RESEARCH PAPER

Effect Of Cognitive Motor Interference on Cognition and Quality of Life on Multiple Sclerosis Patients: A Randomized Controlled Trial

Ahmed Abd El Aziz[1*], Eman S. Fayez[1], Sandra Mohamed Ahmed[2], Mahmoud El Sayed Midan[1,3]

1. *Department of Physical Therapy for Neuromuscular Disorders and its Surgeries, Faculty of Physical Therapy, Cairo University, Egypt.*
2. *Professor of Neurology, Faculty of Medicine, Cairo University.*
3. *Department of Physical Therapy for Neurology Galala university, Egypt.*

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ABSTRACT

Background: Multiple Sclerosis (MS) is a chronic inflammatory demyelinating disease of the central nervous system (CNS). About 40:65% of MS patients complain of cognitive problems. Cognitive Motor Interference (CMI) is a dual task (DT) occurring when the simultaneous performance of a cognitive and a motor task leads to a percentage change in one or both tasks.

Methods: 44 patients were randomly assigned into 2 groups. Study group received 12 sessions in 4 weeks of selective physiotherapy program including10 min walking on treadmill, 5 min balance training on balance board and 15 min neuromuscular stimulation 3 sessions per week in addition to CMI each session about 30 min. control group received 12 sessions of selective physical therapy program including10 min walking on treadmill, 5 min balance training on balance board and 15 min neuromuscular stimulation 3 sessions per week.

Results: There were significant improvements in working memory, visual impairments, auditory impairments and quality of life (Qol) ($p < 0.001$) on study group post treatment in comparison with pretreatment. In contrast, within the control group there were no significant changes in working memory, visual deficits, or auditory deficits ($p > 0.05$). However, QoL showed a significant improvement by 3.98% post-treatment ($p = 0.005$).

Conclusion: CMI is an effective method to improve cognitive abilities and Qol on MS patients.

Key Words: Multiple Sclerosis – Cognition – Quality of Life – Cognitive Motor Interference.

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INTRODUCTION

Multiple sclerosis (MS) is a chronic inflammatory disease of the central nervous system (CNS) that produces demyelination and axonal/neuronal damage, resulting in characteristic multifocal lesions on magnetic resonance imaging (MRI) and a variety of neurologic manifestations **(1).**

Multiple sclerosis has historically been classified as an organ-specific T-cell mediated autoimmune disease **(2).** M S is more common in females. Sex ratio has steadily been increasing, and it is now close to 3:1 (F:M) in most developed countries **(3).**

Cognition is the mental action of acquiring knowledge and understanding thoughts. It includes all intellectual functions such as perception, imagination, formation of knowledge, memory and working. Reasoning, evaluation, problem solving, production of language and decision making are parts of cognitive process. Cognitive processes use existing knowledge to discover new knowledge **(4).**

Cognitive decline is recognized as a prevalent and debilitating symptom of multiple sclerosis (MS), especially deficits in episodic memory and processing speed. with additional difficulties in executive function, verbal fluency, and visuospatial analysis. Patients often report difficulties with multitasking and word-finding, which are sorely under investigation **(5).** It is affecting about 40–50% of patients. It can be present at all stages, even at onset, and in all subtypes **(6).**

Three theoretical frameworks were used to explain cognitive motor interference (CMI). These include a self-awareness hypothesis, the bottleneck theory, and the attentional capacity theory. The attentional capacity theory is the most often used. According to this hypothesis, an individual's attentional capacity is limited, and specific tasks ask for a particular level of attentional capacity. When multitasking, performance on one or both tasks will be reduced if the capacity is reached **(7).**

Quality of life (QoL) is a multidimensional concept emphasizing the self-perceptions of an individual's current state of mind **(8).** QoL includes personal health (physical, mental, and spiritual), relationships, education status, work environment, social status, wealth, a sense of security and safety, freedom, autonomy in decision-making, social-belonging and their physical surroundings **(9).**

**Author for Correspondence: ahmedabdelaziz252525@gmail.com*

I- SUBJECTS

Protocol registered on clinical trials NCT06839924. The purpose of this study is to examine how Cognitive Motor Interference (CMI) affects patients with Multiple Sclerosis (MS) in terms of cognition and Quality of Life (Qol). It was carried out between September 2024 and September 2025. Patients were randomly assigned from Cairo university outpatients clinics based on the following criteria.

Inclusion Criteria

1) According to the Modified Mini Mental State (MMSE), M S patients report mild cognitive impairment.
2) MS patients with both primary and secondary progression types, as well as remission and relapses.
3) Between the ages of 25 and 45.
4) Patients of all sexes.

Exclusion criteria

1) Patients suffer from vision issues
2) Patients experience auditory disturbances
3) Patients who lack education.
4) People suffering from mental illnesses.
5) MMSE-measured patients with moderate to severe cognitive impairment.

Statistical analysis

To compare subject characteristics between groups, an unpaired t-test was used. The distribution of MS courses and sex was compared between groups using the chi squared test. The Shapiro-Wilk test was used to verify that the data had a normal distribution. The homogeneity between groups was examined using Levene's test for homogeneity of variances.

The impact of CMI on working memory, visual deficits, auditory deficits, and QoL was examined using mixed MANOVA. For following multiple comparisons, post-hoc analyses utilizing the Bonferroni correction were performed. For every statistical test, the significance level was set at $p < 0.05$. The Statistical Package for Social Sciences (SPSS) version 27 for Windows (IBM SPSS, Chicago, IL, USA) was used for all statistical analysis.

Ethical approval:

The research was approved by the Faculty of Physical Therapy's ethics commission at Cairo University (No: P.T. REC/012/005458).

Study design:

This study was designed as randomized controlled trial as two groups, pre-post-test (experimental study). All patients were divided randomly into two equal groups (A&B)

Group A:

It consisted of twenty-two MS patients with Mild cognitive impairment received 12 sessions of selective physiotherapy program including 10 min walking on treadmill, 5 min balance training on balance board and 15 min neuromuscular stimulation 3 sessions per week in addition to CMI. each session about 30 min. 3 sessions per week for 4 consecutive weeks.

Group B:

It consisted of twenty-two MS patients with Mild cognitive received 12 sessions of selective physiotherapy program including 10 min walking on treadmill, 5 min balance training on balance board and 15 min neuromuscular stimulation 3 sessions per week.

I- Materials:

1- **Informed consent form:** Before the study began, every participant signed it.
2- **Mini Mental State Exam (MMSE):**
MMSE is a questionnaire consisting of 11 questions with a total score of 30. IT investigates different domains of cognition such as orientation to time and place. Working memory and attention are also investigated by MMSE. MMSE tests severity of cognition with a scoring from 24 to 30 is considered normal cognition. Mild cognitive impairment is registered when the patient scoring is between 18 to 23. Total score below 18 is considered severe cognitive impairment.

3- **Rehacom**
RehaCom software version 6.10.3.0-DE-Hasomed was used to assess working memory and divided attention at baseline and after treatment sessions.

4- **Multiple Sclerosis Quality of Life (MSQOL)-54 Instrument**
MSQOL is 54 questions about different domains in MS patients' life including general health, pain severity and sexual dysfunction. MSQOL is used to assess Qol in MS patients at baseline and after treatment sessions **(Appendix III).**

II- Methods

A- Patients Selection and Allocation:

patients with RR, PP and SP courses of MS were recruited from faculty of physical therapy, Cairo university outpatient clinics. All patients were screened for our inclusion and exclusion criteria. Patients with total score of MMSE between 18 and 23 were included in our research. The goal and nature of the research were described to all included patients, and they assigned a consent form after receiving a full description of the study methodology. Patients were randomly assigned to two groups Intervention and control group by closed enveloped

B- Evaluative procedures:

After patients were included in our study, baseline assessment was performed for working memory, divided attention and QoL. Rehacom software version 6.10.3.0-DE-Hasomed was used to assess working memory and divided attention. Divided attention results from rehacom are splitted to visual and auditory impairments domains. Z- score is used to measure Working memory and divided attention on RehaCom software. It is a score from -5 to +2, -5 means maximum level of impairment and +2 is normal level. MSQOL-54 questionnaire was used to assess quality of life. With a scoring system from 0 to 100. 100 indicate higher level of quality of life.

C- Treatment procedures:

1- Intervention group

Intervention group performed 12 sessions of selective physiotherapy program including 10 min walking on treadmill, 5 min balance training on balance board and 15 min neuromuscular stimulation 3 sessions per week for 4 consecutive weeks in addition to Cognitive Motor Interference program. In CMI program patients received 30 minutes of motor tasks but in direct way depending on Working Memory and divided attention. Before starting the treatment session patients take a task paper for 10 minutes containing different motor tasks, each task is linked to specific number, color and tone.

First four sessions number of tasks was 6 then increased to 8 at the next four sessions ended by 10 tasks at the last four sessions. After 10 minutes patient is asked to leave the paper and start the treatment session. Session is divided into three parts each part consisting of 10 minutes.

On the first part of the session patient is asked to roll dice and perform the task linked to the number appeared on the dice. patient repeated the maneuver for 10 minutes. ***On the second part***, therapist is raising a card of a definite color and asking the patient to perform the task linked to this color. ***On the third part,*** therapist play a specific tone for 10 seconds then asking the patient to perform the task linked to this tone.

At the first four sessions we chose six exercises, three exercises for upper limb and another three exercises for lower limb. Upper limb exercises included put hand behind head, put hand behind back and grasp a small ball. Lower limb exercises included single limb support, Mini squat and standing on tip toe.

We also chose six different colored cards for each exercise. We chose red, yellow, blue, green, white and black. Six different popular tones were chosen ranked A. B, C, D, E and F. All patients heard all tones and knew the name of the tone which was written on task paper. On starting of each session every patient will receive the task paper including 6 serial numbers. Each number was linked to a specific tone, and a specific color. As we tested working memory, every session we changed the order of colored cards and tones **(Appendix IV)** gives an example of task paper for the first 4 sessions.

From session five to eight we increased number of exercises, colors and tone to eight instead of six as we performed on the first four sessions. We added two different exercises which are leaning the trunk forward and closing eyes. In colors cards, we added purple and orange cards. We also added two popular tones named G and H. As Dice containing 6 numbers only, we replaced it by drawing lots using papers on the middle and last four sessions. The same maneuver was repeated as mentioned in the first four sessions. **(Appendix V)** gives an example of task paper for the sessions from five to eight.

On the last four sessions, we increased the number of exercises to ten. We added locking to the ceiling and clapping. Pink and mixed colored cards were added also. Two different tones were added named I and J. We still replaced the dice by drawing lots. Same maneuver was repeated in the same manner. We put an example of task paper for every stage on our program. **(Appendix VI)** gives an example of task paper for the sessions from nine to twelve.

2- Control group

Control group received 12 sessions, 3 sessions per week for 4 consecutive weeks. Selective physiotherapy program for MS includes 10 min walking on treadmill, 5 min balance training on balance board and 15 min neuromuscular stimulation only.

D- Re evaluation

After 4 weeks all patients were re assessed using RehaCom for working memory and divided attention and by MSQoL-54 instrument for quality of life. All results were registered and ready for statistical analysis.

RESULTS

- Subject characteristics:

Table (1) showed the subject characteristics of study and control groups. There was no significant difference between groups in age, MMSE and duration of illness, sex and MS course distribution ($p > 0.05$).

Table 1. Subject characteristics of study and control groups:

	Study group	Control group		
	Mean ±SD	Mean ±SD	t- value	p-value
Age (years)	31.23 ± 3.69	30.59 ± 3.10	0.62	0.54
MMSE	21.55 ± 1.10	21.36 ± 1.18	0.53	0.60
Duration of illness (year)	4.86 ± 2.51	4.77 ± 1.69	0.14	0.89
Sex, N (%)				
Females	19 (86%)	20 (91%)	$\chi^2 = 0.23$	0.64
Males	3 (14%)	2 (9%)		
MS course, N (%)				
RR	20 (91%)	21 (95.5%)	$\chi^2 = 0.36$	0.55
SP	2 (9%)	1 (4.5%)		

SD, Standard deviation; χ^2, Chi squared value; p value, Probability value

Effect of treatment on working memory, visual deficits, auditory deficits and QoL:

Treatment and time had a significant interaction impact, according to mixed MANOVA (F = 26.20, p = 0.001, partial $\eta^2 = 0.73$). There was also a significant effect of time (F = 38.72, p = 0.001, partial $\eta^2 = 0.80$), and a significant effect of treatment (F = 10.89, p = 0.001, partial $\eta^2 = 0.53$).

Within group comparison

There was a significant improvement from pre- to post-treatment in all measured parameters in study group ($p < 0.001$). Working memory improved by 37.77%, visual deficits reduced by 95.94%, auditory deficits decreased by 51.17%, and MSQoL increased by 7.41% following treatment.

In contrast, within the control group there were no significant changes in working memory, visual deficits, or auditory deficits ($p > 0.05$). However, MSQoL showed a significant improvement by 3.98% post-treatment (p = 0.005). (Tables 2-3).

Between group comparison

There was no significant difference between groups pre-treatment ($p > 0.05$). Comparison between groups post treatment revealed a significant improvement in working memory (d = 1.40, $p < 0.001$), visual deficits (d = 3.25, < 0.001), and auditory deficits (d = 1.39, $p < 0.001$) in study group compared with control group. (Table 2).

In addition, there was a significant increase in MSQoL (d = 0.67, p = 0.03) in study group compared with control group. (Table 3).

Table 2. Mean working memory, visual deficits, auditory deficits and MSQoL pre and post treatment of study and control groups:

	Study group	Control group			
	Mean ±SD	**Mean ±SD**	**MD (95% CI)**	**P value**	**d**
Working memory					
Pretreatment	-4.21 ± 1.03	-4.30 ± 0.82	0.09 (-0.48: 0.65)	0.77	
Post treatment	-2.62 ± 1.26	-4.20 ± 0.98	1.58 (0.89: 2.27)	0.001	1.40
MD (95% CI)	-1.59 (-2.068: -1.115)	-0.1 (-0.569: 0.384)			
% of change	37.77	2.33			
	p = 0.001	***p = 0.69***			
Visual deficits					
Pretreatment	-3.94 ± 1.48	-4.04 ± 1.32	0.1 (-0.75: 0.96)	0.80	
Post treatment	-0.16 ± 0.82	-3.96 ± 1.44	3.80 (3.10: 4.52)	0.001	3.25
MD (95% CI)	-3.78 (-4.428: -3.141)	-0.08 (-0.719: 0.568)			
% of change	95.94	1.98			
	p = 0.001	***p = 0.81***			
Auditory deficits					
Pretreatment	-4.26 ± 1.23	-4.46 ± 0.92	0.20 (-0.46: 0.86)	0.55	
Post treatment	-2.08 ± 1.75	-4.38 ± 1.53	2.30 (1.30: 3.30)	0.001	1.39
MD (95% CI)	-2.18 (-2.982: -1.380)	-0.08 (-0.880: 0.722)			
% of change	51.17	1.79			
	p = 0.001	***p = 0.84***			

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, Probability value; d, Cohen effect size

Table 3. Mean MSQoL pre and post treatment of study and control groups:

MSQoL	**Study group**	**Control group**			
	Mean ±SD	**Mean ±SD**	**MD (95% CI)**	**P value**	**D**
Pretreatment	66.12 ± 6.45	65.14 ± 5.86	0.98 (-2.77: 4.73)	0.59	
Post treatment	71.02 ± 4.29	67.73 ± 5.43	3.29 (0.32: 6.27)	0.03	0.67
MD (95% CI)	-4.90 (-6.655: -3.146)	-2.59 (-4.342: -0.834)			
% of change	7.41	3.98			
	p = 0.001	***p = 0.005***			

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, Probability value; d, Cohen effect size

Discussion

In this study, we examined how well cognitive motor interference affects multiple sclerosis patients' quality of life and cognitive abilities.. Our results indicate that there is a significant improvement in working memory, divided attention and Qol on intervention group post treatment comparing pretreatment. In control group and there is no improvement on working memory, visual deficits and

*Author for Correspondence: ahmedabdelaziz252525@gmail.com

auditory deficits posttreatment comparing to pretreatment. There is a slight improvement in quality of life posttreatment comparing to pretreatment on control group.

Although there is broad spectrum of using CMI in neurological conditions, there is a lack of evidence supporting using CMI on cognitive impairments in MS patients. After analysis of 20 papers, one systematic review published in 2015, authors recommended more research to investigate the effect of CMI on MS patients **(10)**

Piche et al investigated the effectiveness of dual tasks on gait kinematics and spatiotemporal parameters on older adults and found that there is a significant improvement in gait kinematics and spatiotemporal parameters such as increase in swing time and cadence **(11).**

Another study investigated the effectiveness of dual tasks on motor performance and cognition in patients with Parkinson disease and found that there is a significant difference in dual task group compared to control group **(12).**

A randomized controlled trial of Huimeng compared the effectiveness of cognitive dual task gait training (CDTG) and motor dual task gait training (MDTG) on patients with sub-acute stroke and concluded that there is no significant difference between two types of training on coordination on sub-acute stroke. Both can be a part of a training program for these patients **(13).**

A meta-analysis of Maiocchi et al published on 2025 about the effectiveness of CMI on walking on healthy individual and confirmed that CMI influences gait measures, as well as on task accuracy, but not on reaction times. As there is a small amount of research included on this meta-analysis, authors recommend more future research on CMI **(14).**

A systematic review of Gao & Liu published in 2025 about the effectiveness of cognitive motor dual task on fall prevention on older adults concluded that there is an effect of CMI on fall prevention on older adults with a recommendation of further research with a high quality and large sample size and longer follow up periods **(15).**

Walin et al compared the effectiveness of CMI on walking and standing in mild, Moderate MS patients and healthy adults. They found that MS group with mild impairments has a positive effect on walking and standing. On the other side MS group with moderate impairment has slight improvement. CMI has no effect on healthy adults' group **(16).**

Borji et al investigated the effectiveness of DT on Standing and balance on adults' patients with down syndrome. They found that CMI has a positive effect on standing balance on patients with down syndrome and has no effect on people with typical developments **(17).**

Tisserand et al. investigated the effectiveness of CMI on dynamic stability on patients post stroke. They concluded that there was a significant improvement in CMI group on mediolateral stability and base of support in comparison to control group **(18).** A systematic review of Postigo et al published in 2018 ensured that CMI has a significant effect on gait cycle parameters such as velocity (m/s), cadence (steps/min), and double support (% gait cycle) on patient with MS **(19).**

On Leone, Carmela, et al. systematic review published in 2017 about the effect of CMI on neurological disease in comparison with studies used CMI on healthy subjects measured by different neuro imaging techniques such as Functional Magnetic resonance imaging (FMRI) or neurophysiological instruments such as event-related potential (ERP), electroencephalography (EEG) and magnetoencephalography (MEG). Results of this systematic review cannot conclude any evidence of using CMI on neurological disorders **(20).**

Al-Yahya et al on their systematic review searching for the evidence of CMI on gait and cognition on neurological disorders. They concluded that CMI has a great effect on cadence, stride length and speed. Cognitive also was improved by CMI **(21).** Decavel et al recommended using CMI on patients with MS rather than using traditional physiotherapy programs **(22).**

Learmonth, & Motl searched the literature on their review about the difference between using CMI on MS patients and healthy individuals on gait and balance. They concluded that there is no difference between using CMI on MS patients or healthy individuals on gait and balance **(23).**

Up to our knowledge, there are no studies investigated the effectiveness of CMI on cognition and quality of life on MS patients. So, our study is considered the first trial investigating cognition and Qol on MS patients by using CMI. Our results supported using CMI on cognitive and quality of life impairments so we must consider CMI on our rehabilitation programs when dealing with these patients. Strength points of our study are it is a randomized controlled trial with moderate sample size, with an objective measure of cognition by Rehacom software.

CONCLUSION

Findings of this study demonstrated that there is an effect of CMI on cognition and quality of life on patients with MS. So CMI must be a part of our rehabilitation program for these patients.

RECOMMENDATIONS

1- Further trials with a larger sample size
2- Further trials with longer follow up periods
3- Examine CMI on Moderate and Severe cognitive impairments
4- Examine CMI effects on PPMS and more SPMS.

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