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Cognitive impairment in a sample of adult patients with multiple sclerosis: an Egyptian study

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Abstract

Background Multiple sclerosis is a chronic neuro-inflammatory disease of the brain and central nervous system. We aimed at assessing the cognitive functions present in adult patients with multiple sclerosis in remission phase of the disease comparing them to healthy control group.

Results This is a cross sectional study using Penn Computerized Neurocognitive Battery (CNB) to measure performance accuracy and speed on specific neurobehavioral domains comparing MS group to healthy group. The MS group showed lower statistically significant difference in the accuracy of spatial memory, the motor speed, Non-verbal reasoning, Spatial orientation, social cognition, and working memory. Also, MS group showed statistically significant longer reaction time in facial memory, attention, spatial orientation, and non-verbal reasoning.

Conclusions Attention, spatial orientation, non- verbal reasoning, Facial memory, working memory, social cognition and spatial memory were affected in patients with MS during their remission phase. cognitive evaluation should constitute a major part of the clinical examination in MS, especially when impairment seems likely.

Keywords Cognition, Multiple sclerosis, Females, CNB

Background

Multiple sclerosis (MS) is a chronic, inflammatory neurodegenerative disease of the central nervous system. MS is characterized by the accumulation of chronic white matter de-myelination with axonal loss and diffuse inflammation. Neuro degeneration can also occur from early disease stages and worsen over time [18].

Although impairment in cognitive function occurs in different neurologic diseases and clinical syndromes, the degree of dysfunction depends on the involvement of different brain structures (cortical or subcortical), the extent of neural damage or number of affected domains, and the patient's previous cognitive reserve and performance [12].

In addition to their physical symptoms, 40% to 65% of people with MS experience some degree of cognitive impairment. Cognition represents the function of several neural pathways involved in the processing of information in the brain. The most commonly affected cognitive domains are complex attention, information processing, executive function, processing speed, and long-term memory [10].

The relationship between MS and cognitive impairment depends on several factors, including the age of onset of the disease, disability level, environmental and lifestyle factors (smoking and alcohol), psychiatric comorbidities mainly depression and anxiety, pain and fatigue.

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Cognitive impairment is present in all disease subtypes; however, it tends to be prominent and more severe in SP and PPMS patients, maybe due to the extensive neurodegenerative brain process and cortical involvement [1].

In a controlled study of newly diagnosed Relapsing remitting multiple sclerosis (RRMS) patients [3], frequency of cognitive impairment was 45%. Another study included RRMS untreated with disease-modifying therapies, found Cognitive impairment in 34.9% of patients [17]. In another study RRMS patients excluding patients with mean disease duration of 75 months, the prevalence of cognitive impairment was 31% [15].

Patients with Multiple sclerosis first show deficits in verbal fluency and verbal memory, and also a decline in visuo-spatial and recall skills. Deterioration in attention, information processing speed and Verbal learning can also be detected [10]. The aim of this study is to assess cognitive function in multiple sclerosis patients during remission phase of the disease.

Methods

Patients were recruited from the out- patient clinics of the Multiple Sclerosis Unit of Neurology Department, Mansoura University Hospital during the year 2020–2022. The calculated sample size of the study was 30 participants for each group at 5% level of significance and 95% power of the study, using G*Power 3 sample size calculator [22].

Inclusion criteria were patients aged between 18 and 50 years old, clinically definite MS, according to the McDonald criteria. All participants were ambulatory (Expanded Disability Status Scale < = 5.5) in a stable phase of the disease without relapses in the last 3 months [2] and agreed to sign informed consent. We excluded patients who had Psychiatric disorders, or drug abuse, MS relapse and receive corticosteroids. Visual acuity less than 6/18 corrected, oscillopsia or diplopia that would interfere with testing, Presence of major medical disorder as hepatic, renal or hearing problems would be excluded and if they were mentally disabled.

Inclusion criteria for the control group included healthy subjects with matched age, gender and education with the patient group. They were relatives of patients admitted in the ward of Neurology Department, Mansoura University Hospital will be recruited as a control group.

A semi-structured sheet: Including socio-demographic data, age, sex, marital status, residence, religion, years of education, past history of psychiatric disorders, family history of psychiatric disorder.

For group I: data about their illness were collected e.g. number of episodes, previous hospitalization, staging of the disease and treatment received. Diagnosis was obtained clinically and confirmed by higher staff members. For group II: healthy individuals with matched age, gender and education.

The Mini- International Neuropsychiatric Interview (M.I.N.I) is a short structured diagnostic interview, developed jointly by psychiatrists and clinicians in the United States and Europe, for DSM-IV and ICD-10 psychiatric disorders. With an administration time of approximately 15 min, it was designed to meet the need for a short but accurate structured psychiatric interview. It was used for clinical assessment to exclude presence of current psychiatric disorder [21] (Arabic version) [5].

Penn Computerized Neurocognitive Battery (CNB) (Arabic version) was designed to measure performance accuracy and speed on specific neurobehavioral domains using tests that were previously validated. Penn CNB consists of 14 tests. Motor Praxis Test (MPRAXIS) was used for assessment of sensorimotor integration speed. The Penn Continuous Performance Test–Number (PCPT-n) for assessment of attention and Face memory (immediate and delayed) with the Penn Face Memory Test (CPF) and Penn Face Memory Test–Delayed Memory (CPFd) were also used.

The Penn Conditional Exclusion Task (PCET) was used for assessment of abstraction and mental flexibility. Short Computerized Finger-Tapping Task (sCTAP) was used for assessment of spatial memory. Short Visual Object Learning Test (s VOLT) and Short Visual Object Learning Test Delayed Memory (s VOLTd) and The Penn Matrix Reasoning Test (PMAT) for assessment of nonverbal reasoning were also used.

The Short Penn Line Orientation Test (s PLOT) for spatial orientation was used. The Age Differentiation Test (ADT) for social cognition, Penn Emotion Recognition Task (ER40) and The Measured Emotion Differentiation Test (MEDF); and finally, the Short Fractal N-Back (SFNB2) for assessment of working memory were used [9].

Statistical analysis and data interpretation

Data analysis was performed by SPSS software, version 25 (SPSS Inc., PASW statistics for windows version 25. Chicago: SPSS Inc.). Qualitative data were described using number and percent. Quantitative data were described using median (minimum and maximum) for non-normally distributed data and mean ± Standard deviation for normally distributed data after testing normality using Kolmogrov-Smirnov test. Significance of the obtained results was judged at the (≤ 0.05) level. Chi-Square and Monte Carlo tests were used to compare qualitative data between groups as appropriate. Student t test and Mann Whitney U test were used to compare between 2 studied groups for normally and non-normally distributed data.

The Spearman's rank-order correlation is used to determine the strength and direction of a linear relationship between two non-normally distributed continuous variables and / or ordinal variables. Binary logistic regression was used to assess the effect of combination of more than 2 independent variables on dichotomous outcome using Stepwise technique.

Results

Regarding socio-demographic variables of studied groups, there was no statistically significant difference between patients and control (Table 1). They were matched in age, gender and education. The mean age of onset of the disease was 27.97 ± 7.01. Median duration since last admission / months was 12(5–48). Number of episodes with Median min–max) were 3(1–10) (Table 2).

On assessing Spatial memory, there was statistically significant difference between both group regarding true negative ($p=0.04$) where control group showed more accuracy than cases and false positive ($p=0.04$) where cases are more accurate than control group. Regarding motor speed, there was statistically significant difference between both group ($p=0.008$) where control group showed better results than cases in accuracy.

On assessing Immediate facial memory, there was statistically significantly difference among both groups regarding true negative ($p=0.009$), false positive ($p=0.009$). Total accuracy ($p=0.002$) &Total time response ($p=0.028$) were statistically significantly difference where control group showed better results in accuracy and less time for response than cases.

On assessing attention using Penn continuous performance task-number version, there was statistically significantly difference among both groups regarding reaction time for true positive response ($p=0.02$) where cases took much time than control group (Table 3).

Regarding Penn Matrix Analysis test, there was statistically significant difference among control and patients' group regarding time response ($p=0.038$) and accuracy ($p<0.001$) where cases took more time and showed less accuracy. On assessing delayed face memory using Penn facial memory delayed, there was statistically significantly difference among both groups regarding accuracy ($p=0.04$), false positive ($p=0.004$) and true negative ($p=0.028$) where cases showed less accuracy than control group.

For abstraction and mental flexibility using Penn conditional exclusion test, There was no statistically significantly difference among both group regarding accuracy ($p=0.194$) and reaction time ($p=0.425$).On assessing delayed memory using Short visual object learning tests, There was statistically significantly difference among both group regarding true negative ($p=0.045$) and false positive ($p=0.045$) where cases showed less accuracy than control (Table 4).

On assessing spatial orientation using short Penn line orientation test, there was statistically significantly difference among both group regarding accuracy ($p=0.001$) and reaction time ($p=0.046$) where cases showed less accuracy than control and more time than control.

Regarding social cognition using Measured emotion differentiation test, there was statistically significantly difference among both groups regarding accuracy ($p=0.005$) and reaction time ($p=0.043$) where cases showed less accuracy than control and more time than control. For Emotion recognition, using Penn emotion recognition test There was statistically significantly difference among both group regarding reaction time ($p=0.004$) where cases showed more time than control. Also, for age differentiation test, there was statistically significantly difference among both group regarding accuracy ($p=0.049$) where cases showed less accuracy than control.

Table 1 Sociodemographic characteristics and clinical variables of the studied groups

	Cases $n=30$	Control $n=30$	Test of significance
Age/years	31.37 ± 6.88	29.70 ± 5.45	t = 1.04 $p=0.303$
Education duration/ years	16.90 ± 1.17	16.20 ± 1.65	t = 1.84 $p=0.07$
Handness			
Right	29(96.7)	29(96.7)	$p=1.0$
Left	1(3.3)	1(3.3)	
Occupation			
Housewife	13(43.3)	5(16.7)	MC = 5.56
Employee	7(23.3)	8(26.7)	$P=0.135$
Health care worker	8(26.7)	17(56.7)	
Student	2(6.7)	0	
Marital status			
Single	4(13.3)	12(40)	$X^2=0.287$
Married	26(86.7)	18(60)	$p=0.592$
Residence			
Rural	16(53.3)	16(53.3)	$p=1.0$
Urban	14(46.7)	14(46.7)	
MS Cases ($N=30$)			
Age of onset / years			
mean ± SD		27.97 ± 7.01	
Duration since last admission/ months			
Median (min–max)		12(5–48)	
Number of episodes			
Median (min–max)		3(1–10)	

t Student t test, *MC* Monte Carlo test, X^2 Chi-Square test

Table 2 Motor speed, spatial memory, immediate facial memory and attention among studied group

	Cases *n* = 30	Control *n* = 30	Test of significance
Motor praxis test accuracy	19.80 ± 0.66	19.77 ± 0.94	t = 0.159 *p* = 0.874
Median response time for mouse praxis	1023.47 ± 263.55	921.35 ± 454.01	t = 1.07 *p* = 0.291
Sum of finger tapping dominant and non- dominant	88.67 ± 18.77	99.91 ± 16.43	Z = 2.66 *p* = 0.008*
Short visual object learning test true positive response	8.10 ± 1.56	8.03 ± 1.61	Z = 0.106 *p* = 0.916
Short visual object learning test true negative response	5.67 ± 2.35	6.87 ± 1.74	Z = 2.06 *p* = 0.04*
Short visual object learning test false positive response	4.33 ± 2.35	3.13 ± 1.74	Z = 2.06 *p* = 0.04*
Short visual object learning test false negative response	1.90 ± 1.56	1.97 ± 1.60	Z = 0.106 *p* = 0.916
Median response time for short visual object learning test	1978.13 ± 617.99	1713.77 ± 316.43	Z = 1.61 *p* = 0.107
Penn facial memory true positive	16.03 ± 2.58	16.50 ± 2.46	t = 0.717 *p* = 0.476
Penn facial memory true negative	11.80 ± 4.60	14.50 ± 3.0	t = 2.69 *p* = 0.009*
Penn facial memory false positive	8.20 ± 4.60	5.50 ± 3.0	t = 2.69 *p* = 0.009*
Penn facial memory false negative	3.97 ± 2.58	3.50 ± 2.46	t = 0.717 *P* = 0.476
Penn facial memory total correct response	27.83 ± 3.79	31.0 ± 3.48	t = 3.08 *p* = 0.002*
Penn facial memory median response time	231.85 ± 682.64	1857.78 ± 430.33	t = 2.20 *p* = 0.028*
Penn continuous performance task-number version true positive response	107.50 ± 10.18	111.60 ± 18.42	t = 1.07 *p* = 0.290
Penn continuous performance task number version false positive response	15.80 ± 11.96	10.17 ± 10.07	t = 1.9 7 *p* = 0.053
Penn continuous performance task-number version true negative response	224.20 ± 11.96	229.83 ± 10.08	t = 1.97 *p* = 0.053
Penn continuous performance task-number version false negative response	12.50 ± 10.18	8.40 ± 18.42	Z = 1.07 *p* = 0.290
Median response time for true positive response	537.97 ± 77.09	493.23 ± 67.77	t = 2.38 *p* = 0.02*
Median response time for false positive response	430.09 ± 125.65	435.05 ± 108.16	t = 0.167 *p* = 0.871

Z:Mann Whitney test, parameters described as mean ± SD t:Student t test, parameters described as mean ± SD *statistically significant

Using short fractal- N-back test to assess working memory, there was statistically significantly difference among both group regarding reaction time ($p = 0.018$) and accuracy ($p = 0.001$) where cases showed more time than control and less accuracy (Table 5).

There was statistically significant negative correlation between Duration since last admission (months) and Motor praxis test for reaction to time. There was no statically significant correlation between disease character and delayed facial memory, Penn matrix and attention.

There was statistically significant negative correlation between Number of episodes and Sum of finger tapping dominant and non- dominant. There was no statistically significant correlation between disease characters and cognitive battery regarding spatial orientation, working memory and social cognition among multiple sclerosis cases.

Table 3 Non-verbal reasoning test, delayed facial memory, abstraction and mental flexibility and delayed object memory test among studied groups

	Cases ***n*** **= 30**	**Control** ***n*** **= 30**	**Test of significance**
Penn matrix analysis test for correct response	9.27 ± 4.36	15.10 ± 5.54	z = 3.85 $p < 0.001$*
Median response time for Penn matrix analysis test	12,573.88 ± 9651.11	17,189.10 ± 9789.34	z = 2.07 $p = 0.038$*
Penn facial memory delayed true positive	16.23 ± 2.40	15.67 ± 2.88	t = 0.827 $p = 0.411$
Penn facial memory delayed true negative	12.97 ± 2.88	15.27 ± 4.03	t = 2.25 $p = 0.028$*
Penn facial memory delayed false positive	7.03 ± 3.88	4.37 ± 2.94	t = 2.99 $p = 0.004$*
Penn facial memory delayed false negative	3.77 ± 2.40	4.33 ± 2.88	t = 0.827 $p = 0.411$
Penn facial memory delayed total correct response	29.20 ± 3.62	31.30 ± 4.10	t = 2.10 $p = 0.04$*
Mean reaction time of penn facial memory delayed	1797.65 ± 576.02	1625.13 ± 317.49	t = 1.44 $p = 0.156$
Penn conditional exclusion test-correct response	40.20 ± 9.79	36.50 ± 6.28	z = 1.29 $p = 0.194$
Median response time for Penn conditional exclusion test	2647.27 ± 1056.43	2383.20 ± 764.31	z = 0.798 $p = 0.425$
Short visual object learning tests	13.0 ± 2.36	14.13 ± 2.08	Z = 1.61 $p = 0.108$
Short visual object learning tests delayed total correct response	13.0 ± 2.36	14.13 ± 2.08	Z = 1.92 $p = 0.06$
Median response time for Short visual object learning tests delayed total correct response	1852.42 ± 760.85	1594.50 ± 398.18	Z = 1.18 $p = 0.237$
Median response time for Short visual object learning tests delayed total correct response	1852.42 ± 760.85	1594.50 ± 398.18	Z = 1.18 $p = 0.237$
Short visual object learning tests delayed true positive response	7.93 ± 1.46	7.80 ± 1.79	Z = 0.083 $p = 0.934$
Short visual object learning tests delayed true negative response	5.07 ± 2.61	6.33 ± 1.77	Z = 2.01 $p = 0.045$*
Short visual object learning tests delayed false positive response	4.93 ± 2.61	3.67 ± 1.77	Z = 2.0 $p = 0.045$*
Short visual object learning tests delayed true positive response	7.93 ± 1.46	7.80 ± 1.79	Z = 0.083 $p = 0.934$

Z: Mann Whitney test, parameters described as mean ± SD *statistically significant

Discussion

Cognitive impairment is a common expression of MS. It is a frequent cause of disability and socio-economic decline for patients with MS. Even though the ability of detecting cognitive difficulties has increased over the last years, there are still many patients remain undiagnosed and their complaints are considered to be part of comorbidities. Sometimes treating the depression, anxiety and fatigue by psychotherapeutic interventions improves the cognitive alterations [16].

Regarding attention, the MS patients showed statistically significant longer reaction time in comparison to the control group. This may be due to subtle motor deficit which may lead to taking longer duration to respond to the test. These results were consistent with results of previous studies such as [7] who showed a lower attention performance in the MS group than the control group. On the other hand, a study carried by [13] revealed a significant deficit among control group than patients group. It may be related to higher levels of depression that was reported by control group.

The patients group showed more time than control and less accuracy regarding working memory. Which may be due to deficit in Information Processing Speed (IPS), affecting primarily the encoding of information. Previous studies agreed with our results such as [20] who found

Table 4 Spatial orientation test, Social cognition, Emotion recognition, Working memory and age differentiation between studied groups

	Cases ***n*** **= 30**	**Control** ***n*** **= 30**	**Test of significance**
Short penn line orientation test total correct	7.50 ± 3.49	10.27 ± 3.50	Z = 3.23 *p* = 0.001*
Median response time for short Penn line orientation test	12,582.20 ± 4332.19	10,636.87 ± 4089.62	Z = 1.99 *p* = 0.046*
Measured emotion differentiation test total correct	22.93 ± 4.25	26.10 ± 4.17	t = 2.91 *p* = 0.043*
Median response time for Measured emotion differentiation test	3536.78 ± 1519.69	2878.67 ± 853.21	t = 2.07 *p* = 0.043*
Penn emotion recognition test correct response	33.80 ± 3.26	35.20 ± 2.48	t = 1.87 *p* = 0.07
Median response time for Penn emotion recognition test	2542.43 ± 708.39	2100.47 ± 393.78	t = 2.98 *p* = 0.004*
Short fractal- N-back true positive responses for 1-back and 2-back	15.27 ± 2.08	17 ± 1.93	t = 3.34 *p* = 0.001*
Short fractal- N-back median reaction time for all positive responses for 1-back and 2-back trials	615.70 ± 207.22	511.48 ± 110.80	t = 2.43 *p* = 0.018*
Total correct age differentiation test trials	21.77 ± 4.56	24.33 ± 5.31	t = 2.01 *p* = 0.049*
Median response time for all age differentiation test	2278.58 ± 774.43	2016.27 ± 538.64	t = 1.52 *p* = 0.133

t: Student t test, parameters described as mean ± SD *statistically significant

that working memory was the most frequently impaired domain in all patients. However, these results were different from previous studies such as, [7] and [8] who found no significant difference between MS patients and control group in relation to working memory. This may be due to less sensitivity of the test than our battery test.

On assessing facial memory (immediate and delayed), control group showed better results in accuracy and less time for response than cases. This may be the extensive neurodegenerative brain process and cortical involvement in MS patients. These results agreed with results of previous studies such as [19] where Long-term memory and immediate memory were the most affected domains in MS, with a prevalence of 33–65% 9 in this study.

However, these results disagree with [13] who found no statistically significant differences emerged between the scores of the two groups.

On testing motor speed, there was a statistically significant difference between both groups where control group showed better results than cases in accuracy. May be this is due to to demyelination of the motor neurons. This may explain why MS patients showed longer time to respond to most of the tests used. This result is in line with a study carried by Maggio et al. [13] among 60 patients.

As for social cognition, using emotional differentiation test, age differentiation test, and emotional recognition tests, MS patients showed less accuracy than control and more time than control. This finding is in line with [6] who identified Significantly decreased performance in MS compared to control.

Regarding non- verbal reasoning, there was a significant difference among control and patients group where patients took more time and showed less accuracy. These results are consistent with [4] study where MS patients showed impaired results in non-verbal reasoning test. However, these results are different with previous study where Logical reasoning was assessed by spatial reasoning task. Results revealed no difference between control and patients' groups. It may be related to the sample size that was large compared to our study [11].

Regarding Spatial memory, there was a statistically significant difference between both group where cases are more accurate than control group in our study. This result agrees with [23] who found there was a spatial memory decline in MS patients more than control.

On assessing spatial orientation, MS patients showed statistically significant less accuracy than control and more time than control. This may be due to damage to white matter structure leading to disconnection between the cortical and subcortical regions responsible for spatial orientation. These results are consistent with previous studies such as [14] who found less accurate spatial orientation performance is present in up to 41% of the participants with early MS.

Table 5 Correlation between disease characters and cognitive battery among multiple sclerosis cases

		Age of onset / months	Number of episodes	Duration since last admission (months)
Motor praxis	R	.031	-.035	.265
	p value	.870	.855	.157
Median response time for motor praxis	R	.080	-.036	-.447[a]
	p value	.674	.852	.013
Penn facial memory true positive	R	-.204	.139	.098
	p value	.279	.464	.607
Penn facial memory true negative	R	.095	.232	-.055
	p value	.616	.217	.773
Penn facial memory false positive	R	-.095	-.232	.055
	p value	.616	.217	.773
Penn facial memory false negative	R	.204	-.139	-.098
	p value	.279	.464	.607
Penn facial memory total correct response	R	.029	.210	.040
	p value	.878	.08	.836
Penn facial memory median total correct response	R	.144	-.121	-.107
	p value	.448	.524	.572
Penn continuous performance task-number version true positive response	R	-.149	.148	-.129
	p value	.433	.435	.496
Penn continuous performance task-number version false positive response	R	.095	.003	.091
	p value	.619	.987	.634
Penn continuous performance task-number version true negative response	R	-.095	-.003	-.091
	p value	.619	.987	.634
Penn continuous performance task-number version false negative response	R	.149	-.148	.129
	p value	.433	.435	.496
Median response time for true positive response	R	.108	.264	-.005
	p value	.572	.159	.978
Median response time for false positive response	R	-.157	.036	-.061
	p value	.415	.854	.753
Penn matrix analysis test24-formA-correct response	R	-.022	.094	.299
	p value	.907	.622	.108
Median response time for correct responses of Penn matrix analysis	R	.064	-.139	.001
	p value	.737	.464	.996
Penn facial memory delayed true positive	R	.026	.107	.215
	p value	.893	.573	.255
Penn facial memory delayed true negative	R	.043	.109	.081
	p value	.822	.565	.669
Penn facial memory delayed false positive	R	-.043	-.109	-.081
	p value	.822	.565	.669
Penn facial memory delayed false negative	R	-.026	-.107	-.215
	p value	.893	.573	.255
Penn facial memory delayed total correct response	R	.060	.196	.154
	p value	.752	.299	.415
Mean total correct response time of Penn facial memory delayed	R	.139	-.348	-.167
	p value	.465	.060	.379
Penn conditional exclusion test correct responses	R	.143	.131	.053
	p value	.450	.490	.782
Median response time for Penn conditional exclusion test correct responses	R	.084	-.041	-.163
	p value	.660	.830	.390

Table 5 (continued)

		Age of onset / months	Number of episodes	Duration since last admission (months)
Short visual object learning test correct response test	R	-.085	-.106	.060
	p value	.655	.577	.753
Sum of finger tapping dominant and non-dominant	R	.081	**-.450**[a]	-.031
	p value	.670	**.013**	.871
Short visual object learning test total correct	R	-.113	.196	.134
	p value	.552	.300	.482
Short visual object learning test true positive response	R	.061	.095	-.122
	p value	.748	.618	.520
Short visual object learning test true negative response	R	-.008	.177	.233
	p value	.967	.348	.215
Short visual object learning test delayed false positive response	R	.008	-.177	-.233
	p value	.967	.348	.215
Short visual object learning test delayed false negative response	R	-.061	-.095	.122
	p value	.748	.618	.520
Short visual object learning test delayed true positive response	R	-.039	.082	-.060
	p value	.836	.665	.753
Short visual object learning test delayed true positive response	R	-.003	-.115	.312
	p value	.988	.544	.093
Short visual object learning test delayed false positive response	R	.003	.115	-.312
	p value	.988	.544	.093
Short visual object learning test delayed false negative response	R	.039	-.082	.060
	p value	.836	.665	.753
Short visual object learning test delayed correct response test	R	-.105	.026	.318
	p value	.583	.892	.087
Median response time for short visual object learning test delayed correct response test	R	-.181	.140	-.030
	p value	.338	.460	.875
Variable short Penn line orientation test	R	-.229	-.041	-.155
	p value	.223	.828	.412
Median response time for correct trials of tests of variable short Penn line orientation test	R	.060	-.340	.079
	p value	.752	.066	.678
Penn emotion recognition test correct response	R	-.246	-.044	-.090
	p value	.09	.816	.635
Median response time for all Measured emotion differentiation test	R	.069	.033	-.065
	p value	.716	.861	.731
Penn emotion recognition test correct response	R	-.225	-.114	-.224
	p value	.231	.547	.235
Median response time for Penn emotion recognition test correct response	R	-.011	-.102	.011
	p value	.955	.590	.954
Short fractal- N-back true positive responses for 1-back and 2-back	R	.028	.209	-.191
	p value	.883	.269	.311
Short fractal- N-back median reaction time for all positive responses for 1-back and 2-back trials	R	.073	-.007	.127
	p value	.700	.973	.505
Total correct age differentiation test trials	R	-.111	-.162	-.043
	p value	.560	.392	.821
Median response time for all age differentiation test	R	.225	-.213	.063
	p value	.232	.259	.740

r: Spearman correlation coefficient

[a] = statistically significant

Conclusions

Cognitive dysfunction has a remarkably negative impact on functionality, compromising employment status, social activities, treatment adherence and quality of life.

In our research we studied cognitive impairment among a representive sample of MS patients in outpatient clinics of Multiple Sclerosis Unite of Neurology Department, Mansoura University Hospital. We used Penn Computerized Neurocognitive Battery. It measured speed and accuracy of cognitive domains. Attention, spatial orientation, non- verbal reasoning, Facial memory, working memory, social cognition and spatial memory were affected in patients with MS during their remission phase. cognitive evaluation should constitute a major part of the clinical examination in MS, especially when impairment seems likely.

Abbreviations

ADT	The Age Differentiation Test
CNB	Penn Computerized Neurocognitive Battery
CPF	Penn Face Memory Test
CPFd	Penn Face Memory Test–Delayed Memory
ER40	Penn Emotion Recognition Task
M.I.N.I	The Mini- International Neuropsychiatric Interview
MEDF	The Measured Emotion Differentiation Test
MPRAXIS	Motor Praxis Test
MS	Multiple sclerosis
PCET	Penn Conditional Exclusion Task
PCPT-n	Penn Continuous Performance Test–Number
PMAT	The Penn Matrix Reasoning Test
s PLOT	The Short Penn Line Orientation Test
s VOLT	Short Visual Object Learning Test
s VOLTd	Short Visual Object Learning Test Delayed Memory
sCTAP	Short Computerized Finger-Tapping Task
SFNB2	Short Fractal N-Back

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Authors' contributions

S. E.: interviewed the patients and applied CNB battery to them and helped in writing the manuscript. I I: analyzed and interpreted the patient data and was a major contributor in writing the manuscript. A. A.: helped in diagnosing and recruiting MS patients. M. K.: helped in the design of the work. All authors revised and approved the final manuscript.

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Consent for publication

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Competing interests

The authors declare that they have no competing interests.

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