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Update on the efficacy of cognitive rehabilitation following moderate to severe traumatic brain injury: a scoping review.

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Abstract

Objectives: To identify, categorize and analyze the methodological issues of cognitive rehabilitation of patients with moderate to severe traumatic brain injury and its efficacy.

Data sources: Pubmed and PsycINFO were searched for studies published between 2015 and 2021 using keywords for cognitive intervention and traumatic brain injury.

Study selection: Two independent reviewers selected articles concerning cognitive rehabilitation for adults with traumatic brain injury. Of 458 studies, 97 full text articles were assessed and 46 met the inclusion criteria.

Data extraction: Data were analyzed by one reviewer according to criteria concerning the methodological quality of studies.

Data synthesis: Results showed a large scope of 7 cognitive domains targeted by interventions, delivered mostly in individual sessions (83%) with an integrative cognitive approach (48%). Neuroimaging tools as a measure of outcome remained scarce, featuring in only 20% of studies. Forty-three studies reported significant effects of cognitive rehabilitation, among which 7 fulfilled a high methodological level of evidence.

Conclusions: Advances and shortcomings in cognitive rehabilitation have both been highlighted and led us to develop methodological key points for future studies. The choice of outcome measures, the selection of control interventions and the use of combined rehabilitation should be investigated in further studies.

Keywords: Brain injuries; Cognitive Remediation; Rehabilitation; Review.

List of abbreviations:

CRTF: cognitive rehabilitation task force

DAI: diffuse axonal injury

DMN: default mode network

EEG: electroencephalography

ECN: executive control network

fMRI: functional magnetic resonance imaging

GAS: goal attainment scaling

GMT: goal management training

ITT: intention to treat

MET: multiple errands tests

NIBS: non-invasive brain stimulation

rTMS: repeated transcranial magnetic stimulation

RCT: randomized controlled trial

SCED: single-case experimental design

tDCS: transcranial direct current stimulation

TBI: traumatic brain injury

WM: working memory

Cognitive disorders after a traumatic brain injury (TBI) have been well described over the last decades. Long-term memory, attention, processing speed, executive functions and self-awareness disorders are frequent and related to the high frequency of temporal and frontal lesions [1]. Cognitive sequelae commonly persist

several years after a moderate to severe TBI [2,3], impacting vocational integration and quality of life [4,5]. Cognitive rehabilitation aims to decrease acquired neurocognitive impairment and disability using various and complementary approaches [6]. Interventions could aim to train or strengthen impaired cognitive functions and/or to implement compensatory mechanisms in addition to external aids [6]. Metacognitive strategies are also trained in order to facilitate the transfer to different environmental contexts [7–9].

Over the last years, the literature has provided quantitative data about cognitive rehabilitation after TBI, leading to a better understanding of the underlying cerebral mechanisms and the development of new interventions. Results were reported across reviews, systematic reviews, meta-analyses and scoping reviews. The most consequent systematic review was conducted by the Cognitive Rehabilitation Task Force (CRTF) of the American Congress of Rehabilitation Medicine [10]. Since 2000, Cicerone and colleagues have published 4 successive systematic reviews on the cognitive rehabilitation of patients with TBI or stroke and established evidence-based clinical recommendations [6,10–12]. Four hundred ninety-one studies have now been reviewed and classified according to the level of evidence, including 109 studies in class I, 68 in class II and 314 in class III. For each cognitive domain, Cicerone et al. [10] provided several levels of recommendations: Practice Standards, Practice Guidelines and Practice Options. Practice Standards, derived from the strongest evidence, have been identified for treatment of attention deficits, left visual neglect, apraxia, mild memory impairments, language and social communication deficits, mild to moderate executive functions deficits and holistic neuropsychological rehabilitation. They concluded that future research could investigate the impact of

individual characteristics, especially the role of psychological insight, residual cognitive reserve and the presence of associated psychiatric comorbidities. They also recommended including the frequency and intensity of cognitive rehabilitation as covariates in statistical models. Furthermore, several scoping reviews addressed complementary aspects of TBI, such as societal dimensions [13–15], neurological and neuropsychological patterns [16–18], psychological conditions associated with TBI [19], delivery mode of rehabilitation [20,21] and state of scientific research on clinical rehabilitation [22,23]. Two scoping reviews have reported the effects of cognitive rehabilitation [24,25] on two very specific approaches that focused on driving rehabilitation [25] and the use of repeated transcranial magnetic stimulation on cognitive functioning [24].

The literature about cognitive rehabilitation following TBI is vast. Reviews on this subject usually analyze the content of rehabilitation to derive recommendations for clinical practice. Here, we chose to focus on methodological criteria to determine the level of scientific evidence of these studies. The most recent substantial systematic review on this subject includes published articles up to 2014 [10]. In this paper, we aimed to review the scope of interventions in cognitive rehabilitation since 2015. Moreover, we chose to select studies including only patients with TBI and to exclude the stroke population in order to limit the heterogeneity of the underlying physiopathology of cognitive disorders. We also excluded the mild TBI population because the functional and cognitive outcomes differ from moderate to severe TBI [26]. Scoping review was an appropriate approach to map the scope and nature of research in cognitive rehabilitation after TBI, summarize research findings and identify gaps in the existing literature. In order to guide our search, we addressed

four main questions: (i) Which cognitive domains does cognitive rehabilitation focus on? (ii) What are the characteristics of interventions in cognitive rehabilitation? (iii) What are the outcome measures used by authors? (iv) What is the efficacy of cognitive rehabilitation?

Methods

The scoping review was based on the framework developed by Arksey & O'Malley [27] including the successive stages described below.

1.1. Search strategy

A systematic search of publications listed in the Pubmed (via Medline) and PsycINFO databases was conducted in August 2021 using the keywords "cognitive rehabilitation" (OR "cognitive remediation," "cognitive intervention," "cognitive training," "cognitive treatment") AND "traumatic brain injury." The following terms were excluded from the systematic search: "children," "pediatric," "concussion," "mild" and "animal." The scope of the search went from January 1, 2015, to July 31, 2021.

1.2. Inclusion and exclusion criteria

Inclusion criteria were: (i) studies including adults or adolescents, no younger than 15 years old, with moderate to severe TBI. The Mayo Classification System criteria were used to define moderate to severe TBI: loss of consciousness lasting 30 minutes or more and/or post-traumatic anterograde amnesia lasting 24 hours or more and/or worst Glasgow Coma Scale score less than 13 in the first 24 hours and/or imaging evidence of intracranial pathology (intracerebral hematoma, subarachnoid hemorrhage, cerebral contusion, etc…) [28]. We also reported for each article if brain lesions were identified by authors through computed tomography / magnetic resonance scanning (Table 1). In a context of mixed samples including several acquired brain injuries, moderate to severe TBI should be the most represented group; (ii) patients had to be included at least 3 months after the onset; (iii) interventions had to investigate the rehabilitation of cognitive functions; (iv) effects of cognitive rehabilitation had to be documented by quantitative or qualitative comparisons throughout follow-up; (v) interventions had to be conducted in a rehabilitation center, ambulatory care or at home.

Reviews and study protocols were excluded from this research, as were those not written in the English language. Then, for all citations, two authors (AJ, ML) conducted an abstract review and excluded articles that did not meet the eligibility criteria. All remaining citations underwent a full text review.

1.3. Data analysis

For each of the four research questions, criteria of analysis were defined and collected in order to classify the characteristics and level of evidence of the reviewed studies.

1.3.1. Cognitive domains targeted by cognitive rehabilitation

All cognitive functions targeted by rehabilitation were listed. When several cognitive functions were trained, we registered all of them. We consider interventions to be "global training" interventions when they focused on three or more cognitive functions, or when the aim was defined with the generic term "cognitive skills."

1.3.2. Characteristics of cognitive rehabilitation

Types of cognitive rehabilitation were divided into three categories of interventions. *Cognitive training* was defined as repetitive exercises without any explicit mention of metacognitive strategy training. *Integrative cognitive intervention* referred to interventions that explicitly combined the training of cognitive functions and

metacognitive strategies. Finally, *external aids training* corresponded to the use of external compensatory mechanisms such as notebooks, cell phone applications and alarms.

We also identified *combined approaches*, which referred to cognitive rehabilitation associated with other interventions like pharmacotherapy or non-invasive brain stimulation (NIBS).

Three other parameters of cognitive interventions were analyzed: the delivery mode including group versus individual sessions, the length and the intensity. Length was studied by distinguishing very short (1 week or less), short (1 week to 1 month), moderate (1 to 3 months) and high (more than 3 months) duration. Intensity was classified as low (1 session per week), moderate (2 sessions per week) or high (3 or more sessions per week).

1.3.3. Behavioral examination and neuroimaging as outcome measures

Concerning behavioral outcome measures, four types of assessment were distinguished: (i) *neuropsychological examination* including standardized neuropsychological tests; (ii) *ecological neuropsychological examination* including standardized tests and/or experimental ecological tasks with reference to daily life situations; (iii) *self-reporting* of cognitive complaints, social participation in everyday activities and quality of life; (iv) *relative-reporting* of patient's difficulties in daily life.

We also counted the number of these types of assessment for each study in order to attest to the exhaustiveness of the assessment.

Neuroimaging outcome measures were classified as structural and/or functional imaging and/or electroencephalography (EEG).

1.3.4. Efficacy of cognitive rehabilitation

The efficacy of cognitive rehabilitation was analyzed according to three main criteria and associated sub-criteria detailed below. A coding grill was used for the extraction of these methodological criteria.

The outcome measures were the first criteria. We first pointed out the results showing a significant improvement in at least one of the outcome measures defined by the authors. Quantitative and qualitative improvements were coded when collected. Second, if a significant and/or clinically relevant change was reported, we distinguished whether it was in the primary or secondary outcome measures.

The internal validity of reviewed studies was assessed as secondary criteria, based on the classification used by Cicerone et al. in systematic reviews [6]. According to this classification, studies were classified as class I when they were well designed, prospective, randomized controlled trials. Class II referred to prospective, nonrandomized cohort studies, retrospective, non-randomized case-control studies or multiple baseline studies that allowed a direct comparison between treatment