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Physiotherapy Interventions for Cognitive Enhancement in Brain Tumor Patients: A Comprehensive Scoping Review

Dr. Sagar Sangtani (PT)[1], Dr Upasna Barthwal (PT)[2], Dr. Shyam Kurapati (PT)[3]

[1]Post Graduate Student, Master's in Physiotherapy (Neurosciences), Department of Neuro Physiotherapy, Dr APJ Abdul Kalam College of Physiotherapy, PIMS(DU), Loni, Maharashtra, India
Corresponding Author Email: *sangtanisagar48[at]gmail.com*

[2]Assistant Professor, Dept of Neuro Physiotherapy, Dr APJ Abdul Kalam College of Physiotherapy, PIMS(DU), Loni, Maharashtra, India
Email: *upasna.barthwal[at]gmail.com*

[3]Head of Department, Department of Neuro Physiotherapy, Dr APJ Abdul Kalam College of Physiotherapy, PIMS(DU), Loni, Maharashtra, India.
Email: *kurapatiphysiotherapy2023[at]gmail.com*

Abstract: ***Background and Need: Cognitive dysfunction is a common outcome of brain tumors, affecting memory, attention, and executive function, reducing independence and quality of life. Physiotherapy-based interventions, including cognitive and physical rehabilitation, have shown potential for neurocognitive recovery, but there is a potential research gap for identifying the number of existing intervention and their effectiveness, thus a scoping review is needed to map the interventions for cognitive enhancement in this population. Objective: To reviews various physiotherapy interventions for cognitive enhancement in brain tumor patients, identifying research gaps, and providing recommendations for future research outcomes. Methodology: The study used various databases Pubmed, Google scholar, ResearchGate were searched for "cognitive enhancement, physiotherapy intervention, brain tumor". Included studies comprised of randomized controlled trials, pilot, and observational studies. Non-interventional studies, cross-sectional studies, duplicate studies, literature reviews, and meta-analysis were excluded. The selected studies were reviewed for intervention used, selected outcome measures, results obtained and were summarized using a flowchart. Results: A total of 16,100 articles appeared with initial search and were screened, of which 14 studies met the inclusion criteria. Most interventions demonstrated significant improvement in attention, memory, and executive functioning. VR/AR-based exercises, yoga, and aerobic programs enhanced cognitive and psychosocial outcomes. Computer-assisted and home-based telerehabilitation programs improved patient engagement and feasibility. Combined aerobic-strength training and early rehabilitation programs positively impacted both physical and cognitive performance. Conclusion: Cognitive and physical rehabilitation interventions, such as computerized training, VR, yoga, aerobic exercise, and telerehabilitation, significantly improve cognitive function, quality of life, and physical performance in brain tumor patients, but further studies are needed.***

Keywords: cognitive enhancement; physiotherapy intervention; brain tumor

1. Introduction

A brain tumor is an abnormal accumulation of cells in the cranial cavity resulting from unregulated cell division and proliferation, leading to the formation of a mass within or around the brain.[1] Patients with brain tumors often experience cognitive dysfunction associated with the disease and during its treatments (such as chemotherapy, radiation, surgery, or hormone therapy), up to 75% of patients develop some kind of cancer-related cognitive impairment (CRCI). In 20% to 35% of survivors, this impairment lasts for months or even 20 years.[2]

Memory, executive function, attention, and concentration deficits are frequently associated with CRCI. The structure and function of the brain are changed in cancer survivors, which is associated with deficits in CRCI areas. [3,4]

CRCI has a detrimental effect on quality of life overall and is linked to tiredness and other symptoms. [5,6] Additionally, it makes employment more difficult, reduces social interactions, and hinders adherence to cancer treatments. [7,8]

These cognitive issues are typically mild to moderate in intensity, and even a modest reduction in cognitive performance can have a big effect on everyday activities and quality of life.[9,10] However, depending on the type, location, and history of treatment of the tumor, cognitive symptoms may differ in their nature and severity. [11,12]

The tumor's anatomical location has significant effects on the degree and pattern of cognitive impairment. While broad disruption of white matter networks contributes to overall cognitive loss, frontal lobe tumors are frequently linked to executive dysfunction and reduced attention, temporal lobe tumors primarily influence learning and memory, and parietal lobe tumors impair visuospatial processing. Patients with brain tumors have cognitive impairment due to a complex etiology. Cognitive decline is caused by a variety of factors, including tumor location, size, histological grade, peritumoral edema, disturbance of structural and functional brain networks, high intracranial pressure, seizures, and neurotoxicity from therapy.
Traditionally, the goal of physiotherapy has been to help patients with neurological problems improve their strength, mobility, balance, gait, and physical function. However, a growing body of research indicates that properly prescribed exercise and physical activity may also improve cognitive

function through a number of neurobiological mechanisms, such as improved synaptic plasticity, hippocampal neurogenesis, increased cerebral blood flow, enhanced neuroplasticity, and increased brain-derived neurotrophic factor (BDNF).

Aerobic exercise, resistance training, balance training, dual-task training, virtual reality, exergaming, yoga, task-oriented rehabilitation, and multidisciplinary neurorehabilitation are just a few of the physiotherapy-based interventions that have shown encouraging results in recent years for patients with brain tumors in terms of attention, executive function, memory, processing speed, fatigue, and quality of life.

The research that is now accessible is nevertheless inconsistent in terms of intervention features, therapy dose, duration, outcome measures, patient demographics, and methodological quality, despite these promising results. Consequently, it is challenging to understand the data and apply it to clinical physiotherapy practice.[13-16]

Many systematic reviews have looked at cognitive rehabilitation in adults with brain tumors; however, rather than concentrating on physiotherapy interventions for cognitive enhancement, the majority have assessed mixed non-pharmacological interventions or combined pharmacological and rehabilitation approaches.

Therefore, a thorough scoping review is necessary to systematically map the evidence that is currently available, identify the kinds of physiotherapy interventions that are currently used, summarize their effects on cognitive outcomes, describe the characteristics of the interventions and outcome measures, and identify research gaps.

Therefore, the aim of this scoping review is to give suggestions for future clinical practice and research as well as a thorough synthesis of the available data addressing physiotherapy therapies for cognitive improvement in patients with brain tumors.

2. Materials & Methods

Design: The design of this study was a scoping review. Scoping review have been described as a process of mapping the existing literature or evidence base.

Database and Search Strategy-
The study includes PubMed, Google scholar, ResearchGate according to PRISMA guideline the search keywords used were “cognitive enhancement, physiotherapy intervention, brain tumor” which is written in English and published between 2013to 2024 non- interventional studies such as cross sectional studies or duplicate studies ,literature reviews and meta analysis were also excluded the study which is made for inclusion and were reviewed for outcome measures and selection which can be summarized according to flowchart

Selection Criteria:

Inclusion criteria:
- It includes study involving cognitive enhancement in brain tumor patients.
- Articles which were written in English.
- The study which were published in Indexed Journal from 2013 to 2024.
- The study included search stratergy all types of data basis which includes pubmed, Google scholar, ResearchGate of all types of articles in that outcome measures are used.
- The study includes RCT’s, pilot RCT’s, observational studies.

Exclusion criteria:
- Articles published in other languages.
- Articles not reported outcome measures.
- Poster presentation, abstracts or articles without enough information about the intervention.
- Duplicate articles were removed.
- Non interventional studies such as cross sectional studies or duplicate studies, literature reviews and meta analysis.

3. Result

A total of 16,100 records were identified through database searching, while no additional records (n = 0) were identified from other sources. After removing 3,348 duplicate records, 12,752 unique records remained for title and abstract screening. During the screening process, 12,185 records were excluded because they did not meet the inclusion criteria. The remaining 567 full-text articles were assessed for eligibility. Of these, 553 articles were excluded after full-text review due to not meeting the predefined eligibility criteria. Finally, 14 studies fulfilled all the inclusion criteria and were included in the review.

Most interventions demonstrated significant improvement in attention, memory, and executive functioning. VR/AR-based exercises, yoga, and aerobic programs enhanced cognitive and psychosocial outcomes. Computer-assisted and home-based telerehabilitation programs improved patient engagement and feasibility. Combined aerobic-strength training and early rehabilitation programs positively impacted both physical and cognitive performance.

S. No.	First Author And Year	Intervention	Outcome
1.	Chiara Zucchella 2013[17]	A four-week RCT had patients complete 16 one-hour sessions of progressively challenging cognitive exercises targeting orientation, attention, reasoning, and memory.	1) Mini Mental State Examination (MMSE) 2) Frontal Assessment Battery (FAB) 3) Attentive Matrices verbal fluency
2.	Seoyon Yang 2014[18]	A randomized controlled trial used the IREX VR system for individualized physical training and the ComCog program for tailored cognitive exercises to improve attention and memory.	1) Computerized Neuropsychological test 2) Forward and backward digit span tests (DSTs) 3) Verbal learning tests and visual learning tests.
3.	Marta Maschio 2015[19]	A pilot study used the personalized TNP software’s 10-week psychologist-supervised RehabTr program to improve	1) Mini Mental State Examination 2) Frontal Assessment Battery

		memory, attention, visuospatial skills, language, and reasoning in patients with focal brain lesions.	3) Clock Drawing test 4) Span forward and backward
4.	Michelle C. Janelsins 2016[20]	A randomized controlled trial tested the YOCAS©® 8-session Hatha–Restorative yoga program, delivered twice weekly in groups and incorporating movement, breath, meditation, visualization, afirmation for cancer survivors.	1) MD Anderson Symptom Inventory (MDASI) 2) Pittsburgh Sleep Quality Index (PSQI)
5.	Bonnie Carlson-Green 2017[21]	A pilot study delivered 35 game-based Cogmed® sessions over 8–12 weeks to improve verbal and visuospatial working memory.	1) The Automated Working Memory Assessment (AWMA) 2) The Behavior Rating Inventory of Executive Function
6.	Magnus Sabel 2017[22]	A randomized pilot study used a home-based Nintendo® Wii™ program, requiring 30 minutes of activity at least 5 days a week for 10–12 weeks, with games promoting physical exercise and balance training.	1) Rey Auditory Verbal Learning Test 2) Rey Complex Figure Test.
7.	Sophie D. van der Linden 2018[23]	A pilot study evaluated the ReMind telerehabilitation program, a six-module sequential cognitive training system combining compensation strategies, psychoeducation, and practical exercises to improve attention, planning, and memory.	1) The computerized neuropsychological test battery 2) Cognitive Failures Questionnaire (CFQ) 3) Hospital Anxiety and Depression Scale (HADS)
8.	Nadine M. Richard 2019[24]	A pilot RCT compared eight-session, brain tumor–adapted Goal Management Training with a Brain Health Program control and a wait-list group, using weekly 2-hour sessions and homework to evaluate strategy-based vs. general cognitive approaches.	1) Sustained Attention to Response Task (SART) 2) Hopkins Test of Verbal Memory-Revised (HVLT-R) 3) Frontal Systems Behavior Scale
9.	Karin Gehring 2020[25]	A pilot RCT tested a 6-month home-based aerobic program with three tailored weekly sessions, supported by physiotherapist guidance using real-time heart-rate data from a GPS watch.	1) Visual Verbal Learning Test 2) MOS Cognitive Functioning Scale 3) Cognitive Failure Questionnaire
10.	Katarzyna Hojan 2020[26]	A prospective observational trial provided tailored rehab for brain tumor patients, with inpatients doing 150 min/day × 6 days and outpatients 120 min/day × 5 days, including cycling, treadmill, Pilates, yoga, and fitness at 60–75% Hrmax.	1) Functional Independence Measure 2) Addenbrooke's Cognitive Examination III (ACE III). 3) The Functional Assessment of Cancer Therapy—Cognitive Scale (FACT-Cog)
11.	Elizabeth Cox 2020[27]	A controlled crossover trial delivered 12 weeks of 90-minute, thrice-weekly group or combined group/home aerobic training at ≥80% peak heart rate, with home sessions added for accessibility, while controls maintained usual activity.	1) Visual-motor Latency in Go / Go-No-Go tasks 2) The 6-Minute Walk Test (6MWT)
12.	Sophie D. van der Linden 2021[28]	A randomized controlled trial tested the 10-week ReMind tablet-based cognitive rehab program, offering six modules with psychoeducation, strategy training, and attention games for 3 hours/week to improve attention, planning, memory, and cognitive functions.	1) The Cognitive Failures Questionnaire 2) Behaviour Rating Inventory of Executive Function 3) Hospital Anxiety and Depression Scale
13.	Esra Dülger 2022[29]	A randomized crossover study implemented a 6-week Combined Aerobic and Strength Training program, with 30-minute treadmill aerobic sessions three times per week followed by calisthenics and weight exercises. A separate 6-week yoga program involved 60-minute sessions, three times per week, focusing on flexibility, balance, and relaxation.	1) Pittsburg Sleep Quality Index 2) Hospital Anxiety and Depression Scale (HADS) 3) Montreal Cognitive Assessment Scale (MOCA).
14.	Anna Pieczyn´ska 2023[30]	A randomized clinical trial tested a 30-day, 5-times/week, 60-minute AR-based Neuroforma rehabilitation program with visual biofeedback, balance training, and interactive virtual tasks during radiotherapy The control group maintained normal daily activities, logged them, and followed standard physical activity guidelines without AR-based exercises.	1) 6-Minute Walk Test 2) Time Up and Go test 3) Functional Independent Measure scale; 4) Addenbrooke's Cognitive Examination III (ACE III)

4. Discussion

This scoping review's primary objective was to methodically map, compile, and evaluate the body of research on cognitive rehabilitation and physiotherapy therapies for improving cognitive function in brain tumor survivors. Patients with brain tumors frequently experience long-lasting neurocognitive deficits in executive, memory, and attention. Therapeutic approaches including cognitive retraining, virtual reality (VR), yoga, physical exercise, and telerehabilitation are key to restoring neurocognitive capabilities after brain tumor treatment by driving adaptive neuroplasticity. As highlighted by Zucchella et al. (2013), initiating cognitive therapy early accelerates functional recovery by reactivating remaining neural pathways through repetitive, targeted exercises.[17]

In order to strengthen attentional, executive, and visual feedback circuits, virtual reality and augmented reality interventions- like those assessed by Yang et al. (2014) and Pieczynska et al. (2023)- integrate concurrent sensory and cognitive stimulation.[18,30] Additionally, specialist software platforms, such as the customized TNP RehabTr program examined by Maschio et al. (2015), provide exercises overseen by psychologists that are specifically designed to target areas such as memory, reasoning, and visuospatial abilities.[19]

Structured working memory interventions like Cogmed® (Carlson-Green et al., 2017) and active exergaming programs like Nintendo® WiiTM (Sabel et al., 2017) show promise for enhancing verbal working memory, balance, and motor-process skills in everyday activities in pediatric and young adult populations.[21,22]

Both cognitive and psychosocial healing are greatly aided by planned exercise programs and mind-body therapies. By controlling physiological stress, sleep architecture, and systemic cortisol levels- all of which support hippocampal integrity- methods like the YOCAS©® yoga program (Janelsins et al., 2016) and combined yoga/exercise protocols (Dülger et al., 2022) improve neurocognition and lessen self-reported memory problems.[20,29]

In order to promote structural neural growth and synaptic connectivity, physically demanding gaming (Sabel et al., 2017) and customized aerobic and resistance training (Hojan et al., 2020; Cox et al., 2020) stimulate dopaminergic pathways, increase cerebral perfusion, and upregulate brain-derived neurotrophic factor (BDNF).[22,26,27] Furthermore, accessible digital platforms such as the ReMind telerehabilitation program (van der Linden et al., 2018; van der Linden et al., 2021) and strategy-based approaches such as Goal Management Training (Richard et al., 2019) show high feasibility, patient engagement, and effectiveness in addressing executive dysfunction, planning, and everyday cognitive failures. Combining multifaceted physical, cognitive, and emotional rehabilitation techniques ultimately produces synergistic results that maximize brain tumor survivors' long-term neuroplastic recovery and functional independence.[23,24,28]

5. Conclusion

Therapeutic interventions for brain tumor patients show multifaceted benefits. Computerized/VR Training and Specialized Cognitive Rehabilitation (e.g., GMT) enhance attention, memory, and executive functions. Aerobic and Combined Exercise Programs improve physical function, quality of life, and subjective neurocognition. Furthermore, approaches like yoga reduce patient-reported memory difficulty, and Active Video Gaming improves motor and process skills in daily activities.

Declaration by Authors

Ethical Approval: Approved

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