

SYSTEMATIC REVIEW

## Use of virtual reality in rehabilitation

## Uso de la realidad virtual en la rehabilitación

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### ABSTRACT

**Introduction:** virtual reality is a promising medical rehabilitation tool, offering patients a safe and interactive experience to improve their quality of life. Scientific studies support its effectiveness in improving balance, coordination, and cognitive function in various conditions.

**Methods:** PubMed was searched for information using descriptors related to virtual reality and physical and mental rehabilitation. Twenty-nine clinical and observational trial articles published in the last 10 years in English and Spanish were selected, and the PRISMA methodology was used for systematic reviews.

**Results:** the results indicate that virtual reality therapy can improve motor, cognitive and psychological function in diverse patient populations. However, the effectiveness of different virtual reality approaches may vary depending on the population and rehabilitation goals.

**Conclusion:** virtual reality therapy improves motor function and quality of life in patients with various medical conditions. Combining it with other therapies can enhance outcomes and shows benefits in treating neurological and psychological conditions.

**Keywords:** Virtual Reality; Physical Rehabilitation; Mental Rehabilitation.

### RESUMEN

**Introducción:** la realidad virtual es una prometedora herramienta de rehabilitación médica, que ofrece a los pacientes una experiencia segura e interactiva para mejorar su calidad de vida. Estudios científicos avalan su eficacia para mejorar el equilibrio, la coordinación y la función cognitiva en diversas afecciones.

**Métodos:** se buscó información en PubMed utilizando descriptores relacionados con la realidad virtual y la rehabilitación física y mental. Se seleccionaron 29 artículos de ensayos clínicos y observacionales publicados en los últimos 10 años en inglés y español, y se utilizó la metodología PRISMA para revisiones sistemáticas.

**Resultados:** los resultados indican que la terapia de realidad virtual puede mejorar la función motora, cognitiva y psicológica en diversas poblaciones de pacientes. Sin embargo, la eficacia de los diferentes enfoques de realidad virtual puede variar en función de la población y los objetivos de rehabilitación.

**Conclusiones:** la terapia de realidad virtual mejora la función motora y la calidad de vida en pacientes con diversas afecciones médicas. Su combinación con otras terapias puede mejorar los resultados y muestra beneficios en el tratamiento de afecciones neurológicas y psicológicas.

**Palabras clave:** Realidad Virtual; Rehabilitación Física; Rehabilitación Mental.

### INTRODUCTION

In the dynamic world of technology, virtual reality (VR) has emerged as a promising ally in various fields, and one of the most fascinating is rehabilitation and medical treatment. Imagine a world where the boundaries

between the real and the virtual blur, and patients with neurological conditions, heart disease, or developmental disorders can immerse themselves in a safe, interactive environment to improve their quality of life. In this exciting scenario, virtual reality is a versatile and effective tool for rehabilitating patients with various clinical conditions.<sup>(1)</sup>

The use of virtual reality for therapeutic purposes has been the subject of increasing interest in recent years, driven by technological advances and the growing understanding of the neurological and cognitive mechanisms involved in rehabilitation. Through immersion in virtual environments, patients can experience being in different places and situations, providing unique opportunities for practice and learning.<sup>(2)</sup> In addition, the interactivity and real-time feedback in these virtual environments allow therapists to personalize and tailor interventions to the specific needs and abilities of each patient.<sup>(3)</sup>

Scientific studies have shown that virtual reality can improve balance and coordination in Parkinson's and chronic stroke patients, allowing them to regain independence and confidence in their motor skills. Likewise, in patients with heart disease, virtual reality has proven to be an effective tool for improving executive function, quality of life and reducing levels of anxiety and depression. In the case of people with fibromyalgia, the use of virtual reality in combination with exercise has led to a significant reduction in pain, fatigue, and an overall improvement in quality of life.<sup>(4,5)</sup>

In addition to the physical benefits, virtual reality has positively impacted patients' emotional and cognitive well-being. Immersion in virtual environments can reduce stress and anxiety, providing a safe avenue for coping with fears and phobias. It has also shown improvements in memory and cognitive function in patients with neurocognitive disorders, which could have important implications for healthy aging.<sup>(6,7)</sup>

Despite exciting advances in the field of therapeutic virtual reality, there are still challenges to be addressed. For example, customizing virtual environments and interventions for different conditions and populations remains an active research area. In addition, it is critical to ensure safety and ethics in using virtual reality in healthcare and evaluate its cost-effectiveness compared with other traditional interventions.<sup>(8)</sup>

This article presents a comprehensive review of various scientific studies that have investigated the effects of virtual reality in rehabilitation and medical treatment. By analyzing common trends and patterns in the literature, we seek to provide an overview of virtual reality's impact on improving patients' physical, emotional, and cognitive conditions. Through this review, it is hoped that healthcare professionals will find solid evidence to support the implementation of virtual reality as a complementary tool in rehabilitation and medical treatment.

## METHODS

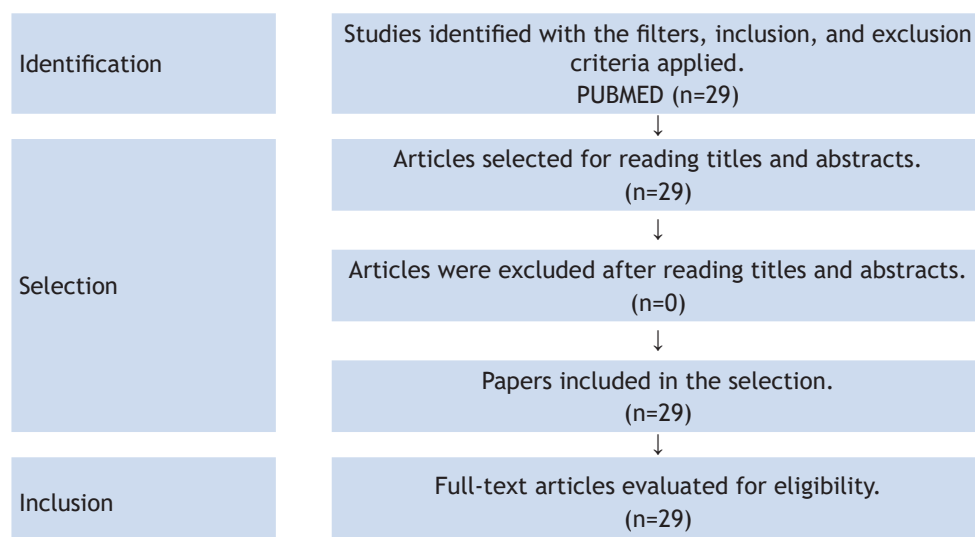
An information search was conducted in PubMed with the following descriptors (Medical Subject Headings-MeSH): virtual reality, physical rehabilitation, and mental rehabilitation.

The temporal criteria used were articles published in the last 10 years; English and Spanish were used as languages. The articles available in full text were selected. According to the source of information of the documentary research, clinical trial, and observational studies were selected. Twenty-nine articles were identified and subjected to review, leaving 29 selected for analysis (figure 1).

The information analyzed is presented in the data collection table, and all the selected evidence was critically read and analyzed.

The PRISMA methodology was used for systematic reviews.<sup>(9)</sup>

## RESULTS



**Figure 1.** Flowchart for the review of the state of the art according to PRISMA methodology

Table 1 summarizes the studies that were investigated. It includes author, country, year, type of study, sample, intervention, and main results.

<b>N</b>	<b>Author Country (Year)</b>	<b>Type of Study</b>	<b>Sample</b>	<b>Intervention</b>	<b>Main Results</b>
1	Pazzaglia et al, Italy. 2020 <sup>(10)</sup>	Randomized Controlled Trial	Patients with Parkinson's disease.	6-week virtual reality (VR) rehabilitation program compared to a conventional rehabilitation program.	The virtual reality (VR) rehabilitation program increased Berg Balance Scale (BBS) score, DGI score, and SF-36 score. A decrease in the DASH scale score was also observed. The VR program was more effective than the conventional program in determining overall improvement.
2	Kayabinar et al, Turkey. 2021 <sup>(11)</sup>	Randomized Controlled Trial	Chronic stroke patients.	Robotic-assisted gait training with augmented virtual reality (VR-RAGT).	VR-RAGT improved gait speed in dual tasks and functional performance in chronic stroke patients but showed no significant difference with RAGT alone in outcome measures after treatment.
3	Manuli et al., Italy. 2020 <sup>(12)</sup>	Randomized Controlled Trial	Chronic stroke patients.	Robotic gait rehabilitation training plus virtual reality (RRG+VR).	RRG+VR significantly improved cognitive function and psychological well-being in chronic stroke patients compared with conventional rehabilitation and robotic training without VR.
4	Winter et al., Germany. 2021 <sup>(13)</sup>	Randomized Controlled Trial	Healthy participants and patients with multiple sclerosis and stroke.	Immersive virtual reality application during gait rehabilitation.	Immersive virtual reality improved walking speed and motivation in healthy participants and patients with multiple sclerosis and stroke without significant side effects.
5	Vieira et al, Portugal. 2018 <sup>(1)</sup>	Randomized Controlled Trial	Patients with coronary artery disease.	Immersive virtual reality application during gait rehabilitation.	The 6-month virtual reality program improved executive function, quality of life, and reduced depression, anxiety, and stress in patients with coronary artery disease in phase III cardiac rehabilitation.
6	Meldrum et al, Ireland. 2015 <sup>(14)</sup>	Randomized Controlled Trial	Patients with unilateral peripheral vestibular loss.	Virtual reality balance exercises vs. conventional balance exercises	No significant differences were found between groups in walking speed. Both groups improved, but the virtual reality group reported more enjoyment and less difficulty and fatigue after exercise.
7	Oh et al., Republic of Korea. 2019 <sup>(15)</sup>	Randomized Controlled Trial	Stroke patients.	Virtual reality training combined with real instrument training.	Combined virtual reality training with real instruments effectively improved upper extremity and cognitive function after stroke, suggesting it to be an innovative strategy for neurorehabilitation.
8	Adomavičienė et al, Lithuania. 2019 <sup>(16)</sup>	Randomized Controlled Trial	Stroke patients.	Armeo Spring virtual reality training vs. Kinect system.	Both systems improved upper extremity functional and motor status, but Armeo Spring training demonstrated greater improvement in cognitive function, whereas Kinect training reduced anxiety.
9	da Silva et al, Brazil. 2015 <sup>(17)</sup>	Randomized Controlled Trial	Patients with hemiparesis post-stroke	Virtual rehabilitation using Nintendo Wii® and conventional physical therapy for post-stroke hemiparetic patients.	Both approaches improved patients' physical functioning on the SF-36 Scale. Significant improvement on the Fugl-Meyer Scale was observed in both groups regarding passive movement and pain, upper extremity motor function, and balance. The conventional physical therapy group significantly differed on the SF-36 Scale for physical function. Overall, both approaches improved patient performance similarly.

10	Monteiro-Junior et al, Brazil. 2017 <sup>(18)</sup>	Randomized Controlled Trial	Institutionalized older adults	Exergame-based physical exercise with virtual reality (PhysEx) improves institutionalized older adults' mental and physical health.	PhysEx improved mobility and strength in institutionalized older adults. The PhysEx group significantly improved gait speed and upper and lower extremity coordination. Although there were no significant differences in the reduction of depression and fear of falling between the groups, the PhysEx group showed a positive outlook on these aspects
11	Szczepańska-Gieracha et al, Poland. 2021 <sup>(19)</sup>	Randomized Controlled Trial	Coronary artery disease (CAD) patients	Immersive virtual reality therapy as a support for cardiac rehabilitation: A pilot randomized controlled trial.	Virtual reality (VR) therapy significantly reduced anxiety, depression, and stress levels in patients with coronary artery disease (CAD) undergoing cardiac rehabilitation.
12	Straker et al, Australia. 2011 <sup>(20)</sup>	Randomized Controlled Trial	Children 10-12 years old	We examined whether motor coordination is improved by access to active electronic video games and whether daily activity, attitudes towards physical activity, and mental health are also improved.	New virtual reality (VR) games can improve motor coordination, physical activity, and mental health in children with developmental coordination disorders.
13	Marivan et al, France. 2016 <sup>(21)</sup>	Pilot study	Older adults after a fall	Virtual reality therapy is an acceptable technique for older adults to rehabilitate psychomotor consequences after a fall.	Older patients found the virtual reality therapy easy to use, enjoyed the experience, and considered it realistic and useful.
14	Munari et al., Italy. 2020 <sup>(22)</sup>	Randomized Controlled Trial	Patients with multiple sclerosis	Robot-assisted training combined with virtual reality in patients with multiple sclerosis: a pilot randomized controlled trial.	Both groups showed significant improvement in executive functions and quality of life after treatment. The robot-assisted training group combined with VR improved walking ability and executive functions.
15	Jóźwik et al, Poland. 2021 <sup>(23)</sup>	Randomized Controlled Trial	Female patients with heart disease	Use virtual reality therapy in cardiac rehabilitation of female patients with cardiac disease.	Virtual reality (VR) therapy as an adjunct to cardiac rehabilitation was efficient in reducing levels of depression, anxiety, and stress in women with heart disease.
16	Gulsen et al., turkey. 2022 <sup>(24)</sup>	Randomized Controlled Trial	Fibromyalgia patients	Effect of fully immersive virtual reality treatment combined with exercise in fibromyalgia patients.	Both groups showed significant improvement in most of the parameters evaluated. The exercise group combined with virtual reality therapy (VRT) showed a significantly greater improvement in pain, kinesiophobia, fatigue, physical activity, and mental component of quality of life in patients with fibromyalgia.
17	Lee et al., South Korea-Colombia. 2015 <sup>(25)</sup>	Randomized Controlled Trial	Women over 65 years of age	Individualized feedback-based virtual reality (IFVR) exercise compared to group exercise.	The IFVR group showed significantly improved mental health and body strength compared to the group exercise (GG) group. Within the IFVR group, increases in several aspects of health-related quality of life were also observed. Both groups showed improvement in physical tests.
18	Gamito et al, Portugal. 2021 <sup>(26)</sup>	Randomized Controlled Trial	Patients with alcohol use disorder in residential treatment.	Virtual reality (VR)-based cognitive training compared to treatment as usual.	Virtual reality (VR)-based cognitive training improved attention and cognitive flexibility in patients with alcohol use disorder compared to the usual treatment group.

19	Romero-Ayuso et al, Spain. 2020 <sup>(27)</sup>	Randomized Controlled Trial	Children between 6 and 11 years old with neurodevelopmental disorders.	Virtual reality-based therapy to improve self-regulation.	Virtual reality-based therapy improved self-regulation skills in children with neurodevelopmental disorders.
20	Burdea et al., USA. 2015 <sup>(28)</sup>	Feasibility Test	Elderly patients with dementia	Use of the BrightBrainer™ cognitive rehabilitation system in patients with dementia.	The BrightBrainer™ cognitive rehabilitation system significantly improved decision-making and depression in elderly patients with dementia.
21	Maidan et al., USA. 2017 <sup>(29)</sup>	Observational Study	Patients with Parkinson's disease	Comparison of the effects of two forms of exercise: treadmill training with virtual reality (TT + VR) and treadmill training alone (TT) on brain activation in patients with Parkinson's disease.	Virtual reality treadmill training reduced brain activation in certain areas in patients with Parkinson's disease compared to treadmill training alone. Improvement in fall frequency correlated with changes in brain activation.
22	Anderson-Hanley et al, USA. 2011 <sup>(30)</sup>	Observational Study	Older adults are participating in an exergaming exercise program.	Participants train in the "cybercycle" video game that combines physical exercise with competition in a virtual environment.	Virtual social facilitation increased exercise effort in more competitive older adults.
23	Karssemeijer et al, Netherlands. 2019 <sup>(31)</sup>	Randomized Controlled Trial	People with dementia in the community	Exergaming training (exercise video game training) compared to aerobic training and an active control group.	Training with exergaming (exercise video games) reduced the level of frailty in people with dementia compared with aerobic training and the active control group.
24	Ballester et al., Spain. 2016 <sup>(32)</sup>	Randomized Controlled Trial	Patients with chronic stroke	Virtual reality-based enhanced movement therapy (RIMT) compared to traditional rehabilitation therapy.	Virtual reality-based enhanced movement therapy (RIMT) significantly improved patients with chronic stroke compared to traditional rehabilitation therapy. Experimental patients showed greater motor gains and were motivated to use the affected arm.
25	Monteiro-Junior et al, Brazil. 2017 <sup>(33)</sup>	Randomized Controlled Trial	Institutionalized elderly	Virtual reality exergames session.	Moderate improvement in semantic memory/executive function after the exergame session. No significant improvement in short-term memory or working memory.
26	Johnson et al., Australia. 2018 <sup>(34)</sup>	Randomized Controlled Trial	Stroke survivors	Interactive virtual therapy for the arm.	After virtual therapy, stroke survivors significantly improved arm motor function and dexterity.
27	Johnson et al., Australia. 2020 <sup>(35)</sup>	Randomized Controlled Trial	Stroke survivors	Interactive virtual therapy for the arm.	Significant improvements in arm motor function in stroke survivors after virtual therapy in a community setting.
28	Kumazaki et al, Japan. 2020 <sup>(36)</sup>	Randomized Controlled Trial	Individuals with autism spectrum disorder	Public speaking training with a simple virtual audience focused on autism.	Increased self-confidence and reduced cortisol levels in the intervention group after the virtual audience training.
29	Hammond et al., United Kingdom. 2014 <sup>(37)</sup>	Randomized Controlled Trial	Children with developmental coordination disorder	Regular use of the Wii Fit video game.	Some children significantly improved motor skills, perceived motor skills, and emotional well-being after regular use of the Wii Fit.

## DISCUSSION

This article summarizes the results of several studies that have investigated the effects of virtual reality therapy in the rehabilitation of different patient populations, including those with Parkinson's disease, stroke, coronary artery disease, multiple sclerosis, fibromyalgic disease, neurodevelopmental disorders, and alcoholism, as well as in the elderly and children. Overall, the studies included in this review have shown promising results for using virtual reality in rehabilitation. However, differences in the effectiveness of different approaches and technologies have also been observed.

One of the most consistent results of these studies is that virtual reality therapy improves motor function and quality of life in various patient populations. For example, in the study by Pazzaglia et al.<sup>(10)</sup>, a virtual reality rehabilitation program improved Berg Balance Scale (BBS) score, Dynamic Gait Index (DGI) score, and SF-36 questionnaire score in patients with Parkinson's disease. Similarly, in the study by Winter et al., virtual reality therapy improved gait speed and motivation in healthy patients and those with multiple sclerosis or stroke.

In addition to benefits in motor function, several studies reported improvements in cognitive function and psychological well-being. For example, Manuli et al.<sup>(12)</sup> found that virtual reality therapy combined with robotic training improved cognitive function and psychological well-being in chronic stroke patients compared with conventional rehabilitation and robotic training without virtual reality. Likewise, the study by Gulsen et al.<sup>(24)</sup> found that virtual reality therapy combined with exercise significantly improved levels of pain, kinesiophobia, fatigue, and quality of life in patients with fibromyalgia compared with the exercise-alone group.

However, differences in the effectiveness of the virtual reality approaches used in these studies were also found. For example, in the study by Kayabinar et al.<sup>(11)</sup>, robot-assisted gait training with augmented virtual reality (VR-RAGT) was compared with robot-assisted gait training alone in patients with chronic stroke. Although both groups showed improvements in gait speed and functional performance after treatment, no significant differences were found between the two groups in outcome measures. Adding virtual reality to robot training may not benefit certain patient populations significantly.

In another study, Adomavičienė et al.<sup>(16)</sup> compared two virtual reality systems (Armeo Spring vs. Kinect) in stroke patients. Both systems improved upper limb function and motor status, but Armeo Spring training demonstrated greater improvement in cognitive function, whereas Kinect training reduced anxiety. These findings suggest that the choice of a virtual reality system may depend on the patient's specific rehabilitation goals and needs.

These results indicate that virtual reality therapy can improve motor, cognitive, and psychological function in diverse patient populations. However, the effectiveness of different virtual reality approaches may vary depending on the population and rehabilitation goals. More research is needed to fully understand how virtual reality can be optimally integrated into existing rehabilitation programs and how approaches can be tailored to meet individual patient needs. Despite this, the findings are encouraging and support virtual reality therapy's continued use and development in neurorehabilitation.

## CONCLUSIONS

Virtual reality therapy offers significant improvements in motor function and quality of life in patients with various conditions: Several studies, such as Pazzaglia et al.<sup>(10)</sup> in patients with Parkinson's disease, Vieira et al.<sup>(1)</sup> in patients with coronary artery disease, and Straker et al.<sup>(20)</sup> in children with developmental coordination disorder, have shown that virtual reality therapy can lead to significant improvements in patients' motor function and quality of life. These findings support the efficacy of virtual reality therapy as an effective tool in rehabilitating diverse patient populations.

Combining virtual reality with other forms of therapy may boost outcomes: Several studies, such as Manuli et al.<sup>(12)</sup> in chronic stroke patients and Oh et al.<sup>(15)</sup> in stroke patients, suggest that combining virtual reality with other forms of therapy, such as robot therapy or real instrument therapy, may result in additional improvements in motor and cognitive function after treatment. This synergy between virtual reality and other therapies may be an innovative and effective strategy for neurorehabilitation.

Virtual reality therapy has potential benefits in the treatment of neurological and psychological conditions: several studies, such as Gulsen et al.<sup>(24)</sup> in patients with fibromyalgia, Gamito et al.<sup>(26)</sup> in patients with alcohol use disorder, and Jóźwik et al.<sup>(23)</sup> in women with heart disease, have found that virtual reality therapy can result in significant improvements in aspects such as pain, fatigue, anxiety, depression, and stress. This suggests that virtual reality therapy is not only effective in improving motor function but also has the potential to address psychological and emotional problems in patients with various medical and neurological conditions.

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The authors declare that there are no conflicts of interest.

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