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REVIEW ARTICLE

Motor imagery promising technique for Rehabilitation of Patients with Parkinson's disease: A Systematic Review

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ABSTRACT

Recent research has suggested that motor imagery may be helpful for the Rehabilitation of Parkinson's disease (PD) patients. Using MI, a movement can be imagined without muscles being activated. MI induces plastic changes in the motor cortex, improving motor performance. This systematic review was designed to examine the effects of MI on the physical Rehabilitation of people with Parkinson's disease. Five databases were used to identify similar studies using selected keywords. This review assessed the "methodological quality of each randomized control trial study" using the eleven-point Physiotherapy Evidence Database scale, widely used to rate physiotherapy "literature". The benefits of using MI to treat patients with PD were identified in this review. Seven studies were identified; 6 studies reported motor function, two studies worked on bradykinesia, two on balance and two reported impairments in Gait in PD using MI. The included studies had small samples, varied methodological approaches, and varied quality from good to fair. According to the current review, MI provides more significant benefits for Parkinson's patients when used along with other therapeutic methods for improving motor function and balance than conventional physical therapy alone.

Keywords: Rehabilitation, Parkinson's disease, Motor imagery, systematic review,

INTRODUCTION

Motor imagery (MI) is a procedure of mentally practicing a motor task or activating specific muscles without explicit feedback[1]. This technique is a motor representation related to the preparation and intention of movements through which a person rehearses or repeats a particular action. It is mainly used in sports training as a mental activity exercise and neurological Rehabilitation. Functional neuroimaging studies have depicted that during mental activation, frontal, parietal, primary cortex, basal ganglia, supplementary motor area, and cerebellum areas are mainly stimulated, especially during the execution of movement[2,3].

The premotor cortex and inferior parietal lobule, related to motor cognition, are stimulated during MI. Movement implementation and core motor learning mechanisms are linked in this way. Imagination and motor execution are, however, highly dependent on task complexity[4]. MI also provides the basis for brain-computer interface development for physically disabled persons, leading to more precise movement execution. MI can be contradictory, depending on how a task or rehearsal is linked with visual, acoustic, somatosensory and balanced perceptions and sensations[5].

In Rehabilitation, the advantage of MI is that it gives freedom of movement capabilities, no chance of physical harm, limited financial costs, increased compliance, and no equipment requirement. In addition, MI also target many motor (for example, range of motion) and non-motor tasks that are cognitive and sensory (for example, self-confidence, pain and motivation) related to performance. MI technique provides various delivery opportunities to physiotherapists virtually, physically and remotely. So this technique is more relevant to many PD communities, including underserved and remote ones, thus targeting gaps and future directions documented by previous studies[6]. The primary motor cortex (M1) processes MI tasks and motor actions, as do the premotor, supplementary, and parietal motor cortexes[7]. The goal of MI is to imagine that movements or muscles are being activated or moved without actually moving or starting them. In many neurological disorders affecting motor recognition and execution, MI is highly effective at improving motor skills[8.]

Our hands and eyes mostly move in a coordinated manner in the execution of particular movements during activities of daily living. The study depicted that the presence of visual data while performing purposeful actions adds to endpoint consistency and accuracy. Eye movements while executing of aimed task during[9]. It has been shown that MI training sessions increase performance in terms of speed, performance accuracy, muscle strength, movement dynamics, and motor skill performance[10].

Alterations in MI have also been known in many progressive or acute neurological disorders, such as multiple sclerosis, PD, and cerebrovascular lesions. MI is believed to engage similar neural pathways used in motor tasks and linked kinesthetic, visual and sensory input integration[11].

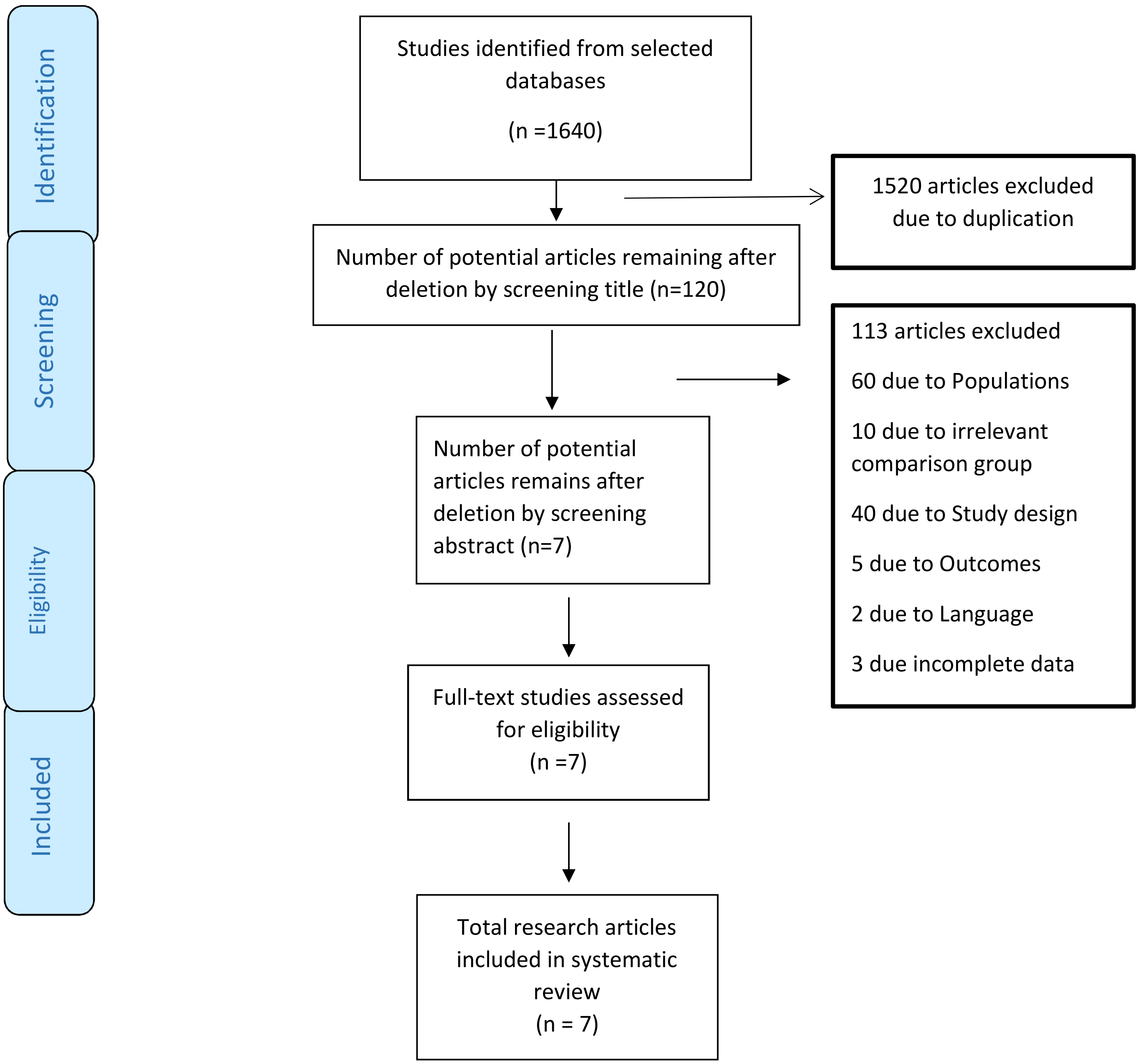
In Parkinson's disease, there is a decline in the level of dopamine in the basal ganglia, which causes motor and non-motor symptoms. Its symptoms may treat with levodopa therapy mainly as a highly active symptomatic treatment. The majority of long-term complications are managed with medications. However, certain motor features and complications require an active role in Rehabilitation. Patients with PD can benefit from several rehabilitation strategies, including the MI technique, to aid them in learning motor skills[12].

One study stated that action observation is a more feasible and safe procedure for Parkinson's patients to improve Gait and balance and reduce falls[13]. Another study reviewed that imagery therapy and home-based action observation are possible in moderate to mild PD and provide an independent, low cost and flexible approach in addition to conventional neuro-rehabilitation[14]. In this systematic review, we aimed to identify and appraise studies that examined the role of MI in the physical Rehabilitation of patients with Parkinson's disease.

METHODOLOGY

This systematic review was conducted to study the MI as a promising tool in the physical Rehabilitation of PD by using keywords' Motor Imagery' or 'Mental Practice' or 'Motor Imagery Training' and Parkinson's disease OR 'Parkinsonism' OR 'Parksonian' on online databases, including Web of Science, Cochrane Library, PubMed, CINHAL and PEDro. One thousand six hundred forty articles were recruited from searches on selected databases. After excluding some articles based on duplication, irrelevant population, study design and outcomes, seven full-text articles were selected to add to this review. The study inquiry for this review was: What role may MI play in the physical Rehabilitation of PD? The PICOS strategy (population, intervention, comparison, outcome measures, study design strategy) was employed in this review. Patients with overt visual, cognitive, or hearing impairment were excluded from the study. The review included MI studies alone or with any other combination, randomized clinical trials, and analyses in English. (**Figure I**)

Figure I: PRISMA flow diagram Eligibility and data synthesis



Data extraction and quality assessment

The data search for the localization of studies with the established strategy of the current systematic review was carried out by two reviewers. Data extraction included age, gender, sample size, intervention, Hoehn-Yahr scale dosage, outcome, and results of the included studies[15] (**Table I**). A Physiotherapy Evidence Database (PEDro) scale, widely used to measure the quality of studies in physiotherapy-based research, was used to assess the methodological quality of each RCT study. Inter-rater reliability of PEDro scores for physiotherapy interventions is 'fair' to 'excellent' (interclass correlation coefficients of 0.53-0.91). Inter-rater reliability of PEDro scale items varies from 'fair' to 'almost perfect' (Kappa 0.36-1.00) in physiotherapy trials. Increasing inter-rater reliability occurs when two or three raters agree on the total PEDro score and the individual PEDro scale items. A PEDro score of 0-3 is considered 'poor', a score of 4-5 is considered 'fair', a score of 6-8 is considered 'good', and a score of 9-10 is considered 'excellent'[16,17].

Table No 1: Data Extraction of included studies

Study	Age Range/Mean age	Gender	Sample size	Experimental Group	Control Group	Hoehn-Yahr scale	Dosage	Outcome Measures	Results
Sarasso E et al.[21]	Dual-task group: 63.81±9.23 Dual task +AOT-MI group: 67.51±6.12	Dual-task group:8M/4F Dual task +AOT-MI group: 8M/5F	25	4 gait/balance Exercises by Using observation/imagination	4 gait/balance Exercises without imagination	01-03	6 weeks, 3 times a week, about 1 hour each session	H&Y scale, MDSUPDRS-II, MDS-UPDRS-III, Mini-BEST, TUG,10-MWT, ABC, PDQ-39 & NFoG-Q	The study's findings reported that Using observation/imagination improved dual-task mobility and balance in patients with PD.
Santiago et al.[20]	CG:61.40±9.05 EG:61.30±9.95	Both genders	20	mental practice and physical practice	Physical practice only	02-03	On the day of the initial assessment, a single training session was conducted, with steps 1, 2, 3, 5 and 7 performed by both groups and steps 4 and 6 performed by the experimental group.	Qualisys Motion Capture & TUG Test	The study found that mental training did not significantly improve TUG scale scores compared to physical training.
Lokhandwala M 2019[22]	60-75Years	Both genders	30	Physical practice and mental imagery were provided to the experimental	The control group received only physical practice. (N=15)	1.5 - 3	Both groups received 20 therapy sessions five days a week for four weeks.	UPDRS, TUG Test, PDQ-39 and Stroop test	Between the two groups, the performance times from supine to standing and standing to supine were significantly different,

				group (N=15).					with a p-value of 0.00, the TUG test with a p-value of 0.003 and the Stroop test with a p-value of 0.004.
Bek J et al.[14]	Range from 47 to 73 Year	M/F: 9/1	10	The experimental group received ACTION-PD combined AO plus MI intervention for individuals with PD. (N= 6)	The control group continued with their usual treatment for PD. (N = 4)	01-03	6-weeks training period	DextQ-24 , KVIQ, PDQ-39	For people with mild to moderate PD, AO + MI training at home, performed via mobile technology, is feasible. In addition, motor performance was better in the experimental group than in the control group.
Abraham A 2018[23]	Mean age in Dynamic Neuro-Cognitive Imagery (DNI) group was 66.4 ± 12.5, and in the control group was 65.1±7.5	M/F: 16/4	20	The experimental group received DNI training (*n* = 10)	In-home learning and exercise program (control; *n* = 10)	01-03	Experimental and control groups completed at least 16 hours of training within two weeks.	MoCA, CPF, MIQ-RS, KVIQ-20, & VMIQ-2	In this study, PD patients with DNI training had improved imageability, disease severity, and motor and non-motor functions.
Tamir R 2007[19]	Experimental group: was 67.4±9.7 and in the Control group: 67.4±9.1	M/F: 15/8	23	The experimental group was treated with both imagery and real practice	The control group received only physical exercises.	1.5-03	Exercises for both groups were applied during 1-hour sessions held twice a week for 12 weeks.	UPDRS, Stroop and clock drawing tests	Compared to the control group, the treatment group showed significantly higher gains in the mental and motor subgroups of the UPDRS and cognitive tests. There was an improvement in daily living activities for both groups.
Braun S 2011[18]	The mean age in the Experimental group was 70±8, and in the Control group was 69±8	M: 47	47	physiotherapy, mental practice and usual care	Physiotherapy , relaxation and usual care	01-04	A six-week intervention period for both groups	VAS, TUG, & 10-MWT	The experimental group improved more than the control group, but not significantly.

RESULTS

Quality appraisal of studies

In total, seven studies, six rated as Good with Score 6 to 8[14,18-22]. Only one study[23] scored Fair with a score of 4 according to Pedro's rating scale[16]. Random allocation, eligibility criteria and baseline prognostic indicators were reported in all seven studies. Out of 7 studies, only two studies[19,23] lack information regarding concealed allocation. Only one study[23] was open-blinded. All seven studies reported between-group statistical comparisons. (**Table II**)

Table II: Quality assessment of included studies

Study.	Randomly allocation	Concealed Allocation	Baseline comparability	Participant blinding	Therapist blinding	Assessor Blinding	<15% dropouts	Intention to treat analysis	Between-group difference reported	Point estimate and variability reported	Eligibility criteria	Total Score
Lokhandwala M 2019[22]	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	7/10
Braun S 2011[18]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	8/10
Tamir R 2007[19]	Y	N	Y	N	N	Y	Y	N	Y	Y	Y	6/10
Abraham A 2018[23]	Y	N	Y	N	N	N	N	N	Y	Y	Y	4/10
Santiago et al.[20]	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	7/10
Sarasso E et al.[21]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	8/10
Bek J et al.[14]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	8/10

Sample characteristics
A total of 175 patients with PD participated in 7 studies. Out of 175 patients, the male-to-female ratio was 103:22 in 5 studies[14,18,19,21,23], 47 male participants were the maximum number[18], and the minimum number was 8[21]. The maximum number of female participants was 8[19]. Bek J et al.[14] researched only one female participant. All studies included patients with stage ≤ 4, according to Hoehn and Yahr classification (H&Y)[15]. The total time duration for treatment ranges from 2 weeks to 12 weeks.

Types of Interventions in experimental groups
Types of interventions used in the experimental group were mental imagery of functional activities[19,20,22], Tablet computer App[14], Dynamic neuro-cognitive imagery[23], mental practice of walking, standing up from a chair or the floor, mental imagery of gait tasks[18], Dual task+ Action Observation Task - MI[21.]

Types of interventions in the control group
Types of interventions used in the control group were Dual Task[21], conventional physical therapy[22], Physical practice of Gait[20], Physical practice14., in-home learning[23], callisthenic exercises[19], flexibility, muscular strength and coordination exercises, relaxation exercises[19], Physiotherapy with relaxation therapy[18].

OUTCOMES

Bradykinesia
Of 7 studies, two worked on bradykinesia[19,22]. Lokhandwala M 2019[22] reported the effectiveness of combination in reducing bradykinesia and fear and anxiety. The study showed improved time and confidence to perform functional activities through integrated physical and mental practice. UPDRS subsets for the experimental group showed less than significant improvement. This improvement is because MI is essential to cognition, motivation and memory. Experimental group. Tamir and fellows[19] also agreed with these findings and showed significant results in reducing bradykinesia and improving motor function.

Outcome Measures for Bradykinesia
Outcomes measures to assess bradykinesia were the performance of a movement sequence, UPDRS[19], TUG (Timed up and go), ST: TS (Supine to Stand), and ST: TS (Stand to Supine) performance time[22].

Motor function
Out of 7 studies, 6 [18-23] were conducted to determine the effectiveness of MI on motor function. According to Amit and coworkers[23], Dynamic neuro-cognitive imagery significantly improved motor function measures, specifically in the TUG manual and 360-degree Turn. Sarasso E et al.[21] reported that combining Action Observation Imagery-MI with the dual task is more beneficial for reorganizing the brain area, and these effects are long-lasting.

Outcome measures for motor function
Unified Parkinson's Disease Rating Scale(UPDRS)[19,22], Single and Dual Timed Up and Go (TUG) test[18,20,21], Forward Gait Speed, 6-Minute Walk Test (6MWT), 30-Second Chair Stand, 360° Turn Test and Push and Release Test (PRT)[23] were used as outcome measuring tools for motor function.

Balance
Of 7 studies, two assessed balance as an outcome[19,21]. Tamir R 2007[19] study also in favor of MI along with physical exercises for the improvement of balance.

Outcome measures for balance

Outcome measuring tools used were Mini Balance Evaluation Systems Test (MiniBESTest)(21) and Activities Balance Confidence Scale (ABC)[19].

Gait

Out of 7 studies, two[20,21] assessed Gait as an outcome. These studies reported improvement in stance and swing time. The intergroup difference was insignificant in one training session; however, the intragroup difference was significant. Braun S 2011[18] described MI does not affect walking performance. However, patients with stages under three on the H&Y scale showed some improvement.

Outcome measures for Gait

New Freezing of Gait Questionnaire (NFoG-Q)[21] and Qualisys Motion Capture System[20] were utilized as outcome measures.

Other outcomes and outcome measures

Dexterity, quality of life, MI ability, visual and kinesthetic ability, vividness, disease severity, psychological measures, and Activity of daily living (ADLs) were evaluated with balance, Gait, motor function, and bradykinesia. No significant improvement was seen in visual and kinesthetic ability and ADLs. Dexterity, cognition, and quality of life were improved. Tamir and fellows significantly improved the mental subset of the Unified Parkinson's Disease Rating Scale (UPDRS).

These outcomes were assessed by Stroop Test[22], Dexterity Questionnaire (DextQ-24)[14], Kinesthetic and Visual Imagery Questionnaire (KVIQ)[23], Parkinson's disease Questionnaire (PDQ-39)[23], Montreal Cognitive Assessment (MoCA)[23], Composite Physical Function Scale (CPF)[23], The Movement Imagery Questionnaire-Revised Second Version (MIQ-RS)[23], Vividness of Movement Imagery Questionnaire-Revised Version (VMIQ-2)[23].

DISCUSSION

Using MI for physical Rehabilitation among individuals with PD was the aim of this systematic review. The benefits of MI for motor recovery are especially evident when long-term rehabilitation programs are used. In terms of neurorehabilitation, MI appears to be a promising future technique. Several studies have demonstrated improved skills, strength, and function through MI in various neurological conditions[24-26.]

The MI improves motivation, concentration and attention in patients with neurological disorders[27]. According to Asavari and colleagues, MI adds value to physical therapy and is a practical way to elicit motor-evoked potentials (MEPs) in patients who cannot receive physical therapy because of severe motor impairments. Despite brain lesions, MI has consistently proven effective in motor rehabilitation through increased treatment or neural stimulation[28]. Compared to other measurement approaches, neurofeedback demonstrates the highest success rates for motor symptoms in the early stages of development[29]. Parkinsonism is characterized by bradykinesia, also associated with Amyotrophic Lateral Sclerosis, which causes progressive degeneration of upper and lower motor neurons[30]. Therefore, Abidi M et al.[31] suggested that postural control can improve gait reorganization by reducing fear of falling, leading to altered gait patterns and locomotion imagery time. Individuals with PD have difficulty working on computers, such as reduced keyboard speed, hitting accidental keys when typing, and difficulty clicking or controlling a mouse. Another study by Woodrow-Hill 2021[34] indicated that MI can be an effective technique for smoothing movement in PD patients.

In their study, Gil-Bermejo-Bernardez-Zerpa A 2021[35] showed that MI and its combination with relaxation exercises helped improve motor skills, Gait, balance and quality of life in patients with Multiple Sclerosis. A study by Nicholson and colleagues found that MI training could improve balance and mobility in older adults without neurological conditions. The results of this study suggested that MI training could be an adjunct to standard physiotherapy care in older adults[25]. MI results in functional reorganization of motor control and executive attention areas when combined with dual-task gait/balance training, and has longer-lasting effects on mobility and balance[21]. Bae et al. [32] found that combining MI with balance training significantly improved patients' balance and gait abilities more than balance training alone.

Li R-Q 2017[33] found an increase in walking speed of 40% after MI treatment and significant improvements in step, foot rhythm, and other aspects. Woodrow-Hill 2021[34] reported that MI provides short-term Gait benefits when measured using walking speed. Another study by Gil-Bermejo-Bernardez-Zerpa A 2021[35] reported that MI enables more demanding or complex motor tasks, improving Gait and mobility in patients with PD. Moreover, it is reported that MI enhances the quality of life through the neurofeedback mechanism[36].

Integrating MI with physical therapy treatment may reduce bradykinesia in patients with PD. MI could be an essential component of the cognitive strategies provided to these patients[37]. Avanzino L 2013[38] observed the effects of MI on sequential movements in Parkinson's patients. The synchronization-continuation paradigm assessed the motor timing arrears in sequential movements through MI. Results suggested that PD patients showed discerning deficits in motor timing and motor execution, which can affect motor planning. It was also concluded that Timing deficits could affect MI abilities.

MI techniques are used not only for PD rehabilitation but also for other disorders, as recent studies suggest for other neurological disorders such as cerebrovascular accidents, spinal cord injury and non-neurological disorders such as after knee arthroplasty and amputation[39,40].

Although MI is very effective in various disorders, its limitations still influence its effectiveness. One necessity of MI is a quiet environment and one's concentration skills, so that these factors can affect its effectiveness. Other factors that control its efficacy are longer session duration and age-related discrepancies[39,41]. Limitations reported in studies were small sample size[6,19,42], no follow-up[6], short duration intervention, uncertainty about the dose and sensitivity of assessment tools[19].
MI in the physical Rehabilitation of PD has an essential role in activating the neural network of the brain, thus enhancing the overall function of the brain. In addition to improving motor function, there are various benefits of MI, such as its non-invasive nature, no safety issues, no need for equipment and trained staff and can be used in home-based intervention[39]. The only English literature added to our review was one of the limitations of our study. Besides these benefits, further high-quality clinical trials are required to implement MI as a therapeutic tool in the physical Rehabilitation of PD. Furthermore, more extensive studies should examine how MI practice combines with conventional PT for patients with Parkinson's disease, given the clinical and statistical significance of the findings.

CONCLUSION

Based on the results of this systematic review, MI interventions in PD are likely to have beneficial effects on balance, Gait, and motor functions. More studies with large sample sizes and a sound methodology should be conducted to assess the utility of MI. Moreover, technological advances could benefit the administration of training based on MI, and their application to Parkinson's Rehabilitation could lead to new protocols.

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AUTHOR CONTRIBUTIONS

Kashif M: Data Interpretation, drafting or critically reviewing its intellectual content, Final approval of the manuscript, agreement to be accountable for all aspects of the research work.
Ahmad A: Interpretation; critically reviewing its intellectual content, Final approval of the manuscript, agreement to be accountable for all aspects of the research work, supervision.
Bashir K: The acquisition, literature review, drafting of the work, final approval of the manuscript, AND the agreement to be accountable for all aspects of the research work.
Farooq M: Design of the work, drafting work, Final approval of the manuscript, and integrity of any part of the work are appropriately investigated and resolved.
Iqbal S: Interpretation of data for the work, revising it critically for important intellectual content, Final approval of the manuscript, and integrity of any part of the work are appropriately investigated and resolved.
Nadeem I: Design of the work, manuscript drafting, and all integrity issues related to the work are investigated and resolved appropriately.

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