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Virtual Reality for Pain Management: A Narrative Review of Randomized Controlled Trials

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ABSTRACT:

Background: Virtual reality (VR) is increasingly studied as a non-pharmacological adjunct for pain management across acute procedural, perioperative, and chronic pain contexts, but the evidence base is heterogeneous in population, intervention design, and outcome reporting. **Objective:** To synthesize randomized controlled trial (RCT) evidence on the use of VR for pain-related outcomes, characterizing study populations, intervention designs, comparators, outcome measures, and pain-related findings. **Methods:** Following title, abstract, and full-text screening against pre-specified eligibility criteria, 75 randomized controlled (including crossover and pilot) trials evaluating VR in relation to a pain outcome were identified and included for analysis. Data on population, pain type, VR intervention characteristics, comparator, setting, outcome measures, key findings, and adverse events were extracted directly from the source records and synthesized narratively. **Results:** Included trials were published between 2016 and 2026, with 65.3% (49/75) published in the final three years, reflecting rapid growth in this field. Most trials enrolled adults (74.7%) and addressed procedural or experimental pain (50.7%), followed by chronic pain (24.0%) and peri-/post-operative pain (17.3%). Immersive head-mounted-display VR was the dominant modality (36/75 explicitly reported). Forty-nine trials (65.3%) reported a statistically significant pain-related benefit of VR over the comparator, 16 (21.3%) found no significant difference, 6 (8.0%) reported mixed results, and 4 (5.3%) did not report extractable quantitative results. Benefit was most consistent for acute procedural pain (68.4% significant) and least consistent for peri-/post-operative pain (38.5% significant). Adverse events, reported in only 24.0% of trials, were uniformly mild and transient, with no serious VR-related harms

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identified. **Conclusions:** VR shows a generally favorable, though context-dependent, safety and efficacy profile for pain-related outcomes, with the strongest and most consistent evidence in supervised, acute procedural settings and pediatric populations, and comparatively weaker and more mixed evidence for home-based chronic pain and perioperative applications.

INTRODUCTION:

Pain — whether acute, procedural, perioperative, or chronic — remains one of the most common reasons patients seek medical care, and its inadequate management is associated with delayed recovery, prolonged hospitalization, psychological distress, and, in the case of chronic pain, substantial long-term disability. Pharmacological analgesia, particularly opioid-based regimens, remains the mainstay of treatment in many of these contexts, but is limited by tolerance, adverse effects, and, especially in the perioperative and post-surgical setting, well-documented risks of misuse and dependence. These limitations have driven sustained interest in non-pharmacological adjuncts capable of reducing pain, anxiety, and analgesic requirements without the risks associated with systemic medication.

Virtual reality (VR) has emerged as one such adjunct. By delivering immersive, multisensory, computer-generated environments through a head-mounted display or comparable device, VR is thought to reduce pain perception primarily through attention-based and cognitive-load mechanisms consistent with gate-control theory: by occupying visual, auditory, and often interactive attentional resources, VR is proposed to leave fewer cognitive resources available for the processing and conscious appraisal of noxious stimuli. Early experimental work using evoked-potential and quantitative sensory testing paradigms in healthy volunteers has provided physiological support for this mechanism (Karaman et al., 2019; Lier et al., 2020), and clinical studies combining VR with hypnosis-like relaxation techniques have further explored the psychophysiological basis of VR-induced analgesia (Rousseaux et al., 2021).

Building on this mechanistic rationale, VR has since been trialed across a remarkably broad range of clinical pain contexts. In pediatric and adult procedural settings, VR has been evaluated for venipuncture and intravenous cannulation (Gold et al., 2021; Perdue et al., 2022; Wong and Choi, 2023), vaccination and skin-prick allergy testing (Sahin et al., 2025; Sánchez-López et al., 2024), dental anesthesia and extraction (Almugait and AbuMostafa, 2021; Bahrololoomi et al., 2025; Martínez-Martín et al., 2024), and painful oncology and burn-related procedures (Emrich et al., 2026; Reitze et al., 2024). In the perioperative arena, VR has been examined as an adjunct across cardiac, gynecologic, and orthopedic surgery (Hu et al., 2026; Mathari et al., 2024; Moharam et al., 2025; Rousseaux et al., 2020; Xiao et al., 2025; Zhang et al., 2025). In chronic pain populations, VR-based exercise, sensorimotor training, and skills-based self-management programs have been trialed for chronic low back and neck pain, osteoarthritis, and high-impact chronic pain more broadly (Buztepe and Çapik, 2025; Maddox et al., 2025; Nusser et al., 2021; Slatman et al., 2025).

Despite this expanding evidence base, the literature remains markedly heterogeneous: VR interventions differ substantially in immersion level, content, dose, and degree of clinical supervision; comparator conditions range from entirely passive controls to other active distraction techniques; and reporting of outcome measures, adverse events, and methodological quality is inconsistent across trials. This heterogeneity makes it difficult for clinicians and researchers to draw clear, context-specific conclusions about when VR is likely to provide meaningful analgesic benefit. A structured synthesis characterizing the populations, intervention designs, comparators, and reported pain outcomes of the available randomized evidence is therefore warranted.

AIM AND OBJECTIVES:

Aim: To systematically identify, characterize, and synthesize randomized controlled trial evidence on the use of virtual reality (VR) for pain-related outcomes across clinical and experimental contexts.

Objectives:

- To characterize the populations, clinical settings, and pain types (procedural, perioperative, chronic, labor, and other) addressed by included trials.
- To catalogue the type, immersion level, and content of VR interventions evaluated, together with the comparator conditions used.
- To determine the proportion of trials reporting a statistically significant pain-related benefit of VR, and to examine how this varies by clinical context.
- To summarize the outcome measures and instruments used to assess pain across included trials.

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- To evaluate the frequency and nature of reported adverse events associated with VR interventions.
- To identify methodological and reporting gaps in the current evidence base to inform future trial design and reporting standards.

MATERIALS AND METHODS:

Search Strategy:

A structured literature search across PubMed/MEDLINE, Scopus, Web of Science, and Cochrane CENTRAL was undertaken to identify randomized controlled trials evaluating virtual reality interventions in relation to a pain-related outcome. Reference lists of relevant reviews were additionally screened for eligible studies not captured by the primary search.

Eligibility Criteria:

Studies were eligible for inclusion if they: (1) employed a randomized controlled, randomized crossover, or randomized pilot/feasibility design; (2) evaluated a virtual reality intervention (immersive or non-immersive) as the primary or a co-primary intervention of interest; (3) reported at least one pain-related outcome (e.g., a validated pain intensity scale, pain-related behavioral measure, or pain-related physiological correlate) as a primary or secondary endpoint; and (4) were published in a peer-reviewed journal. No restrictions were placed on population age, clinical setting, or comparator condition, in order to capture the full breadth of contexts in which VR has been evaluated for pain.

Study Selection:

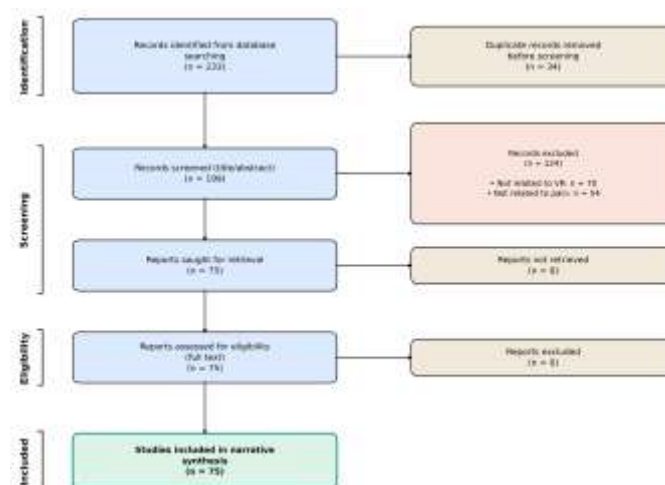
Titles and abstracts of records identified through the search were screened against the eligibility criteria, followed by full-text review of potentially eligible records. After screening, a total of 75 studies met all inclusion criteria and were retained for data extraction and analysis.

Data Extraction

For each included study, the following data were extracted: first author and publication year; pain type and clinical procedure or surgical context; population age group and sex/gender distribution; VR intervention type, immersion level, and content; comparator condition; clinical setting; session duration and frequency; primary pain-related outcome and measurement instrument; key findings; reported adverse events; and available risk-of-bias information. Where a given field was not explicitly reported in the available source text, this was recorded as 'not reported' rather than inferred or estimated, to preserve the accuracy of the extracted dataset.

Data Synthesis

Given the substantial heterogeneity in populations, VR intervention design, comparator conditions, and outcome measures across included studies, a quantitative meta-analysis was not considered appropriate. Findings were therefore synthesized narratively, with studies grouped by broad pain context (procedural/experimental, chronic, peri-/post-operative, labor, and other) to allow comparison of the pattern and consistency of reported pain-related benefit across these categories.



RESULTS:

The database and registry search, together with screening of titles, abstracts, and full texts against the pre-specified eligibility criteria, yielded 75 studies that met all inclusion criteria and were retained for the final analysis. All 75 studies were randomized controlled trials (or randomized crossover/pilot trials) evaluating a virtual reality (VR) intervention in relation to a pain-related outcome, published between 2016 and 2026.

Publication activity in this field increased markedly over the study period: only 1 trial was published in 2016, rising to 7 trials in each of 2020 and 2021, and then accelerating sharply from 2023 onward, with 16 trials published in 2024 and 25 in 2025 alone (representing one-third of the entire dataset), plus a further 8 trials already indexed in 2026. This trajectory indicates that more than half of the eligible evidence base (49/75, 65.3%) was generated in the three years immediately preceding this review.

Table 1. Summary Characteristics of Included Studies (N = 75)

Characteristic	Categories	n (%)
Population age group	Adult	56 (74.7%)
	Paediatric (children)	18 (24.0%)
	Adolescent	1 (1.3%)
Broad pain context	Procedural / experimental pain	38 (50.7%)
	Chronic pain	18 (24.0%)
	Peri-/post-operative pain	13 (17.3%)
	Labor pain	2 (2.7%)
	Other (cancer-, wound-related etc.)	4 (5.3%)
Clinical setting	Hospital / clinic-based	41 (54.7%)
	Home-based / self-administered	7 (9.3%)
	Not specified in abstract	27 (36.0%)

Clinical Contexts and Pain Types:

The included trials spanned a broad range of clinical pain contexts. The largest single category was procedural and experimental pain (38/75, 50.7%), encompassing needle- and injection-related procedures (venipuncture, intravenous cannulation, vaccination, skin-prick allergy testing) (Gold et al., 2021; Perdue et al., 2022; Sahin et al., 2025; Sánchez-López et al., 2024; Wong and Choi, 2023), gynecological and reproductive procedures (oocyte retrieval, hysterosalpingography, intrauterine insemination, hysteroscopy) (Bal et al., 2025; Benazzouz et al., 2024; Deo et al., 2020; Haaps et al., 2025; Ng et al., 2025; Rosielle et al., 2024), gastrointestinal and urological procedures (colonoscopy, extracorporeal shock wave lithotripsy) (Akbulut and Ulubay, 2026; Pavlidi et al., 2025; Sun et al., 2026), dental procedures (local anesthesia injection, extraction, pulpotomy) (Almugait and AbuMostafa, 2021; Bahrololoomi et al., 2025; Martínez-Martín et al., 2024), wound and dressing care (Belhan et al., 2025; Sproka et al., 2024; Xiang et al., 2021), and laboratory-induced experimental pain models in healthy volunteers (Karaman et al., 2019; Lier et al., 2020).

Chronic pain conditions constituted the second-largest category (18/75, 24.0%), including chronic low back pain (Afzal et al., 2022; Buztepe and Çapik, 2025; Matheve et al., 2020; Thomas et al., 2016), chronic neck pain (Bahat et al., 2020; Cetin et al., 2023; Emedoli et al., 2024; Nusser et al., 2021), osteoarthritis of the knee and hip (Guede-Rojas et al., 2025), neuropathic pain following spinal cord injury (Selvaraj et al., 2025), chronic cancer-related pain (Garrett et al., 2024), chronic pain associated with sickle cell disease (Matthie et al., 2024), pain associated with chronic leg wounds (Belhan et al., 2025), chronic pelvic/ endometriosis-related pain and postpartum myofascial pelvic pain (Liu et al., 2026; Merlot et al., 2023), and high-impact chronic pain and chronic musculoskeletal pain more broadly defined (Colloca et al., 2025; Maddox et al., 2025; Slatman et al., 2025).

Peri-operative and post-operative pain accounted for 13 studies (17.3%), covering cardiac surgery (Mathari et al., 2024; Rousseaux et al., 2020; Rousseaux et al., 2021), thoracoscopic (VATS) surgery (Cao et al., 2025), gynecologic surgery (Hu et al., 2026; Zhang et al., 2025), hand surgery under regional anesthesia (Nijs et al., 2025; Xiao et al., 2025), orthopedic surgery (Moharam et al., 2025), otorhinolaryngologic surgery (Mersin et al., 2025), anorectal surgery (Ding et al., 2019), minor vascular-access procedures (Steinkraus et al., 2024), and general pediatric day-care surgery (Eijlers et al., 2019). The remaining studies addressed labor pain (n = 2) (Ebrahimian and Bilandi, 2021; Ebrahimian et al., 2022) and other pain presentations such as cancer-treatment-related and chronic wound pain (n = 4) (Belhan et al., 2025; Garrett et al., 2024; Groninger et al., 2024; Reitze et al., 2024).

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Population Characteristics:

The majority of trials enrolled adult participants (56/75, 74.7%), with a further 18 trials (24.0%) conducted exclusively in pediatric populations (most commonly ages 4–12 years) and 1 trial in an adolescent surgical population. Reporting of sex/gender distribution was inconsistent: only a minority of studies provided a full breakdown of the male-to-female ratio within mixed-sex samples, and several studies did not report gender at all.

VR Intervention Characteristics:

Across the 75 trials, immersive, head-mounted-display-based VR was the dominant intervention modality: 36 studies explicitly described an immersive headset-based intervention (Eijlers et al., 2019; Gold et al., 2021; Martínez-Martín et al., 2024; Wong and Choi, 2023), with several further studies describing smartphone-based or mobile immersive systems (Emrich et al., 2026; Xiang et al., 2021). Only 2 studies used explicitly non-immersive VR (Buztepe and Çapik, 2025; Emrich et al., 2026), and a small number of studies directly compared immersive versus non-immersive or active versus passive VR conditions within the same trial (Garrett et al., 2024; Lier et al., 2020). The specific immersion level was not explicitly reported in 27 studies (36.0%).

VR content was similarly heterogeneous, spanning passive relaxation content (nature scenes/films, calming music, guided relaxation or mindfulness exercises), interactive distraction games, 360-degree immersive video, cartoon/animated content designed for pediatric populations, and structured therapeutic programs combining VR with active exercise, sensorimotor training, or cognitive/behavioral pain-management skills training.

Comparator Conditions:

Comparator conditions were highly heterogeneous, reflecting the range of clinical contexts. The most frequent comparator was an inactive or standard-care control receiving no VR intervention. Other comparators included active non-VR distraction techniques (nature sounds, cartoon videos on a standard screen, tablet-based videos, therapeutic touch, chewing gum during labor, and needle-free distraction devices such as Buzzy® or 'flippits'), pharmacological or procedural comparators (intravenous deep sedation, nitrous oxide analgesedation, topical anesthetic gel), and, in several trials, multi-arm designs comparing VR against both an active distraction technique and a passive control simultaneously.

Outcome Measures:

Pain intensity was predominantly assessed using self-report visual analogue or numeric rating instruments. Explicit use of a Visual Analogue Scale (VAS) for pain was reported in 16 studies, a Numeric/Numerical Rating Scale (NRS) in 11 studies, the Wong-Baker FACES Pain Rating Scale (commonly used in pediatric samples) in 6 studies, and the FLACC (Face, Legs, Activity, Cry, Consolability) behavioral observation scale in 4 studies. A substantial proportion of studies (23/75, 30.7%) did not specify their measurement instrument in sufficient detail within the available abstract text to be coded with confidence.

Effect of VR on Pain Outcomes:

Overall, 49 of the 75 included trials (65.3%) reported a statistically significant reduction in pain and/or a clinically favorable pain-related outcome associated with VR relative to the comparator condition. Sixteen trials (21.3%) found no statistically significant between-group difference in the primary pain outcome, six trials (8.0%) reported mixed findings, and outcome direction could not be determined for four trials (5.3%) because the abstract available for data extraction did not report quantitative results.

By clinical context, the pattern of benefit varied: procedural/experimental pain trials showed the highest proportion of significant benefit (26/38, 68.4%) (Gold et al., 2021; Karaman et al., 2019; Mersin et al., 2025; Sánchez-López et al., 2024), consistent with the acute, single-exposure, distraction-based mechanism through which VR is thought to act during brief noxious procedures. Chronic pain trials also showed a majority of significant benefit (13/18, 72.2%) (Buztepe and Çapik, 2025; Emedoli et al., 2024; Selvaraj et al., 2025), though this category included several higher-quality null results, most notably home-based self-administered VR interventions for chronic musculoskeletal and postsurgical pain (Lier et al., 2024; Slatman et al., 2025), which showed no significant effect on the primary pain endpoint despite significant reductions in secondary anxiety/stress outcomes. Peri-/post-operative pain trials showed a more even split, with 5 of 13 trials (38.5%) reporting a significant pain benefit (Cao et al., 2025; Mathari et al., 2024; Moharam et al., 2025), 5 (38.5%) reporting no significant difference (Chatterjee et al., 2025; Haaps et al., 2025; Ng et al., 2025; Nijs et al., 2025);

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Rousseaux et al., 2021), and 3 reporting mixed results — a pattern suggesting that the analgesic benefit of VR is less consistent once patients have received pharmacological perioperative analgesia and anesthesia.

Both trials of labor pain reported findings favoring VR or an active comparator over routine care (Ebrahimian and Bilandi, 2021; Ebrahimian et al., 2022), though neither isolated VR as superior to an alternative active distraction technique (e.g., chewing gum). All four 'other' trials (cancer-related and chronic wound pain) reported significant benefit (Belhan et al., 2025; Garrett et al., 2024; Groninger et al., 2024; Reitze et al., 2024).

Several notable methodological patterns emerged among the null-result trials. A cluster of well-powered, low-immersion or home-based self-administered VR trials for chronic and postsurgical pain (Lier et al., 2024; Maddox et al., 2025; Slatman et al., 2025) found no significant effect on the primary pain-intensity endpoint despite adequate sample sizes, while consistently showing benefit on secondary psychological outcomes such as anxiety, stress, or catastrophizing — suggesting that self-administered, unsupervised VR may be more reliably anxiolytic than analgesic. Conversely, trials embedding VR within a supervised, in-clinic procedural context (Bahrololoomi et al., 2025; Mersin et al., 2025; Sánchez-López et al., 2024) more consistently demonstrated significant pain reduction, implicating clinician-supervised, high-immersion distraction during a discrete noxious stimulus as the setting in which VR analgesia is most robust.

Adverse Events:

Adverse events or intervention-related side effects were explicitly addressed in 18 of the 75 studies (24.0%). Where reported, the most common adverse effects associated with VR were mild and transient, including cybersickness/simulator sickness symptoms (dizziness, nausea, disorientation), and occasional fatigue. No trial included in this review reported a serious or lasting adverse event attributable to VR exposure.

Risk of Bias and Reporting Quality Considerations:

Several recurring methodological patterns relevant to bias were observed: (1) blinding of participants to VR versus non-VR allocation is inherently difficult given the visible nature of the intervention; (2) sample sizes were frequently modest, with several pilot or feasibility-labelled trials likely underpowered to detect small-to-moderate effect sizes; (3) reporting of allocation concealment, blinding of outcome assessors, and handling of missing data was inconsistently described; and (4) heterogeneity in comparator conditions limits direct comparability of effect sizes across studies.

Table 2 Summary of VR Intervention, Comparator, and Pain Type by Included Study

S.No	Study (Author, Year)	Pain Type	VR Type Used	Comparator
1.	Afzal et al. (2022)	Chronic low back pain	Virtual reality exercises (with routine physical therapy)	Routine physical therapy alone
2.	Akbulut & Ulubay (2026)	Procedural pain	Virtual reality glasses	Standard care (control)
3.	Almugait & AbuMostafa (2021)	Procedural pain	Virtual reality (Oculus Quest headset)	Topical anesthesia gel (20% benzocaine) - within-subject design
4.	Aslam et al. (2026)	Postpartum lumbopelvic pain	Virtual reality (Meta Quest 2 headset + Lumbar Pain Rehab software)	Traditional exercise (TE) therapy
5.	Sarig Bahat et al. (2020)	Chronic neck pain	Virtual reality (vs laser) kinematic training	Laser kinematic training (within same KT protocol)
6.	Bahrololoomi et al. (2025)	Procedural pain	VR headset	Auditory distraction (headphones); no distraction (control) - 3-arm
7.	Bal et al. (2025)	Procedural pain	Virtual reality glasses (VRG)	Therapeutic touch (TT); standard care control (3-arm)
8.	Baltaci et al. (2024)	Procedural pain	Virtual reality + nature sounds	Nature sounds only group; routine care control group (3-arm)
9.	Belhan et al. (2025)	Chronic wound pain	Virtual reality glasses	Standard care
0.	Benazzouz et al. (2024)	Procedural pain	Not reported	Not reported

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1.	Buztepe & Çapik (2025)	Chronic pain	Virtual reality glasses exercise program	Routine hospital treatment
2.	Cao et al. (2025)	Acute postoperative pain	Immersive VR (QTC-VR, interactive) vs Placebo-VR (2D film)	Placebo-VR and standard-care control group (3-arm)
3.	Cetin et al. (2023)	Chronic neck pain	Virtual reality glasses	Motor control (MC) exercises alone
4.	Chatterjee et al. (2025)	Procedural anxiety/discomfort	Immersive VR headset (3D experiences)	Standard of care
5.	Colloca et al. (2025)	Chronic pain	Telehealth VR	Matched audio content control
6.	Deo et al. (2020)	Procedural pain	Virtual reality (immersive video content)	Standard care
7.	Ding et al. (2019)	Postoperative procedural pain	Immersive VR distraction	Standard pharmacological analgesic intervention alone
8.	Ebrahimian & Bilandi (2021)	Labor pain	Virtual reality videos	Chewing gum; control group
9.	Ebrahimian et al. (2022)	Labor pain	Virtual reality	Chewing mint gum; routine care control (3-arm)
0.	Eijlers et al. (2019)	Perioperative pain	Virtual reality exposure (VRE)	Care as usual (CAU)
1.	Emedoli et al. (2024)	Chronic pain	VR sensorimotor training (complementary to manual therapy)	Same exercises without VR (manual therapy alone)
2.	Emrich et al. (2026)	Acute procedural pain	Mobile phone-based virtual reality	Treatment as usual (TAU)
3.	Fabricant et al. (2023)	Procedural pain	VR gaming simulation vs VR goggles (noninteractive video)	Tablet computer with noninteractive video (3-arm)
4.	Felemban et al. (2021)	Procedural pain	Virtual reality goggles (cartoon video)	Cartoon video on screen (non-VR)
5.	Felnhöfer et al. (2025)	Procedural pain	Immersive VR (goal-directed/focused vs free-interaction/exploratory)	Standard-of-care (SoC) distraction (control)
6.	Garrett et al. (2024)	Chronic cancer-related pain	Home-based adjunctive 3D VR (non-pharmacological intervention)	Same content delivered via 2D computer screen
7.	Gerards et al. (2025)	Procedural pain	Virtual reality headset (360° videos)	Routine care (control)
8.	Gold et al. (2021)	Procedural pain	Immersive VR intervention	Standard care (distraction techniques + numbing cream)
9.	Gold et al. (2024)	Procedural pain	Immersive VR (varying immersion level)	Standard of care
0.	Groninger et al. (2024)	Cancer pain (acute/chronic disease- and treatment-related)	Immersive VR distraction therapy	2D guided imagery via handheld tablet
1.	Guede-Rojas et al. (2025)	Chronic pain (osteoarthritis)	Non-immersive virtual reality (NIVR) exergames	Conventional physical therapy (CPT) alone
2.	Gürbüz et al. (2026)	Procedural pain	Immersive virtual reality	Buzzy® device; routine care control (3-arm)
3.	van Haaps et al. (2025)	Procedural pain	VR via head-mounted device	Conscious sedation only (no VR)
4.	Hu et al. (2026)	Postoperative pain	Virtual reality (postoperative)	Conventional postoperative analgesic therapy
5.	Karaman et al. (2019)	Experimental (ischemic) pain	Virtual reality (smartphone-based)	Control (no intervention)
6.	Lier et al. (2020)	Experimental pain	Passive VR vs active (interactive) VR vs no VR	No VR (black screen)
7.	Lier et al. (2024)	Postsurgical pain	Self-administered VR (3 interventions, varying immersion/ interaction)	Control (no VR)
8.	Liu et al. (2026)	Chronic pelvic pain	Virtual reality technology (combined with conventional therapy)	Conventional pelvic floor rehabilitation therapy alone
9.	Maddox et al. (2025)	Chronic pain (high-impact chronic pain, HICP)	Skills-Based Virtual Reality program	Lower-impact chronic pain (LICP)

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				comparison group (same intervention)
0.	Martínez-Martin et al. (2024)	Procedural/intraoperative pain	Immersive virtual reality (IVR)	Control (no VR)
1.	el Mathari et al. (2024)	Postoperative pain	VR distraction therapy	Standard postoperative care
2.	Matheve et al. (2020)	Chronic low back pain	Nonimmersive VR games	Same exercises without VR games
3.	Matthie et al. (2024)	Chronic pain	Not reported	Not reported
4.	Merlot et al. (2023)	Chronic pelvic pain	Immersive digital therapeutic (Endocare)	Sham VR condition
5.	Mersin et al. (2025)	Postoperative pain	VR headset (cartoon viewing, preoperative)	No intervention (control)
6.	Mohamed & Mohamed (2023)	Procedural pain	Virtual reality	Flippits (distraction cards); traditional care control (3-arm)
7.	Moharam et al. (2025)	Perioperative pain	VR immersion (peaceful natural environment with soft music)	Control (no VR)
8.	Ng et al. (2025)	Procedural pain	Virtual reality headset	Standard care
9.	Nijs et al. (2025)	Procedural/perioperative pain	Virtual reality therapy (passive 3D visual/audio program)	No VR therapy
0.	Nusser et al. (2021)	Chronic neck pain	Virtual reality device (sensorimotor training)	Sensorimotor group (no VR); control group (3-arm)
1.	Pavlidis et al. (2025)	Procedural pain	VR distraction device (visual and auditory, hypnosis-like)	Intravenous deep sedation (IVS)
2.	Pekyavas & Ergun (2020)	Musculoskeletal pain (shoulder)	Virtual reality exergaming (Wii)	Home exercise program
3.	Perdue et al. (2022)	Procedural pain	Immersive virtual reality (IVR)	Standard practice
4.	Reitze et al. (2024)	Peri-interventional pain(port and vein punctures)	Virtual reality (crossover)	Standard of care (SOC)
5.	Rişvan & Su (2024)	Procedural pain	Virtual reality glasses	Ball squeezing method; control group (3-arm)
6.	Rosielle et al. (2024)	Procedural pain	Virtual reality (head-mounted device)	HSG without VR
7.	Rousseaux et al. (2020)	Perioperative pain/anxiety/fatigue	Virtual reality hypnosis (VRH) combination	4 arms: control, hypnosis, VR, VRH
8.	Rousseaux et al. (2021)	Perioperative pain	Virtual reality (alone or combined with hypnosis)	4 arms: control; hypnosis; VR; VR+hypnosis
9.	Sahin et al. (2025)	Procedural pain	Virtual reality goggles	Standard procedure (control)
0.	Sánchez-López et al. (2024)	Procedural pain	Immersive VR distraction	Standard distraction techniques
1.	Scherer et al. (2025)	Procedural pain	Immersive VR games	Nitrous oxide analgesia
2.	Selvaraj et al. (2025)	Neuropathic pain	Immersive VR (head-mounted display)	2D animated films (same device)
3.	Slatman et al. (2025)	Chronic musculoskeletal pain	Home-based stand-alone immersive VR	No treatment (waiting list control)
4.	Smith et al. (2020)	Procedural pain	Virtual reality headset (Skylights)	Standard care
5.	Spyrka et al. (2024)	Procedural pain	Oculus Quest 2 VR goggles	No VR equipment (control)
6.	Steinkraus et al. (2024)	Perioperative pain	VR hypnosis (HypnoVR application)	Control (no VR)
7.	Suissa-Cohen et al. (2025)	Procedural anxiety/pain	Virtual reality exposure (scenic movies)	Routine management (no VR)
8.	Sun et al. (2026)	Procedural pain	Virtual reality	Control (no VR)
9.	Thomas et al. (2016)	Chronic low back pain	Virtual reality dodgeball game	Control group
0.	Trinh et al. (2026)	Perioperative pain	Not reported	Not reported
1.	Vitor et al. (2025)	Procedural pain	Immersive virtual reality (IVR) headset	Traditional method
2.	Wong & Choi (2023)	Procedural pain	Immersive virtual reality (IVR)	Standard care only
3.	Xiang et al. (2021)	Procedural (dressing) pain	Smartphone VR game (active vs	Standard care

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			passive)	
4.	Xiao et al. (2025)	Perioperative pain	VR experience (preoperative)	Control (standard anesthetic protocol only)
5.	Zhang et al. (2025)	Perioperative anxiety/pain	Multistage virtual reality intervention	Control group (3-arm: control, preop-visit VR, preop-visit+ waiting-area VR)

DISCUSSION:

This review synthesized 75 randomized controlled trials evaluating virtual reality (VR) as an intervention for pain-related outcomes across a wide range of clinical contexts. The central finding is that VR conferred a statistically significant pain-related benefit in approximately two-thirds of included trials (65.3%), but that this benefit was not uniform: it was strongest and most reproducible for acute, briefly-experienced procedural pain, particularly in supervised clinical settings and in pediatric populations, and weakest and most inconsistent for perioperative pain occurring in the context of concurrent pharmacological analgesia. The rapid growth in publication volume — with nearly two-thirds of the identified evidence base published in the final three years of the search window — indicates that VR analgesia research is a young and still-maturing field.

The consistency of benefit observed in procedural and experimental pain trials (68.4% significant) (Gold et al., 2021; Karaman et al., 2019; Mersin et al., 2025; Sánchez-López et al., 2024) is plausible on mechanistic grounds. Contemporary models of VR analgesia emphasize attention-based gate-control and cognitive-load mechanisms (Karaman et al., 2019; Lier et al., 2020): by occupying visual, auditory, and often interactive attentional channels during a brief, discrete noxious stimulus, VR is thought to reduce the cognitive and neural resources available for pain processing. This mechanism is best suited to short, predictable, single-exposure procedures — exactly the context in which the largest proportion of included trials were conducted, and in which the effect was most reliably significant.

By contrast, the more equivocal results in perioperative and postoperative pain (Nijs et al., 2025; Rousseaux et al., 2021) likely reflect the more complex, multifactorial nature of pain in this setting. Postoperative pain arises from tissue injury, inflammation, and central sensitization processes that are less amenable to attention-based distraction than the acute, anticipatory pain of a single procedure, and is typically already being treated pharmacologically, which may create a ceiling effect that leaves limited additional variance for VR to explain. Few perioperative trials in this dataset explicitly reported that VR reduced anxiety or opioid/sedative consumption without significantly altering pain scores themselves (Nijs et al., 2025; Xiao et al., 2025), suggesting that in this context VR's primary benefit may be anxiolytic and opioid-sparing rather than directly analgesic.

The chronic pain findings present a third, distinct pattern. While the majority of chronic pain trials (72.2%) reported significant benefit (Buztepe and Çapik, 2025; Emedoli et al., 2024; Selvaraj et al., 2025), this category also contained some of the more rigorously designed null results, particularly among home-based, self-administered VR programs delivered without clinician supervision (Lier et al., 2024; Slatman et al., 2025). Interpreted alongside the procedural-pain findings, this raises the possibility that the degree of clinical supervision and the duration/chronicity of pain — rather than VR technology itself — may be key moderators of analgesic efficacy.

A striking feature of this evidence base is the sheer heterogeneity of what is described under the umbrella term 'virtual reality.' Included interventions ranged from brief, passive exposure to a calming nature video, through interactive distraction games, to structured multi-week programs combining VR with active exercise or cognitive-behavioral pain-management skills training. This heterogeneity complicates direct comparison of effect sizes across trials and means that a single pooled estimate of 'VR efficacy for pain' would obscure more than it reveals.

Where adverse events were assessed (24.0% of trials), the safety profile of VR was reassuring: reported effects were mild, transient, and consistent with known cybersickness phenomena, with no serious or lasting harms identified in any included trial. However, the fact that three-quarters of trials did not report on adverse events at all is a meaningful gap, particularly as VR is extended to increasingly vulnerable populations, including postoperative cardiac surgery patients, individuals in active labor, and young children.

This synthesis has several strengths, including a systematically screened set of 75 RCTs spanning a decade of

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research and a broad range of pain contexts, populations, and intervention designs. Several limitations should nonetheless be considered. First, no formal risk-of-bias tool or GRADE certainty framework was applied. Second, publication bias cannot be excluded. Finally, the marked heterogeneity in interventions, comparators, and outcome measures precludes meaningful quantitative pooling (meta-analysis).

For clinical practice, these findings support the use of VR as a reasonable, low-risk adjunct for managing brief procedural pain and anxiety in both pediatric and adult patients, particularly where clinician supervision is feasible. The evidence is less supportive of VR as a stand-alone substitute for pharmacological analgesia in the perioperative period. For chronic pain, home-based VR programs appear more reliably beneficial for psychological and functional outcomes than for pain intensity itself.

For future research, this synthesis points to several priorities: (1) standardized, consistent reporting of adverse events and cybersickness across all VR pain trials; (2) more granular and consistent reporting of intervention characteristics to enable meaningful subgroup and dose-response analysis; (3) larger, adequately powered trials in the perioperative and chronic pain contexts where current evidence is more mixed; and (4) formal risk-of-bias and GRADE-based certainty assessments in future systematic reviews, to allow a quantitative meta-analysis.

CONCLUSION:

Across 75 randomized controlled trials published between 2016 and 2026, virtual reality demonstrated a statistically significant pain-related benefit in approximately two-thirds of studies, with a generally favorable and reassuring safety profile where adverse events were assessed. The studies reviewed suggest that VR may hold promise as a low-risk adjunctive tool for pain management in acute procedural contexts especially in pediatric and outpatient settings, whereas evidence for its role in chronic and perioperative pain remains inconsistent and insufficient to support firm clinical recommendations in those settings. More rigorously designed and reported trials with standardized outcome measures and consistent adverse-event reporting are needed before broader conclusions can be drawn.

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