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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Can virtual reality be used to improve patient education? A scoping review

Saskia Scheveneels
Floor Schildermans

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen

PROMOTOR :
Prof. dr. Bruno BONNECHERE

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Research context

This master's thesis has been written as a part of the master degree in Rehabilitation Sciences and Physiotherapy. It frames within the technology research domain. The thesis is independent and not part of an ongoing research project.

Our scientific internship last year significantly heightened our interest in the application of technology in rehabilitation. Patient education is an essential part of rehabilitation. It enhances patient understanding of their condition and fosters greater involvement in their rehabilitation journey. Consequently, we are investigating the potential benefits of using technology for educational purposes.

The research topic was developed in collaboration with our promotor. Both students have contributed equally to this thesis.

Abstract

Objectives: This scoping review aims to provide insight into the changing field of patient education by examining the incorporation of virtual reality (VR).

Methods: The review follows the reporting guidelines outlined in the PRISMA-ScR. A comprehensive literature search was performed in PubMed, identifying sixteen studies for inclusion based on pre-defined eligibility criteria. The quality of the included studies was assessed using the PEDro scale for RCTs and the NHLBI assessment tools for other types of study.

Results: VR as an educational tool is an effective and accessible tool to provide patients disease-specific knowledge, health knowledge, and maintenance of better health habits. Studies also reported enhancements in motivation, usability, interest, understanding, and peer support. However, limitations include reduced individualization of education, the occurrence of motion sickness, and potential technological issues. Most of the included studies used non-immersive VR.

Conclusion: VR is an efficient educational tool for patients with various medical conditions, enhancing the communication of medical information and knowledge. Further research is essential to determine the specific patient groups that would benefit most from VR applications. The utilization of VR holds significant promise for the future.

Introduction

Patient education is an essential aspect of healthcare that seeks to improve a patient's comprehension of their illness, therapy, and behaviors that promote good health (Cutilli, 2020). Providing patient education of excellent quality enables individuals to make well-informed choices regarding their healthcare, promoting independence and resulting in higher levels of satisfaction, adherence to treatment programs, enhanced physician-patient relationships, and improved health outcomes (Marcus, 2014; Osterberg & Blaschke, 2005; van der Kruk et al., 2022). Nevertheless, the intricate nature of health information might lead to cognitive overload, impeding patients' capacity to comprehend and remember vital information (Paas et al., 2004). A considerable proportion of patients face difficulties in accurately recollecting information conveyed by healthcare practitioners immediately following consultations, hence emphasizing the obstacles in achieving effective patient education (Jimmy & Jose, 2011).

While the importance of educational materials in improving the retention of information is widely documented, only a few information are available about the best way to provide this information to patients (Friedman et al., 2011). Although verbal communication and brochures are often used, they may not effectively guarantee understanding, which could result in negative events or less-than-optimal results (Marcus, 2014). Research has shown that videos, particularly those showcasing actual individuals in movement, are seen as more potent instruments for educating patients (Abu Abed et al., 2014).

The role of therapists in educating patients about their diseases and treatments is essential for promoting patient awareness, health behavior, compliance, and satisfaction (Stenberg et al., 2019). Efficient teaching improves the patient-therapist connection and independence, leading to more involved patients and eventually superior care (Paas et al., 2004). Nevertheless, obstacles such as limited time, insufficient educational resources, cultural variations, language obstacles, and poor healthcare professional training can hinder the provision of excellent patient education (Freda, 2004). Further causes are the lack of reimbursement for time spent with the patient and the fact that healthcare providers may not have received specific training to deliver education correctly (Freda, 2004).

Research in knowledge construction and science education suggests that *'learning-by-doing'* is an effective approach for individuals to retain scientific concepts. With the increasing importance of extended reality (XR), especially in therapeutic settings, there is a growing focus on its use in educating patients during therapy (Curran et al., 2023). XR is an interactive technique in which the patient can navigate and interact in a virtual environment. Two types of extended reality can be used for patient education. With VR the patients transport their virtual avatars into a virtual world for users to interact with. The patient can no longer see the environment around them, while with augmented reality (AR), the users can still see the real world, mixed with holograms (Andrews et al., 2019). A hologram is a three-dimensional object made of light that interferes with the real world (Workman, 2013). Previous research has mostly concentrated on using XR as an additional aid to treatment, but its potential as an instructional instrument for patients has not been extensively investigated in healthcare environments (Aziz, 2018).

However, it is well known that this interactive way increases patient engagement and can provide increased motivation. Consequently, research has already shown that learning in a virtual environment facilitates the learning process (van der Kruk et al., 2022). It has been shown that using VR to care greatly adds value to motivation and adherence to therapy (Fandim et al., 2021; Maggio et al., 2019; Rodríguez-Mansilla et al., 2023). Because VR is often offered in a game form, it is seen as a fun challenge with many possibilities and challenges for the patients (Rodríguez-Mansilla et al., 2023).

There has already been minimal research on the use of VR as an educational tool for patients. In recent years, there has been an increasing interest in the use of VR during rehabilitation. Therefore, this review aims to provide insight into the changing field of patient education by examining the incorporation of VR. It explores the possible advantages of VR in improving patient comprehension, adherence to therapy, and overall healthcare results.

Methods

This review follows the reporting guidelines outlined in the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews) checklist (*Scoping*, n.d.).

Research question

The study explores what is already known about using VR and AR as education tools. This is further divided into sub-questions:

- What is VR/AR and what are the characteristics of using it as an educational tool to inform patients?
- What are the benefits of using VR/AR as an educational tool in health care?
- What are the current or potential limitations of using VR as an educational tool?

Search strategy

A literature search was performed to find relevant studies on using VR for patient education. Between September 2023 and March 2024, Pubmed was searched. No time restriction was used to keep the search strategy as complete as possible. The search strategy is based on mesh terms and general terms, combined with boolean operators. A detailed overview of the search strategy is presented in Figure 1.

Eligibility criteria

This scoping review's in- and exclusion criteria, presented in Table 1, were formulated with PICOs (Patient, Intervention, Comparison, Outcome, Study Design). Studies were included when education was an important aspect of the intervention. Important requirements are that education must be targeted toward patients. Subsequently, patient education should be done through the use of VR. The studies must be individual. They must be in English, Dutch, or French. The studies were excluded if: it is a review or a meta-analysis, the full text is unavailable, and when the education is directed to surgeons, medics, or students.

Literature search

Two independent reviewers (F.S., S.S.) performed the literature search. The articles were first screened by title and abstract with the Rayyan collaboration and research tool. Each reviewer manually rates them according to the eligibility criteria (Table 1). This process is repeated while screening full text. If reviewers needed clarification about whether a study met the requirements, they discussed among themselves to reach an agreement. Furthermore, the quality of the included studies was reviewed using the NHLBI (National Heart, Lung and Blood Institute) assessment tools or the PEDro scale according to the type of study.

Table 1

Eligibility criteria

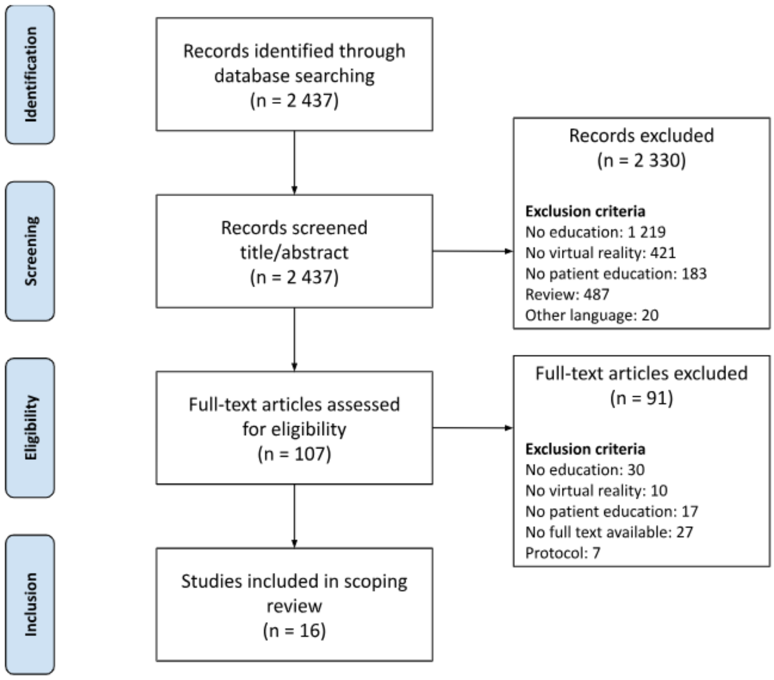
	Inclusion	Exclusion
Population	Patients	Education directed to surgeons, medics or students
Intervention	Any type of VR (immersive or non-immersive) designed to provide information to the patients	
Comparison	No control group or standard education (orally or using booklet)	
Outcome	Any measurements about the acceptability of VR or measurement of health literacy	
Language	English, Dutch or French	
Study design & other		All types of reviews and meta-analysis or when the full text is not available

Results

The search strategy resulted in 2437 studies, screened on title and abstract. 2330 studies were excluded based on the provided eligibility criteria. 107 articles were fully screened and studies were finally included and checked for quality. A PRISMA flowchart shows the process of the study selection (Figure 2). The quality of the individual studies was judged as fair to good, the individual results of the quality assessment are presented in Tables 3 to 6.

Figure 2

PRISMA Flowchart



<u>Patient characteristics</u>

This review contains a variety of populations, genders, conditions, and ages. All the included studies contain a total patient population of 474 patients, the complete descriptions of the studies are presented in Table 2. Population numbers ranged from 6 to 95 participants and included a variety of pathologies/conditions. The most common populations were patients with cardiac problems (3/16), patients with low back pain (2/16), and patients with COPD (2/16) and diabetes (2/16). Other conditions were patients with head and neck cancer (1/16), patients with long covid (1/16), post-surgery patients (1/16), patients with chronic pain (1/16), football players (1/16), and a variety of populations with multiple diseases (2/16).

The most common study design is an interventional study (10/16). Other study designs were Randomized Controlled Trials (3/16), a pilot study (1/16), an observational study (1/16), and a comparative study (1/16). All included studies were published between 2017 and 2023.

Virtual reality characteristics

In Table 2, the characteristics of the VR programs can be found. Five studies used a VR headset, which is “a head-worn apparatus that completely covers the eyes for an immersive 3D experience” (*Definition of VR Headset*, n.d.). Five other studies used screen-based VR platforms, where individuals are visualized as avatars. Bionautica Trails, a treadmill connected to a screen has been used in one study, when the person steps on the treadmill they move forward on a path. Other VR programs were Microsoft Teams (2), online websites (2), and a self-developed application (1). The online websites named ‘Cardiac College’ and ‘Diabetes College’ provide comprehensive online educational resources, supplemented with telephone consultations or exercise interventions.

Content programme

Various programs were utilized for educational purposes. First, Microsoft Teams was used as a program for the virtual pain management of patients with different medical conditions. These patients were divided into focus groups that discussed relevant topics, leading to a set of insights for each group (Booth et al., 2022).

Another study using Microsoft Teams is performed by patients with long Covid (LC). Topics of this virtual course are: understanding LC, fatigue management, causes of breathlessness, sleep and relaxation, mental wellbeing, diet, exercises and activity, breathing retraining, and progressing exercise and activity. This approach emphasized self-management, behavior changes, and peer support (Flannery et al., 2022).

Additionally, the virtual platform Second Life was used for patients with cardiac problems. Participants attended educational sessions on cardiovascular health behaviors (physical activity, diet) and cardiac risk factors (smoking, hypertension, hyperlipidemia). The patients also received more information about relevant topics for cardiac patients such as sexuality, information about their heart disease, and heart medication. They also received information from an online dietician and exercise physiologist (Brewer et al., 2017).

The next program for participants with cardiac problems is performed on Bionautica Trails. During treadmill exercises, patients receive educational pop-ups about sports, diet, medication, and symptoms of heart failure. This approach helps participants learn how to better care for their heart during recovery and provides educational tools to continue improving their health in the future (Gulick et al., 2021).

Further program utilizes VR headsets for patients with chronic pain. Topics of the educational videos are more information about what pain is, the fact that movement can be helpful, that hurt does not equal harm, mindfulness, and they were motivated to change behavior (Brown et al., 2023). A different VR training program for patients with chronic LBP is Reducept: "Reducept consists of five different parts namely the Nerves, Spinal cord, Brain, Alarm centre, and control room" (de Vries et al., 2023). In this way, the patient learns more about pain sensation, pain ports, how the brain reacts less strongly to pain stimuli, and the focus on pain feelings. They learned more about pain not equal to harm and how pain can interact with emotions, memory, and thought. Metaphors are used to enhance understanding of these concepts (de Vries et al., 2023).

DRESS-kinesis is used by low back pain patients and focuses on self-management of pain and disability. Patients receive evidence-based educational messages about physical activity and exercise habits, risk factors, psychological aspects, current health status, and central sensitization (Franchini et al., 2022).

Additionally, a VR headset program is designed for employees to address ergonomic risk factors. The educational sessions were based on three key risk factors: improper postures, repetitive movement, and handling heavy loads. The participants perform different tasks on each risk factor in a VR simulation of their work environment (Diego-Mas et al., 2020).

WebXR platform is used by patients with head-neck cancer. The educational focus is on self-management and promoting physical, mental, and emotional health. The education aims to enhance the quality of life, body image, and self-esteem of patients. Patients receive information about swallowing disorders and exercises often relevant to those with HNC (Greenway et al., 2023).

Educational programs can also be performed on websites. The diabetes college is based on five key aspects of diabetes: treatment of diabetes, the importance of an active lifestyle, healthy food, well-being, and how to control diabetes. The website promotes self-management, behavior change, and goal-setting (Seixas et al., 2022). Cardiac College is another educational website. The material included education of physical activity, nutrition, psychosocial well-being, pharmacotherapy, and action planning (Santos et al., 2023).

The next education program, named Make Play Saf VR app, provides concussion education to athletes aged 9-12 years. This program offers comprehensive information on recognizing concussion signs and symptoms, as well as guidance on reporting a suspected or confirmed concussion to an appropriate adult, such as a parent or coach. Additionally, the program includes a VR scenario where participants experience a simulated concussion and encounter various symptoms and signs firsthand (Sullivan et al., 2023).

SLIDES is a virtual community aiming to provide diabetes self-management education and social support. The education is organized in support sessions between participants and educators. This results in an online community with avatars. The avatars can move around in the virtual platform and get more information about the disease, diets, emotions, and self-beliefs (Pérez-Aldana et al., 2021).

Several programs promote education to COPD patients. The first is the Avachat, which addresses four priority self-management scenarios where patients seek more information. These topics are disease-specific information, acute exacerbations, emotional support, and motivation (Easton et al., 2019). The second program utilizes a VR headset, providing COPD patients with information about their disease and the benefits of participating in pulmonary rehabilitation. Finkelstein et al. (2023) organized their educational content into five modules: introduction, rehabilitation overview, exercise overview, rehabilitation benefits, and telerehabilitation overview.

Another program used for education is an augmented reality application that is used by patients who are undergoing surgery. This intervention requires patients to wear an AR headset, which provides a visual and narrated walkthrough of the operating room. The session lasts three minutes and aims to enhance patient knowledge. It delivers information on presurgical and postsurgical procedures, details about the operation they will undergo, and postoperative management and rehabilitation (Rizzo et al., 2023).

Benefits and barriers

The outcomes are documented in Table 2. The primary advantage observed is the amelioration of disease-specific knowledge (i.e., health literacy) of the patients. Studies also reported enhancements in motivation, usability, satisfaction, interest, understanding, and peer support. Furthermore, there is evidence of a decrease in fatigue, travel- difficulties and expenses, anxiety and a reduction in healthcare costs. Notable barriers included the use of technology and the fact that education is less individualized and not always suited for each and every patient.

Discussion

This scoping review aimed to provide insight into the changing field of patient education by examining the incorporation of VR. Sixteen studies were included.

The majority of the included studies employ non-immersive VR (%). It refers to a type of VR that does not fully immerse the user in a digital environment. In contrast to immersive VR, where the patient is not aware of the real world and the perspective can dynamically alter via head movements while wearing a VR headset. Non-immersive VR is a more cost-effective and easy-to-use method. It can indeed be performed on a tablet, smartphone, or computer, which is for most patients more accessible than a VR headset (Salatino et al., 2023).

VR is becoming a popular tool for educating and supporting patients. Different types of VR make it easy and effective to provide patients with information (Easton et al., 2019). The education can improve patients' disease-specific knowledge, health knowledge, and maintenance of better health habits (Brewer et al., 2017; Finkelstein et al., 2023). Furthermore, VR-based educational initiatives afford temporal and spatial flexibility. It allows patients to access the information whenever and wherever they need it (Brewer et al., 2017). Plus, it saves them the difficulties and costs of traveling to a specific location (Booth et al., 2022).

Implementing this educational approach could enhance the healthcare system’s ability to increase the quality of care (by providing continuous education for patients) without increasing the workload for physiotherapists. As a result, it could contribute to a reduction in overall healthcare costs. Furthermore, early and effective education plays a pivotal role in the decrease of healthcare costs of unnecessary investigations, treatments, medications, and hospitalizations. A better prevention strategy not only enhances healthcare quality but also contributes to lower healthcare expenses (Franchini et al., 2022).

Another advantage of education in a virtual environment is the potential of avatar-mediated peer to peer interactions. Participants not only engage with educators but also with each other. This results in an online community comprising individuals facing similar health challenges or conditions. This peer support mechanism serves as an additional social factor (Pérez-Aldana et al., 2021).

However, despite these - potential - positive points, VR as an educational tool also, currently, presents certain limitations that need to be addressed before this technology can be fully used and integrated into clinical care. First, accessibility remains a concern, as not all individuals have equal access to technology or the same level of digital literacy (Santos et al., 2023). Those less familiar with technology or experience challenges with maintaining a stable internet connection may encounter barriers when attempting to access virtual platforms (Flannery et al., 2022; Santos et al., 2023). Furthermore, the use of this technology is not accessible to less developed countries or people less wealthy in our country which can further exacerbate health inequality Secondly, more specifically concerning immersive VR, headset presents certain challenges as well. Participants encountered difficulties setting up and operating the VR headset, noting constraints in available space within the virtual environment. Additionally, users reported a shortage of support personnel to address issues related to the VR headset. Given that the primary objective of virtual education is to facilitate seamless application and enable home-based usage, refinement in this regard is imperative (Brown et al., 2023).

Another limitation associated with the use of VR technology is the occurrence of motion sickness. Motion sickness encompasses feelings of discomfort induced by movement, particularly evident during travel and immersion in VR environments (Zhang et al., 2015). However, in this case, when providing information and training environment this point should not be too much of an issue since VR sickness is mostly due to the flow (i.e., a sensation of motion) in the environment which is mostly the case in sports and racing games. Additionally, the weight of the VR headset may pose an obstacle for some individuals (Brown et al., 2023).

In this scoping review, the primary emphasis lies in exploring the utilization of VR as a tool for patient education. However, its applicability extends beyond patient education to include the training of medical professionals, surgeons, and students.

For example, immersive VR facilitates surgeons in executing the principal steps of forthcoming operations completely virtually. Several studies have demonstrated that surgeons who undergo training via VR experience have a 29% increase in efficiency compared to traditional methods (Izard et al., 2018).
Moreover, VR training simulators are beneficial for medical students and surgical residents, allowing them to familiarize themselves with various surgical instruments. The development of virtual simulators represents a significant advancement toward creating more intricate and comprehensive surgical simulations (Izard et al., 2018).

Students also benefit from utilizing VR to enhance their comprehension and mastery of anatomy, a fundamental component of medical education. The virtual environment results in accurate information related to the shapes and sizes of bones, organs, and muscles. The anatomical structures situated in deeper layers can be shown to the students so they can imagine and perceive them better. Anatomy training with a 3D immersive VR system presents a promising alternative to traditional instructional approaches (Kurul et al., 2020).

The limitations of this scoping review include that there were exclusively sources from a single database, Pubmed. Furthermore, most of the included studies are interventional designs that lack control groups. The included studies feature a limited patient sample size, thereby reducing the reliability of the findings for generalizing across the entire patient population. Due to the limited number of studies with a control group, this scoping review could not compare VR-based education with standard education. However, the limited studies that included a control group with standard education (n=4) reported some benefits of VR, such as a significant reduction in fear of surgery, increased satisfaction, and heightened interest in education compared to the standard education group (Diego-Más et al., 2020; Gulick et al., 2021; Rizzo et al., 2023; Seixas et al., 2022).

This clearly highlighted the potential of these new technologies. However, to determine the extend to which VR can be used to enhance patient education, additional high-quality studies need to be conducted. While VR usage certainly offers some benefits, its suitability varies among individuals and pathologies.

Conclusion

The current literature indicates that VR is an efficient educational tool for patients with different medical conditions. Patients find VR an effective platform for education. Patients have a better comprehension of the medical information and an enhanced understanding of their condition which can potentially lead to better treatment adherence and therefore quality. Additionally, VR demonstrates benefits in motivation, peer support, and usability. Despite the numerous advantages highlighted in existing literature, further investigation is essential to ascertain for whom VR might be beneficial.

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Appendix

Figure 1

Search Strategy

Search	Actions	Details	Query	Results
#8	···	>	Search: **#1 AND #6 AND #7**	2,437
#7	···	>	Search: **#4 OR #5**	876,047
#6	···	>	Search: **#2 OR #3**	2,831,482
#5	···	>	Search: **rehabilitation[MeSH Terms]**	355,000
#4	···	>	Search: **(((physical therapy modalities) OR (occupational therapy)) OR (physical and rehabilitation medicine)) OR ((rehabilitation) OR (rehab*))**	876,047
#3	···	>	Search: **health education[MeSH Terms]**	263,317
#2	···	>	Search: **(education) OR (patient education) OR (digital health) OR (virtual learning) OR (health literacy) OR (health promotion) OR (Health Knowledge) OR (health communication)**	2,831,482
#1	···	>	Search: **(virtual reality) OR (VR) OR (Immersive virtual reality) OR (iVR) OR (Immersive*) OR (Non-immersive virtual reality) OR (Non-immersive*) OR (Fully immersive*) OR (Semi-immersive*) OR (Real environment) OR (Virtual environment)**	117,233

Table 2

Results

Article	Study design	Population	VR	Type of education	Outcomes	Results
Booth et al., 2022	Interventional study	13 patients: - 4 hypermobility spectrum disorder - 2 CRPS - 3 persisted axial spine pain - 2 fibromyalgie - 1 knee pain - 1 persisted neuropathic arm pain	Microsoft teams	Virtual pain management programme: for 3 weeks education sessions of 3-4 hours a day	Theoretical Framework of Acceptability	Virtual healthcare is a more feasible option for some patients in case of: - Travel expenses - Travel difficulties - Encounter travel difficulties - Access to technology VR healthcare can not replace an individual programme for most of the patients
Brewer et al., 2017	Interventional study	6 patients with cardiac problems	Virtual world platform: Second Life®	For 12 weeks weekly one education session of 1.5 hours about cardiovascular health behaviors and cardiac risk factors	Pre-intervention survey (sociodemographics, social support, digital health information access and prior virtual world experience) Post-intervention survey (intervention acceptability and feedback)	Intervention acceptability: - All participants were highly satisfied with the global virtual world experience - Perceived usefulness is high: understanding specific health problem information (67%), gaining health knowledge (83%) and maintenance of better health habits (67%) Intervention qualitative perceptions: - The platform provides flexibility in time and space - Virtual world simulations enhance the emotional experience that promotes information recall and retention
Brown et al., 2023	Interventional study	15 patients with >3 months pain	Oculus Go VR headset	Pain education in 4 sessions	- The Keele StarT back questionnaire - Open questions for feedback	Potential improvements: - Setting up and operating VR headset - Lack of available support staff to troubleshoot VR headset issues - Insufficient space - Easier education - More recognizable ADL examples for behavior change 67% found the experience with VR excellent

						Physical therapists found that it can provide good complementary care Most of the patients were very likely to increase their physical activity and were much more confident that they could do it safely gradually over time Majority also indicate that the program effectively helps them in changing their pain
de Vries et al., 2023	Interventional study	9 patients with chronic (>6 months) LBP	Reducept (VR training program)	Education about chronic LBP in 9-12 VR sessions of 40-45 minutes each	Primary outcomes: - NRS Secondary outcomes: - Pain Catastrophizing Scale - Symptom Checklist 90-R - Tampa - Pain Coping Inventory - SF36	- Reducept is feasible - Reducept can contribute to the treatment of chronic pain
Diego-Más et al., 2020	Comparative Study	70 employees for an automobile components firm (with the same task in the company)	VR headset (Samsung Gear VR)	Education about ergonomics risk factors - IG: by VR headset - CG: by video presentations on a projection screen Unclear how many sessions (of 2 hours) took place	PQ-questionnaire - 11 questions divided into 5 dimensions: Concern, Control, Loads, Repetitiveness and Postures RQ-questionnaire - 6 questions divided into 3 dimensions: Expectation, Interest and Usefulness SA-questionnaire - 12 questions divided into 5 dimensions: Memory, Concern, Control, Transference and Usefulness LT knowledge test - 30 questions (10 on each ergonomic risk factor)	Before training: no significant differences Immediately after training: - Significant differences IG vs CG: - Receiving information is more interesting - Less fatigued (i.e., more engaged during training) - More interesting learning materials - Usefulness of training - IG found training better than previous similar trainings 3 months after training: - Significant differences IG vs CG: - Higher level of concern about ergonomics risks and the consequences on their long-term - More correct answers on knowledge test => so how training was applied (VR or no VR) does affect level of knowledge or skills 3 months after training - Little transference to workplace in both groups - Although IG found training better than previous similar trainings, they found no significant differences between the groups in the perceived usefulness of the training
Easton et al., 2019	Interventional study	6 patients with COPD and 5 HCPs	AI: avachat	COPD education - Information provision - Crisis support: during acute exacerbations	SUS	- Clear information about self management, support and acute exacerbations - Behavior modification techniques - Peer support

				- Emotional support - Motivation		- Advice on well-being - Acceptable to receive information via the platform
Finkelstein et al., 2023	Interventional study	9 patients with COPD	Oculus Quest 2 (with a PR app) and two controllers	Education about PR - Unclear how many sessions	- BRIEF Health Literacy Screening Tool - PR Education Questionnaire - Post-task survey on 3 domains: Start the VR app, complete the education module, and answer multiple-choice questions - Attitudinal Survey - Heuristic evaluation form - SUS	Patients indicate high interest in using VR for education High acceptance for VR system and successful ability to operate it Significantly better understanding of the general concepts of PR Significantly increase disease-specific knowledge in patients with low health literacy and limited computer skills
Flannery et al., 2022	Interventional study	38 patients with Long Covid and 17 HCPs (5 occupation therapist, 8 physiotherapists, 1 dietician and 3 professionals in another category)	Microsoft Teams (VRP format: early education and self-management techniques)	Education about LC	Outcome of the HCP Questionnaire Interviews with participants (Evaluation VRP) Outcome of persons with Long Covid questionnaire	Facilitators - Self-management is possible by digital delivery - VRP is highly valued Barriers: - Work-life balance - Use of technology - Health inequalities - LC was poorly understood by employers
Franchini et al., 2022	Interventional study	LBP patients (unclear how much)	DRESS-kinesis (Doing Risk sElf assessment and Social health Support)	Education about LBP (self-management about pain and disability) Exercises for improving pain and disability (3 times/week)	- Average number of patients who enter the system - Average number of patients in the system at any given time - Average number of physiotherapists in use over time - Average number of waiting patients and time spent before seeing a physiotherapist - Physiotherapists' cost - Healthcare costs for patients who did not seek care within 14 days of need onset	It results to a - Better capacity for taking on patients - The effort and patient cost stays the same. - Decrease of healthcare costs - For high-risk populations: reduce the burden of chronic diseases
Gulick et al., 2021	RCT	72 patients (41 IG, 31 CG) with moderate cardiac problems	Bionautica Trails	IG: - Standard CR with education while walking on the treadmill (tokens appear on the screen and provide auditory education that comes from handouts and textbooks)	Primary outcome: - 6MWT Secondary outcomes: - Patients' cardiac knowledge - Satisfaction questionnaire	No significant differences in 6MWT Cardiac knowledge is better in IG than in CG at pretest vs follow-up but not statistically significant In both groups, patients are satisfied with their treatment and feel

				CG: - Standard CR with education through handouts, bulletin board displays, and periodic group lectures Both groups had between 18 and 36 education sessions	- Patient adherence to the recommended number of sessions	engaged. In IG most of the patients are satisfied with VR CG had significantly higher completion rates than IG
Greenway et al., 2022	Interventional study	7 patients with HNC and 6 HCPs	WebXR platform	Education for HNC patients (e.g. with exercises about swallowing disorders)	Interview with HNC participants	- Patients felt comfortable by using the VR platform - Realistic and useful support - Relevant materials - Reduced anxiety
Pérez-Aldana et al., 2021	Observational study	20 patients with type 2 diabetes and 4 HCPs	SLIDES (Second Life Impacts Diabetes Education and Support)	Checking social support for people with diabetes	/	Most behavior change techniques shown by coding interactions on the platform: comparison of outcomes (28%), social support (21%), knowledge shaping (19%), natural consequences (17%) and repetition and replacement (8%)
Rizzo et al., 2023	RCT	95 patients (46 IG, 49 CG) undergoing surgery	AR application (not specified)	Pre-operative education - IG: standard education (not specified) + taking the road visually through the surgery space with AR - CG: standard education (not specified)	STAI at 4 times: - Screening - Before intervention - Before surgery - After surgery Pain with VAS Pain medication survey Survey on general feedback and satisfaction	Significant differences - Screening vs post-intervention: IG had a decrease in STAI compared with CG, they had no change - Screening vs preoperative: IG decreased in STAI while CG increased Anatomical location of surgery had no significant impact on STAI scores AR does not affect postoperative pain or use of medication Overall experience with the AR application: most patients enjoyed the AR experience, would recommend the it and would do it again
Santos et al., 2023	Interventional study	34 patients with cardiac problems and 8 HCPs	Cardiac College™	For 12 weeks weekly one education link is sent about CR (exercise, diet, psychosocial health, medication, and action planning) in combination with bi-weekly phone calls	- Coronary Artery Disease Education Questionnaire Short Version - BESES - Pittsburgh Sleep Quality Index - Short Patient Health Questionnaire-2 - International Physical Activity Questionnaire Short Form	Most of the patients and HCPs were very satisfied with virtual education, and the majority of the patients found the information received useful and the bi-weekly calls effective 95% of the patients changed their heart health behaviours after the intervention

						The intervention was associated with positive changes regarding exercise self-efficacy, sleep quality, depressive symptoms, and performance of high-intensity levels of physical activity
Seixas et al., 2022	RCT	15 patients with diabetes (type 1 and 2)	Diabetes College™	Both groups received diabetes education and exercise intervention for 12 weeks (at least 150 minutes of aerobic exercise + 2-3 times of strength training) - IG: by online videos - CG: by a printed version	- Incremental shuttle walking test - Physical activity by a pedometer for 7 days - BMI - Waist circumference - Glycated hemoglobin level - Mediterranean Diet Scale - BESES - Diabetes Education Questionnaire - Newest Vital Sign - Center for Epidemiological Scale Depression - SF36	Most of the patients (80%) were very satisfied with the education Suggestions from patients: - Reduce huge amount of educational information - Develop mobile app that could replace websites and facilitate access Adherence to education was 58% Patients were active an average of 65 minutes per week
Sullivan et al., 2023	Pilot study	33 youth (between 9-12 years old) playing soccer	Make Play Safe VR app with an accompanying VR headset (not specified)	Education on recognizing and reporting (to parent/coach) a concussion in one session	- Concussion knowledge: adapted version of the RoCKAS-ST - Attitudes toward concussion reporting: through 8 statements - Concussion reporting intentions: by assessing 3 scenarios	Significant beter concussion knowledge pre- vs post-intervention No significant differences in attitudes toward concussion reporting Significant beter concussion reporting intentions Good acceptance of youth/parents/coaches for the app

Note. 6MWT= 6 minute walk test; BESES = Bandura's Exercise Self-Efficacy Scale; BMI = body mass index; CG = Control group; COPD = Chronic obstructive pulmonary disease; CR = Cardiac rehabilitation; e.g = for example; HCP = Healthcare professional; HCPs = Healthcare Professionals; HNC = Head and neck cancer; i.e. = in other words; IG = Intervention group; LBP = Low back pain; NRS = numeric pain rating scale; PR = pulmonary rehabilitation; RCT = Randomized Controlled Trial; RoCKAS-ST = Rosenbaum Concussion Knowledge and Attitudes Survey–Students; SF36 = 36-item short form health survey; STAI = State-Trait Anxiety Inventory; SUS = System Usability Scale; VAS = visual analog scale; VR = virtual reality; VRP = Virtual Rehabilitation Program; vs = versus

Table 3

Quality Assessment for Studies With No Control Group

	1	2	3	4	5	6	7	8	9	10	11	12	Quality rating
Booth et al., 2022	YES	YES	YES	YES	NR	YES	NO	NR	YES	NA	NR	NA	Good
Brewer et al., 2017	YES	YES	YES	YES	NR	YES	NO	NR	YES	NA	NR	NA	Good
Brown et al., 2023	YES	YES	YES	YES	NR	YES	NO	NR	YES	NR	NR	NR	Good
de Vries et al., 2023	YES	YES	YES	YES	NR	YES	NO	NR	YES	YES	NR	YES	Good
Easton et al., 2019	YES	YES	YES	YES	NR	YES	NO	NR	YES	NA	NR	NA	Good
Finkelstein et al., 2023	YES	NR	YES	NR	NR	YES	NO	NR	YES	NA	NR	NA	Fair
Flannery et al., 2022	YES	YES	YES	YES	NR	YES	NO	NR	YES	NA	NR	NA	Good
Franchini et al., 2022	YES	NR	YES	NR	NR	YES	YES	NR	NA	YES	NR	NA	Fair
Greenway et al., 2022	YES	YES	YES	YES	NR	YES	NO	NR	YES	NA	NR	NA	Good
Santos et al., 2023	YES	YES	YES	YES	YES	YES	NO	NR	YES	YES	NR	NR	Good
Sullivan et al., 2023	YES	YES	YES	YES	NO	YES	NO	NR	YES	YES	NR	YES	Good

Note. 1 = Was the study question or objective clearly stated?; 2 = Were eligibility/selection criteria for the study population prespecified and clearly described?; 3 = Were the participants in the study representative of those who would be eligible for the test/service/intervention in the general or clinical population of interest?; 4 = Were all eligible participants that met the prespecified entry criteria enrolled?; 5 = Was the sample size sufficiently large to provide confidence in the findings?; 6 = Was the test/service/intervention clearly described and delivered consistently across the study population?; 7 = Were the outcome measures prespecified, clearly defined, valid, reliable, and assessed consistently across all study participants?; 8 = Were the people assessing the outcomes blinded to the participants' exposures/interventions?; 9 = Was the loss to follow-up after baseline 20% or less? Were those lost to follow-up accounted for in the analysis?; 10 = Did the statistical methods examine changes in outcome measures from before to after the intervention? Were statistical tests done that provided p values for the pre-to-post changes?; 11 = Were outcome measures of interest taken multiple times before the intervention and multiple times after the intervention (i.e., did they use an interrupted time-series design)?; 12 = If the intervention was conducted at a group level (e.g., a whole hospital, a community, etc.) did the statistical analysis take into account the use of individual-level data to determine effects at the group level?; NA = not applicable; NR = not reported

Table 4

Quality Assessment Randomized Controlled Trial

	1	2	3	4	5	6	7	8	9	10	11	Quality rating
Gulick et al., 2021	YES	YES	YES	YES	NO	NO	YES	YES	YES	YES	YES	8/10
Rizzo et al., 2023	YES	YES	YES	YES	NO	NO	NO	YES	YES	YES	YES	7/10
Seixas et al., 2022	YES	NO	NO	YES	NO	NO	NO	YES	YES	YES	YES	5/10

Note. 1 = Eligibility criteria were specified; 2 = Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received); 3 = Allocation was concealed; 4 = The groups were similar at baseline regarding the most important prognostic indicators; 5 = There was blinding of all subjects; 6 = There was blinding of all therapists who administered the therapy; 7 = There was blinding of all assessors who measured at least one key outcome; 8 = Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups; 9 = All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"; 10 = The results of between-group statistical comparisons are reported for at least one key outcome; 11 = The study provides both point measures and measures of variability for at least one key outcome

Table 5

Quality Assessment Pérez-Aldana et al., 2021

1	2	3	4	5	6	7	8	9	10	11	12	13	14	Quality rating
YES	YES	YES	YES	NR	YES	YES	NO	NO	NO	NO	NR	YES	NR	Fair

Note. 1 = Was the research question or objective in this paper clearly stated?; 2 = Was the study population clearly specified and defined?; 3 = Was the participation rate of eligible persons at least 50%?; 4 = Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?; 5 = Was a sample size justification, power description, or variance and effect estimates provided?; 6 = For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?; 7 = Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?; 8 = For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?; 9 = Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?; 10 = Was the exposure(s) assessed more than once over time?; 11 = Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?; 12 = Were the outcome assessors blinded to the exposure status of participants?; 13 = Was loss to follow-up after baseline 20% or less?; 14 = Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?; NR = not reported

Table 6

Quality Assessment Diego-Más et al., 2020

1	2	3	4	5	6	7	8	9	10	11	12	Quality rating
YES	YES	NR	YES	YES	YES	YES	YES	YES	YES	NR	NA	Good

Note. 1 = Was the research question or objective in this paper clearly stated and appropriate?; 2 = Was the study population clearly specified and defined?; 3 = Did the authors include a sample size justification?; 4 = Were controls selected or recruited from the same or similar population that gave rise to the cases (including the same timeframe)?; 5 = Were the definitions, inclusion and exclusion criteria, algorithms or processes used to identify or select cases and controls valid, reliable, and implemented consistently across all study participants?; 6 = Were the cases clearly defined and differentiated from controls?; 7 = If less than 100 percent of eligible cases and/or controls were selected for the study, were the cases and/or controls randomly selected from those eligible?; 8 = Was there use of concurrent controls?; 9 = Were the investigators able to confirm that the exposure/risk occurred prior to the development of the condition or event that defined a participant as a case?; 10 = Were the measures of exposure/risk clearly defined, valid, reliable, and implemented consistently (including the same time period) across all study participants?; 11 = Were the assessors of exposure/risk blinded to the case or control status of participants?; 12 = Were key potential confounding variables measured and adjusted statistically in the analyses? If matching was used, did the investigators account for matching during study analysis?; NA = not applicable; NR = not reported

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1/2
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	6
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	7-8
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	7-8
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	9-10
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	9-10
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	9-10
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	9-10
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	9-10
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	9-10
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	9-10
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	9-10
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	9-10

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	11-15
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	11-15
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	11-15
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	11-15
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	11-15
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	16-19
Limitations	20	Discuss the limitations of the scoping review process.	16-19
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	16-19
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	/

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.