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Review Article

ROLE OF THE MENTAL IMAGERY ON UPPER EXTREMITY FUNCTIONAL RECOVERY IN PATIENTS WITH STROKE

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A R T I C L E   I N F O

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A B S T R A C T

Background: Mental Imagery referes to the cognitive process through which the mental reresentation of an action is activated. It represents "motor activation without execution". **Objective:** To determine the effect of mental imagery on UE function in stroke patients based on reviewing evidences. **Method:** Systematic review of the previous studies were conducted and electronic databases were searched by using MEDLINE, Pubmed, PEDRro scale, CINAHL for the years 2000 to 2017, studies were rated for level of Evidence, scored according to PEDro and summarized study elements. **Results:** Studies differed with respect to design, patient characteristics, intervention protocols, and outcome measures. The length of the interventions and number of practice hours varied. Results suggest that mental imagery combined with physical practice improves UE recovery. **Conclusion:** The mental imagery has positive effect on the upper extremity function in stroke patients. Although general guidelines for the clinical use of mental imagery is difficult to make, Future research should explore the dosage, factors affecting the use of mental imagery and most effective mode of delivery.

INTRODUCTION

Global Burden of Disease study estimated the prevalence of stroke in India is projected to increase to 91/ 100,000 in 2015 and to 98/100,000 in 2030.Each year, approximately 5,00,000 people have a first or subsequent stroke. Upper-limb hemiparesis (ULH) is one of the most debilitating effects of stroke, and it is the primary impairment underlying functional disability following stroke (Carr J *et al*, 1998; Trombley CA,1995; O'Sullivan SB,1994).

Anintensive stroke rehabilitation program is beneficial in improving activities of daily living in patients with stroke (Cifu DX *et al*, 1999). Different approaches are used in this field of rehabilitation. One of them takes the form of neurologic facilitation interventions, which are designed to bring about changes in the underlying neural structures affected by stroke, such as neurodevelopmental treatment (Bobath B.,1987), motor relearning approach (Carr J *et al*,1998), and, constraint-induced movement therapy (Page SJ *et al*s, 2001). Another category is the compensatory approach, which aims at substituting the deficits with preserved functions and involves the use of compensatory strategies, such as the one-handed technique and adaptive aids (Liu KP., 2002; Edmans JA *et al*, 2000). These approaches are common in that they involve different extents of relearning of the lost functions.

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Mental Imagery (MI) is a non-invasive cognitive technique in which physical tasks and/or scenarios are mentally rehearsed, usually without voluntary physical movements. The same musculature is activated during MI as during physical practice of the same task (Lafleur MF *et al*, 2002; Lacourse MG *et al*, 2004).

Mental imagery corresponds to a dynamic state during which the representation of a specific action is internally reactivated within working memory without any overt motor output (Corina *et al*, 2009). Why does mental practice work? Simulation Theory, elaborated by Jeannerod (2001), suggests that actions have a covert stage. This covert stage is a representation of the action, which includes the purpose of the action, the information needed to produce it, and the possible outcomes. The theory suggests that similarities exist in terms of neural activity between the state in which an action is simulated and the state of execution and that this similarity results in the benefits seen in mental practice (Jeannerod, 2001).

Additional evidence for a similarity between the two comes from literature that has shown that physiological correlation for imagined and executed actions are comparable. When people engage in mental practice, changes in vegetative functions (Decety *et al*, 1991; Livesay *et al*, 1998), muscle activity (Guillot *et al*., 2007; Livesay *et al*, 1998), and muscle strength (Fontani *et al*., 2007; Sidaway *et al*, 2005;) occur in a fashion comparable to that seen during physical activity. Perhaps the most convincing line of evidence comes from studies investigating the neural correlates of imagined and executed actions in healthy people. Studies using positronemission tomography (Lafleur *et al*., 2002; Stephan *et al*., 1995), functional magnetic resonance imaging (Ehrsson *et al*, 2003; Gerardin *et al*., 2000; Michelon *et al*, 2006; Porro *et al*., 1996) and transcranial magnetic stimulation (Pascual-Leone *et al*., 1995) have all revealed commonalities in the neural substrate governing imagined and executed actions.

Need of the study

Several review articles examining the impact of mental imagery have been published. Two reviews (Braun *et al*, 2006; Zimmermann-Schlatter *et al*, 2008) examined stroke outcomes in general and did not limit their review to upper-extremity–focused outcomes. Both articles included studies that were published in 2005 or earlier. Additional reviews focused on upper-extremity outcomes from studies published in2006 or earlier (Sharma *et al*., 2006) 2017 or earlier (Aditi Chaturvedi; 2017); those reviews, however, did not attempt to rate the studies reviewed in terms of Pedro Rating Scale they provided. Thus, in this review, it was determined whether mental imagery is an effective intervention strategy to remediate impairments and improve upper-limb function after stroke by examining and rating the current evidence and Pedro Rating.

METHODOLOGY

Sources

Literature search was carried out in the databases including Science Direct, Medline, PubMed, the Cochrane Database, PEDro Scale, CINAHL from 2000 to 2017. In addition, bibliography of theobtained articles have been searched manually. Search terms included mental imagery, mental practice, motor imagery, stroke, Upper extremity function, functional training, hemiplegic, rehabilitation, dexterity, arm, and hand function. The search was limited to journals published in English.

Study selection criteria

All levels of evidence were considered for this review, from Level I (randomized controlled trials, or RCTs) to Level V (case reports). Published and completed studies were included in this review if they met the following criteria:

- Articles published in time period between 2000 to 2017.
- The participant's primary diagnosis was a stroke, Studies involving adults (age ≥ 18 years) at all stages of stroke with no restrictions applied on the type or localisation.
- Mental practice was used as part of the intervention plan either in isolation or in conjunction with other therapies
- Mental practice was used to reduce upper-extremity impairment or improve upper extremity function.

Exclusion Criteria

- Duplicate studies as well as theses and articles where the full text was unavailable were excluded.
- Other studies excluded were those involving nonstroke participants as well as focusing on lower extemity function.

Data extraction

The articles were reviewed that met the inclusion criteria and extracted the following data: study objectives, level of evidence and design, description of participants (e.g., age, time since stroke, lesion sites), intervention description, outcome measures, and dimension of the outcome measures based on the International Classification of Functioning, Disability and Health (World Health Organization, 2001). For this review, the following levels of evidence (table 1) were used:

Level I	systematic reviews, meta-analyses, RCTs
Level II	nonrandomized controlled trials, case control trials
Level III	pretest–posttest designs, cross-sectional designs
Level IV	single-subject designs, case series
Level V	case reports, narrative literature reviews

Additionally, the quality of the included studies were assessed by using the PEDro scale (partitioned; 2003). The PEDro (partitioned) ratesa study's internal validity and statistical reporting using 8-point and 2-point scales, respectively, with higher scores indicating higher quality. This scale has been found to be a reliable instrument for assessing the internal validity and statistical reporting of RCTs (Tooth *et al*., 2005).

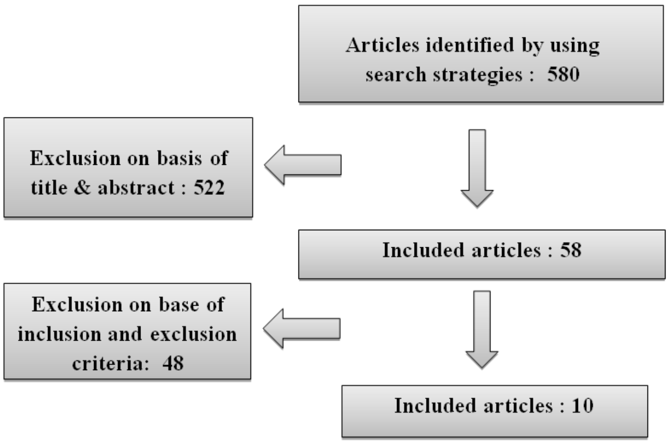

Figure 1 Flow chart.

RESULTS

580 articles were originally located using the previously mentioned key words, titles, abstracts and study selection criteria. Of those articles, 522 articles were excluded on the bases of title & abstract and 48 articles were excluded on the bases of inclusion criterias. Therefore, a total of 10 articles were reviewed and classified according to the criteria described earlier & given Pedro score. The resultsare summarized in Table2.

DISCUSSION

The studies reviewed in this study have shown that mental practice reduces impairments and improves functional recovery of the upperlimb. Thus, it appears to be an appropriate intervention strategy to be used during post stroke rehabilitation. However, the limited number of studies and small sample sizes must be noted when considering the strength of results. Moreover different evaluation methods were used in various articles and the length of the interventions and number of practice hours were also varied. Studies differed with respect to patient characteristics, intervention protocols and outcome measures.

Table 2 Summary of evidence on effect of mental imagery to improve upper extremity function in stroke survivors.

Author	Participants & Duration	Outcome measures & Method	Results	Conclusion	Evidence & score
Vikasini rokalla *et al*	60 chronic stroke survivors aged between 40-70 years, Can actively flex 10° at wrist. 30 min session 5 days/week for 4 weeks.	WMFT Audio delivered	The mental practice showed significant improvement in WMFT in stroke survivors.	Addition of mental practice to task oriented therapy is useful adjunct to improve UL functional recovery in stroke survivors.	Level I Pedro: 6/11
Thankamani Rajesh	30 Stroke survivors aged between 30 to 80 years, MMSE > 24, MIQ –RV ≥56. 28 min per session for 3 weeks	UE-MAL, SSQOL Audio & Video delivered	The MI group showed significant improvement in UE-MAL & SSQOL.	MI is effective in improving U.E. functional task performance & quality of life among stroke survivors.	Level III
Park J *et al*.	29 participants, hemiplegia forover 6 months 10 min/session, once aday, 5 times a week ,for 2 weeks	ARAT, FMA, Modified Barthel Index Audio delivered	The mental practice showed significant improvement p<0.05 in ARAT, MBI, and FMA-UE of theaffected side.	MI intervention is effective at improving stroke patient's UE function and daily activity performance	Level I Pedro: 6/11
Liu H *et al*.	20 participants, first stroke with neurological deficit in the affected UE (hand function level beyond Brunnstorm 3rd),KVIQ≥25 45 min/day, 5 days a week for 4 weeks	ARAT Video & Therapist delivered 1st person perspective	ARAT score increased, significant difference in the ARAT. P=0.04	Combining MI may be a more effective treatment strategy for improvement in Hand function	Level I Pedro: 8/11
Annick Aetal.	160 participants, first stroke with 2 to 6 weeks after stroke at inclusion, 3 times per day for 6 weeks	Fug- Meyer Test, Wolf Motor Function Test, Barthel Index, Frenchay activities Index Video (DVD) delivered 1rd person perspective	No significant difference in trainingeffects between groups wasdemonstrated.	the use of MI in addition to therapy as usual in patients with sub-acute stroke has no additional effect over Neuro developmental therapy.	Level I Pedro: 8/11
Magdalena *et al*.	135 subjects, a history of stroke 1-6 months prior to participation, ARAT score of3-51, nosevere aphasia, MMSE score of >23, KVIQ ≥ 20 45min daily/week for 5 weeks	ARAT Audio& video delivered	Patients engaging in mentalrehearsal of variety of UL movements showedenhanced motor recovery and improvement in hand function.	The idea of enhancing motor recovery through the use of MI is important with potential implications for clinical practice.	Level I Pedro: 10/11
Riccio *et al*.	Participants: 36 patients with stroke with UE hemiparesis Convention rehabilitation(3 h a day, 5 d a week) followed by 3 week of conventional therapywith additional 60 min of MP. A separate group received the same intervention in reverse order	Motricity Index (UE section), Arm Function Test–Functional Ability Scale and time Audio delivered	The conventional 1 MP group at the 3-wkcrossover point showed statistically significant improvement comparedwith the control group atthe 3-wk crossover point on all outcome measures. There were no significant differences betweengroups at the end of treatment period	These results suggest that MI could be used to complement to the conventional neuro rehabilitative treatments usually prescribed for post stroke neuromotor recovery.	Level I Pedro : 7/11
Stephen J *et al*.	Participants: 10 patients with chronic stroke (7 men). Mean age 61.4 ± 3.02 y. Age range 48–79 yAverage time after stroke 28.5 month MP (30 min/d) and mCIT or mCIT alone; both interventions 3d/week for 10 week	ARAT and FM Audio delivered 1st person perspective	mCIT 1 MP group showed significantly greater increases on the FM (7.8 vs 4.1, P =0 .01) and ARAT (15.4 vs 8.4, P<.001) immediately following and 3-months after intervention	mCIT's efficacy appears to be enhanced by use of mental practice provided directly after mCIT clinical sessions.	Level I Pedro : 7/11
Stephen J *et al*.	32 Participants, history of no more than onestroke, a score>24 on theMMSE, age >18and <80 years 30min, 2 days/ week for 6 weeks.	ARAT, FMA Audio delivered 1st person perspective	Subjects receiving MI showed significant reductions in affected hand impairment and significant increases in daily arm function. P= <0.0001	Supports the efficacy of programs incorporating MI for rehabilitating affected arm motor function.	Level I Pedro: 8/11
Page*et al*.	Eleven patients who had a stroke more than 1 yearbefore study entry and whoexhibited affected arm hemiparesis and nonuse 30-minute therapy sessions 2 days a week for 6 weeks.	The Motor Activity Log and Action Research Arm (ARA) test. Audio delivered	Affected limb use as rated by MP patients and their caregivers increased (1.55, 1.66, respectively), as did patientand caregiver ratings of quality of movement (2.33, 2.15, respectively) and ARA scores(10.7). In contrast, the controls showed nominal increases in the amount they used their affected limb and in limb function.	Participation in an MP protocol may increase a stroke patient's use of his/her more affected limb.	LevelI Pedro : 7/11

Neurorehabilitation literaturein the area of mental practice has proposed that thefirst-person perspective and kinesthetic imagery are synonymous, whereas the third-person perspective correspondsto visual imagery (de Vries *et al*, 2007). According to Stevens (2005), a motor representation contains both the kinesthetic and the biomechanical constraints associated with the action, as well as the spatial coordinates of the action. Therefore, the visual imagery modality (i.e., "seeing" your hand move) may be used to represent the spatial coordinates (i.e., distance and location), and the kinesthetic imagery modality (i.e., "feeling"your hand move) may be used to represent the biomechanical constraints (Stevens, 2005).

However, one can engage inboth imagery modalities from either perspective. For example, one may be able to "see" or "feel" one's hand moving from either point of view. The assumption that only the internal perspective is suitable for the generation questioned in the literature (Callow *et al*, 2004).

Thus, although conclusion of this review is similar with the conclusions reached by deVries *et al* (2007) regarding the need to determine the benefits of internal versus external motor imagery, we suggest that perspective (i.e., internal vs. external), modality (i.e., visual vs. kinesthetic), and the relationship between the two are separate areas needing further investigation in patient populations. Further investigation is warranted in terms of appropriate dosing, mode of presentation, the effects of visual and kinaesthetic motor imagery, and the effects of imagery perspective during mental practice. In addition, it remains to be determined whether the benefits of mental practice are retained over time and to what degree mental practice affects physical performance.

Studies differed with respect to patient characteristics, intervention protocols and outcome measures. It remains unclear what the optimal dosing is regarding the amount of Mental Practice or the ratio of Mental to Physical practice needed to obtain a positive effect. Most studies have shownthat mental practice reduces impairments and improves functional recovery of the upper limb. Future research should explore the dosage, factors affecting the use of Mental Practice, effects of Mental Therapy alone without in combination with other interventions.

Moreover, it would be of interest to determine whether onetype of instruction is more beneficial to facilitating imagery than another and to what extent imagery training before engagement in mental practice is beneficial (Hall C *et al*, 1983).

Limitations to this systematic review include limiting the search to journals published in English, the possibility of missing some studies because of combinations of search terms and terminology used in published papers, and, in general, studies with statistically significant or positive findings being more likely tobe published than trials with nonsignificant or negative findings.

CONCLUSION

The results of the studies reviewed in this study were positive indicates the potential mental practice has for the improvement of upper extremity function in stroke survivors, but general guidelines inclusive of practice hours, most effective method delivered technique and perspective are difficult to conclude and at this stage, future research should investigate them to improve upper limb function in stroke survivors.

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