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# Does Mental Imagery Training Affect Cognitive Functions in Patients with Stroke?

ABEER A. ELWISHY, Ph.D.*; EMAN S. FADLE, M.Sc.*; HANAN HELMY, M.D.** and RASHA M. EL REWAINY, Ph.D.*

*The Department of Neuromuscular Disorders and its Surgery*, Faculty of Physical Therapy, Cairo University and Neurology Department**, Faculty of Medicine, Cairo University*

## Abstract

*Background:* Stroke is one of the most common reasons of physical disability around the world, about 80% of individuals who have a stroke moving one side, or suffer from weakness on one side of their bodies. Mental imagery is a technique applied to stroke patients in a rehabilitation program to promote cognitive functions domains and in the relearning of every day task performance which has not been widely recognized.

*Aim of Study:* To investigate the effect of mental imagery training on cognitive functions in patients with stroke.

*Subjects and Method:* Thirty stroke patients from both sexes participated in this study, they were randomly assigned into two equal groups; the control group (B), received cognitive training (dual task training) only and the study group (A) received the dual task training in addition mental imagery training. The sessions were conducted three times per week, for four weeks, the duration of session was sixty minutes. Both groups were assessed before and after therapy by MOCA scale.

*Results:* This study showed that there was a significant improvement ($p<0.05$) in MOCA scale scores. There was a significant increase in the MOCA of the group A (STUDY GROUP) in comparison with that of group B (CONTROL GROUP ) post treatment ($p=0.02$).

*Conclusion:* Mental imagery training has a positive effect on improving cognitive function in patients with stroke.

***Key Words:*** *Mental imagery – Cognitive functions – Stroke.*

## Introduction

**ACCORDING** to the World Health Organization, Stroke is the second leading cause of death and the third leading cause of disability worldwide **[1]**. The number of people affected by strokes is increasing substantially over the coming years due to aging leading to various Challenges in the health care system **[2]**.

***Correspondence to:*** Dr. Abeer A. Elwishy,
E-Mail: dr.abeerelwishy2011@gmail.com

A stroke is caused by a disruption in the brain's blood and oxygen flow, resulting in brain tissue damage. Stroke survivors may experience motor impairments as well as cognitive and emotional difficulties, depending on the brain area affected **[3]**.

A stroke affects cognitive skills including attention, memory, language, executive processes, spatial perception, and orientation. Mental practice of tasks (MP) is a relatively recent therapy that is attracting a lot of interest in rehabilitation research **[4,5]**.

Mental practice has the ability to increase the amount of practice received during recovery in a safe and cost-effective manner. After initial training, the patient can use the mental practice approach independently of the therapist, location, or time of day **[6]**.

In order to organize rehabilitation therapy, the therapist must consider both cognitive and motor

***Abbreviations:***

ADL : Activitiesof daily living.
CI : Cognitive impairment.
CNS : Central Nervous System.
CVA : Cerebrovascular Accident.
MI : Motor Imagery.
MIT : Motor Imagery Training.
MOCA : Montreal Cognitive Assessment.
MP : Mental practice.
MP : Mental Practice.
PFC : Prefrontal Cortex.
RTP : Repetitive task-specific practice.
SMA : Supplementary Motor Area.
SPSS : Statistical Package for the Social Software.
STS : Sit-to-stand.
TIA : Transient ischemic attack.
TUG : Timed Up and Go task.
VCI : Vascular cognitive impairment
WHO : World Health Organization.

training. In patients with neurological abnormalities following a stroke, interference between cognitive tasks and motor control activities is critical for functional rehabilitation. A dual task requires the patient to do multiple complex activities at the same time, emphasizing the importance of cognitive and concentration [7].

This current study was designed to investigate the effect of mental imagery training on improving cognitive functions in patients with stroke. This study was conducted in the outpatient clinic of Faculty of Physical Therapy from October 2020 until January 2021, Cairo University and from El-Kasr El-Any Hospital, Cairo University.

The hypothesis of this study was that motor imagery training has no effect on improving cognitive functions in patients with stroke.

## Subjects and Methods

*A- Participants:*

The present study was held in the outpatient clinic, Faculty of Physical Therapy, Cairo University. It is a randomized controlled trial; it was approved by the ethical committee of the faculty of physical therapy, Cairo University, Egypt (Approval Number: 012/002937).

Thirty stroke patients from both sexeswere selected. The patients were diagnosed, and referred from a neurologist. Computed tomography scan and/or MRI was be used to confirm the diagnosis. The patients was selected from Outpatient Clinic of Faculty of Physical Therapy, Cairo University and from El-Kasr El-Ainy Hospital. The patients were assigned randomized into two equal groups, the control group (GB): This group include 15 patients with chronic stroke, was received cognitive training only as (dual task training, Cognitive-Motor Interference). And the studygroup (GA): This group include 15 patients with chronic stroke, was received mental practice and cognitive training as (dual task training, Cognitive-Motor Interference).

All the patients was signed an informed consent form after receiving information on the study purpose, procedure, possible benefits and risks, privacy and use of data.

All patients were evaluated before training and at the end of the four weeks training period with the same procedures.

*B- Instrumentation:*

MOCA scale The Montreal Cognitive Assessment (MoCA) was created to be a quick screening tool for mild cognitive impairment. It measures attention and focus, executive processes, memory, language, visual constructional skills, conceptual thinking, arithmetic, and direction, among other cognitive domains. It takes about 10 minutes to administer the MoCA. A total of 30 points is possible; a score of 26 or higher is deemed typical. The cognitive functions of stroke patients were assessed using The Montreal Cognitive Assessment, MoCA [8] is stroke-based cognitive screening tool [9] that is used particularly in mild to moderate strokes without significant aphasia. The MoCA contains more test items assessing stroke-relevant domains and has been shown to have better sensitivity in detecting global impairment than the MMSE [10].

All cognitivefunction domains measured by MOCA scale werebe assessed before and after treatment period.

*Inclusion criteria:*

Included in this study are patients with Duration of illness ranges from (4-12) months after stroke, Able to follow instruction, patients with age range between 45 to 60 years, patients with the Ability of the patient to walk with or without assistive devices, Patients with sufficient cognitive abilities that enables them to understand and follow instructions (MOCA SCALE score between 18 and 25) (mild cognitive impairment), patients with The ability to stand for at least 2 minutes and the ability to sit erect without a back rest for at least 2 minutes

*Exclusion criteria:*

Included the patients with unstable medical history (e.g. Recent myocardial infarction that might limit participation, Patients with Neurological diseases that affect cognition other than stroke (e.g: Multiple sclerosis, Peripheral neuropathy, Parkinsonism .... etc.), patients with Visual, auditory problems, patients with Sever cognitive impairment, patients with Absence of orthopedic conditions patients who experienced severe aphasia, and hemi neglect, Patients with Included disabilities caused by diseases other than stroke such as dementia, parkinsonian syndromes, and brain tumors, patients with Orthopedic conditions or pain affecting natural gait and patients with body mass index more than 30.

3- *Therapeutic procedures for both groups:*

All patients in group (A) 15 stroke patients, (2 female and 13 male) received treatment by sit to stand mental practice for 30 minute the training time was five minute relaxation, ten minutes practice visual imagery, ten minutes practice kinesthetic imagery.

The motor imagery practice was carried out in a quiet room in the clinic. Pre-prepared written instructions were delivered verbally by the instructor to each subject individually while seated on a chair with eyes closed. The subjects were asked to report when they completed the imagery practice task.

The sitto stand imagery training was for a period of four weeks. Patients were training in both Visual and Kinesthetic motor imagery. Week 1; the sit to stand task was done asone block. Week 2; the phase of transfer from anterior acceleration of the trunk until separation of the but tocks from the chair was trained. Week 3; the stabilization phase was trained at which there is an extension of the hips and the knees associated with straightening of the trunk until complete stance. Week 4; the STS task was practiced again as a whole one block, but with different speeds **[11]**. Then conventional physical therapy program (cognitive training; dual task training) The TUG task was applied by asking the participants to get up from an armless chair, walk 3m as quickly as possible without running, turn around, walk back to the chair, and sit down. During the TUG cog, participants completed the same walking task while recalling words with a specific letter as example (word begin with letter F) asked him/her to recall words begin with letter as F letter during walking TUG from get up from chair, doctor ask him say words with letter F and ask from him not stop and complete walking 3 meters and return to chair and sit down this is called (phonologic fluency) **[12]** for 30 minutes for four weeks.

All patients in group (B) 15 stroke patients. (3 females and 12 males) received conventional physical therapy program (cognitive training; dual task training; time up and go task with phonologic fluency) for 60 minutes for four weeks **[13]**.

4- *Statistical analysis:*

*The collected data were coded, tabulated, and statistically analyzed using:*

Descriptive statistics and unpaired *t*-test were conducted for comparison of subject characteristics between groups. Chi-squared test was used for comparison of sex and cause of lesion distribution between groups. Normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to test the homogeneity between groups. Unpaired *t*-test was conducted to compare the mean values of MOCA scale between groups. Paired *t*-test was conducted for comparison between preand post treatment in each group. The level of significance for all statistical tests was set at $p<0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

**Results**

*Subject characteristics:*

A total of 15 control group and 15 study group participants were included in the analysis. Subject's characteristics were demonstrated in Table (1). There was no significant difference between groups in age, weight, height, BMI, duration of illness and sex and cause of illness distribution ($p>0.05$).

The age of the patients ranged from 45 to 60 years with a mean age of 45±6.5 years for group A and 53.2±5.91 for group B. General Characteristics of the patient group are shown in Table (1).

Results showed that in the MOCA scale, there was significant difference between the control and the study group as shown in Fig (1).

*Significance of results:*

The alpha point of 0.05 was used as a level of statistical significance (when $p=0.08$ classed as "trend wise significant", $p=0.05$ is usually classed as “significant”, $p=0.01$ as “highly significant”, and $p=0.001$ as “very highly significant”) **[33]**.

Table (1): Basic characteristics of participants.

| | Group A Mean ± SD | Group B Mean ± SD | *p*-value |
|---|---|---|---|
| Age (years) | 54±6.5 | 53.2±5.91 | 0.72 |
| Weight (kg) | 79.4±10.11 | 78.6±8.2 | 0.81 |
| Height (cm) | 168±5.04 | 169.6±4.76 | 0.37 |
| BMI (kg/m$^2$) | 28.1±3.08 | 27.35±2.97 | 0.5 |
| Duration of illness (months) | 8.33±2.35 | 8.66±1.95 | 0.67 |
| *Sex, n (%):* | | | |
| Females | 2 (13%) | 3 (20%) | 0.62 |
| Males | 13 (87%) | 12 (80%) | |
| *Cause of illness, n (%):* | | | |
| Ischemic | 12 (80%) | 11 (73%) | 0.66 |
| Hemorrhagic | 3 (20%) | 4 (27%) | |

SD: Standard deviation; *p*-value, level of significance.

Effect of treatment on MOCA scale:

- *Within group comparison:*

There was a significant increase in MOCA scale post treatment compared with that pretreatment in the group A and B ($p>0.001$). The percent of increase in MOCA scale in the group A was 13.45%, while that in the group B was 7.8%. (Table 1, Fig. 1).

- *Between group's comparison:*

There was no significant difference in MOCA scale between groups pre-treatment ($p$>0.05). Comparison between groups post treatment revealed a significant increase in MOCA scale ofthe group A compared with that of the group B ($p$>0.05). (Table 1, Fig. 1).

Table (2): Mean MOCA scale pre and post treatment of the group A and B.

| MOCA scale | Group A Mean ± SD | Group B Mean ± SD | MD | t-value | p-value |
|---|---|---|---|---|---|
| Pre treatment | 21.33±2.28 | 20.53±1.64 | 0.8 | 1.1 | 0.28 |
| Post treatment | 24.2±2.54 | 22.13±1.99 | 2.07 | 2.47 | 0.02 |
| MD | –2.87 | –1.6 | | | |
| % of change | 13.45 | 7.8 | | | |
| $t$-value | –7.61 | –8.41 | | | |
| | $p$=0.001 | $p$=0.001 | | | |

SD : Standard deviation.
MD: Mean difference.
$p$-value: Probability value.

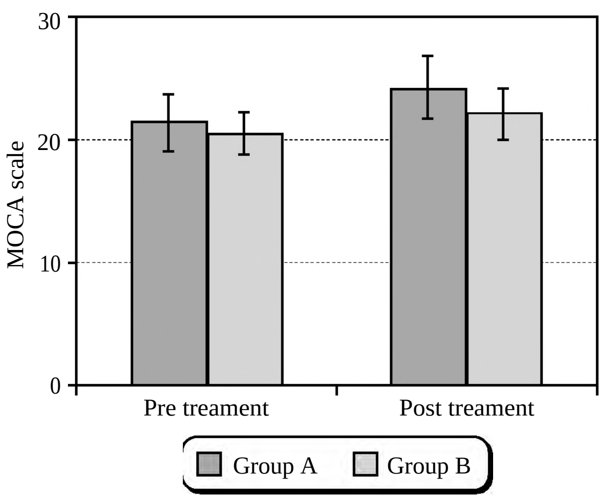


Fig. (1): Mean MOCA scale pre and post treatment of the group A and B.

## Discussion

This study was conducted to investigate the effect of mental practice on cognitive functions domains in patients with stroke. This study examined the potential mental practice for improving the performance of basic task frequently used in everyday activities but often impaired in individuals with stroke patients, STS task which are is commonly dysfunctional in individuals with chronic stroke and effect on cognitive functions in patients with stroke.

In the present study the patient's age ranged from 45 to 60 years. To eliminate effect of aging, it was noted that MI abilities globally well-preserved for simple movements, but may be altered for difficult movements and also older adults, much as younger ones, do recruit the motor system during mental simulation of movements. These findings provide support for the use of mental practice in the elderly population with advantage of providing a unique opportunity to engage safely in the training-retraining of actions while reducing physical demands and thus reach levels of performance beyond what can be achieved with physical practice alone [14].

It has been found from the present work that detected positive results in patients in the sub-acute phase and chronic. Also [15] approved that MIT appears as beneficial in the sub-acute and chronic post-stroke phase. Comparison between both groups before treatment for demographic information about participants (age, sex, height, weight and duration of illness), no statistically significant difference was found showing that subjects are matched for baseline characteristics.

The MOCA scores were assessed before and after applying the treatment program for the patients for successive four weeks.

The result of current study showed there was a significant effect of post treatment mean values of MOCA of both groups (A and B): There was a significant increase in the MOCA scores of the group A compared with that of group B post treatment.

Based on this evidence, the use of MoCA as a brief cognitive tool in both the acute/sub-acute and chronic post stroke periods seems overall feasible. Used in the acute period, MoCA has a good predictive value for the development of PSCI in the follow-up. Shorter versions of MoCA are available to make the application of MoCA even faster without significantly decreasing its sensitivity and specificity [16]. The evaluation of cognition in patients with stroke is important and the use of a brief cognitive test may facilitate this assessment since the early phases. However, MoCA presents some advantages, such as shortness, easiness of use, availability in different languages, and the free access.

There are some drawbacks to using MoCA in the stroke population. A side from the previously stated remarks about norms, it should be noted that this test does not examine domains that are commonly affected after a stroke, such as intellectual functioning, information processing speed, and nonverbal memory. However, although MoCA is primarily used as a screening tool, stroke rehabilitation attempts to assist people in regaining lost functions and reintegrating back into society. Previous research has shown that mental imagery (MI) has a positive impact on learning [17].

Liu et al., [18] provedthat the mental practice intervention included strategy training, and that after a stroke, individuals were better able to create cognitive maps of routes and plan activities in unfamiliar surroundings than the control group.

Braun et al., [19,20], found that acute adverse side-effects of mental practice like “too much effort,” “not worthwhile,” and “too confronting.” Some participants after stroke showed diminished concentration and signs of tiredness at the end of mental practice training sessions [21].

There is also some evidence for effects on cognition and emotion (e.g., effects on attention, planning actions in unfamiliar surroundings) and several reported side effects (e.g., may increase motivation and arousal and reduce depression, but may also lead to diminished concentration and irritation) [20].

Ietswaart et al., [22] investigated the rationale for the efficacy of mental practice in stroke, the idea that activating motor brain areas through visualization can improve brain plasticity is widely accepted by researchers and clinical practitioners, resulting in a strong belief that this is a useful rehabilitation strategy.

Mental imagery involves memory retrieval, and the generation and maintenance of images [18]. It is believed that generating the image, 'seeing the performance of the behavior with the mind's eye', prior to performance of the task, activates neural substrates that are subsequently involved in the actual performance of the task. This effect is thought to facilitate the planning and execution of the task, thereby increasing the level of independent task performance.

Some of the studies analyzed in this review aim to determine the potential of mental practice to contribute to task relearning, as well as the possibility of transferring positive outcomes to new environment [23], these motor changes translated to a new ability to perform a task that had not been possible for months, mental practice causes brain reorganization: New cortical areas are recruited [18].

Based on this evidence, the authors concluded that this technique is a promising cost-effective and non-invasive adjuvant to traditional therapy, which substantially reduces, decline and improves functional results. Poor selection of patients having sufficient cognitive ability to engage in this practice, or situations in which it was impossible to take time away from conventional therapy [24].

Malouin et al., [25] it was discovered that stroke patients improved their weight bearing capacities of the paretic leg when standing following only one motor imagery training session, and that this improvement lasted for one day.

Likewise, a previous study by Braun et al., [26] showed that the mental practice protocol was less applicable than was expected, and that this could have been due to lack of experience among therapists.

It has been found from the present work that for effects on cognition and emotion (e.g., effects on attention, plan actions in unfamiliar surroundings) and reports several observed side effects (e.g., might increase motivation and arousal and reduce depression, but may also lead to diminished concentration and irritation). Previous studies have reported that the application of motor imagery practice can be an effective means of enhancing STS movement for treatment of hemiplegic stroke patients [22].

Several studies have shown that mental practise training can help individuals with post-stroke hemiparesis improve their functional ADL task performance, increase motivation, increase awareness of body schema, and promote self-confidence [27].

The mental practice training is most beneficial if started soon after the stroke, so that patients will not develop negative habits and will experience therapeutic success as early as possible Rabadi, [28]. Motor imagery practice, on the other hand, can be employed at any point during recovery after a stroke, even in the chronic period, as the current findings show.

The Timed Up and Go task (TUG) with serial subtraction is commonly used to assess cognitive-dual task performance during walking for fall prediction. Some stroke patients cannot perform number subtraction and it is unclear which cognitive task can be used to substitute for the subtraction task in the TUG test in persons with stroke but who can perform number subtraction, the subtraction task produced larger negative effects on cognitive-motor performance during cognitive-dual tests than in the other cognitive tasks examined [25].

In this study, we showed that the subtraction task was more difficult than phonologic fluency since it required more cognitive effort. The difficulty of the subtraction problem may be attributed to the fact that it requires more brain activity than the phonologic fluency challenge. The subtraction exercise elicited neuronal activity in the inferior parietal network on both sides [29,30].

Whereas phonologic fluency activated neural networks only in the left inferior frontal cortex and supplementary motor area [28]. The phonologic fluency task was considered to be the easiest task among the other cognitive tasks.

The result of the current study came to the tract that the motor imagery training is significantly effective in improving cognitive functions in stroke patients.

*Conclusion:*

It was concluded that training of stroke patients by cognitive training combined with mental practice for four successive weeks has a beneficial effect rather than training by cognitive training only.

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# تأثير التدريب التخيلى الحركى على وظائف الادراك المتعددة فى مرضى الشلل النصفى

الخلفية: السكتة الدماغية هى واحدة من أكثر أسباب الإعاقة الجسدية المعروفة فى جميع أنحاء العالم، حوالى من الأفراد الذين أصيبوا بسكتة دماغية يعانون من مستوى معين من الصعوبة فى تحريك جانب واحد، أو يعانون من ضعف فى جانب واحد من أجسامهم. الصور الذهنية هى تقنية يمكن من خلالها التدرب على الأداء الجسدى معرفياً بطريقة آمنة ومتكررة. تم تطبيقه على مرضى السكتة الدماغية فى برنامج إعادة التأهيل لتعزيز مجالات الوظائف الإدراكية. لم يتم الاعتراف على نطاق واسع باستخدام تقنية الصور الذهنية فى إعادة تعلم أداء المهام اليومية.

الهدف من هذه الدراسة: هو تحديد تأثير تدريب الممارسة العقلية على الوظائف المعرفية لدى مرضى السكتة الدماغية.

طريقة البحث: شارك فى هذه الدراسة ثلاثون مريضاً مفلو جاً من كلا الجنسين وتم تقسيمهم عشوائياً إلى مجموعتين متساويتين. تلقت المجموعة الضابطة (A) تدريباً معرفياً (تمرين مهمتين) فقط، وحصلت مجموعة الدراسة (B) على نفس البرنامج بالإضافة إلى تدريب الممارسة العقلية (MPT) تم إجراء برنامج العلاج الطبيعى ثلاث مرات فى الأسبوع لمدة شهر. تم تقييم كلا المجموعتين قبل وبعد العلاج بمقياس MOCA.

النتائج: أظهرت نتيجة هذه الدراسة أن هناك تحسناً معنوياً ($p$<0.05) فى درجة MOCA. كانت هناك زيادة معنوية فى MOCA للمجموعة A مقارنة بالمجموعة B بعد العلاج ($p$<0.02).

الخلاصة: تدريب الممارسة العقلية له تأثير إيجابى على الوظيفة الإدراكية لدى مرضى السكتة الدماغية.