

Access this article online
Quick Response Code:

Website: http://www.braincirculation.org
DOI: 10.4103/bc.bc_28_22

# Can mental practice adjunct in the recovery of motor function in the upper limbs after stroke? A systematic review and meta-analysis

Danielle Aprigio<sup>1,2</sup>, Juliana Bittencourt<sup>1,2,3</sup>, Maria Ramim<sup>2,4</sup>, Victor Marinho<sup>5</sup>, Igor Brauns<sup>3,4</sup>, Isabelle Fernandes<sup>1,2</sup>, Pedro Ribeiro<sup>2,4,6</sup>, Bruna Velasques<sup>1,2,6</sup>, Ana Catarina Alves E Silva<sup>7</sup>

<sup>1</sup>Department of Psychiatry, Neurophysiology and Neuropsychology of Attention Laboratory, Institute of Psychiatry of the Federal University of Rio de Janeiro, <sup>2</sup>Institute of Applied Neuroscience, Rio de Janeiro, <sup>3</sup>Veiga de Almeida University, Rio de Janeiro, <sup>4</sup>Department of Psychiatry, Brain Mapping and Sensory Motor Integration Laboratory, Institute of Psychiatry of the Federal University of Rio de Janeiro, <sup>5</sup>Department of Bioscience, School of Physical Education of the Federal University of Rio de Janeiro, <sup>6</sup>Department of Psychiatry, National Cancer Institute - INCA, Interdisciplinary Head and Neck Laboratory, Rio de Janeiro, <sup>7</sup>Department of Psychiatry, Neuro-Innovation Technology and Brain Mapping Laboratory, Federal University of Delta do Parnaíba, Parnaíba, Brazil

## Address for correspondence:

Dr. Victor Marinho, Danielle Aprigio, Av. Venceslau Brás, 71 Fundos - Botafogo, Rio de Janeiro, Brazil.  
E-mail: victormarinophb@hotmail.com

Submission: 30-05-2022  
Revised: 05-08-2022  
Accepted: 08-08-2022  
Published: 21-09-2022

## Abstract:

**BACKGROUND:** Studies indicate that mental practice can be an adjuvant rehabilitation, improving motor functions.

**AIM:** To synthesize the evidence on the intervention with the mental practice for the rehabilitation of the upper limb after stroke in the context of a dependent task.

**METHODS:** The review was registered on the PROSPERO with protocol number: CRD42020166624. We searched the PubMed, Medline, Embase, Central, PEDro, and Web of Science from randomized clinical trials from 1975 to 2022. A literature review was conducted with 13 studies that synthesized findings on mental practice such as adjuvant rehabilitation in the recovery of the upper limb after stroke based on Fugl-Meyer Assessment (FMA) Motor and action research arm test (ARAT) scores.

**RESULTS:** The sample size was 232 were part of the intervention group and 180 of the control group. The findings no showed results in favor of mental practice after stroke accordingly to ARAT and FMA Motor scores ( $P > 0.05$ ).

**CONCLUSION:** Current evidence does not support the use of the mental practice to increase the recovery of the upper limb after stroke, although the evidence is conflicting for some aspects of the technique.

## Keywords:

Functional performance, mental practice, motor imagery, stroke, upper extremity

## Introduction

Stroke is a common and debilitating disease, which can cause cognitive, sensory, and motor disorders or the sum of these. Stroke directly compromises physical and functional capacity, impacting the performance of activities of daily living.<sup>[1-4]</sup> Even after joining a rehabilitation program, functional limitations, or permanent disabilities remain in these subjects. Among the dysfunctions presented,

hemiplegia or hemiparesis is one of the reported motor impairments,<sup>[5]</sup> mainly the deficit of muscle strength in the upper limb.<sup>[6]</sup>

Park *et al.*<sup>[5]</sup> through a systematic review demonstrated that a range of rehabilitation strategies developed to overcome the disability observed in the paretic arm. According to the study, mental practice proves to be superior because it does not require technological apparatus, is of low cost, and is applicable to different patients. In this context, the motor recovery of

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow\_reprints@wolterskluwer.com

**How to cite this article:** Aprigio D, Bittencourt J, Ramim M, Marinho V, Brauns I, Fernandes I, *et al.* Can mental practice adjunct in the recovery of motor function in the upper limbs after stroke? A systematic review and meta-analysis. *Brain Circ* 2022;8:146-58.

patients is a priority in the physical rehabilitation program.

The mental practice with the use of motor images for stroke patients is a promising technique for acquiring motor skills.<sup>[2]</sup> Thus, the cognitive rehearsal of movement consists of a training method in which the internal reproduction of a given event is repeated extensively for new skill learning or retrieving a lost skill.<sup>[7,8]</sup> In this light, the MP presents the possibility of using motor images training as a resource to adjuvant rehabilitation in the recovery of the upper limb after stroke, through cortical adaptation and compensatory neurotransmission effects.<sup>[6]</sup> The recovery is due to the triggering of neural processes, with activation of brain areas (frontal cortex, premotor and primary motor, cerebellum, putamen, lower frontal gyrus, and supplementary motor area) similar to those activated during the planning and execution of the movement.<sup>[2]</sup> Our hypothesis predicts that central nervous system reorganization depends on the task and timing of the training, enabling learning from experience and recurrence.<sup>[9,10]</sup> This would point to a temporal integration mechanism, resulting from the dynamics of loops and synchronization of neural impulses depending on the activated during the motor planning.

O'Shea and Moran<sup>[11]</sup> showed evidence by Simulation Theory, which the actions performed share the same neural substrates involved in the intended and imagined actions.<sup>[2,12]</sup> Thus, patients who suffered a stroke, unable to move their limbs, can stimulate brain regions responsible for the movement performed, using only mental images. Training with mental simulation in subjects with stroke can increase the upper limb's functional performance and optimize the relearned motor.<sup>[2,6,7,13]</sup> However, the rehabilitation programs remain unclear about the patient's characteristics who would benefit from such training and issues involving the mental technique's temporal parameters.

Therefore, the research question for this systematic review was: In people with stroke, can mental practice improve the rehabilitation of the upper limb in the context of a dependent task when compared with control conditions, when compared with other interventions and when used as an adjunct to other treatments? We used the terms mental practice and physical practice in this study, where the mental practice is meant (mental simulation or motor imagery exercises directed to a specific task context) and physical practice (conventional physiotherapy or occupational therapy rehabilitation exercises). As motor recovery after stroke is a primary concern of patients and health professionals, this review aimed to synthesize evidence available in studies on the effect of mental practice on motor recovery of the upper limb after a stroke.

## Methods

The systematic review was conducted in line with the preferred reporting items for systematic reviews and meta-analyses statements for the main items reported in systematic reviews and meta-analyses.<sup>[14]</sup>

### Protocol and registration

The study protocol was submitted to the International Prospective Registry of Systematic Reviews (PROSPERO), approved under the title Task-oriented mental practice to recover upper limb function in Stroke (CRD42020166624).

### Information sources

Six databases were searched for eligible trials without language restriction from inception until June 2021, and repeated in August 2022 (1975–2022): PubMed, Medline, Embase, Central, PEDro, and Web of Science. Manual searches were conducted of the reference lists of prior systematic reviews on this topic and any trials included in the present review. Clinical trial records databases were also searched.

We used the following descriptors Medical Subjects Headings and synonyms used within the search area: stroke, motor imagery, mental practice, mental simulation, functional performance, and upper limb. The keywords were combined using the Boolean operators AND and OR. The search engine was recognized for each database, and we used combinations of descriptors and their respective synonyms. The detailed search strategies are described in Table 1.

To avoid publication bias and reduce positive bias, all types of gray literature, such as conference studies, thesis, and dissertation studies, which met the eligibility criteria, were analyzed for possible inclusion in this review.

Two independent reviewers independently screened all titles and abstracts retrieved by the searches to identify potentially eligible trials. Any record that was judged potentially eligible by at least one of the reviewers was retrieved in full text and assessed by both reviewers against the eligibility criteria. A third reviewer resolved any disagreements. All researchers have expertise in rehabilitation in neurological diseases, neuroscience, and behavior.

### Studies selection

#### *Inclusion criteria*

Studies were considered eligible for inclusion if they related to cross-cultural adaptation in a specific language and were published as a full manuscript in a peer-reviewed journal. There were no language

**Table 1: Search strategy in databases**

**Search strategy**

Combination of specific MeSH descriptors in the search for subjects with the use “entry terms”

*Population:* (Stroke) [Mesh] OR (Strokes) OR (Cerebrovascular Accident) OR (Cerebrovascular Accidents) OR (CVA (Cerebrovascular Accident)) OR (CVAs (Cerebrovascular Accident)) OR (Cerebrovascular Apoplexy) OR (Apoplexy, Cerebrovascular) OR (Vascular Accident, Brain) OR (Brain Vascular Accident) OR (Brain Vascular Accidents) OR (Vascular Accidents, Brain) OR (Cerebrovascular Stroke) OR (Cerebrovascular Strokes) OR (Stroke, Cerebrovascular) OR (Strokes, Cerebrovascular) OR (Apoplexy) OR (Cerebral Stroke) OR (Cerebral Strokes) OR (Stroke, Cerebral) OR (Strokes, Cerebral) OR (Stroke, Acute) OR (Acute Stroke) OR (Acute Strokes) OR (Strokes, Acute) OR (Cerebrovascular Accident, Acute) OR (Acute Cerebrovascular Accident) OR (Acute Cerebrovascular Accidents) OR (Cerebrovascular Accidents, Acute)

**AND**

*Intervention:* (Motor Imagery) OR (Motor Imagery Training) OR (Mental Practice) OR (Mental Simulation) OR (Imagery (Psychotherapy)) OR (Kinesthetic Imagery) OR (Visual Imagery) OR (Motor Imagery Protocols) OR (Functional task-oriented) OR (Physical therapy) OR (Modalities, Physical Therapy) OR (Neurological Physiotherapy) OR (Physiotherapy, Neurological) OR (Rehabilitation) OR (Stroke Rehabilitation)

**AND**

*Comparison:* (Control Groups) [Mesh] OR (Control Group) OR (Group, Control) OR (Groups, Control)

**AND**

*Outcomes:* (Functional Performance, Physical) OR (Functional Performances, Physical) OR (Performance, Physical Functional) OR (Performances, Physical Functional) OR (Physical Functional Performances) OR (Functional Performance) OR (Functional Performances) OR (Performance, Functional (Performances, Functional)) OR (Physical Performance) OR (Performance, Physical) OR (Performances, Physical) OR (Physical Performances) OR (Extremities, Upper) OR (Upper Extremities) OR (Membrum superius) OR (Upper Limb) OR (Limb, Upper) OR (Limbs, Upper) OR (Upper Limbs) OR (Extremity, Upper)

**AND**

*Randomized filters:* (randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR (“clinical trial”[tw] OR ((singl\*[tw] OR doubl\*[tw] OR trebl\*[tw] OR tripl\*[tw]) AND (mask\*[tw] OR blind\*[tw])) OR (“latin square”[tw] OR placebos[mh] OR placebo\*[tw] OR random\*[tw] OR research design[mh: noexp] OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control\*[tw] OR prospectiv\*[tw] OR volunteer\*[tw]) NOT (animal[mh] NOT human[mh]))

restrictions and all nonEnglish papers were translated by accredited professionals or native speakers.

1. Randomized clinical trials with mental practice training for the upper limb, considering only the target population, adult subjects, for the study
2. Randomized clinical trials for intervention, when compared with control conditions, when compared with other interventions, and when used as an adjunct to other treatments

3. Intervention studies with outcomes related to improved motor performance and functional gain in the upper limb.

*Exclusion criteria*

1. Intervention studies with mental practice associated with the observation of the action of the upper limb or with the imagination of the movement-oriented by an auditory, olfactory stimulus, or static images
2. Mental practice guided by virtual reality
3. Mental practice guided by neurofeedback
4. Experiments with a sample of children and adolescents under 18 years of age.

After selecting potentially eligible articles, they were read in full by the evaluators to determine the manuscript’s eligibility. The data extracted from the articles for the characterization of the studies included: the first author and year of publication, studied population (the type of stroke), intervention protocol, intervention for the experimental group, and control group [Table 2]. Table 2 summarizes information on outcome tests, preintervention, postintervention, and conclusion results.

**Types of participants**

Participants were not excluded by gender. The sample size was 232 were part of the intervention group and 180 of the control group. With a higher prevalence for males and elderly, the age group from 18 to 95 years old, with stroke patients diagnosed: whether ischemic or hemorrhagic stroke. Trials that presented a mixed sample (acute/subacute and chronic together) were included only when the data were presented separately. Moreover, we excluded trials in which the participants presented comorbidities.

**Types of interventions**

Trials were only included if they estimated the effects of any type of experimental groups receiving the intervention with MP, with treatment protocols that varied between studies, with sessions distributed between 3 and 6 weeks, with an average of 13.4 (±1.5) sessions.

The eligible comparators are listed: (1) Comparisons between intervention and control for mental practice with videos-DVDs, and photos and/or images. (2) Mental practice from the perspective of the first person, third person, or combination of the first and third. (3) Comparisons between intervention and control for mental practice with motor imagery.

**Types of outcomes measures**

The primary outcomes were: Fugl-Meyer Assessment (FMA) Motor and action research arm test (ARAT)

**Table 2: Summary of the characteristics of the studies included in the systematic review**

Author/Year	Country	Stroke type	Age	Intervention EG	Frequency of intervention (EG)	Intervention CG	Frequency of intervention (CG)
Dijkerman et al., 2004	Scotland	Chronic	64±9	EG (n=10): PP + MP reach-to-grasp task	Daily, during 4 week. MP (3 <sup>rd</sup> person perspective)	CG 1 (n=5): PP reach-to-grasp task + MP nonmotor exercises CG 2 (n=5): PP reach-to-grasp task	Daily, during 4 week, MP (3 <sup>rd</sup> person perspective)
Nilsen et al., 2012	United States	Subacute	28–77	EG 1 (n=6): PP+MP (1 <sup>st</sup> person perspective) EG 2 (n=7): PP+MP (3 <sup>rd</sup> person perspective)	PP 2x/week, 30 min, 6 weeks	CG (n=6): PP + MP with images of relaxation	PP 2x/week, 30 min, 6 weeks
Timmermans et al., 2013	Netherlands <sup>a</sup>	Subacute	EG: 59.7±7.3 CC: 58.7±9.6	EG (n=21): PP+MP (1 <sup>st</sup> person perspective)	PP + MP 6 weeks, 3x/day	CG (n=21): PP + bimanual exercises + Bobath	PP training during 6 weeks, 3x/day
Oh et al., 2006	South Korea	Subacute	57.9±15.47	EG (n=5): MP of functional tasks + PP isolated	MP (initial three weeks) 3x/week, 20 min PP (final three weeks) 5x/weeks, 30 min, 6 weeks	CG (n=5): PP isolated + MP of functional tasks	PP isolated (initial three weeks) 5x/week, 30 min + MP (final three weeks) 3x/week, 20 min
Page 2005	United States	Chronic	62.3±5.1	EG (n=6): PP + MP-ADLs	PP 2x/week, 30 min + MP daily in 6 weeks.	CG (n=5): PP-ADLs + Relaxation techniques	PP 2x/week, 30 min
Park et al., 2015	South Korea	Chronic	EG: 60±10.9 CG: 58±11.7	EG (n=14): MP+ PP	MP 10 min/day, 5x/week in 2 weeks +PP 20 min	CG (n=15): PP	PP 30 min/day, 5x/week in 2 weeks
Page et al., 2000	United States	Chronic	63.2±4	EG (n=8): PP+MP	PP+MP 1h, 3x/week in 4 weeks	CG (n=8): PP	PP 1 h, 3x/week in 4 weeks
Liu et al., 2004	China	Chronic	EG: 71.0±6.0 CG: 72.7±9.4	EG (n=26): PP+MP	PP 1 h, 5x/week, 15 sessions+MP 1 h/day in 3 weeks	CG (n=20): PP	PP 1 h, 5x/week, 15 sessions in 3 weeks
Page et al., 2007	United States	Chronic	EG: 58.7±12.9 CG: 60.4±14.2	EG (n=16): PP-ADLs+MP	PP 30 min. 2x/week in 6 weeks+MP 30 min daily (1 <sup>st</sup> person perspective)	CG (n=16): PP-ADLs + MP with images of relaxation	PP 30 min, 2x/week, in 6 weeks
Riccio et al., 2010	Italy	Acute	60.38±14.2	EG (n=18): PP+MP	PP 3 h/day, 5x/week in, 3 weeks + MP por 1 h, 3 weeks	CG (n=18): MP + PP	MP (initial 3 weeks) + PP (final 3 weeks)
Letswaart et al., 2011	England <sup>a</sup>	Subacute	EG 1: 69.3±10.8 EG 2: 68.6±16.3 CG: 64.4±15.9	EG 1 (n=39): MP EG 2 (n=31): MP não motora com a mesma intensidade	MP 45 min, 3x/week, in 4 weeks and independent sessions 2x/week, 30 min (1 <sup>st</sup> person perspective for EG1)	CG (n=32): PP without additional training	MP 45 min, 3x/week in 4 weeks and independent sessions 30 min, 2x/week
Grabherr et al., 2015	Switzerland	Chronic	EG: 61.3±15.3 CG: 68.9±14.7	GE (n=13): MP	MP 6 sessions, 30 min (1 <sup>st</sup> person perspective)	CG (n=12): PP	PP 6 sessions in 30 min
Kim and Lee, 2015	South Korea	Chronic	EG: 64.2 CG: 59.4	EG (n=12): PP+MP	PP 30 min, 5x/week in 4 weeks+MP 30 min, 3x/week in 4 weeks (1 <sup>st</sup> and 3 <sup>rd</sup> person perspective)	CG (n=12): PP	PP 30 min, 5x/week in 4 weeks

<sup>a</sup>Multicenter clinical trials. MP: Mental practice, PP: Physical practice, CG: Control Group, EG: Experimental Group, ADLs: Activities of daily living

scores. These outcomes reflect the most recent core outcome set for people with stroke. However, we summarize all the outcomes used in the included studies [Table 3].

### Assessment of characteristics of the studies

Two reviewers independently extracted the following data from the included trials: bibliometric data, sample size, characteristics of the participants (age, gender, the type of stroke), and details of the interventions, outcome measures, and results. A third reviewer resolved any disagreements. When necessary, the authors of the included trials were contacted to provide additional information or trial data. Table 2 summarizes information on outcome tests, preintervention, postintervention, and conclusion results.

### Risk of bias

The risk of bias in the included trials was rated using RoB 2, which also rates the completeness of statistical reporting. We followed the Cochrane Collaboration's current recommendation to select studies' methodological quality.

Two independent reviewers evaluated any included trial with the RoB 2. This tool uses a domain-based assessment, composed of two parts, containing seven domains, named: generation of random sequence, concealment of allocation, blinding of participants and professionals, blinding of outcome evaluators, incomplete outcomes, selective outcome reporting, and other sources of bias. The first part refers to describing what was reported in the study being evaluated in sufficient detail for the judgment to be made based on this information. The second part is the judgment on the risk of bias for each of the domains analyzed, classified into three categories: low risk of bias, high risk of bias, or risk of uncertain bias.<sup>[15]</sup>

### Data analysis

Quantitative analysis (meta-analysis) was performed using the random-effects model for studies with available raw data. Studies that included research questions, interventions, assessment instruments, and the population of similar participants were included so that a combined estimate would be meaningful. The STATA 14.0 program (Stata Corporation, College Station, TX, USA) was used to compare the means and differences of means between groups (experimental group and control group) before and after the interventions employed, with the obtaining of forest plot graph and combined measure.

Heterogeneity was assessed using the statistical estimates of the Chi-square test and the  $I^2$  index. The presence of between-trial statistical heterogeneity was assessed using

the  $I^2$  statistic. The quality of evidence was downgraded for inconsistency if considerable between-group statistical heterogeneity ( $I^2$ : 50%) was detected.

The outcome considered in this review was the recovery of the upper limb's function associated with mental practice. We extracted the following information from the studies for the meta-analysis: (1) sample size, mean, and standard deviation from the baseline and the evaluation after the intervention, (2) the countries of the study, (3) the instruments used to measure the outcome, (4) the number and duration of the rehabilitation sessions, and (5) the year of publication.

Given the diversity of instruments used by the selected studies, the meta-analysis was conducted considering the most used instruments among most studies with available results (10 studies). The effect size was calculated by the difference between the simple average and its respective confidence intervals (CI 95%), appropriate when all the analysis studies used the same scale.

## Results

### Flow of studies through the review

The initial electronic database search identified a total of 7,059 records. Of these, 1,508 duplicate articles and 5,522 according to the eligibility criteria were excluded from the study. Of the 27 records of revised full texts, 14 articles were considered ineligible, justified by: inadequate clinical trial record ( $n = 03$ ); outcome of interest ( $n = 03$ ); type of study ( $n = 04$ ); and articles unavailable in full text, with no return from the authors ( $n = 04$ ). Finally, 13 articles were included for qualitative analysis; of these, 5 were eligible for meta-analysis [Figure 1].

### Characteristics of the included studies

#### Risk of bias

The results of the risk of bias assessment are presented in Figures 2 and 3. The figures showed the methodological quality of the included studies. Of the 13 final studies, 12 show the subjects' random sequence; five describe the allocation concealment methods. The blinding of participants and professionals was adopted in three studies. Seven studies report blinding outcome evaluators. The 13 studies described the results adequately for each primary outcome, including losses and exclusion from analysis. However, only five studies presented sufficient data for inclusion in the meta-analysis. As for the reporting of selective outcomes, two studies presented insufficient information to allow judgment. Other types of bias are found in three of the studies analyzed: selection, performance, and reporting biases. Besides, it is noteworthy that only five studies presented sufficient information for inclusion in the meta-analysis.

**Table 3: Description of the outcomes of the summarized studies**

Author/Year	Outcome tests	Preresults	Postresults	Conclusions		
Dijkerman <i>et al.</i> , 2004	TOEA, RLOC, HADS, BI, FLP	TOEA	CG=12.9 (3.4) EG=12.4 (4.7)	TOEA	CG=14.2 (2.9) EG=13.6 (3.7)	Improvement of motor performance in all groups. Unattended MP at home can improve performance only on the trained task. The relationship between PM, attention and perceived personal control over recovery remained uncertain
		RLOC	CG=35.4 (2.7) EG=36.7 (5.4)	RLOC	CG=35.3 (3.3) EG=35.8 (4.3)	
		HADS	CG=13.9 (7.8) EG=17.0 (5.3)	HADS	CG=13.8 (6.8) EG=16.2 (3.9)	
		BI	CG=95.6 (9.8) EG=95.6 (6.4)	BI	CG=95.6 (9.8) EG=95.6 (6.4)	
		FLP	CG=53.4 (11.8) EG=52.8 (14.9)	FLP	CG=57.2 (8.4) EG=50.0 (13.7)	
Nilsen <i>et al.</i> , 2012	FMA, JTTHF, COPM	FMA	CG=38.2 (4.3) EG 1=41.8 (3.6) EG 2=35.7 (5.6)		The MP combined with the PP improves the recovery of the ES after the Stroke. MP does not seem to improve self-perceived performance	
		JTTHF	CG=344.8 (135.9) EG 1=249.9 (113.2) EG 2=542.7 (131.4)			
		COPM	CG=16.2 (2.3) EG 1=15.8 (4.8) EG 2=19.7 (3.9)			
Timmermans <i>et al.</i> , 2013	BI, FAI, FMA, FAT, WMFT, grip force	FMA	CG=45.4 (15.6) EG=41.6 (17.4)		The results do not support the hypothesis that the use of MP has an additional effect on functional gains, in addition to conventional therapy	
		BI	CG=74.4 (17.8) EG=70.3 (15.7)			
		FAI	CG=56.0 (2.2) EG=56.8 (2.6)			
		FAT	CG=3.7 (1.7) EG=3.1 (1.8)			
		WMFT	CG=3.1 (1.2) EG=3.0 (1.2)			
		Grip force	CG=14.5 (11.4) EG=14.5 (13.1)			
Oh <i>et al.</i> , 2006	3D movement analysis, FMA-UE, MAL-AOU, MAL-QOM				MP as adjuvant therapy had no significant effect on the function of the ES after a stroke	
Page 2005 <sup>a</sup>	MAL, ARAT	MAL	1.05	MAL	1.15	MP rehabilitation programs can increase the function of the affected ES after stroke
		ARAT	GC (T1)=33.6 (1.7) GC (T2)=34.6 (1.8) EG (T1)=34.0 (2.2) EG (T2)=32.2 (5.3)	ARAT	CG=38.7 (1.2) EG=43.8 (3.1)	
Park <i>et al.</i> , 2015	ARAT, FMA, MBI	FMA	EG=42.0 (7.5) GC=50.8 (10.3)	FMA	EG=46.5 (8.1) GC=50.7 (10.1)	MP intervention is effective for improving ES function and performance in ADLs after stroke
		ARAT	GC=49.1 (9.9) EG=48.7 (9.5)	ARAT	GC=49.0 (9.9) EG=51.5 (9.0)	
		MBI	GC=66.2 (12.7) EG=71.3 (12.6)	MBI	GC=66.2 (12.6) EG=72.7 (12.4)	
Page <i>et al.</i> , 2000	FMA	FMA	GC=22.23 (4.4) EG=22.13 (3.4)	FMA	GC=26.89 (5.4) EG=29.97 (4.1)	MP can be an important resource associated with PP in the recovery of ES
aLiu <i>et al.</i> , 2004 <sup>b</sup>	Trained and untrained tasks, FMA, CTT	Trained tasks	GC (T1)=5.4 (0.8) GC (T2)=4.7 (0.7) GC (T3)=3.9 (1.1) EG (T1)=5.1 (1.1) EG (T2)=4.4 (0.7) EG (T3)=3.8 (1.2)	Trained tasks	GC (T1)=5.8 (0.5) GC (T2)=5.0 (0.6) GC (T3)=4.0 (0.9) EG (T1)=6.5 (0.8) EG (T2)=6.2 (0.7) EG (T3)=5.3 (1.0)	The MP can be used to promote the relearning of daily tasks after acute Stroke and favors the planning and motor execution of the tasks
			Untrained tasks		GC=3.8 (0.9) EG=5.1 (1.3)	

*Contd...*

**Table 3: Contd...**

Author/Year	Outcome tests	Preresults	Postresults	Conclusions
Page <i>et al.</i> , 2007	ARAT, FMA	FMA GC=35.7 (9.5) EG=33.0 (8.4) ARAT GC=17.2 (14.3) EG=18.0 (11.0)	FMA GC=36.7 (10.7) EG=39.7 (6.9) ARAT GC=17.7 (13.7) EG=25.8 (11.3)	The effectiveness of programs that incorporate MP to rehabilitate the affected ES in patients with chronic stroke indicated clinically significant changes
Riccio <i>et al.</i> , 2010 <sup>c</sup>	MI-UE, WMFT, AFT-FAS, AFT-T	AFT-T GC (T0)=48.9 (13.3) EG (T0)=49.2 (13.1)	AFT-T GC (T1)=48.2 (13.3) EG (T1)=34.6 (8.9) GC (T2)=34.1 (9.0) EG (T2)=33.8 (8.9)	The MP can be used to promote the relearning of daily tasks after acute Stroke and favors the planning and motor execution of the tasks
Letswaart <i>et al.</i> , 2011	ARAT, grip strength, hand function, BI, functional limitations profile	ARAT CG=23.1 (17.7) EG 1=25.6 (18.1) EG 2=26.2 (17.9) Grip strength CG=25.1 (28.0) EG 1=32.6 (34.2) EG 2=27.9 (29.9) Hand function CG=124.0 (52.3) EG1=121.5 (53.3) EG2=109.3 (54.2) BI CG=12.28 (5.41) EG1=13.08 (4.81) EG2=14.87 (4.33) Functional limitations profile GC=62.5 (14.3) EG 1=58.4 (15.0) EG 2=64.2 (14.0)	ARAT CG=30.4 (20.5) EG 1=31.5 (20.7) EG 2=32.9 (20.8) Grip strength CG=34.3 (33.8) EG=38.1 (36.1) EG 2=34.5 (34.8) Hand function CG=107.3 (56.2) EG 1=104.4 (55.9) EG 2=95.7 (57.6) BI CG=14.9 (4.8) EG 1=16.2 (4.1) EG 2=16.8 (3.7) Functional limitations profile CG=53.5 (18.7) EG 1=50.3 (18.8) EG 2=55.4 (15.8)	MP does not favor motor recovery right after stroke. Is MP a valid rehabilitation technique in its own right?
Grabherr <i>et al.</i> , 2015	Task-recognition Task-movement			It provides evidence for the benefit of MP training in patients with hemiparesis and suggests the integration of cognitive training in conventional physical therapy practice
Kim and Lee, 2015	FMA, WMFT	FMA CG=28.6 (5.0) EG=27.9 (7.6) WMFT CG=35.1 (25.2) EG=44.7 (21.9)	FMA CG=31.0 (5.3) EG=36.1 (9.9) WMFT CG=40.2 (25.3) EG=51.0 (21.6)	The MP positively influences the performance of the ES improving mobility during the rehabilitation of the stroke

<sup>a</sup>First week (T1), after 6 weeks (T2), <sup>b</sup>1 week (T1), 2 weeks (T2) and 3 weeks (T3), <sup>c</sup>Baseline (T0); after 3 weeks (T1); after 6 weeks (T2). CG: Control Group, EG: Experimental Group, MP: Mental practice, PP: Physical practice, ES: Upper Extremity, ADLs: Activities of daily living, RLOC: Recovery Locus of Control Scale, TOEA: Test of Everyday Attention, HADS: Hospital Anxiety and Depression Scale, BI: Barthel Index, FLP: Modified functional limitations profile, FMA: Fugl-Meyer motor assessment, JTTHF: Jebsen-Taylor Test of Hand Function, COPM: Canadian Occupational Performance Measure, FAI: French Activities Index, FAT: Frenchay Arm Test, WMFT: Wolf Motor Function Test, FMA-UE: Fugl-Meyer Assessment of the Upper Extremity, MAL: Motor Activity Log, MAL-AOU: MALs For Amount of Use, MAL-QOM: MAL Quality of Movement, ARAT: Action Research Arm Test, MBI: Modified Bathel Index, CTT: Color Trails Test, MI-UE: Motricity Index Upper Extremity, AFT-FAS: Arm Functional Teste – Functional Ability Scale, AFT-T: Arm Functional Teste – Time, 3D: Three-dimensional, GC: Group control, PM: Performance measure

### Sample

The weighted effect was analyzed for 232 individuals part of the intervention group and 180 of the control group. With a higher prevalence for males and elderly, age group from 18 to 95 years old. The studies by Oh *et al.*,<sup>[16]</sup> Riccio *et al.*,<sup>[17]</sup> Page *et al.*,<sup>[18]</sup> and Grabherr *et al.*<sup>[19]</sup> characterized the participants regarding the diagnosis of stroke, whether ischemic or hemorrhagic stroke.

As for the lesion location, Page *et al.*<sup>[18]</sup> and Letswaart *et al.*<sup>[20]</sup> characterize the sample in cortical, subcortical, or mixed strokes. The studies by Dijkerman *et al.*,<sup>[6]</sup> Oh *et al.*,<sup>[16]</sup> Page *et al.*,<sup>[21]</sup> Park *et al.*,<sup>[3]</sup> Riccio *et al.*,<sup>[17]</sup> Letswaart *et al.*,<sup>[20]</sup> Page *et al.*,<sup>[18]</sup> Grabherr *et al.*,<sup>[19]</sup> and Kim and Lee,<sup>[22]</sup> refer to the affected hemisphere or pointing the hemiplegia being right or left. Only

Riccio *et al.*<sup>[17]</sup> recruited participants with acute stroke; four studies recruited participants with subacute stroke,<sup>[2,16,20,23]</sup> and the remaining eight studies included participants with chronic stroke.<sup>[3,6,18,19,21,22,24,25]</sup> The period between the stroke diagnosis and the recruitment of study participants ranged from 2 weeks to 14.5 years.

### The country of the study

A detailed description of the countries of the trials demonstrated 13 studies included comprised subjects with a diagnosis of stroke, performed in several countries.

The list of the countries: Scotland;<sup>[6]</sup> the United States;<sup>[21,23]</sup> the Netherlands;<sup>[2]</sup> South Korea;<sup>[3,16,22]</sup> China;<sup>[25,26]</sup> Switzerland;<sup>[19]</sup> Italy;<sup>[17]</sup> and England.<sup>[20]</sup>

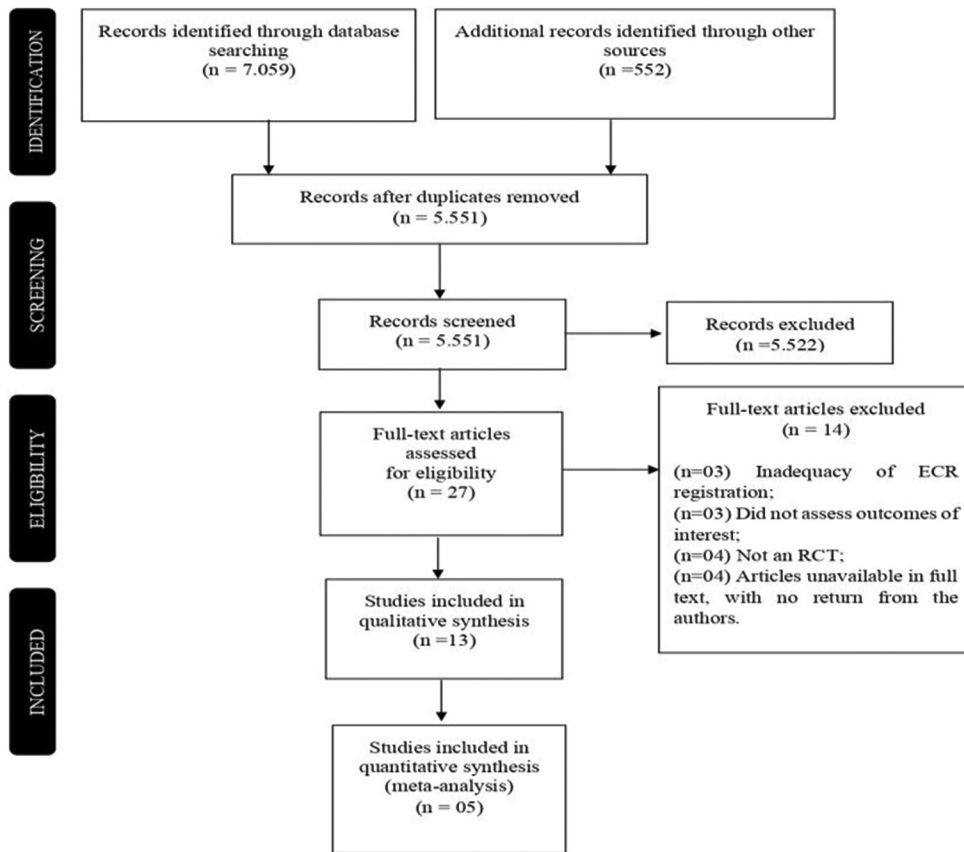


Figure 1: Flow chart for the search strategy (based on PRISMA). PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Author	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Trimmermans et al, 2013	+	+	?	+	+	+	?
Riccio et al, 2010	+	+	?	+	+	+	?
Park et al, 2015	+	+	?	+	+	+	?
Page et al, 2007	+	+	?	+	+	+	?
Page et al, 2005	+	+	+	+	+	+	?
Page, 2000	+	+	+	+	+	+	?
Oh et al, 2010	+	+	+	+	+	+	?
Nilsen et al, 2012	+	+	+	+	+	+	?
Liu et al, 2004	+	+	+	+	+	+	?
Letswaant et al, 2011	+	+	+	+	+	+	?
Kim et al, 2015	+	+	+	+	+	+	?
Grabhera et al, 2015	+	+	+	+	+	+	?
Dijkerman et al, 2004	+	+	+	+	+	+	?

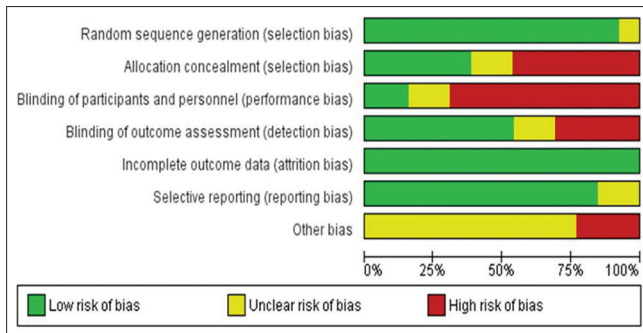
Figure 2: Risk of bias summary: review author’s judgements about each risk of bias item for each included study

Two of the studies were crossover randomized controlled trials,<sup>[16,17]</sup> and two studies were multicentric randomized clinical trials involving hospitals, rehabilitation, and home environment.<sup>[2,20]</sup> Moreover, government agencies funded three studies.<sup>[19,20,26]</sup> Table 1 shows the characterization of the studies included.

### Intervention

The experimental groups received the intervention with mental practice, with treatment protocols that varied between studies, with sessions distributed between 3 and 6 weeks, with an average of 13.4 (±1.5) sessions. The session duration with mental practice showed an average





**Figure 3:** Risk of bias graph: review authors judgements about each risk of bias item presented as percentages across all included studies

of 36.4 ( $\pm 4.7$ ) min, varying between 30 and 60 min. Only two studies<sup>[2,17]</sup> presented follow-up assessment after therapy to measure the long-term effects of the mental practice training.

Videos-DVDs,<sup>[2,25]</sup> audios,<sup>[16,17,18,20,21,23,24]</sup> and photos and/or images.<sup>[6,25]</sup>

The activities proposed to the intervention groups were MP of functional exercises of the upper limb and activities of daily living: reaching, holding, dropping a glass, drinking water, wearing a button-down shirt, hanging and folding clothes, brushing teeth, answering a phone call, handling money and medicines, opening the door, turning the page of a book, using a pencil and pen, using transport, among others. While the protocols for the control groups involved manual, bimanual, activities of daily living, neuroevolutionary activities through the Bobath method, relaxation techniques, and nonmotor exercises.

Four studies used MP from the perspective of the 1<sup>st</sup> person,<sup>[2,18-20]</sup> only one study refers to the use from the 3<sup>rd</sup> person perspective,<sup>[6]</sup> two of the studies report the use separately, or in the combination of the 1<sup>st</sup> and third.<sup>[22,23]</sup> Finally, the remaining six studies do not mention the perspective of employed motor imagery.<sup>[3,16,17,21,24,25]</sup>

Only the studies by Dijkerman *et al.*,<sup>[6]</sup> Ietswaart *et al.*,<sup>[20]</sup> Nilsen *et al.*,<sup>[23]</sup> and Timmermans *et al.*<sup>[2]</sup> demonstrated some objection or caveat regarding the use of mental practice for better performance of the paretic limb, while the other studies suggest a positive influence of training with mental practice on improving mobility and functionality of the limb after stroke.

Ietswaart *et al.*<sup>[20]</sup> and Grabherr *et al.*<sup>[19]</sup> established a mental practice protocol applied in isolation for the experimental groups. The other eleven studies used mental practice in combination with the physical practice for the group intervention. The control group exercises were applied in isolation with mental practice or physical practice and the combination of both.

### Outcome measures

We observed that eight studies used the FMA.<sup>[2,3,16,18,22-25]</sup> Nilsen *et al.*,<sup>[23]</sup> Timmermans *et al.*,<sup>[2]</sup> and Oh *et al.*<sup>[16]</sup> do not describe the averages of this scale after the intervention. The studies by Park *et al.*,<sup>[3]</sup> Page,<sup>[24]</sup> Liu *et al.*,<sup>[25]</sup> Page *et al.*,<sup>[18]</sup> and Kim and Lee<sup>[22]</sup> report the results of the FMA after the mental practice, which reflect an improvement in the motor performance of the compromised upper limb.

Four studies used the ARAT score.<sup>[3,18,20,21]</sup> Although everyone showed an increase in this measure in the experimental group, Ietswaart *et al.*<sup>[20]</sup> were the only ones to state that mental practice did not favor motor recovery.

Timmermans *et al.*,<sup>[2]</sup> and Kim and Lee<sup>[22]</sup> used the Wolf Motor Function Test. Kim and Lee<sup>[22]</sup> suggest it improved mobility and quality of movement after intervention with mental practice, evidenced by better results at the Wolf Motor Function Test. Three studies used the Barthel Index.<sup>[2,6,20]</sup> Park *et al.*<sup>[3]</sup> used the modified version of this scale, the Modified Barthel Index, except for the study by Timmermans *et al.*,<sup>[2]</sup> who claim to have found no evidence of an additional effect of mental practice on functional gains, the other studies reported an increase in the measure with improved performance for the activities of daily living. Page *et al.*<sup>[21]</sup> used the motor activity log, with an increase in the measurement after training with mental practice, reflecting in the improvement of the quantity and quality of movement in the affected limb.

Dijkerman *et al.*<sup>[6]</sup> used the recovery locus of control scale, the test of everyday attention, the hospital anxiety and depression scale, and modified functional limitations profile. The study declares improvement in motor performance; however, it suggests that recovery based on mental practice remained uncertain concerning attention and personal control. In addition to these instruments, the authors included the task of motor training, pegboard, and dynamometry.

Nilsen *et al.*<sup>[23]</sup> carried out the following tests: Jebsen-Taylor Test of Hand Function and the Canadian Occupational Performance Measure. Timmermans *et al.*<sup>[2]</sup> still used the French Activities Index and the Frenchay Arm Test in their research. Oh *et al.*<sup>[16]</sup> included in their experiment a 3D analysis of the movement, the motor activity logs for amount of use, and the quality of movement. Liu *et al.*<sup>[25]</sup> used the Color Trails Test, while Riccio *et al.*,<sup>[17]</sup> the Motricity Index, and the Arm Function Test. Grabherr *et al.*<sup>[19]</sup> considered their study a task of recognition and a specific movement, indicating mental practice evidence for hemiparesis, despite not presenting measures related to the intervention. Ietswaart *et al.*,<sup>[20]</sup> in addition to ARAT and Barthel Index, used the grip strength, hand function, and functional limitations profile, in which he

also observed better results in secondary measures at the level of activities of daily living.

*Meta-analysis of trials comparing the results for Fugl-Meyer motor assessment and action research arm test scales*

Of the seven studies that used the FMA Motor, four presented data referring to the intervention and control groups before and after the intervention,<sup>[3,18,22]</sup> enabling the meta-analysis inclusion. Four studies used the ARAT.<sup>[3,18,20,21]</sup> Of these, the study by Ietswaart *et al.*,<sup>[20]</sup> as it included participants with a subacute stroke, was not followed up for evaluation by the meta-analysis.

The quantitative analysis included 112 participants, 56 from the experimental group and 56 from the control group. We used the mean and standard deviation data before and after the training protocol to analyze the differences between groups. The findings no demonstrated significant for FMA and ARAT scores ( $P > 0.05$ ).

In relation to FMA analysis, the results showed no significance for mean difference in the Asia subgroup ( $z = 0.52$ ;  $P = 0.605$ ) and North America ( $z = 2.93$ ;  $P = 0.312$ ) [Figure 4a]. Furthermore, the results evidenced no significance for mean difference in the FMA subgroup ( $z = 1.11$ ;  $P = 0.269$ ) [Figure 4b]. However, the results showed greater heterogeneity between the studies carried out in the Asian continent ( $I^2 = 50.3\%$ ;  $P = 0.134$ ) when compared with studies carried out in the United States ( $I^2 = 28.6\%$ ;  $P = 0.241$ ). This suggests no benefit of MP in motor recovery in the experimental group when compared to the control group [Figure 4a].

The ARAT results no demonstrated significant results for intervention, with ( $z = 2.52$ ;  $P = 0.112$ ). Regarding the

heterogeneity, the studies showed greater heterogeneity for ARAT scale ( $I^2 = 55.2\%$ ;  $P = 0.107$ ) [Figure 4b].

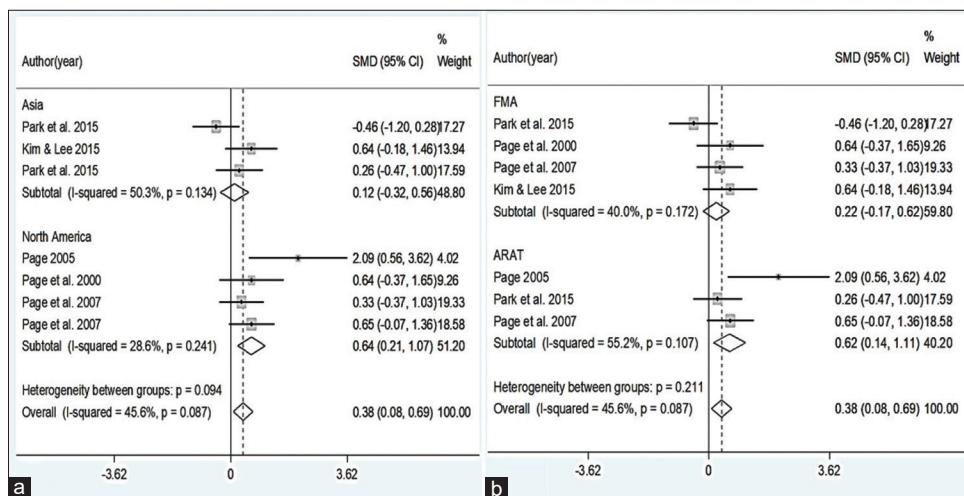
In general, the heterogeneity between the studies was not considered high, ( $I^2 = 45.6\%$ ;  $P = 0.087$ ), indicating a combined measure of mean difference between intervention and control favorable to the intervention (DM = 0.38; CI 95% = 0.08–0.69). The Egger’s test found no evidence of publication bias (coefficient = 4.76;  $P = 0.105$ ; CI 95% = -1.81–11.34).

The meta-regression for session numbers and the duration of therapy [Figure 5], evidenced both coefficients suggest a directly proportional relationship between the number of sessions and the exercise duration in minutes, with a more significant group’s difference. After intervention with mental practice. However, this difference was not statistically significant, probably limited to the number of studies included and their sample sizes.

**Discussion**

The current study aimed to synthesize available evidence from studies on the effect of mental practice on motor recovery of the upper limb after stroke. Based on the research findings analyzed, through qualitative and quantitative data, it appears that the different protocols for interventions with mental practice may confer some effect on the functionality and mobility of the paretic upper limb. However, the meta-analysis with five studies no showed results that support the relationship between the frequency and duration of rehabilitation with poststroke mental practice.

The findings reveal a wide range of mental practice protocols aimed at motor recovery of the upper limb after stroke. We observed different assessment



**Figure 4:** Differences in means between intervention and control groups for mental practice, according to the continent of the study (a) and the assessment tools (b) FMA and ARAT. Legend: SMD: Standardized mean difference, FMA: Fugl-Meyer Assessment, ARAT: Action research arm test

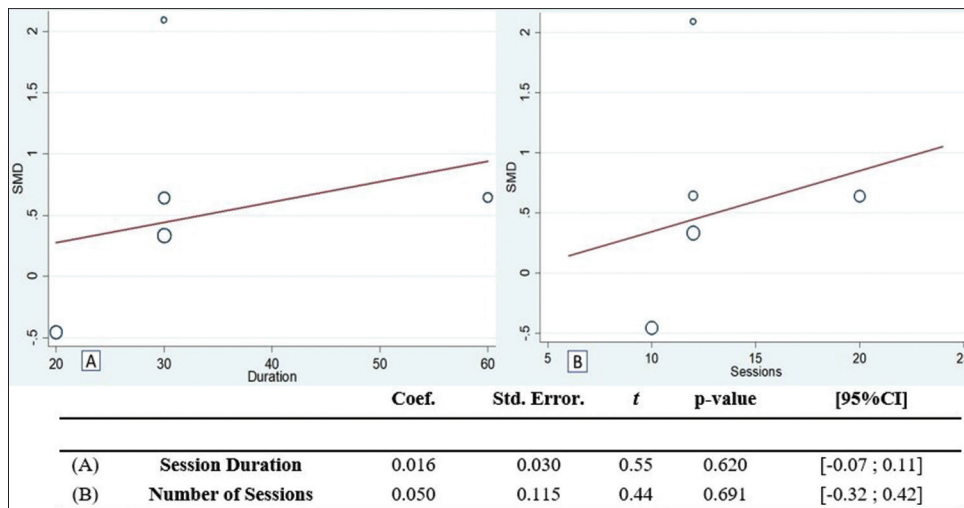


Figure 5: Adjusted meta-regression of mean differences on performance after rehabilitation with inclusion of mental practice, by duration (A) and number of sessions (B)

measures and different intervention proposals using mental practice, including participants in the disease's different stages. Regarding the protocols used, there was significant variability in terms of the tasks employed, duration and number of sessions, modality of Motricity Index used, guidance, and facilitation strategy (such as videos, audios, and images). In addition, there was a predominance of subjects in the stroke's chronic phase in the study. In previous reviews and meta-analyses, including Barclay-Goddard *et al.*,<sup>[27]</sup> Kho *et al.*,<sup>[28]</sup> and Machado *et al.*,<sup>[29]</sup> the study of participants in the chronic phase also predominated. However, studies reported positive results of the technique for the acute phase of stroke in the study by Riccio *et al.*<sup>[17]</sup> and the subacute phase by Nilsen *et al.*<sup>[23]</sup> and Oh *et al.*<sup>[16]</sup>

The weighted effect estimate included in this review no showed beneficial results of the technique and encourage the use of the mental practice as a complementary therapy to physical practice.<sup>[16-19,21,23,24]</sup> Page *et al.*<sup>[21]</sup> and Park *et al.*<sup>[3]</sup> report an improvement in motricity functionality, inferred by the better performance in the Activities of Daily Living. Kim and Lee<sup>[22]</sup> refer to the use of the mental practice in addition to gaining function and mobility and quality of movement. In comparison, Liu *et al.*<sup>[25]</sup> present mental practice as an excellent strategy within the rehabilitation program for the motor relearning of functional tasks and the generalization of this learning for untrained tasks.

Although some studies pointing out that MP is an intervention method adjuvant to physical practice and that it may offer some benefit,<sup>[3,24]</sup> such a conclusion must be taken with caution, as the evidence is contradictory.<sup>[2,20]</sup> The study by Ietswaart *et al.*<sup>[20]</sup> stands out, a carefully controlled trial, with a representative sample of subjects with stroke in the subacute phase, presenting a protocol that considered mental practice intensively and

supervised, not combined with physical practice. The authors showed no intervention effect of mental practice in rehabilitation after stroke, raising some important questions regarding the benefit of the technique in clinical practice. The effectiveness of mental practice is not independent of physical practice, thus, it is not clear the mechanisms of brain modulation and plasticity arising from the technique's applicability in isolation. They conclude that subacute stroke patients with limited cognitive resources or critical muscle weakness may not benefit from the technique. Likewise, its results refuted the study by Timmermans *et al.*<sup>[2]</sup> They conclude that mental practice combined with usual therapy in patients with subacute stroke does not affect rehabilitation.

Based on the methodological quality assessment interpretation, there was no significant difference in the studies' quality. The studies by Dijkerman *et al.*<sup>[6]</sup> and Grabherr *et al.*<sup>[19]</sup> had a comparatively lower score on the Cochrane evaluation instrument. In the studies mentioned above, inadequate procedures were observed for hiding allocation, blinding of participants, professionals, and/or uninsured evaluators, in addition to other biases. There were also flaws in the randomization of some studies, as well as incomplete blinding. Blinding prevents bias at various research stages, such as knowing the allocation influences outcome measurement (observation bias). Despite this, clinical trials are prone to bias, either due to the researchers' arbitrariness in selecting the sample and measurement of the variables analyzed or in difficulty in controlling other factors that may influence the clinical outcome.<sup>[30]</sup>

Different outcomes were presented concerning the variables analyzed, reflecting a significant variability in the studies' measures. These mostly considered the domains of body function and structure, activity, and participation, covered by the International Classification

of Functionality and Disability (ICFD).<sup>[31]</sup> Our meta-analysis selected five studies where the primary outcome measures FMA and ARAT. According to the ICFD, both instruments can be considered measurements of motor function and recovery. The FMA is a quantitative questionnaire for the sensorimotor measurement of stroke recovery. FMA proposes a measure based on neurological examination and sensorimotor activity of the upper and lower limbs.<sup>[3,18]</sup> ARAT, on the other hand, is a functional assessment of complex activities of the upper extremity (compression, grasping, clamping, and reaching activities) and assesses motor impairment after stroke.<sup>[3,21]</sup>

In the findings, we did not find intervention effects. However, Kho *et al.*<sup>[28]</sup> found a significant result in ARAT, while in FMA, not. This result would be due to the FMA assessment's correlation versus the participants' profile. FMA demonstrated a ceiling effect in subjects with mild motor impairment. In the study by Barclay-Goddard *et al.*,<sup>[27]</sup> there was no significant effect for FMA. Guerra *et al.*,<sup>[32]</sup> on the other hand, refer to improved motor performance based on the results found in the analysis of both instruments, both ARAT and FMA. Comparing the instruments, both have advantages and disadvantages over each other. However, scales are widely used and accepted in assessing upper extremity impairment, useful measures for clinical trials, with similar responsiveness to change during the intervention.<sup>[33]</sup> In addition, the numerous pathophysiological mechanisms such as inflammation, immune exhaustion, and neurovascular can be mediated by acute and chronic changes in protein kinase C activity, therefore, it may interfere with a possible ability to change the clinical outcome for cognitive improvement.<sup>[34,35]</sup>

We observed in the meta-regression that a more significant number of sessions and the duration of the exercise in minutes, more significant the effectiveness of the intervention with mental practice. However, there was no statistical significance in the results analyzed. The question remains whether with the increase in sessions there can be an improvement in clinical conditions. For this, this assumption would be in line with the concepts of learning and relearning, performance, and motor control, which function as a basis in the process of neurorehabilitation.<sup>[25]</sup>

### Study limitations

This study has some limitations. The risk of selection bias may be present even after using a systematic search strategy. There are also other sources of variability within the literature that may have limited the conclusions drawn from this review. Some of these factors, such as the sensory modality, intensity, size, complexity, and familiarity are not standardized in the various studies

on mental practice in the stroke patients. Limitations involved on population size. Another limitation is the small number of articles included in the meta-analysis, as it may represent an inadequate statistical power due to the size of the sample included.

Some limitations are addressed in this study, for example, the lack of standardization between the protocols may be responsible for generating conflicting information between the trials. Some questions about this area of study still exist and are challenging. Unanswered questions are adherence, exercise variability, repetition of imagined tasks, and motivation to treatment,<sup>[2,12,20,32]</sup> as well as ideal dosage<sup>[2,28]</sup> and the best time for the introduction of MP.<sup>[20,32]</sup> Follow-up during mental practice versus monitoring parameters such as participants' heart and respiratory rates have also been questioned. Although the mental practice is a cognitive task, this type of training can generate autonomic changes, so it is essential to pay more attention to these aspects.<sup>[32]</sup>

## Conclusion

Based on the evidence from the studies analyzed in this review, there seems to be no evidence of intervention effect that supports the mental practice for motor recovery of the affected upper limb after stroke. Despite this, great diversity was observed in the design and methods used in the studies, such as the appropriate time to apply the technique (stage of pathology), frequency, duration (minutes per session) and intensity, impaired limb (laterality), the modality of imagery employed (visual or kinesthetic), feedbacks provided (videos, audios, photos), and uncontrolled confounding factors. Thus, we cannot affirm that task-oriented MP training effectively improves motor recovery of the compromised upper limb after stroke. Nevertheless, its application can be a useful alternative and complement the traditional rehabilitation in these subjects.

It is essential that the trials provide a rationale for the choice of parameters and/or that these parameters are optimized. In addition, the trials should investigate the optimal MP dosage and "therapeutic window" for a given health condition. Moreover, all mental practice parameters should be described as clearly and completely as possible, preferably as a table in the manuscript. Finally, trials that investigate the long-term follow-up are necessary to determine the mental practice value in task-specific for individuals after stroke.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

## References

- Page SJ, Dunning K, Hermann V, Leonard A, Levine P. Longer versus shorter mental practice sessions for affected upper extremity movement after stroke: A randomized controlled trial. *Clin Rehabil* 2011;25:627-37.
- Timmermans AA, Verbunt JA, van Woerden R, Moennekens M, Pernot DH, Seelen HA. Effect of mental practice on the improvement of function and daily activity performance of the upper extremity in patients with subacute stroke: A randomized clinical trial. *J Am Med Dir Assoc* 2013;14:204-12.
- Park J, Lee N, Cho M, Kim D, Yang Y. Effects of mental practice on stroke patients' upper extremity function and daily activity performance. *J Phys Ther Sci* 2015;27:1075-7.
- Song K, Wang L, Wu W. Mental practice for upper limb motor restoration after stroke: An updated meta-analysis of randomized controlled trials. *Top Stroke Rehabil* 2019;26:87-93.
- Park SW, Kim JH, Yang YJ. Mental practice for upper limb rehabilitation after stroke: A systematic review and meta-analysis. *Int J Rehabil Res* 2018;41:197-203.
- Dijkerman HC, Ietswaart M, Johnston M, MacWalter RS. Does motor imagery training improve hand function in chronic stroke patients? A pilot study. *Clin Rehabil* 2004;18:538-49.
- Nilsen DM, Gillen G, Gordon AM. Use of mental practice to improve upper-limb recovery after stroke: A systematic review. *Am J Occup Ther* 2010;64:695-708.
- Barclay RE, Stevenson TJ, Poluha W, Semenکو B, Schubert J. Mental practice for treating upper extremity deficits in individuals with hemiparesis after stroke. *Cochrane Database Syst Rev* 2020;5:CD005950.
- Teixeira S, Magalhães F, Marinho V, Velasques B, Ribeiro P. Proposal for using time estimation training for the treatment of Parkinson's disease. *Med Hypotheses* 2016;95:58-61.
- Marinho V, Pinto GR, Bandeira J, Oliveira T, Carvalho V, Rocha K, *et al.* Impaired decision-making and time perception in individuals with stroke: Behavioral and neural correlates. *Rev Neurol (Paris)* 2019;175:367-76.
- O'Shea H, Moran A. Does motor simulation theory explain the cognitive mechanisms underlying motor imagery? A critical review. *Front Hum Neurosci* 2017;11:72.
- Braun S, Kleynen M, van Heel T, Kruithof N, Wade D, Beurskens A. The effects of mental practice in neurological rehabilitation; a systematic review and meta-analysis. *Front Hum Neurosci* 2013;7:390.
- Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. *Cochrane Database Syst Rev* 2018;9:CD006876.
- Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: Elaboration and explanation. *BMJ* 2016;354:i4086.
- Higgins JP, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, *et al.* The cochrane collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 2011;343:d5928.
- Oh HS, Kim EJ, Kim DY, Kim SJ. Effects of adjuvant mental practice on affected upper limb function following a stroke: Results of three-dimensional motion analysis, fugl-meyer assessment of the upper extremity and motor activity logs. *Ann Rehabil Med* 2016;40:401-11.
- Riccio I, Iolascon G, Barillari MR, Gimigliano R, Gimigliano F. Mental practice is effective in upper limb recovery after stroke: A randomized single-blind cross-over study. *Eur J Phys Rehabil Med* 2010;46:19-25.
- Page SJ, Levine P, Leonard A. Mental practice in chronic stroke: Results of a randomized, placebo-controlled trial. *Stroke* 2007;38:1293-7.
- Grabherr L, Jola C, Berra G, Theiler R, Mast FW. Motor imagery training improves precision of an upper limb movement in patients with hemiparesis. *NeuroRehabilitation* 2015;36:157-66.
- Ietswaart M, Johnston M, Dijkerman HC, Joice S, Scott CL, MacWalter RS, *et al.* Mental practice with motor imagery in stroke recovery: Randomized controlled trial of efficacy. *Brain* 2011;134:1373-86.
- Page SJ, Levine P, Leonard AC. Effects of mental practice on affected limb use and function in chronic stroke. *Arch Phys Med Rehabil* 2005;86:399-402.
- Kim SS, Lee BH. Motor imagery training improves upper extremity performance in stroke patients. *J Phys Ther Sci* 2015;27:2289-91.
- Nilsen DM, Gillen G, DiRusso T, Gordon AM. Effect of imagery perspective on occupational performance after stroke: A randomized controlled trial. *Am J Occup Ther* 2012;66:320-9.
- Page SJ. Imagery improves upper extremity motor function in chronic stroke patients: A pilot study. *Occup Ther J Res* 2000;20:200-15.
- Liu KP, Chan CC, Lee TM, Hui-Chan CW. Mental imagery for promoting relearning for people after stroke: A randomized controlled trial. *Arch Phys Med Rehabil* 2004;85:1403-8.
- Li F, Zhang T, Li BJ, Zhang W, Zhao J, Song LP. Motor imagery training induces changes in brain neural networks in stroke patients. *Neural Regen Res* 2018;13:1771-81.
- Barclay-Goddard RE, Stevenson TJ, Poluha W, Thalman L. Mental practice for treating upper extremity deficits in individuals with hemiparesis after stroke. *Cochrane Database Syst Rev* 2011;2011:CD005950. doi: 10.1002/14651858.CD005950.
- Kho AY, Liu KP, Chung RC. Meta-analysis on the effect of mental imagery on motor recovery of the hemiplegic upper extremity function. *Aust Occup Ther J* 2014;61:38-48.
- Machado S, Lattari E, de Sá AS, Rocha NB, Yuan TF, Paes F, *et al.* Is mental practice an effective adjunct therapeutic strategy for upper limb motor restoration after stroke? A systematic review and meta-analysis. *CNS Neurol Disord Drug Targets* 2015;14:567-75.
- Carvalho AP, Silva V, Grande AJ. Avaliação do risco de viés de ensaios clínicos randomizados pela ferramenta da colaboração Cochrane. *Diagn Tratamento* 2013;18:38-44.
- Rauch A, Cieza A, Stucki G. How to apply the International Classification of Functioning, disability and health (ICF) for rehabilitation management in clinical practice. *Eur J Phys Rehabil Med* 2008;44:329-42.
- Guerra ZF, Lucchetti AL, Lucchetti G. Motor imagery training after stroke: A systematic review and meta-analysis of randomized controlled trials. *J Neurol Phys Ther* 2017;41:205-14.
- Rabadi MH, Rabadi FM. Comparison of the action research arm test and the fugl-meyer assessment as measures of upper-extremity motor weakness after stroke. *Arch Phys Med Rehabil* 2006;87:962-6.
- Lucke-Wold BP, Turner RC, Logsdon AF, Simpkins JW, Alkon DL, Smith KE, *et al.* Common mechanisms of Alzheimer's disease and ischemic stroke: The role of protein kinase C in the progression of age-related neurodegeneration. *J Alzheimers Dis* 2015;43:711-24.
- Sriram S, Mehkri Y, Quintin S, Lucke-Wold B. Shared pathophysiology: Understanding stroke and Alzheimer's disease. *Clin Neurol Neurosurg* 2022;218:107306.