Comparison of Rehabilitative Interventions That Ameliorate Post-stroke Working Memory Deficit: A Systematic Review

Lakshmi Sai Deepak Reddy Velugoti 1, Godfrey Tabowei 2, Greeshma N. Gaddipati 3, Maria Mukhtar 2, Mohammed I. Alzubaidie 2, Raga Sruthi Dwarampudi 3, Sheena Mathew 3, Sumahitha Bichenapally 2, Vahe Khachatryan 2, Asmaa Muazzam 4, Chandani Hamal 5, Lubna Mohammed 2

1. Department of Neurology, California Institute of Behavioral Neurosciences & Psychology, Fairfield, USA
2. Department of Internal Medicine, California Institute of Behavioral Neurosciences & Psychology, Fairfield, USA
3. Department of Research, California Institute of Behavioral Neurosciences & Psychology, Fairfield, USA
4. Department of Pathology Research, California Institute of Behavioral Neurosciences & Psychology, Fairfield, USA
5. Department of Internal Medicine/Family Medicine, California Institute of Behavioral Neurosciences & Psychology, Fairfield, USA

Corresponding author: Lakshmi Sai Deepak Reddy Velugoti, deepak.velugoti@gmail.com

Abstract

Stroke is one of the most common causes of disability in the world. It has sensory, motor, and cognitive symptoms. Many cognitive domains might get involved in a stroke. This systematic review focuses on working memory domain deficits after stroke and their various rehabilitation methods. This review is based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. For this review, we have searched PubMed, Google Scholar, and Science Direct databases and screened thoroughly with the inclusion criteria of free full-text English papers in the last 10 years that have exclusively studied humans. The articles included in the search are randomized control trials (RCTs), observational studies, meta-analysis studies, systematic reviews, and traditional reviews. Consequent quality assessment was done using the most commonly used tools for each type of study and eight papers were selected. From these papers, full-text articles were studied, analyzed, and tabulated. We found five different rehabilitation methods: transcranial direct-current stimulation, computer-assisted cognitive rehabilitation, physical activity, goal setting, and multimodal rehabilitation. We found that goal setting, computer-assisted cognitive rehabilitation, and multimodal rehabilitation can improve working memory deficits. While transcranial direct current stimulation and physical activity were inconsistent, further studies are needed. The small sample size, no follow-up, the inclusion of only a few studies, the size of the stroke, and comorbid conditions like mild cognitive impairment, dementia, and depression were the main limitations of this study. Future reviews must include a larger number of studies with large sample sizes, including follow-up as an inclusion criterion. We need more clinical trials on these methods for better knowledge.

Introduction And Background

Stroke is the second most common cause of dementia and the third most common cause of morbidity [1]. It can occur due to ischemic (most common) or hemorrhagic causes and can decrease the blood supply of the brain. The most common involved symptoms besides physical deficits (such as complete or partial paralysis, sensory loss, and altered sensations) are dysfunction in learning, memory, and executive functions. This affects nearly 83% of post-stroke patients with cognitive dysfunction, and more than 60% of stroke survivors report cognitive dysfunction, even for up to 10 years [2]. While motor and sensory deficits can affect patients’ quality of life and economic status, memory deficit will affect patients’ daily activities, their profession, and their families. Although the motor and cognitive functions are fundamentally treated as well-defined and separate entities while treating and diagnosing, both entities play an essential role in the post-stroke assessment of behavior and disability [3]. When it comes to cognitive function, working memory has a fundamental role in performing complex behavior [4]. Damage to working memory function causes a drop in the complex cognitive function of the brain to perform everyday activities such as memorization, communication, planning, reading, and writing [5].

What is working memory? It is defined as a multi-component system involved in goal-directed behavior that involves retaining and manipulating information [6]. In simple terms, it is explained as a “sketchpad of conscious thought” [7], for example, problem-solving in our mind and navigating to our home within our mind. Baddeley and Hitch described it as an essential model with four sub-components arranged hierarchically [6]. They are the phonological loop, visuospatial sketchpad, central executive, and episodic buffer [6]. The central executive supervises the other three subcomponents to store visual, spatial, and phonological information [6]. Working memory reaches its optimal capacity by 20 to 25 years of age. Then each subcomponent declines slowly with further aging at a different rate, which is explained by visual...
memory declining faster than phonological memory [9]. Many previous imaging studies found that working memory is a part of the lateral prefrontal and parietal cortex of the brain [10]. These areas are supplied by the middle and anterior cerebral artery branches and later drained into cerebral venous sinuses. The stroke affecting these regions will impair the functions.

Though post-stroke dementia, episodic memory, and long-term memory deficits after stroke have been studied abundantly, working memory deficits after stroke have less information. There is ongoing research on various methods to improve working memory skills and reduce the patient’s morbidity on the efficacy of each rehabilitation. To our knowledge, there is a lack of information on the comparison and efficacies of each intervention; such information is vital for selecting an effective intervention. This review article compares rehabilitative interventions to reduce the working memory deficit after stroke.

**Review**

**Methods**

This systematic review was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [11].

**Search Strategies**

We performed this systematic review using PubMed, Google Scholar, and Science Direct databases with keywords “stroke” and “working memory deficits” in all three databases, including Medical Subject Headings (MeSH) terms and keywords in PubMed search, and included multiple filters for each journal. These details are illustrated in Table 1.

| Databases          | Keywords                                      | Search strategy                                                   | Filters applied                                                                 | Search results                      |
|--------------------|-----------------------------------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------|-------------------------------------|
| PubMed             | Stroke, Working memory deficit                | Stroke OR "Stroke/psychology"[Majr] AND Working memory deficit OR Short term memory loss OR "Memory, Short-Term/drug effects"[Majr]) | 1. Free Full text, 2. Last ten years, 3. Humans, 4. English, 5. Article type, a) Randomized control trials (RCT,) b) Observational studies, c) Meta-analysis, d) Systematic review, e) Traditional Review | 106 (Last searched on May 22, 2022) |
| Google Scholar     | Stroke, Working memory deficit                | “Stroke” AND “Working memory deficit intervention”                | Publications from 2012 to 2022; Screened first 300 articles                      | 17,800 (last searched on May 22, 2022) |
| Science Direct     | Stroke, Working memory deficit                | “Stroke” AND “Working memory”                                    | Publications from 2012 to 2022                                                  | 2,382 (last searched on May 22, 2022) |

**TABLE 1: Databases used, keywords, search strategy, and filters applied**

**Inclusion and Exclusion Criteria**

We have included free, full-text English papers that have exclusively studied humans in the last 10 years. The articles included are randomized control trials (RCTs), observational studies, meta-analysis studies, systematic reviews, and reviews.

**Selection Strategy**

Two reviewers selected the articles independently using the same search strategy in all three databases. At first, articles were screened from the title of articles and abstracts and then later by reading full-text articles. If contradicting results regarding the article’s eligibility occurred, reviewers assessed the full-text article until the group reached a consensus.

**Data Collection, Items, Analyses, and Outcome Assessment**

Two reviewers collected data independently, and if reviewers found contradicting results, a full-text article was scrutinized and discussed until all reviewers reached a consensus. Collected data were analyzed and
tabulated under various headings such as (i) first author and year, (ii) population along with dropout patients (for RCTs)/number of studies included (for systematic review, traditional review, and meta-analysis, (iii) intervention, (iv) duration of intervention, (v) outcome measures and assessment, (vi) follow-up assessment, and (vii) funding sources. Due to heterogeneity in the population, different interventions, and unique outcomes of each study when compared with other studies, it was not possible to perform the meta-analysis.

Risk of Bias Assessment

Each selected study was assessed for risk of bias by two reviewers independently using commonly used tools for each type of study, and only studies that scored more significant than 70% were included in this review. Table 2 shows the quality assessment tools used for each type of study and accepted studies.

| Quality assessment tool | Type of study | Total score | Accepted score (>70%) | Accepted studies |
|------------------------|--------------|-------------|-----------------------|------------------|
| Cochrane collaboration risk-of-bias tool (CCRB) | Randomized Control Trial | 7 | 5 | Fishman et al. [12]. Studer et al. [13]. Park et al. [14]. Liu-Ambrose et al [15]. Bunketorp-Käll et al. [16] |
| Preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 | Systematic Review | 44 | 31 | Van de Ven et al. [17] |
| Scale for the assessment of narrative review articles (SANRA) | Meta-analysis | 12 | 9 | Oberlin et al. [2] |

TABLE 2: Risk of bias assessment

Results

There were 174 potentially related titles found in the database search. One hundred and fifty-nine records were kept after duplicates were removed. When the titles and abstracts of these records were evaluated based on the qualifying criteria for this review, 25 articles remained. From these, 15 reports were discarded because of irrelevant data. Eight papers with a score of more than 70% were allowed in the review after each publication underwent a quality assessment. There were four RCTs, one traditional review, one meta-analysis, one systematic review, and one pilot research. A flow diagram of the study selection and screening process is shown in Figure 1.
FIGURE 1: Flowchart of the study selection process

CCRBT: Cochrane collaboration risk-of-bias tool

Study Characteristics

The main characteristics of the clinical trials, pilot study, meta-analysis, traditional review, and systematic review are shown in Tables 3, 4 respectively. Of these eight studies, one pilot study and one traditional review used transcranial direct current stimulation intervention, one systematic review and the same pilot study used computer-assisted cognitive rehabilitation (CACR) intervention, one RCT and one meta-analysis focussed on physical activity as intervention, one RCT applied goal setting as intervention, and one RCT adopted multimodal rehabilitation with follow-up. All these articles assessed the working memory domain using different outcome measures.
| Study | Patients | Intervention | Outcome | Funding |
|-------|----------|--------------|---------|---------|
| Studer et al. 2021 [13] | Adult stroke patients with visuospatial memory impairments | 95(12) | Both intervention (patients with precommitment) and the control group were asked for self-directed training for 30 minutes a day for two weeks in addition to standard therapy. | No follow-up |
| Liu-Ambrose and Eng 2015 [15] | Chronic single stroke patients (≥12 months after stroke) | 28(4) | Six months of community programs that include two exercise training sessions, one recreational session, and one leisure activity session per week for the intervention group. | No follow-up |
| Fishman, et al. 2021 [12] | Chronic stroke patients (≥3 months after stroke) | 72 (0) | The intervention group was instructed to set a goal to improve their performance, and the control group was given standard therapy. | No follow-up |
| Bunketorp-Käll et al. 2017 [16] | Patients who had stroke ≥10 months back and ≤5 years before enrollment in this study | 123 (8) | Two intervention groups (one is allocated to R-MT, and the other is H-RT) and a control group allocated to rhythm and music therapy one year after the intervention. | It was funded by Sten A Olsson Foundation for Research and Culture, Swedish Brain Foundation, the Swedish Stroke Association, and others. |

**TABLE 3: Study characteristics of the pilot study and clinical trials**

IfDCS: transcranial direct current stimulation; CPT: continuous performance test; RCT: randomized control trial; WSST: Wechsler Spatial Span Test; R-MT: rhythm and music therapy; H-RT: horse riding therapy.
TABLE 4: Study characteristics of the traditional review, systematic review, and meta-analysis

| Study                        | Type of study        | Population                          | The number of studies included | Intervention                      | Duration of training                                                                 | Results                                                                 | Follow-up | Funding sources                                      |
|------------------------------|----------------------|-------------------------------------|--------------------------------|----------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------|-----------|------------------------------------------------------|
| Madhavan and Shah 2012 [18]  | Narrative Review     | Stroke affected                     | 12 studies                      | tDCS                             | Typically, a current intensity of 0.5–2 mA for a 5–20 minute period, providing a current density of 0.02-1 mA/cm² and a total charge of 15-100 micro coulombs/cm². Different studies used different values within this range. | Improvement in the two back letter memory task is found.               | No follow-up | Not reported                                         |
| van de Ven et al. 2016 [17]  | Systematic Review    | Adults who have suffered from stroke or acquired traumatic brain injury | 20 studies                      | Computer-assisted cognitive rehabilitation | Cogmed training for 30-40 minutes a day five times a week for five weeks for exclusive working memory training studies Rehacom training for both attention and working memory training for variable time in other studies | WM training studies have improved subjective and objective cognitive functions. This training enhanced only verbal WM but not visual WM. In both attention and WM combined training studies, no consistent improvements were found. Only immediate short-term improvements were seen. | No follow-up | Funded by Netherlands Initiative Brain and Cognition, a part of the Organization for Scientific Research |
| Oberlin et al. 2017 [2]     | Meta-analysis        | Stroke patients ≥ 18 years old      | 14 studies                      | Physical activity (aerobic exercise, resistance therapy, or physiotherapy) | More than four weeks of physical activity | WM domain has no statistical significance | No follow-up | Funded by the NIH Training Grant                     |

Outcome Measures

Working memory is usually measured using the digit span, letter-number sequencing, Wechsler spatial span, and visual cognitive performance tests. Each article used one or more of these tests. Though these tests help assess improvement in working memory, much more ecologically valid measures are required to evaluate real-life situations.

Discussion

In this systematic review, we aimed to compare the efficacies of rehabilitation that reduce working memory deficits after stroke. We selected five randomized control trials, two systematic reviews, and one traditional review and collectively showed five different rehabilitation methods to improve working memory. For better understanding, all included papers were divided into rehabilitation methods and discussed in detail.

Transcranial Direct Current Stimulation (tDCS)

In our review, two papers were included regarding transcranial direct stimulation of the brain. Although tDCS has the advantage of being a non-invasive procedure that delivers a low-intensity direct current through the scalp, it still has areas to hone itself because of the presence of variables from person to person, such as conductivity, the resistance of the scalp, and the dosage of current. Though there are many types of tDCS, Anodal tDCS is the most commonly used and it has significant evidence from many publications that enhance working memory when stimulated by the dorsolateral prefrontal cortex (DLPFC) [18].

In healthy individuals, anodal tDCS has increased correct responses and fewer errors were noted when compared to other types of tDCS such as cathodal or sham tDCS [18]. Some studies described that anodal tDCS promotes neural plasticity in chronic stroke survivors, which were shown as alpha waves in the
Physiological Activity

A six-month randomized control trial of 28 stroke survivors who had an episode > one-year onset and had completed their rehabilitation was divided into an intervention group and a control group. The intervention group received two sessions of exercise training and one session of recreation and leisure activity, the control group received usual care. The intervention group was found to have a 45% improvement in working memory [15]. The effect is dependent on the duration and type of training (aerobic or multimodal exercise training) [15,21]. Although very few studies had shown improvement in working memory [15], many studies had contradicting results to support this statement [1,2]. Some studies have shown improvement when combined cognitive and exercise interventions are included [22]. Because of the small sample size and other contradicting studies, further extensive sample studies are needed.

Unlike the single RCT, we also included a meta-analysis of randomized control trials for the effect of physical activity on post-stroke working memory deficits [2]. This meta-analysis included around 14 studies, but only five out of 14 studies had working memory as an outcome [2]. This study did not reach a statistical significance on working memory to support physical activity as an intervention [2].

Both studies included in this review have a small sample, not distributed evenly, worked only in the chronic phase after stroke, and one study has not shown statistical significance for the working memory domain [15,2]. Though this might not help us decide with the present studies, other cognitive domains were included along with working memory to study in these studies. Along with physical activity, domains such as selective attention, set-shifting, processing speed measures, conflict resolution, and mood are included in their outcome. Some of these outcomes have positive effects with statistical significance. Physical activities
such as aerobic and recreational activities play a significant role in the development of these cognitive domains.

**Goal Setting**

National Clinical Guidelines promote goal setting as an essential aspect of stroke rehabilitation. Many studies have shown improvement in patients’ confidence and motivation to work on rehabilitation with prior goal setting to improve motor and cognitive skills [25,24]. There are some different goal perspectives between patients and hospital staff that impede the development of the patient. The patient goal is usually long-term oriented, returning to normal and vaguely described. In contrast, the hospital staff goal is short-term, specifically focused on impairment, and motivated by financial and organizational pressures [23]. Terminating these barriers with open discussion of the goal with the patient and their families and positively encouraging and promoting the environment created by staff enabled many patients to participate in the rehabilitation [23] actively. There are tools used for goal setting, such as Return to Work (RTW) goal working sheet by American Stroke Association and goal management training [12], and can also be created and tailored per patients’ requirements. Integrating well-defined, achievable goals into the goal and working on them daily will motivate the patient to work on them. We included a RCT of goal setting and its effect on stroke survivors with accurate power and a good sample size. This trial showed improvement in the intervention group [12]. It is not attributable to age, education, time since stroke, sleep, depression, or vascular risk factors after multiple corrections using SPSS statistical software (IBM Corp., Armonk, New York, United States). This signifies the importance of ‘goal setting’ as a tool that covers a broad spectrum of various stroke survivors. While the trial has given promising results in rehabilitation, it did not have a follow-up and did not include aphasia and dementia patients. Further studies could provide a better opinion when including a follow-up and inclusion of aphasia and dementia patients.

**Multimodal Rehabilitation**

Multimodal rehabilitations promote patients to have a wide range of functions to help with motor, sensory and cognitive functions. Because of multiple different approaches simultaneously, these can have an additive or synergistic effect. Also, some studies show an enriched environment promotes recovery with better results than being alone and socially inactive. A RCT was included in our studies, which had one control group and two intervention groups in which one had rhythm and music therapy (R-MT) and the other had dance and horse riding therapy (H-RT) for 12 weeks with two sessions weekly [16]. Many outcomes, including working memory, were statistically analyzed. It was found that the R-MT group improved working memory, even after six months of rehabilitation. Other groups did not have statistical significance to provide a proper result. Unlike all the prior rehabilitation methods, this had a good follow-up and promising results that show the retention of improvements even after rehabilitation. This study had a small strength of participants from a single region. So, a broader study region with a better number of participants can help us better understand how to incorporate a multimodal approach into clinical settings.

**Limitations**

This study has several limitations such as the size of the stroke and comorbid conditions like mild cognitive impairment, dementia, and depression. Along with these factors, other major limitations are most of the studies included has a small sample size, no follow-up, and only mentioned their use in the chronic phase of stroke, so they cannot be generalized to the overall population. Some of these methods have not yet been thoroughly studied. Hence future studies on these methods with RCTs would benefit us to know the benefits and side effects of these methods.

**Conclusions**

There are several individual studies on each cognitive rehabilitation method, but to our knowledge, we have not found any study on the comparison of one with another rehabilitation method. We found five different rehabilitation methods in these studies, in which goal setting, CACR, and multimodal rehabilitation can improve working memory deficits. TDCS and physical activity were inconsistent and further studies are needed. From this review, the multifaceted approach with synergistic effects is seen to be the best approach because one method’s disadvantage can be counterbalanced with another rehabilitation method. This systematic review has a few limitations, such as small number of studies included, small sample size in a few papers, and availability of follow-up only in two studies. Future studies must include large sample sizes and follow-ups as inclusion criteria. More RCTs are needed on these methods for better knowledge.

**Additional Information**

**Disclosures**

**Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no
other relationships or activities that could appear to have influenced the submitted work.

References

1. Unibaso-Markaida I, Iraurgi I, Ortiz-Marqués N, Amaya I, Martínez-Rodríguez S: Effect of the Wii Sports Resort on the improvement in attention, processing speed and working memory in moderate stroke. J Neuroeng Rehabil. 2019, 16:32. 10.1186/s12984-019-0500-5

2. Oberlin LE, Waiwood AM, Cumming TB, Marsland AL, Bernhardt J, Erickson KI: Effects of physical activity on poststroke cognitive function: a meta-analysis of randomized controlled trials. Stroke. 2017, 48:3093-100. 10.1161/STROKEAHA.117.017319

3. Einast MD, Saltvedt I, Lydersen S, et al.: Associations between post-stroke motor and cognitive function: a cross-sectional study. BMC Geriatr. 2021, 21:105. 10.1186/s12877-021-02055-7

4. Lindelev JK, Overgaard R, Overgaard M: Improving working memory performance in brain-injured patients using hypnotic suggestion. Brain. 2017, 140:1100-6. 10.1093/brain/awx001

5. Xu JJ, Ren M, Zhao JJ, et al.: Effectiveness of theta and gamma electroacupuncture for post-stroke patients on working memory and electrophysiology: study protocol for a double-center, randomized, patient- and assessor-blinded, sham-controlled, parallel, clinical trial. Trials. 2020, 21:910. 10.1186/s13063-020-04807-2

6. Lugtmueijer S, Lammers NA, de Haan EH, de Leeuw FE, Kessels RP: Post-stroke working memory dysfunction: a meta-analysis and systematic review. Neuropsychol Rev. 2021, 31:202-19. 10.1007/s11065-020-09462-4

7. Miller EK, Lundqvist M, Bostom AM: Working memory 2.0. Neuron. 2018, 100:463-75. 10.1016/j.neuron.2018.09.023

8. Baddeley A: Working memory: theories, models, and controversies. Annu Rev Psychol. 2012, 63:1-29. 10.1146/annurev-psych-120710-100422

9. Freundish-Walsh S, Lépine-Barroso D, José Torres-Priozis M, Croxon PL, Berthier ML: Plasticity in the working memory system: life span changes and response to injury. Neuroscientist. 2018, 24:261-76. 10.1177/1073858417717210

10. Nord CL, Popa T, Smith E, et al.: The effect of frontoparietal paired associative stimulation on decision-making and working memory. Cortex. 2019, 117:266-76. 10.1016/j.cortex.2019.05.015

11. Page MJ, Moher D, Bossuyt PM, et al.: PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. BMJ. 2021, 372:n160. 10.1136/bmj.n160

12. Fishman KN, Ashbaugh AR, Schwart BH: Goal setting improves cognitive performance in a randomized trial of chronic stroke survivors. Stroke. 2021, 52:458-70. 10.1161/STROKEAHA.120.032131

13. Studer B, Timm A, Sahakian BJ, Kalenscher T, Knecht S: A decision-neuroscientific intervention to improve cognitive recovery after stroke. Brain. 2021, 144:1764-73. 10.1093/brain/awab128

14. Park SH, Koh EI, Choi HY, Ko MH: A double-blind, sham-controlled, pilot study to assess the effects of the concomitant use of transcranial direct current stimulation with the computer assisted cognitive rehabilitation to the prefrontal cortex on cognitive functions in patients with stroke. J Korean Neuropsych Soc. 2015, 54:484-8. 10.3540/jkns.2015.54.6.484

15. Liu-Ambrose T, Eng JJ: Exercise training and recreational activities to promote executive functions in chronic stroke: a proof-of-concept study. J Stroke Cerebrovasc Dis. 2015, 24:130-7. 10.1016/j.jstrokecerebrovasdis.2014.08.012

16. Bunkeortorp-Käll L, Lundgren-Nilsson Å, Samuelsson H, et al.: Long-term improvements after multimodal rehabilitation in late phase after stroke: a randomized controlled trial. Stroke. 2017, 48:1916-24. 10.1161/STROKEAHA.116.016453

17. van de Ven RM, Murre JM, Veltman DJ, Schmand BA: Computer-based cognitive training for executive functions after stroke: a systematic review. Front Hum Neurosci. 2016, 10:150. 10.3389/fnhum.2016.00150

18. Madhavan S, Shah B: Enhancing motor skill learning with transcranial direct current stimulation - a concise review with applications to stroke. Front Psychiatry. 2012, 3:66. 10.3389/fpsyt.2012.00066

19. Hordacre B, Mozezi B, Ridding MC: Neuroplasticity and network connectivity of the motor cortex following stroke: a transcranial direct current stimulation study. Hum Brain Mapp. 2018, 39:3526-39. 10.1002/hbm.24079

20. Dubovik S, Ptač R, Aboulafia T, et al.: EEG alpha band synchrony predicts cognitive and motor performance in patients with ischemic stroke. Behav Neurosci. 2015, 26:187-9. 10.3233/BEN-2012-129007

21. Fernandez-Gonzalo R, Fernandez-Gonzalo S, Turon M, Prieto C, Tesch PA, García-Carreira Mdel C: Muscle, functional and cognitive adaptations after flywheel resistance training in stroke patients: a pilot randomized controlled trial. J Neuroeng Rehabil. 2016, 13:57. 10.1186/s12984-016-0144-7

22. Sun R, Li X, Zhu Z, Li T, Li W, Huang P, Gong W: Effects of combined cognitive and exercise interventions on poststroke cognitive function: a systematic review and meta-analysis. Biomed Res Int. 2021, 2021:4558279. 10.1155/2021/4558279

23. Plant SE, Tyson SF, Kirk S, Parsons J: What are the barriers and facilitators to goal-setting during rehabilitation for stroke and other acquired brain injuries? A systematic review and meta-synthesis. Clin Rehabil. 2016, 30:921-30. 10.1177/0269215516658556

24. Littof J, Doedeman S, Holla J, et al.: Setting meaningful goals in rehabilitation: A qualitative study on the experiences of clients and clinicians in working with a practical tool. Clin Rehabil. 2022, 36:415-28. 10.1177/02692155211046465