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The Impact of Mental Practice on Motor Function in Patients With Stroke: A Systematic Review and Meta-analysis

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HIGHLIGHTS

- Mental practice can facilitate post-stroke upper limb motor recovery.
- Mental practice can improve post-stroke upper limb function.
- Mental practice can enhance post-stroke independence in activities of daily living.

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The authors have no potential conflicts of interest to disclose.

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Conceptualization: Seok H, Choi YH; Data curation: Choi YH; Formal analysis: Choi YH;

ABSTRACT

Mental practice (MP), the cognitive rehearsal of physical activities without overt movements, has recently emerged as a promising rehabilitation method for patients with stroke. This paper presents a systematic review and meta-analysis critically evaluating the existing evidence to offer a comprehensive estimate of the overall effect of MP on motor function in stroke patients. A systematic search of 3 international databases (PubMed, Embase, and the Cochrane Library) was conducted for randomized controlled trials. We finally selected 31 randomized clinical trials and conducted meta-analysis to determine the effectiveness of MP on motor recovery of upper extremity, upper extremity function, activities of daily living, and gait velocity in stroke patients. The results of the systematic reviews showed that MP combined with conventional therapy has a positive impact on improving upper extremity motor function, with a moderate quality of evidence. However, the beneficial effect of MP on gait velocity was not demonstrated. It is recommended to treat with MP in addition to conventional rehabilitation therapy to improve the motor outcome of stroke depending on the patient's condition (Recommendation level: Conditional Recommend Evidence certainty: Moderate).

Keywords: Stroke; Mental Practice; Systematic Review; Meta-analysis

INTRODUCTION

Stroke stands as one of the leading causes of long-term disability worldwide, compelling a continued search for effective rehabilitation strategies. Difficulties in using upper limb is the most common deficit after stroke, and is reported by at least 70% of stroke survivors [1]. This has a significant effect on daily activities, and has been shown to reduce independence, the likelihood of returning to employment and hobbies, and poorer mental health and quality of life [2,3]. Also, it is reported that a significant 70% of survivors experience diminished walking speed, while 20% continue to be reliant on wheelchairs at 3 months after stroke [4,5]. Post-stroke impairments in walking ability also notably hamper an individual's independence, ability to move, participation in daily tasks, and involvement in community activities [6]. Therefore, many rehabilitation strategies have been developed to overcome hemiparetic arm disability and gait disturbance [7-10].

Methodology: Seok H, Choi YH; Validation: Seok H; Visualization: Choi YH; Writing - original draft: Choi YH; Writing - review & editing: Choi YH.

Mental practice (MP), which refers to the cognitive rehearsal of a physical activity in the absence of overt physical movements, have started to surface in the arena of stroke rehabilitation. It doesn't require complicate equipment and can be applied to a wide range of patients [11]. Studies suggest that MP can act as an adjuvant to traditional physical therapy, capitalizing on the brain's inherent neuroplasticity, potentially strengthening the neural circuits involved in motor recovery after stroke [11-14].

Despite a growing body of evidence showing promising outcomes of MP in stroke rehabilitation, the results vary across studies [15-21]. The heterogeneity in methodology, including differences in the protocols of MP, the types of outcome measures used, and the characteristics of participants involved, can obscure our understanding of the true effectiveness of this intervention [22,23].

In response, this systematic review aims to conduct a meta-analysis of the existing randomized controlled trials (RCTs), critically evaluating the evidence to quantify the overall effect of MP on motor recovery in stroke patients. This integrative approach will allow us to not only provide a robust estimate of the efficacy of MP, but also explore potential moderators that may influence the outcome. By taking this comprehensive approach, this paper strives to offer valuable insights that can guide future research and clinical applications, fostering more targeted and efficient strategies for stroke rehabilitation. Ultimately, through this exploration, we hope to deepen our understanding of the possibilities inherent in the interplay of cognition and physical rehabilitation, and thus contribute to improving the quality of life and functional independence for stroke patients worldwide.

MATERIALS AND METHODS

Electronic searches

The process of literature search was delegated to 6 information retrieval specialists, employing 3 international databases: PubMed (https://pubmed.ncbi.nlm.nih.gov/), Embase (http://embase.com), and the Cochrane Library (http://cochranelibrary.com). For a comprehensive literature exploration, no specific commencement date was set, and the search extended up until February 28, 2022.

Search strategy

The search terms identified were used with Medical Subject Headings (MeSH) terms in PubMed and Cochrane Library, and Emtree terms in Embase, all of which were combined with natural language to enhance search sensitivity. If necessary, a manual search strategy was employed to supplement search results. The search terms were (motor imagery OR mental practice OR mental imagery OR mental rehearsal OR mental training OR imagery) AND (stroke OR cerebrovascular disorder OR intracranial hemorrhages OR cerebral vascular accident OR cerebral hemorrhage OR cerebral ischemia OR cerebrovascular accidents). MeSH terms were used in relevant databases: (STROKE [MeSH] OR stroke* OR cerebrovascular* OR cerebral*) AND (Imagery [MeSH] OR mental* OR imagery* OR Practice, Psychological [MeSH]).

Selection

The identified search results were ultimately screened by 2 reviewers, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram. Selection of the related papers was based on the target population (human stroke patients), research design and methodology (only comparative studies including human-targeted RCTs were included, while case reports, technical reports, and animal studies were excluded), outcome measures, and language (Korean and English). The primary selection involved a review of the titles and abstracts of the literature, followed by a secondary selection that entailed a review of the full text of the papers. In case of differing opinions during the literature selection process, consensus was sought.

Data extraction

Data were extracted by one reviewer and data extraction was checked by a second reviewer. The following data were extracted: citation details; total number of participants; number of groups; number in each group; number lost to attrition in each group; randomization; blinding; intervention characteristics (frequency of MP sessions; duration of each MP session; the length of the entire MP intervention; number of completed sessions; total minutes of completed MP; duration and length of control intervention; baseline, postintervention, and follow-up [when available]) point estimates, outcome measures and results. After that, all the information was analyzed and then summarized (**Supplementary Table 1**).

Risks of bias (quality) assessment

We assessed each potential bias as high risk, low risk, or unclear risk by reviewing each research article. We chose high risk if the specific bias appeared to be present, low risk if bias did not appear to be present, and unclear risk if there was no mention of the bias or if bias was not clear in the article. We used the "risk of bias" tool judgements as described in the Cochrane Handbook for Systematic Reviews of Interventions. We assessed random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome, and any other bias [24]. The evaluations were then reviewed through a consensus process.

Analysis

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. Outcome measures used in the meta-analysis were upper extremity Fugl-Meyer Assessment (FMA-UE) for motor recovery, action research arm test (ARAT) scores for upper extremity function, Barthel Index (BI) or Modified Barthel Index (MBI) for activities of daily living, and gait velocity. They are widely used tools in poststroke rehabilitation studies, and we intended to make relevant comparisons by mean differences (MDs) of FMA-UE, ARAT, MBI/BI and gait velocity in the analysis. All outcomes produced continuous data. The effect size was calculated by the MD and its respective 95% confidence interval (CI), appropriate when all the analysis studies used the same scale. We used the standardized mean difference (SMD) and the 95% CI for different outcomes that measured the same constructs. Heterogeneity was assessed using the statistical estimates of the χ^2 test and the I^2 index. The presence of between-trial statistical heterogeneity was assessed using the I^2 statistic. We planned to examine the presence of publication bias by visual inspection of funnel plot if 10 or more trials were included [24]. We used the Cochrane Review Manager software for all data analyses [25].

Grading of Recommendations Assessment, Development and Evaluation (GRADE)

We applied GRADE to assess the certainty of the evidence. We used the 5 GRADE considerations of study limitations, inconsistency of results, indirectness of evidence, imprecision, and publication bias to assess the quality of the body of evidence for each outcome, considering the studies included in the meta-analyses. We used methods described in the GRADE Handbook [26].

RESULTS

The foundation of this systematic review study was established through the analysis of RCTs that directly compared motor function enhancement via MP to control groups, resulting in a final selection of 31 papers. To analyze the impact of MP, the interventions used in each study were reviewed to confirm the inclusion of this technique. The meta-analysis was then conducted, separating the groups that included this therapeutic technique from those that did not. Given this comparison method, there was potential for overlapping subjects within each outcome indicator. Thus, the overall analysis in the meta-analysis was avoided, and only subgroup analysis was performed. The types of outcome measures included motor recovery, upper extremity function, activities of daily living, and gait velocity. The results were examined immediately before and after the intervention.

Through comprehensive literature searches, a total of 2,972 studies, which had duplicates removed, were independently screened by 2 members following the PRISMA guidelines, ultimately selecting 31 RCT studies [14,18,27-55]. Among these 31 RCTs, 23 studies focused on upper limb motor function, while the remaining 8 studies targeted lower limb motor function. If data extraction for the meta-analysis was not feasible from the final selected studies, those papers were excluded from the analysis [14,34,35,37,39,44-48,50] (**Fig. 1**).

The results of the risk of bias assessment are presented in **Fig. 2**. The figures showed the methodological quality of the included studies. Of the 31 final studies, 21 show the subjects' random sequence; 11 describe the allocation concealment methods. The blinding of participants and professionals was adopted in 6 studies. The 18 studies report blinding outcome evaluators. The 27 studies described the results adequately for each primary outcome, including losses and exclusion from analysis. However, only 5 studies presented sufficient data for inclusion in the meta-analysis. As for the reporting of selective outcomes, 2 studies presented insufficient information to allow judgment. Other types of bias are found in 3 of the studies analyzed: selection, performance, and reporting biases. Besides, it is noteworthy that only 9 studies for motor recovery, 7 studies for upper extremity function, 7 studies for activities of daily living, and 6 studies for gait velocity presented sufficient information for inclusion in the meta-analysis.

Motor recovery of upper extremity

The results of the meta-analysis included 9 RCT studies [27,29,31-33,36,38,42,43] sing outcome measures related to motor recovery of upper extremity (FMA-UE). Regarding motor recovery, the group that underwent MP showed a significant effect compared to the group that did not (MD, 2.40; 95% CI, 0.64–4.15) (**Fig. 2A**)

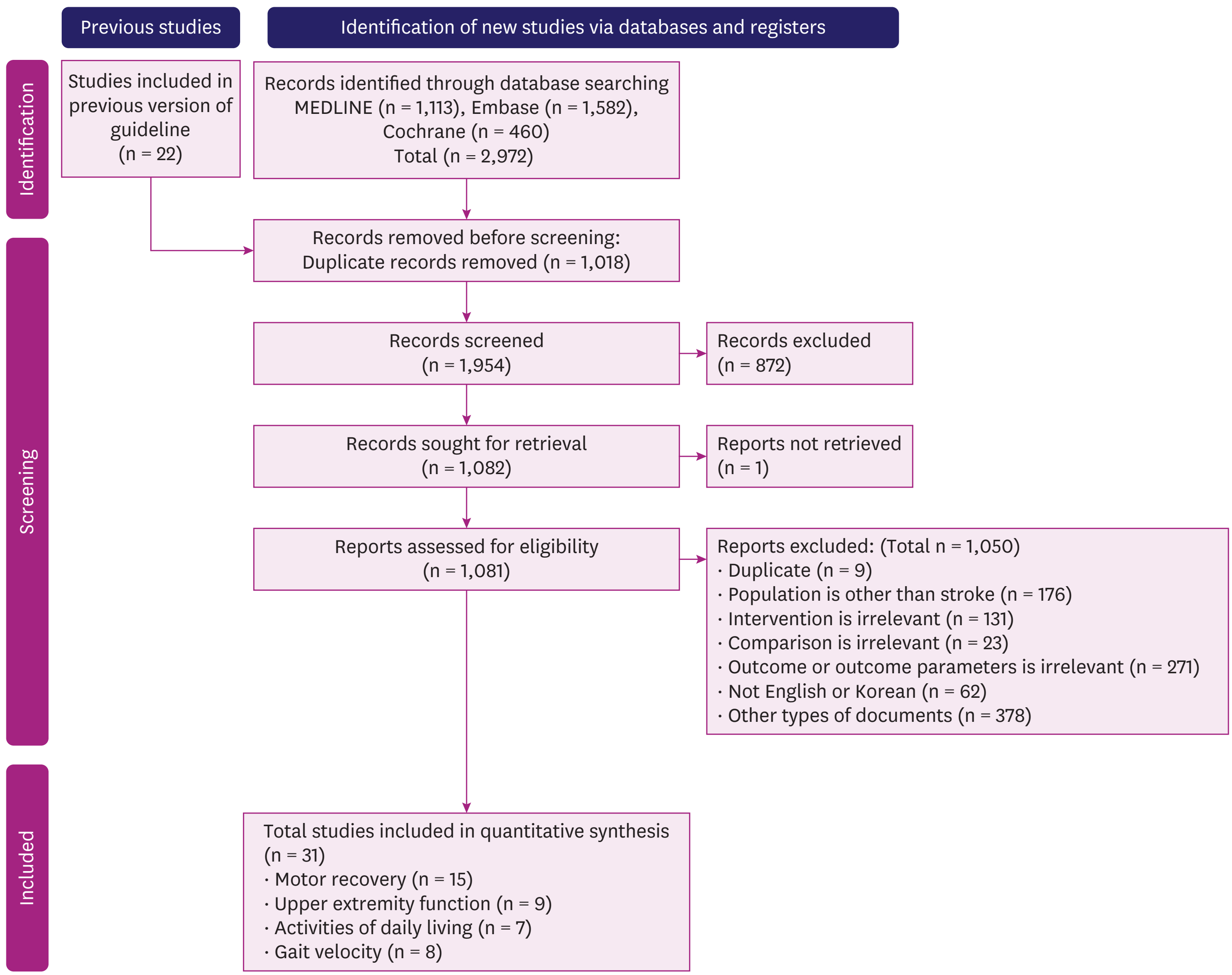

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart.

Upper extremity function

In the meta-analysis, 4 RCT studies [18,28,30,41] were included using outcome measures related to the upper extremity function. The group that received MP showed a significant improvement in upper extremity function compared to the group that did not (MD, 4.98; 95% CI, 2.74–7.23) (**Fig. 2B**).

Activities of daily living

In activities of daily living, 7 RCT studies [18,31-33,38,49,55] were incorporated. The group that underwent MP showed a significant improvement in activities of daily living compared to the group that did not (SMD, 0.60; 95% CI, 0.29–0.92), indicating a significant effect. However, the magnitude of the effect on daily living activity performance was not significant (**Fig. 2C**).

Gait velocity

Six RCT studies [49,51-55] were included using outcome measures related to gait velocity. The effect on gait velocity did not show any significant difference between MP group and the control group (SMD, 0.30; 95% CI, −0.04–0.64) (**Fig. 2D**).

When the certainty of evidence was evaluated using the GRADE approach for key outcome indicators, no serious risk of bias was found in all key outcome indicators, and no inconsistencies, indirectness, or publication bias was observed. However, deductions were made for imprecision due to insufficient number of research subjects, resulting in a moderate level of certainty of evidence. The importance of end points on motor recovery, upper extremity function, and activities of daily living after the intervention period were all determined critical. Conversely, considering clinical significance, walking speed was determined as important, but not critical outcomes for decision making (**Table 1**).

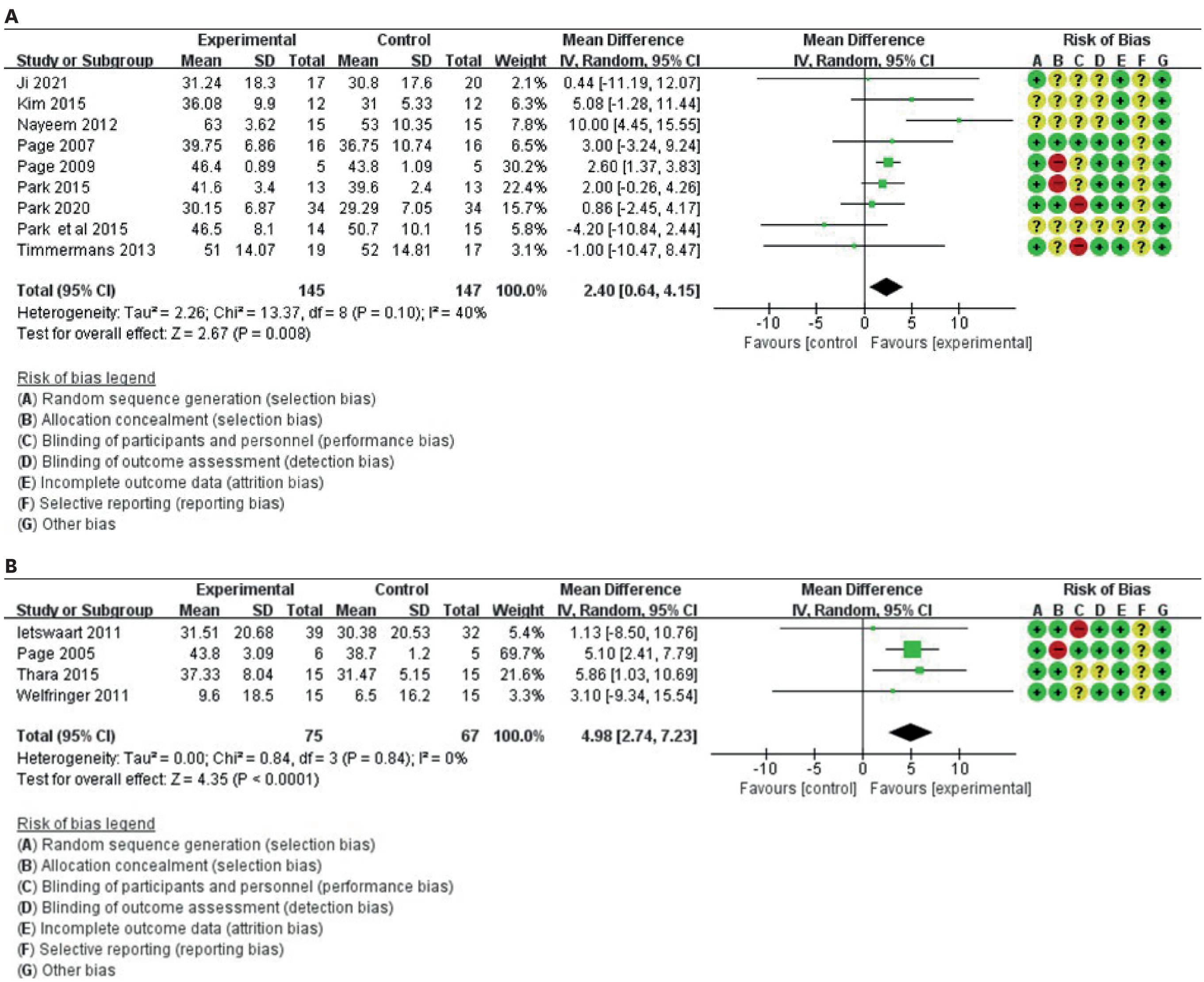

Fig. 2. Forest plot and Risk of Bias of mental practice effect. (A) Mental practice effect on motor recovery of upper extremity. (B) Mental practice effect on upper extremity function. (C) Mental practice effect on activities of daily living. (D) Mental practice effect on gait velocity.
SD, standard deviation; CI, confidence interval.

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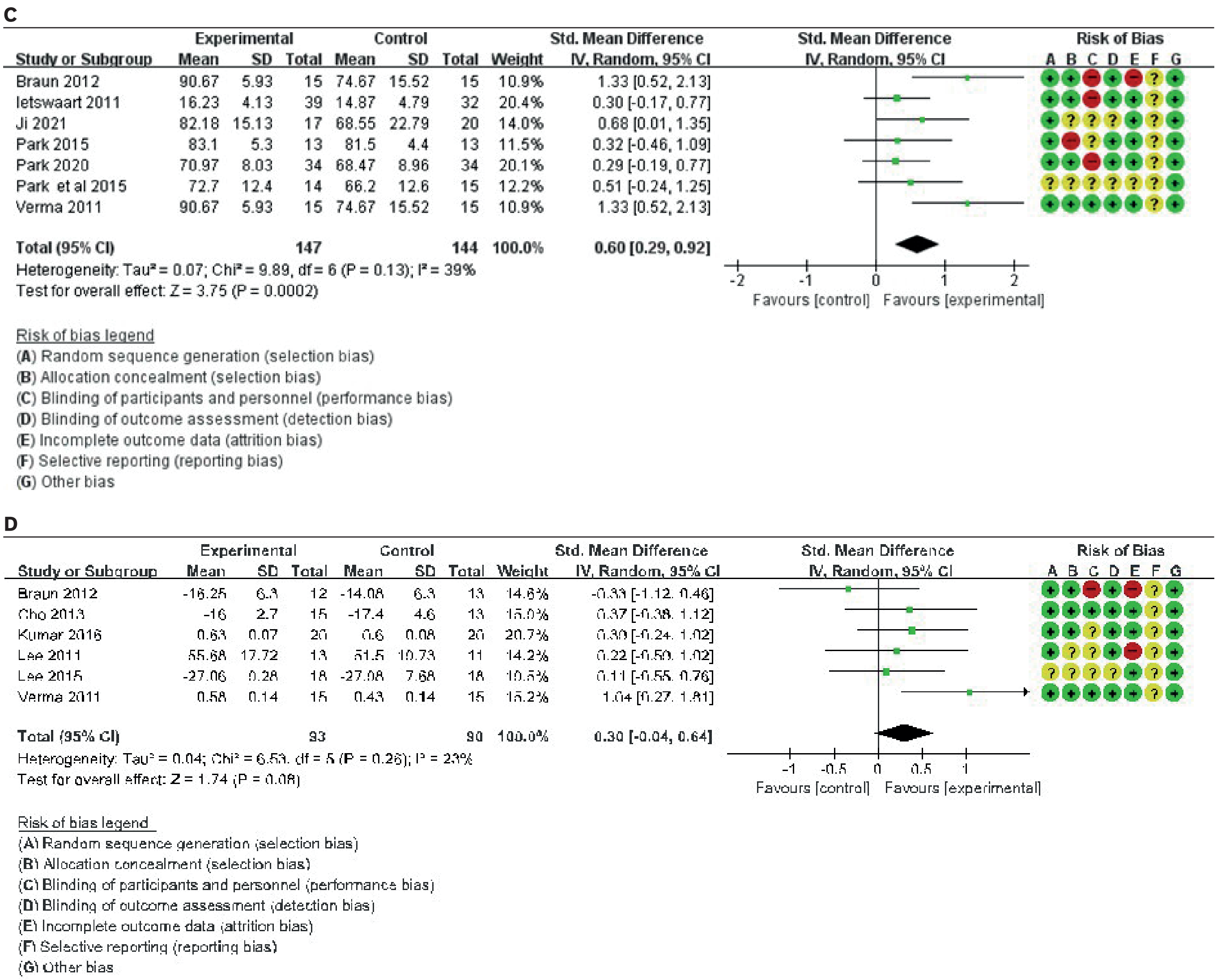

Fig. 2. (Continued) Forest plot and Risk of Bias of mental practice effect. (A) Mental practice effect on motor recovery of upper extremity. (B) Mental practice effect on upper extremity function. (C) Mental practice effect on activities of daily living. (D) Mental practice effect on gait velocity.
SD, standard deviation; CI, confidence interval.

Table 1. Summary of findings

Outcomes	Importance	No. of participants (studies)	Certainty of evidence (GRADE)	Statistical method	Effect size
1. Motor recovery	9	292 (9)	Moderate	MD (IV, Random, 95% CI)	2.40 (0.64–4.15)
2. Upper extremity function	9	142 (4)	Moderate	MD (IV, Random, 95% CI)	4.98 (2.74–7.23)
3. Activities of daily living	9	291 (7)	Moderate	SMD (IV, Random, 95% CI)	0.60 (0.29–0.92)
4. Gait velocity	6	183 (6)	Moderate	SMD (IV, Random, 95% CI)	0.30 (−0.04–0.64)

GRADE, Grading of Recommendations Assessment, Development and Evaluation; MD, mean difference; SMD, standardized mean difference; CI, confidence interval.

DISCUSSION

This systematic review aimed to synthesize available evidence from studies of the effectiveness of MP on the motor function after stroke. The overall result of this study supports beneficial effect of MP on upper extremity motor recovery, upper extremity function and activities of daily living when given with other therapies. However, the effect of MP on gait velocity was not demonstrated in the current meta-analysis. The main results of this review were largely based on moderate quality trials and heterogeneity was relatively low in the meta-analyses (40% for motor recovery, 0% for upper extremity function, 39% for activities of daily living, and 23% for gait velocity), supporting the validity of these results. Out of 31 RCT studies, 13 studies included in the meta-analysis directly compared MP and conventional therapy. The remaining studies were about MP in conjunction with conventional therapy (task-specific training, gait training, contralateral upper limb restriction therapy, neuromuscular electrical stimulation therapy, etc.) versus conventional therapy alone (16 studies controlled total treatment time, 2 studies did not). Therefore, it is suggested to incorporate MP in addition to conventional rehabilitation therapy rather than implementing MP alone.

MP is a proven safe and effective treatment technique that offers benefits such as improved daily living activities and enhanced upper limb motor function for stroke patients. The MP does not require special equipment and it can be repeated many times without great physical effort. If carried out by skilled professionals, there are no expected risks associated with MP. Also, research conducted by Page et al. [40] reported high treatment compliance and patient satisfaction when MP was applied to acute stroke patients. Furthermore, according to a study by Page et al. [44], patients can perform MP at home without the guidance of medical staff. As of 2022, under South Korea's healthcare system, only prescribed methods must be used to provide exercise therapy for motor function improvement. Currently, there is no separate medical billing in South Korea for MP alone, and policy is structured to claim it along with other rehabilitation therapy prescriptions implemented concurrently. To ensure patients receive sufficient MP from skilled experts according to their needs in the current South Korean medical system, a policy expansion of medical billing is needed for each rehabilitation therapy prescriptions.

There are some limitations in this study. Most of the studies have small samples that cannot be representative of the population. Also, 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, target patients (age range, location of the stroke lesion, stroke subgroups, chronicity), timing of therapy, dosage, frequency, and duration of MP [18]. In this study, we intended to investigate the chronicity of the participants in the included papers and analyze whether the time interval from stroke onset to the study period influenced the effects of the intervention. However, we were unable to analyze the effects of the time interval as many papers either did not specify the time interval or enrolled participants with a mix of subacute and chronic conditions. Therefore, in future study, RCTs with high quality are needed to clarify the clinical effects of MP as a rehabilitation method for motor function in stroke patients.

For the motor recovery, improvement of upper extremity function, and functional independence following a stroke, it is recommended to consider incorporating MP in addition to conventional rehabilitation therapy. However, it is advised to use it selectively depending on the patient's condition (Recommendation level: Conditional Recommend Evidence certainty: Moderate) However, the benefit of MP for improving walking speed after a stroke is not distinctly evident based on current research, and additional research results are anticipated.

SUPPLEMENTARY MATERIAL

Supplementary Table 1

Characteristics of included studies

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