RESEARCH ARTICLE

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Effect of Early Physiotherapy on Patients with Severe Traumatic Brain Injuries: A Systematic Review and a Meta-Analysis

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Abstract

Introduction: The management of Traumatic Brain Injuries (TBIs) begins with immediate treatment and continues throughout rehabilitation with physiotherapy. Its goals include enhancing motor function and avoiding problems like contractures. Depending on the severity, treatment includes restoration, compensation, preventive, and complementary therapies like exercise, massage, and hydrotherapy. Physiotherapy helps TBI sufferers recover and reintegrate into society. **Aim and Objectives:** To evaluate the efficacy of physiotherapeutic interventions at an early stage in severe TBI patients with impaired consciousness. **Method:** This systematic review used PubMed and Google Scholar to find randomised controlled trials from 2000 to 2024. Individuals with moderate to severe traumatic brain damage and impaired consciousness were studied through physiotherapy therapies. We used the PEDro scale to evaluate the quality. The primary outcomes were optimal health, functional capacity, mental acuity, and overall well-being. We used standard deviations and mean differences to synthesize the data. **Result:** The study has found that intervention groups notably improved during post-intervention follow-up, surpassing non-intervention groups. Similarly, Wu *et al.*'s study and Chanokporn's 2020 study showed substantial post-intervention improvements in intervention groups compared to non-intervention groups. It was also revealed that increased post- intervention scores for both groups, with intervention groups consistently scoring higher. Overall, interventions led to marked improvements across studies, favouring intervention groups in post-intervention scoring. It demonstrated a meta-analysis of early physiotherapy's effect on severe traumatic brain injury patients. It suggests a positive impact on outcomes, with a statistically significant mean difference of 1.09 ($p<0.00001$). Overall, there was negligible bias associated with the included studies. **Conclusion**: Early Physiotherapy, especially sensory stimulation, has been shown to be statistically significant.

Major findings: The study has shown that sensory stimulation can significantly improved outcomes for patients with severe traumatic brain injuries, including motor function, consciousness levels, and overall well-being, with intervention groups consistently outperforming non-intervention groups in post-treatment assessments. This study uniquely synthesizes findings from multiple randomized controlled trials to demonstrate the distinct, statistically significant improvements in early intervention groups compared to non-intervention groups.

Keywords: Brain Injury, Impaired Consciousness, Rehabilitation, Severe Trauma, Traumatic Brain

1. Introduction

Millions of individuals worldwide suffer from TBI, a leading cause of disease and death, especially in young adults[1]. Severe TBI patients make up about 10% of all cases. Disorders of consciousness are a clinical characteristic of acute TBI[2]. Some comatose patients stay in a minimally conscious condition, even though many

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wake up in the first several days or weeks after their injury (MCS; restricted conscious communication with one's environment) or in a state of unconsciousness (VS; do unawareness of self as well as environment; laid out new terminology: inaccessible wakefulness syndrome)[3].

Managing treatment for moderate-to-severe traumatic brain injury. Adults and children with moderate-to-severe TBIs could be required to stay in an acute care facility for several days or weeks[4]. This may include a critical care unit, where longer-term intubation and ventilation might be necessary for serious damage. The physical therapist's job during this acute period is to collaborate with the medical team to enhance respiratory function, avoid respiratory problems, and stop further brain injury[5].

Physiotherapy is essential to the emergency room scenario by preventing or minimizing the development of a contracture (more on this below), as well as by keeping an eye on, reporting, and managing difficulties with the nursing and medical teams[6]. Admittance to inpatient rehabilitation is necessary for severe TBI and stays there are sometimes weeks or months long[7]. As a member of a team of professionals that offers inpatient rehabilitation treatment, physiotherapists are crucial[8]. Following discharge, further physiotherapy management is frequently necessary as a component of multidisciplinary care, which may last longer than a year, to promote the goal of community reintegration and improve functional results[9].

Physiotherapy is a recognized part of a patient's post-trauma care plan. For TBI patients, physical therapy involvement often starts as soon as they check into the acute care facility and lasts the duration of their recovery. TBI can produce anything from a minor, temporary impairment to a severe, lifelong handicap[10].

Various strategies, such as active workouts, passive movement, posture, balancing exercises, gait re-education, and other functional activities, can be used in physiotherapy for those suffering from catastrophic brain injuries. The aim of using these approaches is to reduce joint stiffness, muscle shortening, and sensory deprivation while normalizing muscle tone, improving movement quality, and facilitating balance[11].

The recommended treatment plan is determined by the patient's condition and severity. Patients with TBI require different physiotherapies based on their motor control and neuroplasticity. Motor functioning is improved for TBI patients by physiotherapy treatment sessions. This helps to lessen how severe the impairment is[12].

The goal of the treatment also influences the physiotherapeutic treatments. The following are some of the several physiotherapy methods for treating traumatic brain injury[13]. Measures of restoration: In this kind of intervention, the goal of physiotherapy is to help patients regain their range of motion. Penumbra and diaschisis reactivation are among its features[14]. Compensatory measure: These therapies aim to improve the patient's capacity for certain abilities or tasks[15]. Enhancing the functions to make up for the lost functions, aids in maintaining equilibrium.

Preventive measures: The main goal of this kind of physiotherapy care is to stop the progression of impairment or disability. It also entails improving the TBI patient's overall health[16].

Complementary measures: To get the greatest outcomes for certain patients, it is necessary to combine different therapies[17]. These treatments include of physiotherapy, therapeutic massage, acupuncture, dry needling, acupressure, and hydrotherapy. The patient's individual needs determine this therapy. These activities support general fitness, muscular activation, and weight control[18].

2. Method

2.1 Study Type and Population

To conduct this systematic literature, data was collected from several databases, such as PubMed, Google Scholar, ScienceDirect, SPORTDiscus, PEDro, and Ovid MEDLINE. The MeSH terms used while searching were Traumatic Brain Injury, Consciousness Disorders, Physical Therapy Modalities, Rehabilitation, Physical, Brain Injuries, Traumatic, Coma, Outcome Assessment (Health Care), Treatment Outcome, and Rehabilitation. On the other hand, this study collected data from 2000 to 2024 relevant articles. In addition, the reference lists of all relevant systematic reviews, trial registries, and protocols were manually checked, and all included full-text articles to ensure that no studies were missed. Research involving non-human subjects, papers abstracted from conferences, or studies in languages other than English were not included. It included Randomized Controlled Studies (RCTs) investigating the impact of early physiotherapy after severe TBI with impaired consciousness in individuals with moderate-to-severe TBI. Although crossover RCTs were included, only data

from the first phase was provided. Studies with at least half of the participants having a moderate to serious TBI at any point after the injury and people of any age were included, as long as separate data for those with TBI was available.

2.2 Intervention

Authors were contacted for details on the injury severity of research participants when not explicitly stated in the article. A physical activity intervention is any that helps participants satisfy WHO recommendations for physical activity. This refers to structured exercise, physical recreation, or any intervention promoting physical activity. Physical activity can be supervised or self-led as a standalone intervention or rehabilitation package. The intervention can be implemented at any care continuum and setting stage.

2.3 Quality Assessment

Researchers used the Physiotherapy Evidence Database (PEDro) scale to evaluate the quality of the studies. Quality assessments of RCTs in the review were gathered from the PEDro database. Each study received a score (0-10), with lower scores suggesting more bias risk and ≥7 indicating moderate to high quality. No studies were excluded for quality assessment.

2.4 Outcome Assessment

The study examined health outcomes such as physical function, cognition, quality of life, physical activity, participation, comorbidities, mortality, and psychological function. Studies were evaluated for adverse event occurrence. This review aligns with WHO guidelines for physical activity and sedentary behaviour for people with disabilities and other important outcomes for moderate-to-severe TBI patients.

2.5 Data Extraction

Data extraction was done by a single reviewer using a customized template in Microsoft Excel. A second reviewer verified the retrieved data for accuracy and completeness. A data extraction form was created and tested on two studies by two reviewers (two qualified physiotherapists). The data extraction covered study design, setting, location, sample size, characteristics, intervention components, outcome measures, and key findings.

2.6 Data Synthesis

Population, intervention, comparison, and outcomes were synthesised. Using a random-effects model, we calculated Mean Difference (MD) and 95% Confidence Intervals (CI) for outcomes on the same scale. Using a random-effects model to pool estimates, we estimated the Standardised Mean Difference (SMD) (Hedges' g) and 95% CI for different assessments and measures. Means and standard deviations were reported in the included research.

3. Results

3.1 Search Result

The PRISMA flow diagram (Figure 1) shows the selection of studies in this meta-analysis. The authors obtained 56 studies initially. However, 22 studies were removed due to mismatching titles or irrelevant keywords. Then, 34 studies were evaluated for eligibility, and 25 were removed. Interventions unrelated to physiotherapy and abstracts failing to meet inclusion criteria, such as unconsidered outcome assessments and multiple scoring systems, were among the reasons for exclusion. There were some studies which used a scoring system that we did not consider in our meta-analysis. So, 14 studies were excluded in this way and 11 studies were obtained. In addition, non-English language and inconsistent data excluded 6 papers. Finally, 5 studies were included in this meta-analysis and were analyzed.

4. Study and Participants Characteristics

Table 1 outlines the characteristics of several included studies, detailing their study location, type, follow-up duration, intervention type, scoring method used, and the number of participants in both the intervention and non-intervention groups. The study by Mandeep[19] in 2012 conducted in India was a Randomized Controlled Trial (RCT) with a 2-week follow-up period, employing sensory stimulation as the intervention. The scoring method utilized was the Glasgow Coma Scale (GCS), with 15 participants in each group. Similarly, Mandeep's 2013

study[20], also conducted in India, was an RCT lasting 2 weeks, employing sensory stimulation as the intervention and the Coma Recovery Scale (CRS) for scoring, with 30 participants in each group. Wu *et al.*'s study[21] from 2023 in China, another RCT, had a 7-day follow-up period, utilizing RMNS as the intervention and GCS for scoring, with 167 participants in the intervention group and 162 in the non-intervention group. Chanokporn's 2020[22] study in Thailand, an RCT lasting 5 days, employed multimodal and sensory stimulation as the intervention, with GCS for scoring and 30 participants in the intervention group and 15 in the non-intervention group. Finally, Adineh *et al.*'s study[23] in Iran, an RCT with a 7-day follow- up, utilized sensory stimulation as the intervention, GCS for scoring, and included 33 participants in each group. Overall, these studies varied in location, duration, intervention type, and participant numbers, providing a diverse range of data for analysis.

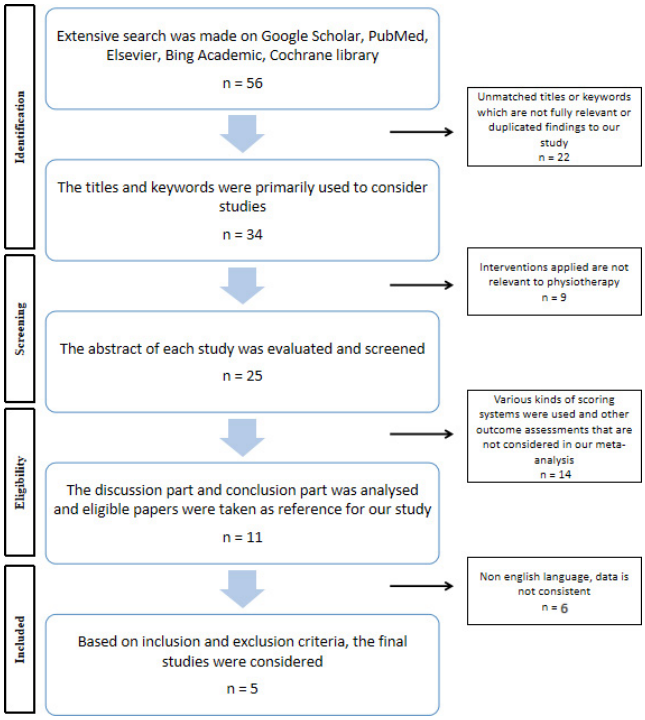


Figure 1. PRISMA flowchart of this meta-analysis.

5. Intervention

In Mandeep[19], Coma arousal therapy consisted of kinesthetic, auditory, tactile, and visual stimulation techniques. Patients underwent repeated kinesthetic movements, auditory stimuli through bells and familiar voices, varied tactile textures, and visual stimuli focusing on different visual fields. These interventions aimed to promote neurological recovery in coma patients. In the case of Mandeep[20], Kinesthetic stimulation involved repetitive extremity motions to stimulate sensory and motor networks. Auditory stimulation included recognizable voices and religious chanting, while tactile stimuli varied textures. Visual stimulation engaged patients with colourful blocks and practical objects. These holistic interventions aimed to stimulate sensory modalities and promote neurological recovery in coma patients. Wu *et al.*[21]: Patients with acute coma post-TBI received Right Median Nerve electrical Stimulation (RMNS) in addition to routine therapy. RMNS involved daily electrical pulses targeting the right median nerve. This intervention aimed to promote neurological recovery and awareness emergence in coma patients following

Table 1. Characteristics of the included studies

Study	Study Place	Typ e	Follow up	Intervention		Scoring used	Number of participants	
				Intervention group	Non-intervention group		Intervention group	Non-intervention group
Mandeep[19]	India	RCT	2 weeks	Sensory Stimulation	Routine	GCS	15	15
Mandeep[20]	India	RCT	2 weeks	Sensory Stimulation	Routine	CRS	30	30
Wu X *et al.*[21]	China	RCT	7 days	RMNS	Routine	GCS	167	162
Chanokporn[22]	Thailand	RCT	5 days	Multimodal and Sensory Stimulation	Conventional	GCS	30	15
Adineh *et al.*[23]	Iran	RCT	7 days	Sensory Stimulation	Routine care	GCS	33	33

TBI. Chanokporn[22] included auditory, visual, olfactory, gustatory, and tactile stimulation sessions, conducted twice daily for two weeks. Participants received sensory stimulation to engage various sensory modalities. This program aimed to promote cognitive recovery in patients with severe brain injury. Adineh *et al.*[23] used the Sensory Stimulation Programme (SSP) involved consistent sensory stimulation sessions delivered by family members during ICU hospitalization. These sessions included verbal signals, auditory, visual, olfactory, tactile, and motor stimulation. The SSP aimed to improve patients' sensory experiences and cognitive arousal during intensive care unit treatment.

6. Outcome Assessments

Outcome assessment of Mandeep[19] has used the Glasgow Coma Scale (GCS) to evaluate patients' level of consciousness before and after coma arousal therapy. The experimental group demonstrated a statistically significant improvement in GCS scores compared to the control group. The Coma Recovery Scale (CRS) was employed by Mandeep[20] to assess cognitive recovery before and after the therapy. Significant improvements in CRS scores were observed in the intervention group, indicating enhanced cognitive recovery compared to the control group. Wu *et al.*[21] included various neurological function scales such as GCS, Full Outline of Unresponsiveness Scale (FOUR), and Coma Recovery Scale-Revised (CRS-R) at multiple time points up to 6 months post-injury. RMNS aimed to improve neurological recovery and function in TBI patients in acute coma. Chanokporn[22] used cognitive recovery using the Coma Recovery Scale-Revised (CRS-R) at baseline and on days 1–14 of the intervention. The intervention aimed to promote cognitive recovery in patients with severe brain injury. Adineh *et al.*[23] utilized the Glasgow Coma Scale (GCS) and the Behavioural Pain Scale (BPS) to measure patients' state of consciousness and pain before and after the intervention. Additionally, in-depth unstructured interviews were conducted with intervention group patients 3 months after ICU discharge.

7. Findings of Meta-Analysis

Table 2 presents pre-intervention and post-intervention scores for both intervention and non-intervention groups across several studies. In Mandeep's studies from 2012[19] and 2013[20], the intervention group saw substantial improvements from pre to post-intervention, with post-intervention scores notably higher than those of the non-intervention group. Similarly, in Wu *et al.*'s study[21] from 2023, the intervention group displayed a significant increase in post- intervention scoring compared to the non-intervention group. Chanokporn's study[22] from 2020 showcased a considerable improvement in the intervention group's post-intervention scores, far surpassing those of the non-intervention group. Adineh *et al.*'s study[23] from 2022 exhibited a noticeable increase in post-intervention scores for both intervention and non- intervention groups, although the intervention group's scores remained higher. Overall, the data suggest that interventions led to marked improvements across the studies, with intervention groups consistently outperforming non-intervention groups in post-intervention scoring.

The forest plot shows the results of a meta-analysis on the effect of early physiotherapy on outcomes in patients with severe traumatic brain injury. Each study is represented by a horizontal line. The point estimate (mean difference) for each study is shown by a square. The size of the square reflects the weight of the study in the meta-analysis (larger studies are weighted more heavily). The horizontal lines extending from each square represent the 95% Confidence Interval (CI) for the mean difference.

Table 2. Findings of net outcomes (the result of a change in score/scale between pre- intervention and post-intervention) of the interventions applied in each study

Study	Pre-intervention scoring		Post-intervention scoring	
	Intervention group	Non-intervention group	Intervention group	Non-intervention group
Mandeep[19]	3.93 ± 1.09	3.93 ± 1.27	8.46 ± 0.91	5.93 ± 1.94
Mandeep[20]	2.055±1.02	2.06 ±1.01	8.660 ±1.36	4.633 ±2.12
Wu *et al.*[21]	6+-0.37	5.95+-0.56	8.96+-0.56	8±0.75
Chanokporn (2020)[22]	4.36+-1.39	4.53+-1.5	18.4+-4.40	12.33+-5.86
Adineh *et al.*[23]	6.93 ± 0.7881	6.93 ± 0.74	8.23±0.7	6.99±0.49

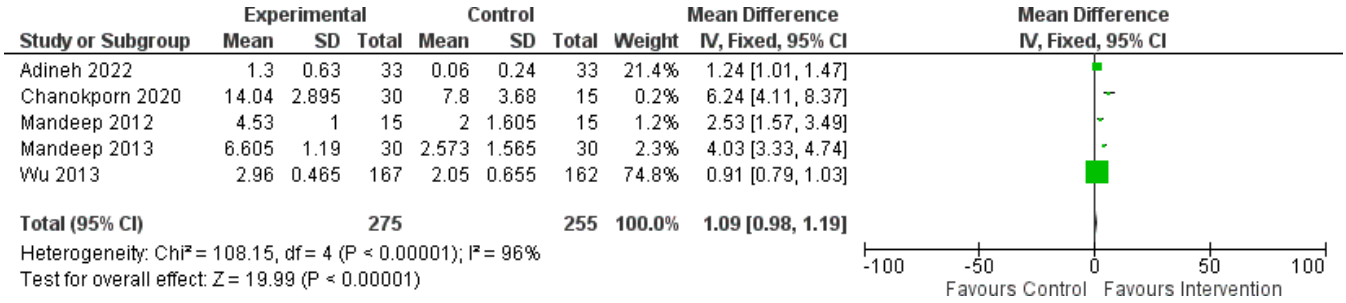


Figure 2. Forest plot shows the mean differences in outcome (by providing early physiotherapy in patients with severe traumatic brain injury) in patients with severe traumatic brain injury.

Table 3. Specific bias assessment of each study

Studies	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomple te outcome data (attrition bias)	Selecti ve report ing (reporting bias)
Adineh *et al.*[23]	-	+	?	?	?	?
Chanokporn 2020[22]	-	?	-	-	?	-
Mandeep[19]	-	-	-	-	?	-
Mandeep[20]	?	?	?	?	-	?
Wu *et al.*[21]	-	+	-	-	-	?

+ indicates high bias; - indicates low bias; ? indicates unknown bias

Overall, the forest plot suggests that early physiotherapy has a positive effect on outcomes in patients with severe traumatic brain injury. The mean difference for all studies combined is 1.09, which is statistically significant ($p<0.00001$). This means that patients who received early physiotherapy had an average improvement of 1.09 points on the outcome measure compared to those who did not receive early physiotherapy.

There is some heterogeneity among the studies, however (chi-square = 108.15, df = 4, $p<0.00001$), which means that the effect of early physiotherapy may vary depending on the specific study.

8. Bias Assessment

The specific biases of each study were assessed across various criteria (Table 3). Adineh *et al.*[23] did not report information on random sequence generation, while allocation concealment was rated as unclear. Blinding of participants and personnel as well as blinding of outcome assessment were marked as unknown. The completeness of outcome data and selective reporting were also uncertain. Chanokporn[22] did not provide data on random sequence generation and blinding of participants and personnel, with allocation concealment marked as unclear. Blinding of outcome assessment was not addressed, while incomplete outcome data and selective reporting were labelled as unknown. Mandeep's studies in 2012[19] and 2013[20] showed limited information across all bias categories, with most aspects rated as unclear or unknown. Lastly, Wu *et al.*[21] did not provide data on random sequence generation or blinding of outcome assessment, while allocation concealment was rated as low bias. Blinding of participants and personnel was not addressed, and incomplete outcome data and selective reporting were marked as unknown.

9. Discussion

An essential part of treating individuals with traumatic brain damage is physiotherapy. The data supporting how well physical therapy works for treating these individuals is reviewed in this publication[19]. The impact of physiotherapy on the following three specific domains is discussed here: (1) Flexibility in movement, unusual tone of muscles, the ability to do functional tasks; (2) The quality and movement, balance, among conscious level; and (3) The outcomes in areas such as independence

of daily life, the workplace, and social domains[20]. There is proof that methods like splinting or casting can help those with traumatic brain injury who have a limited range of motion. It is impossible to make any clear judgments about how physiotherapy affects a patient group's mobility, balance, degree of consciousness, ability to carry out functional tasks, or other factors since there is either no study on the subject or there is so little data available[21].

The study was conducted to clarify how physiotherapists treat individuals who experienced traumatic brain injury during the first inpatient and later at-home stages of recovery. Examining the techniques they employ for diagnosis, therapy, and outcome evaluation was another goal[22]. The findings showed that new techniques for assessment and overall outcome evaluation are required, ones that can fully capture the rehabilitative process and give greater weight to functional performance and quality of life[23].

As of right now, there are no set standards for the physical therapy of people who have suffered TBI, which happens in a wide range of methods and levels of intensity. A literature provided evidence-based recommendations for physiotherapy in the aftermath of traumatic brain injury, during the post-acute period[24]. There are numerous unanswered problems about the treatment of TBI in humans, even though certain suggestions regarding the efficacy of physical therapy methods might be made. There isn't much research, particularly on involvement and activity levels[25].

To support the conversion of the WHO's physical activity recommendations to clinical guidelines, the aim of a study was to find concrete evidence of the impact of exercise affect health outcomes in people with traumatic brain injury that ranges from moderate to severe[26]. The available data supports the recommendation of physical exercise for individuals with traumatic brain damage ranging from moderate to severe in the review. More thorough research is still desperately needed to create practice recommendations that will aid clinicians in making decisions about how much physical exercise to prescribe for this population[27].

It is well established that physiotherapy improves young people's chances of recovery after traumatic brain injury. A scoping study sought to define any knowledge gaps, suggest research areas, and highlight areas that needed more investigation in the field of physiotherapy therapies for older patients who had traumatic brain injuries. They are unable to determine whether one intervention is more beneficial than another due to the variability of our data[28]. Even yet, we discovered that older people benefit from physiotherapy therapies just as much as adults do. Nevertheless, further high-calibre research is needed before we can offer firm recommendations.

One typical problem in those who have post-TBI is balance difficulties. Deficits in balance might limit day-to-day activities and constructive social interaction. No comprehensive reviews have looked at how physical therapy interventions affect balance after TBI to date[29]. There was no data about how physical therapy therapies affected the patient's ability to balance following a brain trauma. To further understand the significance of exercises in TBI patients who complain of balance problems, more randomized controlled studies are most definitely necessary[30].

10. Conclusion

The meta-analysis has concluded that the physiotherapeutic interventions at an early stage led to significant improvements in the outcome of severe traumatic brain injury and other neurological deficits in patients with severe traumatic brain injury. Severe TBI may result in reduced quality of life among the patients after several months. There may be long-term complications. This can be prevented and quality of life can be improved by applying physiotherapy at the early stage of treatment of the patients. The study provides valuable insights into the effectiveness of physiotherapeutic interventions for patients with severe TBI at an early stage. Firstly, there is a dearth of long-term follow-up data, which is essential for assessing the sustainability of treatment benefits beyond the immediate post-intervention period. However, this meta-analysis does not give any perspective on the long-term outcomes of the interventions. For this, a separate analysis is required and currently, it is beyond the scope of this study. Longitudinal studies tracking patients over extended periods could elucidate whether the observed improvements in motor function, balance, and overall well- being persist or diminish over time. Additionally, investigating factors that influence long-term treatment adherence and maintenance of gains, such as patient motivation, social support, and access to continued rehabilitation services, could inform strategies to enhance the sustainability of treatment outcomes.

Moreover, examining the cost-effectiveness of long-term physiotherapy interventions compared to alternative rehabilitation approaches could provide valuable insights for healthcare policymakers and practitioners in resource allocation and treatment planning. Overall, future research focusing on long-term outcomes and sustainability of physiotherapy interventions has the potential to optimize rehabilitation strategies and improve the quality of life for individuals with severe TBI.

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