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SYSTEMATIC REVIEWS

Review of clinical trials on the effectiveness of cognitive rehabilitation in patients with traumatic brain injury

Revisión de ensayos clínicos sobre la eficacia de la rehabilitación cognitiva en pacientes con lesión cerebral traumática

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ABSTRACT

Introduction: Traumatic brain injury (TBI) can impact patients' cognitive functioning and quality of life. This study assesses the effectiveness of cognitive interventions in TBI patients and examines factors influencing their success, aiming to enhance care and customize treatments for optimal rehabilitation outcomes.
Methods: a systematic review of 31 scientific articles evaluating the effectiveness of cognitive rehabilitation in patients with traumatic brain injuries was conducted, following the PRISMA workflow. The studies covered the period from 2017 to 2021, and specific terms were used to search the PubMed and Scopus databases.
Results: the research on cognitive interventions in patients with traumatic brain injuries has involved various countries, with notable contributions from the United States, Norway, the United Kingdom, and Canada. Cognitive training has proven to be effective, showing significant improvements in symptoms and quality of life. Other therapies, such as transcranial direct stimulation and vocational rehabilitation, have also been investigated.
Conclusions: cognitive training has proven to be an effective technique in managing traumatic brain injuries, demonstrating significant improvements in composite cognitive measures and patients' quality of life. Some therapies, such as hyperbaric oxygen therapy, have shown promising results in treating symptoms such as post-traumatic stress, depression, and anxiety in patients with traumatic brain injuries.

Keywords: Cognitive Training; Craniocerebral Trauma; Traumatic Brain Injuries; Cerebrovascular Trauma; Diffuse Brain Injuries.

RESUMEN

Introducción: la lesión cerebral traumática (LCT) puede afectar al funcionamiento cognitivo y a la calidad de vida de los pacientes. Este estudio evalúa la eficacia de las intervenciones cognitivas en pacientes con LCT y examina los factores que influyen en su éxito, con el objetivo de mejorar la atención y personalizar los tratamientos para obtener resultados óptimos de rehabilitación.
Métodos: se realizó una revisión sistemática de 31 artículos científicos que evaluaron la efectividad de la rehabilitación cognitiva en pacientes con lesiones cerebrales traumáticas, siguiendo el flujo de trabajo PRISMA. Los estudios abarcaron el período comprendido entre 2017 y 2021, y se utilizaron términos específicos para buscar en las bases de datos PubMed y Scopus.
Resultados: la investigación sobre intervenciones cognitivas en pacientes con lesiones cerebrales traumáticas ha involucrado a varios países, con contribuciones notables de los Estados Unidos, Noruega, el Reino Unido y Canadá. El entrenamiento cognitivo ha demostrado ser eficaz, mostrando mejoras significativas en los síntomas y la calidad de vida. También se han investigado otras terapias, como la estimulación directa transcraneal y la rehabilitación profesional.

Conclusiones: el entrenamiento cognitivo ha demostrado ser una técnica eficaz en el manejo de las lesiones cerebrales traumáticas, demostrando mejoras significativas en las medidas cognitivas compuestas y en la calidad de vida de los pacientes. Algunas terapias, como la oxigenoterapia hiperbárica, han mostrado resultados prometedores en el tratamiento de síntomas como el estrés postraumático, la depresión y la ansiedad en pacientes con lesiones cerebrales traumáticas.

Palabras clave: Entrenamiento Cognitivo; Traumatismo Craneoencefálico; Lesiones Cerebrales Traumáticas; Traumatismo Cerebrovascular; Lesiones Cerebrales Difusas.

INTRODUCTION

Traumatic brain injury (TBI) is a condition that can have a significant impact on individuals' cognitive functioning. It is characterized by impairments in various cognitive functions such as memory, attention, processing speed, executive function, and visuospatial skills. These cognitive difficulties can negatively affect the quality of life, functional independence, and social reintegration of TBI patients.[1,2]

These injuries occur as a result of an external impact or force that affects the brain, causing structural and functional damage. The consequences of traumatic brain injury can be significant, especially in terms of cognitive functions.[3]

Brain plasticity is a concept that underlies cognitive interventions for patients with traumatic brain injury. It refers to the brain's ability to change and adapt in response to experience and training. Although traumatic brain injury can cause damage to brain cells and neuronal connections, it has been shown that the brain has the capacity to reorganize and generate new neuronal connections in undamaged areas.[4]

Brain plasticity is based on various neurobiological mechanisms such as synaptogenesis, neurogenesis, and dendritic remodeling. These processes allow the brain to recover and compensate for the damaged cognitive functions. In the context of cognitive interventions, the aim is to harness brain plasticity to improve cognitive skills and promote functional recovery in patients with traumatic brain injury.[5]

One of the most commonly used cognitive interventions is cognitive training. This intervention is based on the principle that the brain can enhance its cognitive functioning through practice and repeated training of specific tasks. Cognitive training focuses on areas such as memory, attention, executive function, and visuospatial skills, which are often affected in patients with traumatic brain injury.[6]

In addition to cognitive training, other therapeutic interventions have shown effectiveness in managing patients with traumatic brain injury. For example, hyperbaric oxygen therapy has shown benefits in improving symptoms of post-traumatic stress disorder, memory, cognitive functions, depression, anxiety, sleep, and quality of life in patients with persistent post-concussion syndrome.[7]

Vocational rehabilitation also plays an important role in the management of patients with traumatic brain injury. This intervention focuses on helping patients reintegrate into the workforce by providing them with the necessary skills and support to successfully return to work. The combination of cognitive and vocational interventions has been shown to be effective in improving the employment return rate in patients with traumatic brain injury.[8]

In addition to these interventions, other strategies such as transcranial stimulation and virtual rehabilitation therapy have been investigated. These interventions aim to leverage emerging technologies to provide an interactive and personalized rehabilitation environment for patients with traumatic brain injury.[9]

Over the years, numerous studies and interventions have been conducted to address the cognitive difficulties associated with TBI and improve the quality of life of patients. In this article, we present a comprehensive literature review of 31 studies investigating different approaches to cognitive and therapeutic intervention in patients with TBI, addressing the following research question: What is the effectiveness of cognitive interventions in patients with traumatic brain injury, and what factors influence their effectiveness?

This research aims to evaluate the effectiveness of cognitive interventions in patients with traumatic brain injury and understand the factors that may influence their effectiveness. Identifying the most effective interventions and the factors that affect them will enable us to improve care and personalize treatments to optimize rehabilitation outcomes and patients' quality of life.

The studies included in this review cover a wide range of therapeutic approaches and samples of TBI patients from different countries. Among the reviewed studies, randomized controlled trials, observational studies, and pilot studies were found, evaluating the efficacy of interventions such as cognitive training, hyperbaric oxygen therapy, vocational rehabilitation, transcranial stimulation, virtual rehabilitation therapy, among others.

METHODS

A systematic review was conducted following the PRISMA workflow. Scientific articles of clinical studies on

the effectiveness of cognitive rehabilitation in patients with traumatic brain injuries were included. The study period ranged from 2017 to 2021.

The search was performed in the PubMed and Scopus databases. The search expression was constructed using the following MeSH terms: (Cognitive Training) AND (Craniocerebral Trauma OR Traumatic Brain Injuries OR Cerebrovascular Trauma OR Diffuse Brain Injuries).

The following filters were applied: years 2017-2021; full-text available; clinical trial, clinical trial protocol, phase I, II, III, and IV clinical trial; English and Spanish language.

Duplicate articles and those that did not fit the research topic were removed.

Finally, 31 articles were selected.

RESULTS

A total of 31 articles were included with the previously described criteria and filters. The authors and origin, trial type, sample characteristics, cognitive intervention used, and main results were analyzed. The presence of conflicts of interest was also identified.

Figure 1 presents the workflow according to the PRISMA methodology.[10] It outlines how the criteria and filters were applied.

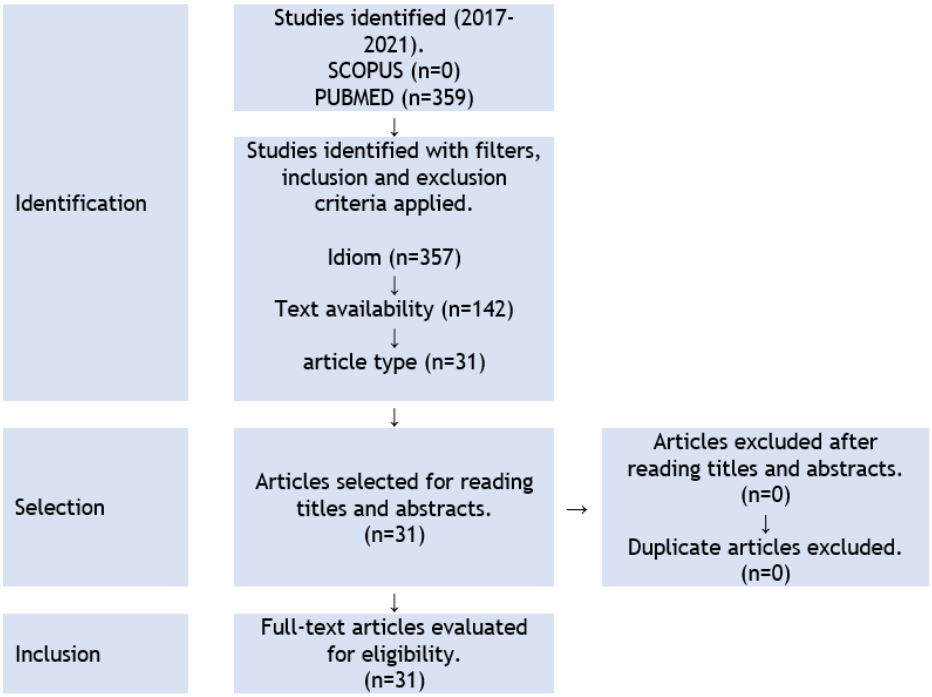

Figure 1. Flowchart for the review of the state of the art according to PRISMA methodology

Table 2 displays the main results of the 31 articles studied.

DISCUSSION

When analyzing the results of the included studies, a wide variety of countries involved in the research of cognitive interventions in patients with traumatic brain injuries can be observed. Among the prominent countries are the United States, represented by studies such as Harch et al.[12], which demonstrated significant improvements in post-traumatic stress disorder symptoms, memory, cognitive functions, depression, anxiety, sleep, and quality of life through hyperbaric oxygen therapy. Norway, represented by studies like Fure et al.[11] and Howe et al. [14], which showed that cognitive training combined with vocational rehabilitation increased the rate of return to work in patients with traumatic brain injuries. The United Kingdom and Canada have also made significant contributions in this field, such as the study by Elbogen et al.[22], which demonstrated reduction in anger and maladaptive interpersonal behaviors in veterans with traumatic brain injuries and post-traumatic stress disorder.

Regarding the most used techniques, cognitive training in its various forms stands out. The study by Mahncke et al.[13] demonstrated significant improvements in composite cognitive measures in the treatment group compared to the control group. Additionally, the study by Lu et al.[15] showed that intensive rehabilitation training combined with hyperbaric oxygen therapy improved functional disorders and prognosis in patients with traumatic brain injuries.

Table 1. Main characteristics of the included studies

No	Author (Year)	Country	Type of study	Sample	Cognitive Intervention/ Treatment/ Intervention	Main outcomes
1	Fure et al.[11], 2021	Norway	Randomized controlled trial	116 individuals with mild to moderate traumatic brain injury	Cognitive training and vocational rehabilitation	The intervention group showed a significantly higher proportion of participants returning to stable employment at 3 months compared to the treatment as usual group. No significant differences were found in other outcome measures
2	Harch et at.[12], 2020	United States of America	Randomized controlled trial	63 civilian and military subjects with persistent postconcussion syndrome after mild traumatic brain injury	Hyperbaric oxygen therapy	Subjects who received hyperbaric oxygen therapy experienced significant improvements in post-traumatic stress disorder symptoms, memory, cognitive functions, depression, anxiety, sleep and quality of life compared to the control group
3	Mahncke et al.[13], 2021	United States of America	Randomized controlled trial	Military/veteran participants with a history of mild traumatic brain injury and cognitive impairment.	Cognitive training based on plasticity	The treatment group showed significantly greater improvement in the composite cognitive measure compared to the active control group. Improvements were also seen in other measures of cognitive function
4	Howe et al.[14], 2017	Norway	Randomized controlled trial	Patients with mild to moderate traumatic brain injury who experienced difficulties returning to work	Combined cognitive and vocational interventions	The group that received combined cognitive rehabilitation and job support showed a higher proportion of participants returning to work at 12 months compared to the control group
5	Lu et al.[15], 2021	China	Randomized controlled trial	Traumatic brain injury patients	Early intensified rehabilitation training with hyperbaric oxygen therapy	Intensive rehabilitation training combined with hyperbaric oxygen therapy improved functional disorders and prognosis in patients with traumatic brain injury
6	Teel et al.[16], 2018	United States of America	Randomized controlled trial	Healthy participants with aerobic training	Aerobic workout	Aerobic training had no significant effect on clinical assessments of sports-related concussion in healthy participants
7	Fleming et al.[17], 2017	Australia	Randomized controlled trial	Participants with traumatic brain injury	Prospective memory rehabilitation plus metacognitive skills training	Prospective memory rehabilitation therapy coupled with metacognitive skills training improved cognitive skills and psychosocial integration in adults with traumatic brain injury
8	Han et al.[18], 2020	United States of America	Neuroimaging study	Participants with traumatic brain injury	Cognitive training	Cognitive training reorganized modular networks in the brain after traumatic brain injury
9	Krawczyk et al.[19], 2019	United States of America	Randomized controlled trial	Participants with chronic traumatic brain injury	Executive function training	The electronic cognitive rehabilitation program improved daily cognitive skills and daily functions in individuals with chronic traumatic brain injury
10	McDonald et al.[20], 2017	United States of America	Randomized controlled trial	Participants with traumatic brain injury	Methylphenidate and adaptive memory and attention training for persistent cognitive symptoms	The combination of adaptive memory and attention training and the use of methylphenidate improved cognitive function after persistent traumatic brain injury

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11	Freitas et al.[21], 2021	Brazil	Double-blind, randomized, placebo-controlled trial	36 participants with chronic, moderate, and severe traumatic brain injury	Transcranial direct current stimulation (tDCS) and simultaneous cognitive training on episodic memory	Improvements in episodic memory with active tDCS compared to sham tDCS. Differences in episodic memory scores between active lDLPFC and BTC stimulation. Reduced cortical activity measured by qEEG in the active tDCS group
12	Elbogen et al.[22], 2019	United Kingdom	Randomized controlled trial	112 dyads of veterans with TBI and PTSD	Cognitive rehabilitation with mobile technology and social support	Reduction in anger and maladaptive interpersonal behaviors in the CALM group. Improvement in PTSD symptoms in the CALM group
13	Corti et al.[23], 2018	Italy	Exploratory study	32 Italian adolescents with congenital or acquired brain damage	Computer-based cognitive training at home	Feasibility of computer-based cognitive training program CCT (Lumosity) with high adherence and no significant technical problems
14	Corti et al.[24], 2020	Italy	Randomized controlled trial	Unspecified sample of pediatric patients with acquired brain lesions	Computer-based cognitive training at home	Improvements in visuospatial working memory after training. The training-first group also showed improvements in arithmetic calculation speed
15	Assecondi et al.[25], 2020	United Kingdom	Randomized controlled trial	Patients with acquired brain damage	Simultaneous brain stimulation (tDCS) and working memory training on cognitive performance.	Results not yet available
16	Séguin et al.[26], 2018	Canada	Randomized controlled trial	Participants with pediatric TBI	Intensive training of attention processes	Improvements in working memory, inhibition and cognitive flexibility after the RST training program
17	Novakovic-Agopian et al.[27], 2018	United States of America	Randomized controlled trial	Veterans with chronic TBI and executive difficulties	Goal-oriented attention self-regulation	Significant improvements in cognitive and functional performance after goal-regulated attention training
18	Cisneros et al.[28], 2021	Canada	Controlled before and after study	Older patients with TBI	Multimodal cognitive rehabilitation in executive functions	Improvements in executive functions and ability to resume daily activities after multimodal cognitive rehabilitation program
19	Lu et al.[29], 2021	Norway	Randomized controlled trial	Construction workers with craniocerebral trauma	Rehabilitation training based on the concept of the International Classification of Functioning, Disability and Health (ICF)	Significant improvement in neurological function, cognitive function, limb motor function and self-care ability with rehabilitation training based on the ICF concept
20	Gilmore et al.[30], 2019	United States of America	Observational study	Young individuals with chronic acquired brain injury	Cognitive-communicative rehabilitation	Significant improvements in cognitive-linguistic functioning, classroom participation, and quality of life after intensive cognitive-communicative rehabilitation (ICCR) program
21	Du et al.[31], 2018	China	Observational study	60 patients with brain injury	Scalp acupuncture and cognitive training	Scalp acupuncture combined with cognitive training improved cognitive impairment in patients with brain injury

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22	Kim et al.[32], 2021	South Korea	Randomized controlled trial	32 patients with acquired brain injury	Computerized cognitive rehabilitation and traditional cognitive rehabilitation	Improvements in executive functions and complex attention in both computer-assisted cognitive therapy (CCR) and therapist-delivered cognitive therapy (TCR) groups
23	Neumann et al.[33], 2017	United States of America	Phase I trial	17 adults with moderate to severe traumatic brain injury	Emotional self-reflection	Improvements in emotional awareness and emotional regulation after emotional awareness treatment
24	Sood et al.[34], 2018	Australia	Randomized controlled trial	Unspecified sample of children with pediatric traumatic brain injury	Cogmed-based working memory and decision making training	Study protocol to evaluate the efficacy of Cogmed (working memory training) in children with pediatric traumatic brain injury
25	Belchev et al.[35], 2021	Canada	Randomized controlled trial	84 participants with chronic traumatic brain injury	Remotely delivered environmental enrichment intervention	Study protocol to evaluate a remotely delivered environmental enrichment program for rehabilitation of chronic traumatic brain injury
26	Brandt et al.[36], 2021	Norway	Randomized controlled trial	76 children with chronic pediatric acquired brain injury	Goal Management Training (GMT) with active control in the improvement of executive function	Goal management training (GMT) tailored for children was not shown to be more effective than a psychoeducational control in improving parent-reported executive function
27	Ettenhofer et al.[37], 2019	United States of America	Pilot clinical trial	11 participants in the intervention group and 6 on the waiting list	Neurocognitive Driving Rehabilitation in Virtual Environments (NeuroDRIVE)	The NeuroDRIVE intervention was associated with significant improvements in working memory and visual selective attention. No significant changes were observed in untrained cognitive areas, neurobehavioral symptoms, or driving skills
28	Cho et al.[38], 2018	United States of America South Korea	Correlation study	30 college soccer players	Association between the shape of the amygdala, mood and post-concussion symptoms	A positive correlation was found between negative mood and the shape of the laterobasal subfield of the left amygdala in college soccer players. No significant relationship was found between postconcussion symptoms and amygdala shape
29	Hypher et al.[39], 2019	Norway	Randomized controlled trial	80 survivors of pediatric acquired brain injury	Goal Management Training (GMT) in pediatric version (pGMT)	The objective is to determine the efficacy of a pediatric version of GMT (pGMT) in children and adolescents with acquired brain injury and executive dysfunction. Primary outcomes will measure parent-reported changes in executive function in daily life
30	Pinto et al.[40], 2019	Brazil	Randomized controlled trial	90 patients with central nervous system injury	Sensorimotor and cardiorespiratory rehabilitation associated with transcranial photobiomodulation	The objective is to evaluate the effects of sensorimotor and cardiorespiratory sensory rehabilitation associated with transcranial photobiomodulation in patients with central nervous system lesions
31	Bosch et al.[41], 2019	Australia	Randomized controlled trial	31 emergency department patients	Clinical practice recommendations in the management of patients	The NET intervention significantly improved appropriate assessment of posttraumatic amnesia. However, it did not significantly increase the performance of CT scans or the provision of written information at discharge

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On the other hand, there were techniques that have not shown effectiveness in this context. For example, the study by Teel et al.[16] showed that aerobic training had no significant effect on the clinical assessment of sports-related concussions in healthy participants. In the case of Brandt et al.[36], goal management training (GMT) tailored for children was not shown to be more effective than a psychoeducational control in improving parent-reported executive function.

In addition to cognitive interventions, other therapies have been investigated, such as transcranial direct current stimulation, as evidenced by the study by De Freitas et al.[21], which showed improvements in episodic memory through transcranial direct current stimulation in patients with traumatic brain injuries. Vocational rehabilitation and virtual rehabilitation therapy have also been explored, as shown in the studies by Bosch et al.[41] and Novakovic-Agopian et al.[27], respectively.

CONCLUSIONS

- The research on cognitive interventions in patients with traumatic brain injuries has involved a wide variety of countries, with notable participation from the United States, Norway, the United Kingdom, and Canada.
- Cognitive training has proven to be an effective technique in managing traumatic brain injuries, demonstrating significant improvements in composite cognitive measures and patients' quality of life.
- Certain therapies, such as hyperbaric oxygen therapy, have shown promising results in treating symptoms such as post-traumatic stress, depression, and anxiety in patients with traumatic brain injuries.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHORSHIP CONTRIBUTION

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