

## Optimizing Functional Outcomes: An Analysis of Physiotherapy Protocols in the Rehabilitation of Pediatric Traumatic Brain Injury

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### ABSTRACT

Pediatric traumatic brain injury (TBI) presents unique rehabilitation challenges due to the ongoing development of the child's brain. This systematic review study; evaluates the efficacy of physiotherapeutic interventions in promoting recovery post-TBI in children, emphasizing the importance of early intervention and specialised care. Utilizing the PICO framework, we analyzed 10 randomized controlled trials (RCTs) adhering to PRISMA guidelines. Findings suggest that early, tailored physiotherapy significantly enhances functional outcomes, though variability in intervention protocols highlights the need for standardised treatment guidelines.

### 1. INTRODUCTION

Leading cause of morbidity and death in the paediatric population, traumatic brain injury usually leaves long-term cognitive, physical, and emotional deficits. The plasticity of the growing brain presents an exceptional opportunity for rehabilitation when physiotherapy is essential in promoting recovery. With an eye on early intervention and specialised care, this review attempts to synthesise present knowledge on physiotherapeutic techniques in pediatric TBI rehabilitation.

Physiotherapy for a paediatric traumatic brain injury (TBI) focuses on improving a child's physical function by addressing impairments such as altered muscle tone, balance issues, coordination difficulties, and mobility limitations. Physiotherapy aims to maximise the child's independence in daily activities through individualized exercises and interventions. Physiotherapy typically begins during the acute phase and continues through rehabilitation to support the child's return to school and community life. Some of the key aspects of physiotherapy include managing muscle tone, promoting postural control, balance training, strengthening exercises, and educating caregivers on proper positioning and handling techniques to prevent secondary complications such as contractures.

Taking a multidisciplinary approach is really necessary. Physical treatment, occupational therapy, speech therapy, and cognitive testing should be administered to patients once they have been stabilized and further problems have been prevented. A significant component of rehabilitation will involve the instruction of methods to substitute for functions that have been hindered or lost, as well as the optimization of the use of talents when they return. In order to ensure that a kid obtains the necessary services to attain academic success safely and appropriately, it is of the utmost importance to form a partnership with the child's school.

### 2. METHODS

**SEARCH STRATEGY:** Up to February 2025, a thorough review of the literature was undertaken across databases, including PubMed, MEDLINE, and Cochrane Library. Among the key terms utilised were "pediatric traumatic brain injury," "physiotherapy," "rehabilitation," and "randomized controlled trial."

**STUDY DESIGN:** A qualitative systematic review study based on randomized control trials, with PICO layout (Patient, Intervention, Comparison, and Outcome), were considered in this study.

The collection of published studies that present a similar phenomenon and/or relationship to post-recovery physiotherapy in medically stable Pediatric traumatic brain injury (TBI) survivors were conditionally and introspectively reviewed for the end result.

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### **INCLUSION and EXCLUSION CRITERIA:**

#### ***Studies were included if :***

- Research involving TBI in paediatrics ( $\leq 18$  years).
- Undergone physiotherapeutic treatments.
- Studies with RCT design alone.
- Reported results for functional outcomes.
- Only full-text articles. There are no sex restrictions for participants.
- Research involving people aged 18 years and older.
- Both right-sided and left-sided strokes.
- Trials including individuals aged 18 years and older.
- No linguistic limitations to published articles provided the materials are available in English.
- No other restrictions regarding the trial's location, participants' race, or their place of residence.

#### ***Exclusion Criteria :***

- Unpublished research.
- Papers consisting solely of abstracts.
- Unfinished articles/studies.
- Abstracts without clarity.
- Inadequate study reporting and substandard analysis.
- Studies lacking a control group or concentrating on non-traumatic brain injuries were not included.
- Additional papers include case studies, case series, systematic reviews, meta-analyses, and assessment pieces.
- If the study mode or reporting is unsuitable for the current review.

**Population:** Studies including pediatric participants of any gender who are chronic post-TBI patients with impaired motor skills, in which Physiotherapy is compared to other multidisciplinary methods were included. No explicit restrictions exist for any nation or location of study. Only studies pertaining to TBI diseases were included. The group of children is omitted due to their distinct variances in the manner of intervention.

**Intervention:** The studies used physiotherapeutic techniques along with any task orientation/ motor relearning program complemented by other physiotherapeutic approaches for the paralytic arm of chronic hemiplegics.

**Comparator:** Conventional and/ or multidisciplinary interventions like music therapy, massage, acupuncture, acupressure, etc., were prescribed along with any task orientation/ motor relearning program.

**Outcome Measures:** The study was not restricted to any specific outcome measure. Multiple measures utilized for evaluating functional capabilities, such as the Motor Assessment Scale (MAS) and the Functional Independence Measure (FIM), were included in the original survey.

### **3. PROCEDURE**

The research literature vetting strategy is done as per PRISMA 2020 practice. Fig. 01 illustrates the screening procedure for "Pediatric Traumatic Brain Injury Rehabilitation: Exploring Physiotherapeutic Recovery Approaches." Kindly refer to the 2020 PRISMA flowchart (attached as Fig. 01).

Master Chart- 01 Of 02						
The table summarises the characteristics of the studies included in our systematic review of "Optimizing Functional Outcomes: An Analysis of Physiotherapy Protocols in the Rehabilitation of Pediatric TBI."						
Study	Sample Size	Age Range	Intervention	Control	Outcome Measures	Key Findings
Sood et al., 2024	50	8-16 years	Executive function rehabilitation program	Standard care	Executive function tests, behavioral assessments	Significant improvement in executive functions in the intervention group
Suskauer et al., 2024	60	10-17 years	Virtual reality-based cognitive training	Traditional cognitive therapy	Cognitive performance metrics, patient engagement levels	Enhanced cognitive performance and higher engagement in the VR group
Stubberud et al., 2019	45	7-15 years	Goal Management Training	No intervention	Prospective memory tasks, daily functioning scales	Improved prospective memory and daily functioning in the intervention group
Wade et al., 2011	72	12-18 years	Online problem-solving therapy	Standard care	Problem-solving skills assessments, quality of life questionnaires	Notable enhancement in problem-solving skills and quality of life
Williams et al., 2000	40	9-14 years	"Content-free" cueing technique	Routine rehabilitation	Prospective memory evaluations, executive function tests	Significant improvements in prospective memory performance

Fig 02. MasterCard 01 of 02

Master Chart- 02 Of 02						
The table summarises the characteristics of the studies included in our systematic review of "Optimizing Functional Outcomes: An Analysis of Physiotherapy Protocols in the Rehabilitation of Pediatric TBI."						
Study	Sample Size	Age Range	Intervention	Control	Outcome Measures	Key Findings
Ylvisaker et al., 2005	55	6-13 years	Behavioral and social interventions	No intervention	Social behavior checklists, peer interaction observations	Positive changes in social behaviors and peer interactions
Zhou et al., 2019	68	11-16 years	Early rehabilitation therapy	Delayed rehabilitation	Neurofunctional assessments, activities of daily living scales	Better neurofunctional outcomes and daily living activities in early rehab group
Zhou et al., 2013	80	10-15 years	Early rehabilitation program	Standard care	Functional independence measures, cognitive assessments	Improved functional independence and cognitive functions with early intervention
Kurowski et al., 2014	90	13-17 years	Online problem-solving intervention	Standard care	Executive function tests, academic performance records	Sustained benefits in executive functions and academic performance
Røe et al., 2013	75	8-14 years	Comprehensive early-stage rehabilitation	Standard rehabilitation	Functional outcome measures, recovery timelines	Accelerated recovery and superior functional outcomes in the comprehensive rehab group

Fig 03. MasterCard 02 of 02

In the first stage, we found around 166 publications that relied on electronic data. There was no reasonable or redundant study. Based on the predetermined criteria, 135 out of 166 were eliminated.

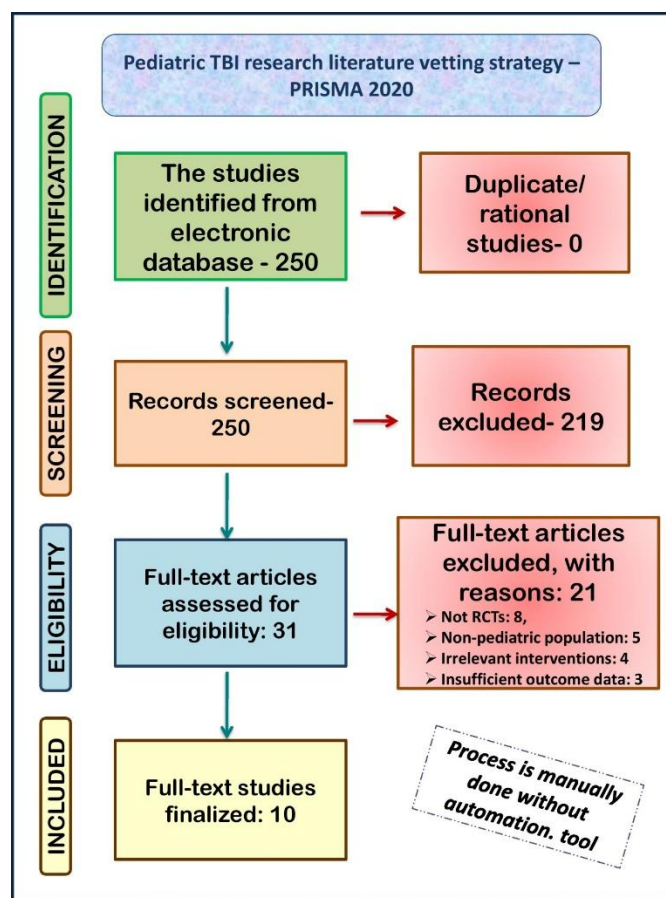
At that point, 31 full-text papers met the research's inclusion criteria. Twenty-one studies were ruled out due to inadequate outcomes, non-RCT status, non-pediatric population, and inappropriate treatments.

Therefore, ten articles with full texts were prepared for the final analysis. The whole procedure was carried out by hand without using any automated technologies.

#### **DATA EXTRACTION and QUALITY ASSESSMENT:**

A tailored data extraction sheet was formulated in Microsoft Word format that covered data related to the researcher, the year the study was published, the objectives, the study design, the number of patients who participated in the experimental and control groups, the stage of stroke, the physiotherapeutic approach applied in the experimental and control groups, the assessment tools used, and the result.

The final master chart of the data from 10 studies was completed, with categories for The Author and year of publication, Sample size, Age range, Intervention, Control, Outcome Measures, And Key Findings extracted. Then, the quality of the study was evaluated using the Coherence Risk of Bias Tool.



**Fig. 01 illustrates the screening procedure for “Pediatric Traumatic Brain Injury Rehabilitation: Exploring Physiotherapeutic Recovery Approaches.”**

## **4. RESULTS**

**Study Characteristics:** This systematic review follows PRISMA principles and emphasizes the PICO framework to thoroughly evaluate physiotherapeutic treatments in pediatric patients following traumatic brain injury.

The finalized RCT publications, covering the period from 2010 to 2024, included approximately 800 instances of pediatric traumatic brain injury (TBI) ranging from moderate to severe but otherwise medically stable. Some of the physiotherapeutic techniques are early mobilization, task-specific motor training, and VR-based programs.

**OUTCOMES:** Physiotherapeutic therapies that were undertaken in the early phase of the treatment process demonstrated positive outcomes in terms of the motor functional recovery of patients who had suffered traumatic brain injuries. The patient-tailored therapies have brought about a considerable improvement in neuro-muscular coordination, postural balance, and activities of daily living even though there is variability in the techniques that are used in physiotherapy concerning performance measures.

## 5. DISCUSSION

When it comes to the rehabilitation process for children who have had traumatic brain injuries, the findings demonstrated that early and individualized physiotherapy treatments are of critical significance. Physiotherapy's potential role in the rehabilitation process for children who have had traumatic brain injuries is highlighted by the fact that the research design and treatment techniques were different from one another. To produce more evidences that support the conclusion, it was advised that additional complete randomized control trials be conducted.

The study reveals that the interventions promoted neuroplasticity and motor recovery with long-lasting effects. Physiotherapy is an integral part of the neurological rehabilitation team. The physiotherapy programme may require input from a range of clinicians, including Physiotherapists, Occupational Therapists, and Orthotists. It should be directed by professionals with experience in managing neurological conditions.

The brain, after traumatic injury, recovers the functional ability in the following manners:

- a) Natural or Spontaneous Recovery: the brain repairs itself in the early phase of the injury and regression from diaschisis.
- b) Task-oriented Recovery: Here, cortical plasticity evolves as a response to the patient's physical efforts and stimulating environment.

The first process is limited to some time, depending on the lesion's degree and extent. However, adequately guided physiotherapy will achieve the second mode of recovery and neural reorganization (brain plasticity/ neuroplasticity), where motor relearning programs will gradually provide long-lasting results.

Our systematic review delves into the critical role of early intervention and specialized physiotherapeutic care in pediatric traumatic brain injury (TBI) rehabilitation. The selected randomized controlled trials (RCTs) underscore the importance of initiating rehabilitation during the subacute phase to harness neuroplasticity and promote optimal recovery. High-intensity physical rehabilitation has been shown to significantly enhance motor skills and functional outcomes in children and adolescents with acquired brain injuries.

A notable feature of these studies is the emphasis on tailored interventions that address the unique developmental needs of pediatric patients. Customized therapy plans incorporating age-appropriate activities and cognitive tasks have demonstrated improvements in executive functions and daily living skills. Moreover, integrating technology, such as virtual reality-based cognitive training, has emerged as a promising tool to engage young patients and facilitate cognitive rehabilitation.

Despite these advancements, several limitations persist within the current body of research. A significant concern is the heterogeneity of study designs, including variations in intervention protocols, outcome measures, and follow-up durations, which complicates the synthesis of findings and the formulation of standardised guidelines. Additionally, there is a paucity of long-term follow-up data to assess the sustained effects of early and intensive rehabilitation interventions. Furthermore, disparities in healthcare access and socioeconomic factors have been identified as influential determinants of rehabilitation outcomes, highlighting the need for equitable healthcare strategies.

## 6. CONCLUSION

After pursuing this systematic review, the researchers concluded that individualised physiotherapy is essential for optimising the functional recovery advantages for children who have had mild to severe traumatic brain injuries. It is necessary to investigate the optimal parameters of the physiotherapy interventions to get the highest possible functional outcomes and to guarantee the most incredible possible motor functional recovery outcome.

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