

Motor imagery mental practice: A potential role in Neurologic Rehabilitation (NR)

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Abstract Motor imagery technique is used to improve motor learning and support neurological rehabilitation in stroke patients. Neurologic disorders like stroke, brain injury, and neurodegenerative conditions cause motor dysfunctions like physical disability and distressed feelings due to the impairments. Motor imagery mental practice (MIMP) is a nonpharmacological and cognitive intervention recognized to stimulate motor-related brain capacities without any motor movement. This systematic review explores how MIMP contributes to neurologic rehabilitation by improving motor function, neural plasticity, and patient engagement. The study synthesizes empirical and conceptual literature produced between 2020 and 2024 by thoroughly examining peer-reviewed publications and clinical reports from key academic databases like PubMed, Scopus, IEEE, and Web of Science. MIMP helps to promote motor recovery, patient motivation and the benefits of physiotherapy. This research addresses the structure of the intervention and the mechanisms of the neural response, and obstacles faced in integrating the clinical aspect. MIMP technique was a cost-effective alternative to conventional care since neurologic impairment is closely linked to decreased quality of life and long-term disability. Functional outcomes were enhanced with the use of structured imagery sessions, guided visualization, and motor rehearsal, which are exercised through motor pathways. Motor imagery is employed throughout the healing process, enabling patients to resume exercise even in cases of flaccid paralysis. The impact of motor imagery therapy on strokes is used to evaluate more randomized clinical studies. This review describes ideal therapies, evaluation models, and methods of incorporating MIMP into standard neurologic rehabilitation. These findings offer motor imagery that is used to supplement more conventional rehabilitation methods to improve functional outcomes and quality of life for stroke patients when paired with other therapeutic strategies.

Keywords: neuroplasticity, cognitive intervention, patient motivation, neural activation

1. Introduction

Motor imagery is the mental process of visualizing an action without physical movement. It has drawn much interest in the field of neurologic rehabilitation (NR). The development of cognitive neuroscience and motor imagery mental practice (MIMP) has led to the development of mainstream auxiliary rehabilitation methods (Jin et al., 2020). With respect to neurological injuries, such as stroke, traumatic brain injury (TBI), spinal cord injury, Parkinson's disease, and multiple sclerosis, some patients frequently develop severe motor dysfunction, which interferes with independence, mobility, and quality of life (Villa-Berges et al., 2023). Traditional physiotherapy and occupational therapy focus more on the repetition of the task and retraining functions (Abraham et al., 2021). Motor imagery is a mentally involved procedure that is exercisable regardless of the physical ability to assess the ease of motor recovery and functional restoration in neurologically affected patients. It helps to build autonomous models of how to execute movements, improves sensorimotor coordination, and improves the linkage between action and perception (Behrendt et al., 2021).

Patients can be motivated, feel capable, and be more engaged in therapy by practicing goal-oriented movements in their minds. MIMP offers the possibility of sustained practice without the clinical context where patients have a chance to directly participate and facilitate a more holistic rehabilitation process (Morone et al., 2022). The MIMP theoretical model is based on the belief that imagining movements stimulate the brain pathways engaged in real physical motion (Donati et al., 2024). Neuroimaging has revealed that motor imagery activates the primary motor cortex (M1), premotor cortex, supplementary motor area (SMA), cerebellum, and parietal areas, which are also involved in planning and execution of voluntary movement. This overlap in brain activity supports the idea that MIMP might strengthen neural networks and paths interrupted by

neurologic injuries (Riquelme-Ros et al., 2020). This activation may be used to recover motor representations, minimizing cortical map atrophy, and motor training.

It is particularly important during the initial stages of rehabilitation, where patients fail to actively participate in physical therapy because of pain, exhaustion, or lack of mobility (Gaur et al., 2021). MIMP has been used to increase the ability of the general circulation to move in humans affected by Parkinson's disease. MIMP tends to be combined with other modalities, such as transcranial magnetic stimulation (TMS) and brain–computer interface (BCI) technologies, to represent a shift toward greater utilization of integrative, multimodal neurorehabilitation. Therapists should adequately train patients in neurophysiological concepts (Lambert et al., 2022). Neurofeedback helps the user self-regulate neural substrate systems by providing additional visual or auditory input, which directly controls external equipment. Motor regions and pathways are improved for stroke patients to train neurofeedback functions to become healthy individuals (Srimadumathi & Reddy, 2024). Figure 1 represents the MIMP in neurologic rehabilitation research trends from 2020–2024.

The objective of this study was to examine how MIMP interventions can be applied in neurologic rehabilitation settings to improve motor function, promote neural plasticity, and support nonpharmacological strategies to enhance recovery and quality of life in patients with stroke and other neurologic conditions. The remaining part of this research provides a comprehensive description of the PRISMA framework, followed by a discussion of the research findings and a summary of the key conclusions drawn from the study.

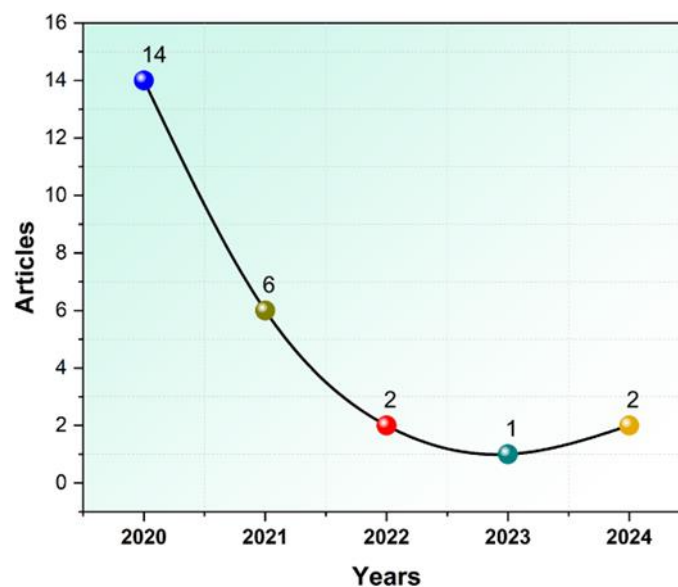


Figure 1 MIMP in neurologic rehabilitation research trends between 2020 and 2024. *Source:* Scopus Database.

2. Methodology

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) was employed to systematically evaluate relevant research on the effects of MIMP in enhancing neurologic rehabilitation, particularly in stroke patients. A comprehensive search was conducted across multiple databases using well-defined criteria to identify studies relevant to the objectives of the study; this approach enabled the proper selection of the learning objectives. This systematic review ensured a high degree of transparency in methodology, reduced bias, and facilitated the rigorous identification of studies examining the effects of MIMP on motor recovery, neuroplasticity, and patient engagement.

- PRISMA diagram

The PRISMA guidelines were used to increase the effectiveness of MIMP in neurologic rehabilitation. This study ensures participant selection, intervention design, and anxiety assessment via validated clinical and neurofunctional measures. It helps to identify and assess standardized MIMP protocols. Figure 2 depicts the processing of PRISMA.

- Database

This study synthesizes findings from recent research (2020–2024) across databases to provide a comprehensive analysis of MIMP in neurologic rehabilitation. This study ensures a structured approach by clearly defining the search strategy from databases such as PubMed, Scopus, IEEE, and Web of Science. This approach ensures an in-depth understanding of current developments, new trends, and significant obstacles in addressing motor dysfunction and neural recovery, providing a comprehensive view of cognitive intervention strategies in stroke and neurorehabilitation settings.

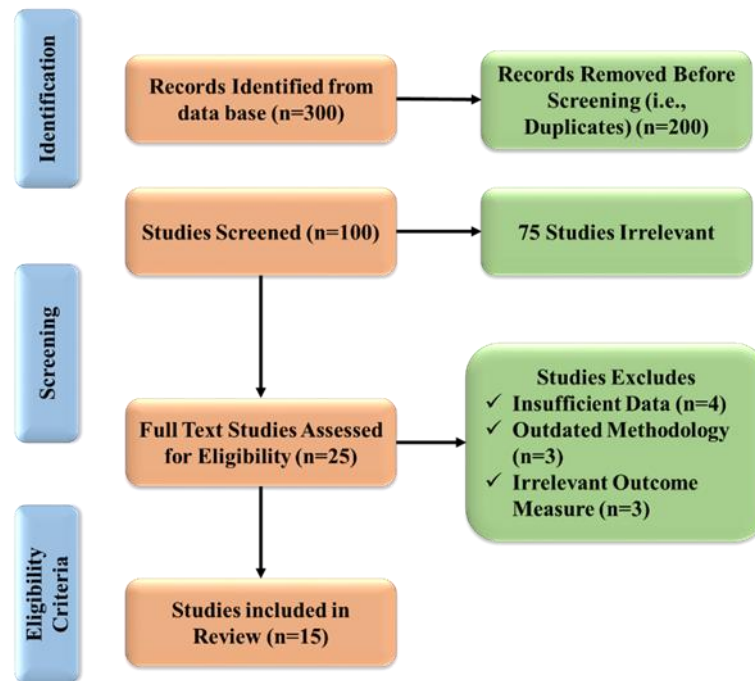


Figure 2 PRISMA flow diagram.

- Search strategy

The keywords relevant to the topic include motor imagery, mental practice, neurologic rehabilitation, stroke recovery, neuroplasticity, cognitive intervention, motor function improvement, nonpharmacological therapy, patient engagement, and functional recovery. These keywords help in finding relevant research articles and literature that examine the prospects, innovations, and related difficulties of using MIMP to enhance rehabilitation outcomes in individuals with neurologic impairments.

- Inclusion criteria

To establish criteria for selecting papers related to the objective of exploring the effects of MIMP in neurologic rehabilitation. In this section, after screening 200 documents, 300 were identified as potentially relevant for further review. Studies were selected on the basis of predefined criteria relevant to motor recovery, neuroplasticity, cognitive rehabilitation techniques, and nonpharmacological therapies for neurologic impairments, particularly stroke. For example, published works investigating brain activity during motor imaging or sensitivity to mental training by patients were conducted at a relatively high level. Through the 100 records screened, 75 studies were identified as irrelevant, and 25 full-text publications were identified as eligible, of which only the studies most relevant to the objective of the investigation were included in the final stage to achieve the synthesis.

- Exclusion criteria

The exclusion criterion was studies that did not satisfy the necessary criteria to be included in the MIMP review in neurologic rehabilitation. Following initial screening, 4 of the records were excluded, along with 3 articles that utilized outdated methodology and 3 full-text articles that were concluded to be irrelevant to the present focus on motor imagery or neurologic conditions. Studies with insufficient data, publications published in languages that the people doing the study cannot read, and rehabilitation studies not aimed at either cognitive or motor-specific interventions were excluded. Studies with major systematic weaknesses or influences and articles that did not focus on the therapeutic effect of MIMP on motor or neuroplasticity were excluded. It allowed only 15 studies to enter the final synthesis, which was based on the best and most relevant evidence that could be used by the research.

3. Neural Decoding and Motor Imagery Systems

Chaisaen et al. (2020) decoded the continuous electroencephalogram (EEG) rhythms of standing and sitting activities via motor execution (ME), activation observation (AO), and motor imagery. Motor imagery was strengthened through the use of the deep learning (DL) technique. The algorithm is implemented in the following way, starting with the filter bank spatial filtering (FBSF) block: raw electroencephalographic data obtained are translated to an equivalent intermediate EEG stage, and the two-stage convolutional neural network (TSCNN) block is used to decode the intermediate EEG stage (Chen et al., 2020). Mallik et al. (2020) analyzed whether mirror therapy and mental imagery are effective at eliminating phantom limb pain. It

compares itself to two methods of treatment. The results indicated that the two treatments were effective in sensory methods, with mirror therapy providing better sensory input and mental imagery providing cognitive reorganization and a decrease in chronic pain among the amputees. Attallah et al. (2020) developed the BCI to help individuals with limb motor pathologies perform everyday activities. The system recognizes the signals of the brain that operate the external assistive machines, thereby minimizing movements. The BCI exploits the motion of the brain to transform it into commendable codes through sophisticated pattern and signal classification. The technique enhances self-reliance and livelihood among motor-impaired patients, as this method does not require their hands to operate their tools and equipment. The efficiency of this system provides a solution that can be used as a channel of communication between the brain and assistive technology, hence increasing independence in the routines of humans.

Benzy et al. (2020) conducted a study on motor imagination in stroke victims via EEG to analyze cerebral cortical activity. It assists in establishing how patients conceive of the paths in which they are constrained to make hand movements. Discrete neural activation associated with directional intent might be detected by examining EEGs during the visualization of the movement of hands. These findings can be used in the development of neurorehabilitation approaches and BCI systems that are stroke specific. These findings support the feasibility of decoding motor intentions through MI-based EEG analysis as a potential noninvasive method for restoring motor control and enhancing rehabilitation outcomes after a stroke. In Souto et al. (2020), motor imagery as a supplementary intervention was trained to induce potential improvements in upper limb motor function in children with hemiplegic cerebral palsy (HCP). During their studies, they focused on how MI can access the same systems of the brain that are involved in physical motor performance by only imagining movements without actually using them physically. It can be used to complement standard treatments, enhance motor planning and motor coordination, and facilitate functional recovery in children with HCPs. Motor imagery constitutes a powerful supplementary or alternative rehabilitation option that allows for more personalized, comprehensive treatment for the recovery of HCPs.

3.1. Neural basis of motor imagery and its clinical implications

Motor imagery is a promising neurorehabilitation strategy, especially for stroke rehabilitation, as it involves the neural foundations and regulatory mechanisms involved in normal movement. Despite the existence of exact neurological linkages, the brain has been associated with motor imagery for over 20 years. The cortical and subcortical regions employed for motor imagery tasks involved in movement execution significantly overlap, according to several neuroimaging findings. A mental action is conducted without any physical movement, activating brain networks that execute comparable tasks to initiate particular movements (Li et al., 2020). The somatosensory cortex receives a motor signal that begins in the spinal cord and travels through specific muscles to stimulate them. The somatosensory cortex then transmits both conscious and unconscious sensory information to the brain after the contraction of the muscles. The planning and preparation phases of motor control work by triggering mental images of potential movements. Motor imagery was generated via similar computational processes that share similar brain locations.

3.2. Cognitive motor practice in stroke rehabilitation

Neuroprotective stroke treatments are rarely employed. Owing to the anatomical similarities between motor imagery and movement execution, motor imagery has been emphasized as an effective neurorehabilitation (NR) treatment for stroke patients. Motor imagery has been added to regular physiotherapy for four weeks in the treatment of stroke patients (Xuefang et al., 2021). Cortical excitability and upper limb motor recovery increased significantly, and stroke patients might benefit from more synchronous action observation and neurorehabilitation. Motor imagery was recommended by a number of randomized controlled trials. The assessments of the groups revealed that the patients in the EG were much stronger and faster. Table 1 presents the motor imagery and neurorehabilitation techniques used across various neurologic conditions.

3.4. Future perspectives

Motor imagery interventions are susceptible to interpersonal differences in the capacity to use imagery, especially in patients who are cognitively impaired and have limited attention capacity. There is a lack of standardized procedures with respect to longevity, repetition, and modalities of imagery, which results in inconsistency. Future research should focus on implementing standardized and evidence-based motor imagery protocols specific to a particular neurologic condition, including strokes. Real-time monitoring and individualization of motor imagery training might be enhanced by including neuroimaging and BCI devices. The combination of VR and flexibility in feedback systems could enhance patient motivation and learning motors.

Table 1 Motor imagery and neurorehabilitation techniques across various neurologic conditions.

Ref	Algorithm	Databases	Scope of Application	Significant Findings	Limitations	Result
Paolucci et al. (2020)	Motor Imagery, Mirror Therapy	Mime-therapy and myofascial-approach	Facial Nerve Palsy (FNP) rehabilitation	Integrated Motor imagery for quality of life, and Emotional depression	Limited predictive factors	Experimental group showed better FNP, and physical function
Choi et al. (2020)	Immersive Virtual Reality; Motor Imagery	EEC signals	Motor imagery enhancement and EEG-based performance	VR headsets enhanced neural rhythm patterns	Limited EEG signal analysis and lab setting	Improved spatial EEG features and embodiment with VR
Kanthack et al. (2020)	Mental Chronometry & Psychometric	Ventilatory threshold	MI performance under fatigue	MI degraded after intermittent but not continuous exercise	Task-specific fatigue impact, limited generalizability	Intermittent exercise impaired MI ability;
Zhang et al. (2020)	sensorimotor rhythm (SMR) analysis, Transfer learning,	Motor imagery brain-computer interfaces (MI-BCIs)	MI-BCI inefficiency and user variability	Low SMR linked to inefficiency; user types categorized	Few studies focus on improving inefficient user performance	Emphasized the need for personalized MI-BCI strategies
Mane et al. (2020)	BCI-based intervention	cognitive rehabilitation	Poststroke motor, cognitive, and emotional rehab	BCI for multidomain synergy	Mostly conceptual; needs experimental validation	Integrating BCI model for Broader Recovery
Hussain and Park (2021)	EEG Biomarkers	48 stroke patients	Poststroke classification via EEG	EEG biomarkers distinguished stroke from healthy adults	Task-specific findings; moderate sample size	accuracy: 78–89% across various functional states
Tarantino et al. (2021)	Computer-based Executive Functions (EFs) Training	Clinical trial	Poststroke cognitive rehabilitation	EF training improved attention, fluency, and independence	Small sample; short-term follow-up	EF group outperformed control in cognitive and functional measures

3.3. Patient engagement with cognitive-based motor rehabilitation

Patient adherence and engagement ratings were used to measure patient engagement with MIMP as part of neurologic rehabilitation programs. These statistics indicate that 45% were adequately engaged with guided mental imagery activities, whereas 35% were moderately involved, participating regularly with occasional absences, and 15% indicated low participation in mental activity. Five percent of the respondents dropped out for various reasons, including a lack of perceived gain. This finding shows that MIMP is highly accessible and has psychological attraction. It helps patients address traditional therapies. Table 2 and Figure 3 illustrate the patient adherence and engagement ratings.

Table 2 Patient adherence and engagement ratings.

Engagement Level	Values (%)
Very Engaged	45%
Moderately Engaged	35%
Low Engagement	15%
Dropped Out	5%



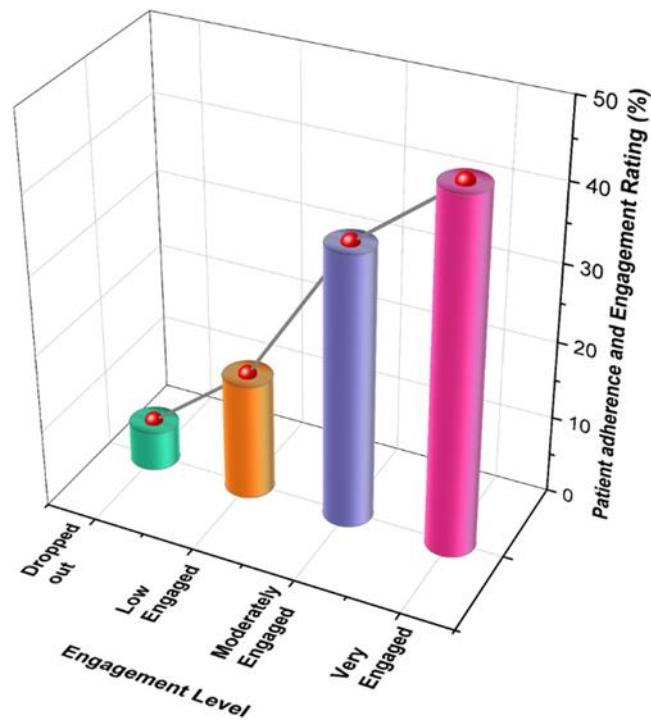


Figure 3 Visualization of the engagement level. *Source:* Scopus Database.

4. Conclusion

The MIMP theoretical model is based on the belief that imagining movements stimulates the brain pathways engaged in real physical motion. The MIMP model is a type of cognitive stress therapy used to restore motor function and neuroplasticity in patients with neurological damage, such as stroke, neurodegenerative disorders, and brain injury. This intervention is a nonpharmacological approach that plays a significant role in motor learning, emotional resiliency, and involvement in neurotherapy rehabilitation. This systematic review addressed how the practical application of MIMP applies to the domains of key rehabilitation, such as the stimulation of motor functions, cortical reorganization, patient motivation, and adaptive learning. The functional outcomes were enhanced with the use of structured imagery sessions, guided visualization, and motor rehearsal, which are exercised through motor pathways. Motor imagery is employed throughout the healing process, enabling patients to resume exercise even in cases of flaccid paralysis. Many studies have examined the risk of motor imagery in people who have a stroke. The impact of motor imagery therapy on strokes was used to evaluate more randomized clinical studies. It offers policy recommendations that can help clinicians make responsible decisions and potentially lead them to integrate MIMP in neurologic practice via patient-specific recovery interventions, cost-effective treatment regimens, and measures that promote quality of life and functional independence sustainability.

Ethical Considerations

Not applicable.

Conflict of Interest

The authors declare no conflicts of interest.

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