participants blind to treatment assignment?

Q5. Were the caregivers blind to the treatment assignment? Q6. Were outcome assessors blinded to treatment assignment? Q7. Were the treatment groups treated identically except for the intervention of interest?

Q8. Was follow-up complete, and, if not, were differences between groups in terms of follow-up adequately described and analyzed? Q9. Were participants analyzed in the groups to which they were randomized? Q10. Were outcomes measured in the same way for treatment groups? Q11. Were the results measured reliably? Q12. Was appropriate statistical analysis used?

Q13. Was the trial design appropriate, and were any deviations from the normal design of a randomized clinical trial (individual randomization, parallel groups) taken into account in the conduct and analysis of the trial?

It is essential to highlight that due to the nature of the intervention, the blinding of participants and those responsible for carrying out the intervention was mentioned in only two studies. However, in a partial way, intervention. The blinding of outcome assessors was clearly described in only two studies. In six studies, more information was needed to conceal group allocation.

Assessing the certainty of findings

Assessment of the certainty of discoveries using the GRADE[12,13] system, according to the summary presented in Table 3, was moderate for the pain effect due to the high inconsistency (I2 51%). For the effects of time thinking about pain and time to change the dressing, inconsistency was also high (I^2 81%). After assessing the certainty of the evidence, it was decided to downgrade to a lower level due to variations in the population of primary studies and in the scores of the scales used to measure the primary and secondary outcomes. The use of IVR associated with medications contributed to reducing pain (SMD -0.73; 95% CI -1.01 - 0.45 N = 475 = I^2 = 51%) and time thinking about pain (SMD –0.70; 95 % CI –1.36–0.04 N = 196 = I^2 = 81%) and time to change the dressing (SMD –0.79; 95 % CI –2.14–0.56 N = 155 = I^2 = 43 %), related to burn injuries in adults and children, as shown in Table 3.

Table 3. Assessment of the certainty of findings according to the GRADE system for pain, time thinking about pain and time to change the dressing. São Paulo. (SP), Brazil – 2022

Certainty of Evidence							Number of patients		Effect		Certainty	Importance
Number of studies	Design of study	Risk in bias	Inconsistency	Indirect evidence	Inaccuracy	Other Considerations	Immersive Virtual Reality	Standard treatment	Relative (95% CI)	Absolute (95% CI)		
Pain (follow-up: average 6 days; evaluated with: Mean and standard deviation)												
10	randomized clinical trials	not severe	severe	not severe	not severe	none	239	236	-	SMD **0.72 SD smaller** (1 minor to 0.44 minor)	⨁⨁⨁◯ Moderate	IMPORTANT
Time thinking about pain (follow-up: average 6 days; assessed as minutes)												
10	randomized clinical trials	not severe	severe	not severe	not severe	none	98	98	-	SMD **0.7 SD smaller** (1.36 minor to 0.04 minor)	⨁⨁⨁◯ Moderate	IMPORTANT
Time to change the dressing (assessed as in minutes)												
10	randomized clinical trials	not severe	severe	not severe	not severe	none	141	140	-	SMD **0.34 SD smaller** (0.66 lowest to 0.01 highest)	⨁⨁⨁◯ Moderate	IMPORTANT

CI: Confidence interval; SMD: Standard Mean Deviation; 1The certainty of evidence was downgraded one level due to variations in outcome measures and the population included in primary studies, and I2 was considered high. Source: Elaborated by the authors

Descriptive summary

Ten articles were selected, resulting in a sample of 502 adults and children. Nine articles contained information about gender, of which 246 (59.4%) were male and 168 (32.6%) were female. As for the age of the population, it ranged from 5 to 80 years.

All studies were conducted using a randomized clinical trial design, with a control group and an intervention or randomized group[5,7,17-24]. The interventions[5,7,19,20,21,24,25] planned for virtual reality were interactive games, being non-interactive in only one study[25].

Regarding the etiology of burns described in primary studies, they were: silencer and motorcycle, hot water bottle, gasoline and hot oil on the barbecue, traffic injuries, war explosives, electric flame, scald and chemical burn[18,19,20].

Regarding the type of dressing used, only two studies describe this information: petroleum-based and Acticoat, silver ions, algal acid salt and Povidin Iodine[21,23].

The total body surface area burned ranged from 2.6 to 86%, as described in six studies[7,19,20,22-24]. The prominent locations affected by burns were described in two studies: hands, arms, feet, legs, neck/head, trunk and groin[7,22].

A study provides information that the nurses involved in the study had five to more years of experience in caring for children with chronic wounds[24].

Regarding the scales used to measure the physiological effects that it promoted in reducing pain, the following Scales were used: FACES, Legs, Activity, Cry, and Consolability, (FLACC-R) Legs, Activity, Cry, and Consolability-Revised, VAS Visual Analogue Scale, Faces Scale, Graphic Rating Scales, Pain Catastrophizing Scale for Children (PSC-C), Stanford Hypnotic Clinical Scale, Numeric pain scale. Anxiety was measured using the State-Trait Anxiety Inventory for Children (STAI-CH) scale and fear using the Children's Fear Scale.

Quantitative synthesis

In an analysis composed of eight studies[7,19-23,25,26] intending to verify the effect of IVR on pain relief during dressing changes for burn injuries, the result favored the use of IVR when compared to standard treatment, despite moderate heterogeneity (SMD -0.73; 95% CI - 1.01 - 0.45 N = 475 = I^2 = 51%) in adults and children undergoing dressing changes due to burns, as shown in Fig. 2.

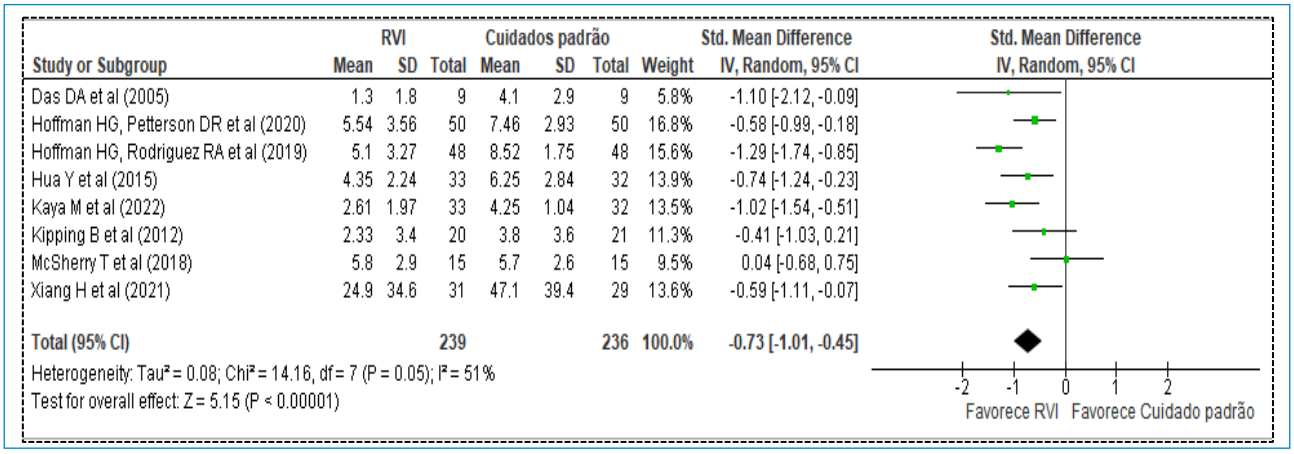

Figure 2. Immersive Virtual Reality Versus Standard Treatment for Pain Reduction in Children Undergoing Burn Dressing Change. São Paulo (SP), Brasil – 2022.

Source: elaborated by the authors

After an analysis of two studies[7,25] to evaluate the secondary effects of using IVR on the time patients thought about pain while the dressing was changed, the result was in favor of the intervention compared to standard treatment (SMD –0.70; 95% CI –1.36 –0.04 N = 196 = I^2 = 81% - Fig 3).

When analyzing four studies to verify the time required to change the dressing, the result was in favor of the intervention compared to standard treatment (SMD –0.34; 95% CI –0.66–0.01 N = 281 = I^2 = 43% - Fig. 3) [21,22,24,25]. An analysis of three studies was also carried out[19,25,26] to check anxiety levels, and we found no difference compared to standard treatment (SMD –0.79; 95% CI –2.14–0.56 N = 155 = I^2 = 43%).

DISCUSSION

This present study aimed to verify the effect of isolated IVR associated with pharmacological therapy to reduce pain in patients undergoing dressing changes due to burn injuries. With the meta-analysis, it was possible to observe that IVR brings benefits such as lowering the pain score, the time patients think about pain during the dressing and the time to change the dressing. These results are in line with the results of a recent study, which found that virtual reality reduces pain in burn patients and those returning to rehabilitation.[27]. Eight studies[7,19-23,25,26] presented the pain score using virtual reality associated with the use of analgesics and data only on the use of isolated analgesics. The pain score was lower when associated with the immersive virtual reality intervention and the use of the medication.

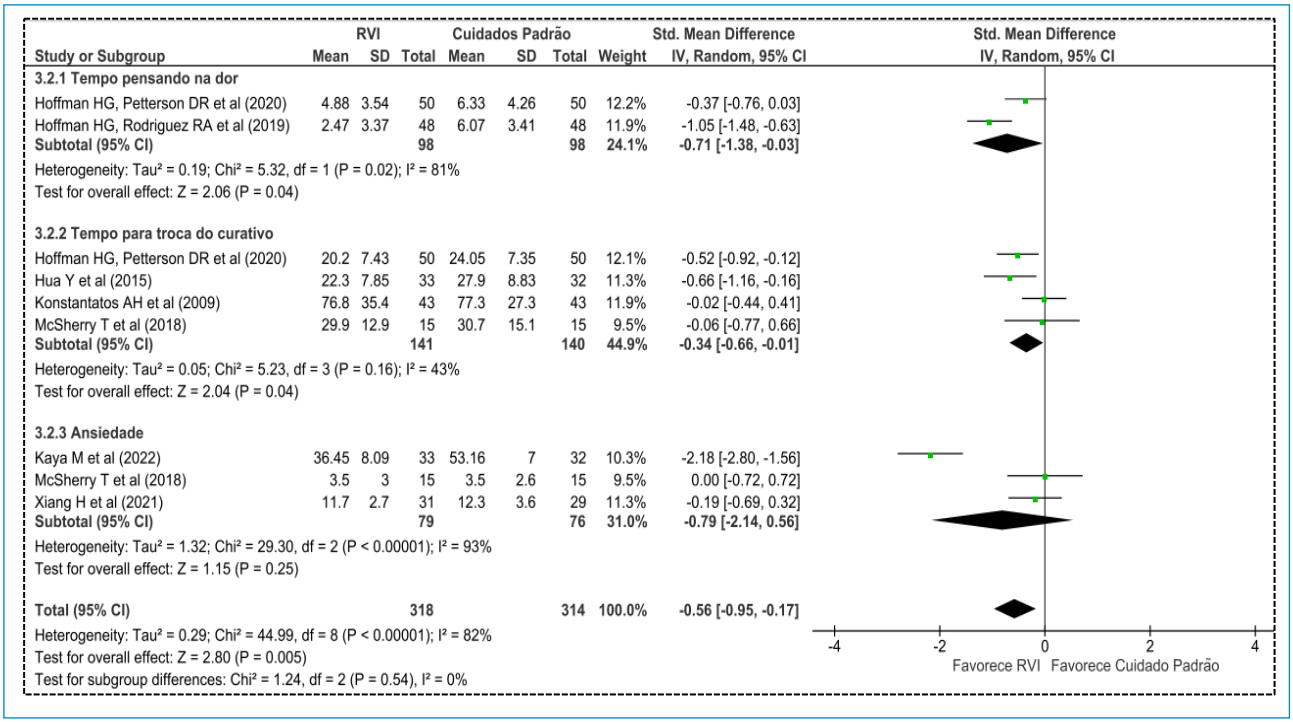

Figure 3. Immersive virtual reality versus standard treatment to assess pain side effects. São Paulo (SP), Brazil – 2022
Source: elaborated by the authors

Psychosocial and neurosensitive factors influence pain. It does not depend solely on the intensity of the stimulus for its modulation in the central nervous system. The way pain is felt is personal and non-transferable. In burn patients, several aspects must be considered, such as age, clinical condition, TBSA, the meanings attributed to pain by the family, empathy and attitudes of health professionals, as well as beliefs and values, anxiety and capacity for distraction and control of pain[27].

Among the studies included in this review, seven of them report the burned body surface area, the lowest being 2.6% and the highest 86%.[5,7,19,20,22,23,26]. Only two studies describe the areas affected by burns[7,22]. These findings are in line with results from reports from national and international bodie[s1,2].

In two studies, patients who experienced IVR demonstrated better satisfaction when compared to the group who received standard treatment[7,22]. Patients who underwent IVR showed more fun.

The Konstantatos et al. [24] study found no difference in opioid consumption. However, in another study by McSherry et al. [25] there were reports that opioid consumption was lower with the use of the intervention. As there were only two studies that evaluated opioid consumption, it was not possible to assess the effect of the intervention, thus remaining a question to be answered in the future.

IVR shifts patients' attention when changing the dressing and transports them to an environment where they will not experience the debridement procedure. Immersion influences the interaction with the virtual environment through translation (change in position), rotation (change in orientation), point of view (perspective) and field of view[28].

Non-VR content, i.e., regular videos (cartoons) or 360° videos, creates less immersion as the user is limited to the movements and tempo of the video. This difference in content is important, as it has been hypothesized that more immersion is related to more pain reduction since less attention is paid to pain perception.[29,30].

When we looked at using virtual reality to reduce anxiety, we found no difference. These inconclusive results may occur due to the small number of studies that evaluated these outcomes in this specific population.

After the meta-analysis of the studies selected in the sample of children with burn injuries, high to moderate heterogeneity was observed between the studies, which limits decision-making regarding how and when to apply this intervention in practice. There is still a need for new studies with children with a more robust sample. Furthermore, standardized and reproducible

procedures are necessary to allow a more precise assessment of the effect of virtual reality so that we can indicate it more broadly and with the potential to be incorporated into our health policies.

CONCLUSION

There is evidence to support the use of IVR to reduce pain, time thinking about pain, and time to bandage in adults and children undergoing dressing changes for burn injuries.

Despite the high heterogeneity for the outcome time thinking about pain and moderate heterogeneity for the outcomes pain and time for dressing change, we understand that IVR, associated with pharmacological therapy, can be included as a non-pharmacological therapy in the dressing change procedure for adults and children. Still, it is essential to remember that due to the small sample analyzed in this review, it is impossible to generalize these results. However, they guide us when deciding on whether or not to include IVR as an adjuvant measure for those patients using high doses of opioids, considering that they are addictive. For these results to be incorporated into healthcare environments with greater robustness, it is necessary to review a more significant number of primary studies, preferably conducted with clinical trials.

Implications for practice

It is known that the pain felt during burn care is often neglected and thus remains insufficiently treated. Medication with oral analgesics before wound treatment is not sufficient to prevent episodes of intense pain during the debridement procedure in burn patients.

This review suggests the use of IVR associated with analgesics as a non-pharmacological intervention during wound treatment. It is a valuable and low-cost resource, effectively reducing pain, reducing the patient's time thinking about pain (suffering) and increasing patient satisfaction.

Given the above, it is of great importance that healthcare professionals have access to the benefits of this intervention and training on how to indicate and use this type of intervention in the healthcare environment to improve care when approaching procedures that cause pain to patients or even to reduce the consumption of medications such as opioids, which present, in addition to dependence with constant use, intestinal constipation.

Recommendations for research

Virtual reality must still be explored as an isolated intervention or associated with other interventions within Brazilian hospitals. Furthermore, although one of the inclusion criteria in the present review was the design of a randomized clinical trial, there was variation in how each study measured its results. This lack of standardization in outcome measures implies the low generalization power of the results.

Conducting research that measures its results in a standardized way would facilitate the grouping of results in meta-analyses and thus allow for more precise conclusions, adding value and strengthening decision-making in clinical practice.

Limitations of the study

A limitation of this study was the small sample size and the variation in how the results were measured, despite sufficient data reporting for inclusion in the meta-analysis, which limits the generalizability of the results.

AUTHORS' CONTRIBUTION

Conceptualization: Perciliano CC; **Methodology:** Souza VP; Santos MLBM; **Investigation:** Monteiro ACS; **Writing First version:** Perciliano CC NC; Souza VP; **Writing – Review and Editing:** Silva AM.

DATA STATEMENT AVAILABILITY

All data were generated or detailed in the present study.

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Not applicable

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Not applicable

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APPENDIX I

Search strategy

DATABASE	SEARCH EQUATION	TOTAL
PubMed (MEDLINE) #1	(((((Immersive Virtual reality) AND (burns)) AND (pain)) AND (anxiety)) AND (children)) AND (adults)	44
CINAHL	("Virtual reality exposure therapy" OR "Virtual reality" "Virtual realities") AND ("burns" OR "burn"OR "burn units")	15
Web of Science	("Virtual reality exposure therapy" OR "Virtual reality" "Virtual realities") AND ("burns" OR "burn"OR "burn units")	126
EMBASE	(##3 AND ('clinical trial'/de OR 'controlled study'/de OR 'randomized controlled trial'/de) #1 AND ('clinical trial'/de OR 'randomized controlled trial'/de)	28
Clinicaltrial.gov	(virtual reality AND Burns)	1