Neurological Sciences (2023) 44:1009–1016
https://doi.org/10.1007/s10072-022-06524-8

ORIGINAL ARTICLE

# Assessment of cognitive function and its predictors in patients with multiple sclerosis: a case–control study

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Received: 15 July 2022 / Accepted: 20 November 2022 / Published online: 29 November 2022


## Abstract

**Introduction** Cognitive dysfunction can be seen in patients with MS (PwMS) and has been gaining attention in recent years. This study aimed to assess cognitive function and its determinants in PwMS using Addenbrooke Cognitive Assessment Battery (ACE-R).

**Material and methods** This case–control study was conducted at an outpatient MS clinic in Istanbul. The sample consisted of 60 consecutive patients with definite MS and 60 matched controls. Cognitive function was evaluated by using the ACE-R. Subjective cognitive function, anxiety, depression, and fatigue were evaluated by validated scales.

**Results** The mean age of the patients was 38.8, and the time since diagnosis was nine years. The majority of the patients had relapsing–remitting MS. Compared to age, sex, and education-matched healthy controls, all ACE-R scores, attention/orientation ($p=0.020$), memory ($p=0.003$), verbal fluency ($p=0.002$), language ($p=0.002$), visuospatial ($p=0.001$), and general cognitive functioning ($p<0.001$), were found to be lower in PwMS. The patients obtained the lowest scores in memory and fluency and the highest in the visuospatial domain. Age, education, mobility, subjective cognitive dysfunction, anxiety, depression, and fatigue were associated with cognitive test scores. However, only education, depression, and fatigue remained significant in the multivariable analysis.

**Conclusion** This study revealed impaired domains of cognitive functioning and its predictors in PwMS. Understanding cognitive dysfunction and its predictors in PwMS may enable healthcare providers to identify patients who might benefit from interventions to improve cognitive function. Assessment of PwMS at outpatient clinics with a practical cognitive test that does not require special competence can be suggested.

**Keywords** Multiple sclerosis · Cognitive function · Addenbrooke Cognitive Assessment Battery · Depression · Fatigue

## Introduction

Multiple sclerosis (MS) is a chronic, progressive, and neurodegenerative central nervous system disease. Depending on the location and extent of the damage, a wide variety of symptoms can be seen in patients with MS. One of these symptoms is a cognitive dysfunction, which has been gaining attention in recent years. Studies have shown that cognitive impairment may affect up to 75% of MS patients, not only in advanced disease but also from the early period [1–4]. It has been reported that patients, compared to healthy controls, obtained lower scores in cognitive tests. Impairments may be seen in information processing (speed and efficiency), executive function, attention, working and long-term memory, visual and spatial perception, and verbal fluency [3, 5–7].

Cognitive impairment may lower the work performance of these patients and may cause financial problems. Cognitive impairment may also have an impact on disease management, decision-making for medical or financial issues, participation in daily life, social and personal relations, family roles, driving, and emotional well-being [8–11].

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All these aforementioned consequences of cognitive dysfunction highlight the importance of cognitive assessment in this patient population. In the neuropsychological assessment of a patient with MS, the most frequently used tests in studies are, among others, PASAT (Paced Auditory Serial Attention Test), SDMT (Symbol Digit Modalities Test), TMT (Trail Making Test), verbal fluency tests, WCST (Wisconsin Card Sorting Test), Brief Visuospatial Memory Test–Revised (BVMT–R), and SRT (Selective Reminding Test). Each test used to evaluate cognitive functions can only measure certain domains. Therefore, in studies, a separate test is applied for each domain that is thought to be impaired. There are also cognitive batteries (such as Brief International Cognitive Assessment for Multiple Sclerosis [BICAMS], Brief Repeatable Battery [BRB], or Minimal Assessment of Cognitive Function in MS [MACFIMS]) that combine some of these domains [12]. However, most of these tests have limitations in their use in practice, i.e., they may require competence (being neuropsychologist) and often available for a fee; their use is time-consuming [13]; and although they are used in studies, most of them (except for BICAMS) have not been validated in the Turkish language. This situation poses an obstacle to the application of tests, especially in the absence of a psychologist or in busy outpatient clinic conditions. There is a clear need for brief, easy-to-practice clinical settings, and sensitive and specific cognitive screening tests. Researches in the literature indicate that ACE-R, which is a short battery evaluating attention/orientation, memory, verbal fluency, language, and visuospatial functions, seems to be a good candidate to meet this need. The ACE-R is widely used for the assessment of cognition in dementia [14–16], amyotrophic lateral sclerosis [17], migraine [18], and multiple sclerosis [13, 19, 20]. The test is available free of charge and without restrictions, not only for doctors or neuropsychologists but also for other broadly defined healthcare professionals. Learning the technique is simple and takes a few hours; free training materials are available. Therefore, our study was carried out to evaluate the cognitive function of MS patients using ACE-R and determine predictors of cognitive functioning.

## Material and methods

### Sample and setting

The sample of this study consisted of 60 consecutive patients with MS (PwMS) and 60 healthy controls (HC). The sample size was calculated with the G-power program, with a type I error of 5% and a type II error of 20%. The calculation was based on a previous study [16] reporting that the ACE-R total score was 86/100 in healthy subjects, and the sample size was determined as 110, predicting that the score could be 75/100 or lower in MS patients. Inclusion criteria for study participants were being between the ages of 18 and 60 (to minimize the confounding effect of age), being literate, and having Turkish as their native language. Patients with a diagnosis of definite MS (according to McDonald's 2010 criteria) were included in the study. Patients who had a communication problem (having hearing or language problem), had any severe visual, hearing, and/or motor deficits that could affect their ability to perform the cognitive tasks, had an attack or steroid use in the previous 3 months, had any known psychiatric disorder (anxiety, depression, etc.) or a neurological disease other than MS (dementia, etc.) were excluded from the study. In the study, the control group consisted of healthy individuals (without any known disease) who were matched to the patient group in terms of age, sex, and education. The study was conducted in an MS outpatient clinic of a tertiary-level hospital (Goztepe Training and Research Hospital) in Istanbul.

### Study design

The case–control study was conducted in an MS outpatient clinic between January and July 2015. Patients were approached during their periodic clinical visits by the first author, a staff nurse in the hospital where the study was conducted. A neuropsychological evaluation was conducted by the first author after getting training to apply the cognitive test. All evaluations were administered in a quiet room free from distractions. Permission has been received to use the cognitive test. Written informed consent was obtained from all participants. Ethical approval was obtained from the Ethical Board of the Hospital (30.12.2014, 2014/0178).

### Study measures

A study measuring ACE-R, Multiple Sclerosis Neuropsychological Screening Questionnaire (MSNQ), Hospital Anxiety and Depression Scale (HADS), and Fatigue Impact and Fatigue Severity Scale were used. A patient information form to collect data regarding sociodemographics, clinical characteristics, and self-reported walking capacity to assess functional status was used. Functional status was categorized as 'no or mild problem' (~EDSS 0–3.5) if the patient can walk without any difficulties, 'moderate problem' (~EDSS 4.0–6.0) if the patient has problems in mobility but can walk 500 m without aid, and 'severe problem' (~EDSS > 6.0) if the patient has severe problems in mobility and cannot walk without two aids.

**Addenbrooke Cognitive Assessment Battery (ACE-R)** ACE-R is a brief bedside test for assessing cognitive functions based on Mini-Mental State Examination (MMSE) [14]. It is treated by clinicians as an extension of cognitive

performance assessment when the results of shorter tests are inconclusive [16]. The ACE-R assesses five cognitive domains (in 26 items), namely attention/orientation (max 18 points), memory (max 26 points), verbal fluency (max 14 points), language (max 26 points), and visuospatial (max 16 points) abilities. Its Turkish version was developed by Yildiz and Gurvit [21]. Any trained health professional can apply it without requiring competence. It takes about 15 min to apply. The maximum score that can be obtained from this battery is 100, and higher scores indicate better cognitive functioning.

**Multiple Sclerosis Neuropsychological Screening Questionnaire (MSNQ)** MSNQ is a self-report form to screen for neuropsychological impairment in MS [22]. It consists of 15 questions asking how often and severe neuropsychological problems occur. It is a Likert-type questionnaire (5 options). Lower scores indicate better neuropsychological function, and the cut-off score is 23.

**Hospital Anxiety and Depression Scale (HADS)** HADS is a Likert-type self-evaluation questionnaire with 14 items (7 for anxiety and 7 for depression). The cut-off value is 10 points for anxiety and 7 points for depression for the Turkish population [23].

**Fatigue Impact and Fatigue Severity Scale:** The Fatigue Impact Scale measures the impact of fatigue on a patient's daily life. The Fatigue Severity Scale measures the severity of fatigue and its effect on a person's activities and lifestyle in patients with various disorders. These scales have been adapted for the Turkish population [24, 25].

### Statistical analysis

Data were presented as frequency, percentage, mean ± standard deviation, and median. The maximum score that can be achieved is different for each domain of the ACE-R. Considering the difficulty in comparing the scores among domains, we converted domain scales by multiplying the adjusted mean score by 100 and then dividing by the possible maximum score. Independent samples *t*-test or Mann–Whitney *U* test was used to compare continuous variables, and the chi-square test was used to compare categorical variables. A general linear model was used to adjust data for fatigue and compare cognitive functions between PwMS and HC groups. The association between ACE-R and the sociodemographic, clinical, psychological variables, fatigue, and subjective cognitive function was tested one by one in simple linear regression. Variables that were statistically significant at $p < 0.01$ were entered in a multivariable linear regression analysis. The standardized regression coefficients β were used to compare the relative correlation between predictors and ACE-R outcome. In all other analyses, a *p*-value of $< 0.05$ for two-sided tests was considered statistically significant. SPSS program (version 21.0, IBM) was used for analyses.

## Results

The sociodemographic characteristics of 60 patients were compared with 60 healthy controls (Table 1). The patient and control groups were similar in terms of sociodemographic characteristics, which may impact cognitive function. The mean age was 38.8 ± 9.2 years in the PwMS group and 38.0 ± 11.6 in the HC group ($p = 0.665$). The mean educational level was 10.6 ± 4.8 years in the PwMS group and 10.8 ± 4.8 in the HC group ($p = 0.778$). The majority of the group was female (71.7% in PwMs vs. 73.3% in HC, $p = 0.838$). The patients had MS for 9.0 ± 6.0 years, the majority had RRMS (80%), and again the majority (88.3%) were on a disease-modifying therapy. Thirty-eight percent of the patients had no problem or minimal problem in mobility (Table 1).

A comparison of anxiety, depression, and fatigue scores among patients and healthy controls is presented in Table 2. When psychological variables were compared between the two groups, anxiety scores were similar ($p = 0.539$). Although depression scores were worse in PwMS than in the HC group, the difference was not statistically significant ($p = 0.153$). Compared to the HC group, the PwMS group had higher fatigue scores ($p = 0.040$ for impact and $p = 0.539$ for severity scale), as expected (Table 2).

The performance of PwMS in various cognitive domains is presented in Table 3. Since fatigue may impact cognitive test performance, test scores were adjusted for fatigue and then compared between the two groups. Compared to age-, sex-, and education-matched healthy controls, the PwMS group obtained lower scores from all cognitive domains. The mean ACE-R total score adjusted for fatigue was 72.39 in the PwMS group when it was 80.27 in the HC group ($F = 15.103$, $p < 0.001$) (Table 3). Both groups, including PwMS and the control participants, scored lowest in the memory (50.08 vs 58.96) and fluency (68.78 vs 79.71) domains and the highest in the visuospatial domain (86.13 vs 93.56). The difference in converted mean scores across ACE-R domains for PwMS and HC showed that the most deteriorated domains in PwMS were fluency and then memory, and the least deteriorated one was attention (82.72 vs 87.94) (data not shown in tables).

Patients were also asked about their perception of cognitive impairment; their mean score of MSNQ was found to be 17.6 ± 11.43 (range 1–45) (data not shown in tables). When the ACE-R scores of the PwMS group were evaluated according to the subjective cognitive dysfunction determined by MSNQ, the objective test scores of the patients

**Table 1** Sociodemographic and clinical characteristics of the participants

| Characteristics | PwMS ($n=60$) | | HC ($n=60$) | | | |
|---|---|---|---|---|---|---|
| | *n* | % | *n* | % | $\chi^2/t$ | *p* |
| Age (mean ± SD) (range) (*t*, *p*) | 38.8 ± 9.2 | 20–60 | 38.0 ± 11.6 | 19–60 | 0.434 | 0.665 |
| Education (*y*) (mean ± SD) (range) (*t*, *p*) | 10.6 ± 4.8 | 0–18 | 10.8 ± 4.8 | 0–22 | − 0.282 | 0.778 |
| Sex | | | | | | |
| Male | 17 | 28.3 | 16 | 26.7 | 0.042 | 0.838 |
| Female | 43 | 71.7 | 44 | 73.3 | | |
| Working status | | | | | | |
| Employed | 25 | 41.7 | 40 | 66.7 | | |
| Other (retired/homemaker/student) | 35 | 58.3 | 20 | 33.3 | | |
| Disease duration (year) (mean ± SD) (range) | 9.0 ± 6.0 | 1–32 | | | | |
| Type of MS | | | | | | |
| Relapsing–remitting MS | 48 | 80.0 | | | | |
| Progressive forms | 12 | 20.0 | | | | |
| Comorbidity | 10 | 16.7 | | | | |
| Use of DMTs | 53 | 88.3 | | | | |
| Mobility | | | | | | |
| No or mild problem (~ EDSS 0–3.5) | 23 | 38.3 | | | | |
| Moderate problem (~ EDSS 4.0–6.0) | 31 | 51.7 | | | | |
| Severe problem (~ EDSS > 6.0) | 6 | 10.0 | | | | |

*PwMS*, patients with multiple sclerosis; *HC*, healthy controls; *SD*, standard deviation; *DMT*, disease-modifying therapy; *EDSS*, Expanded Disability Status Scale. Chi-square test and independent samples *t*-test were used

**Table 2** Comparison of anxiety, depression, and fatigue scores among patients and healthy controls

| Characteristics | PwMS ($n=60$) Mean ± SD | HC ($n=60$) Mean ± SD | *Z* | *p* |
|---|---|---|---|---|
| HADS: anxiety | 6.21 ± 3.65 | 6.65 ± 3.83 | − 0.615 | 0.539 |
| HADS: depression | 7.21 ± 3.71 | 6.30 ± 3.35 | − 1.428 | 0.153 |
| Fatigue Impact Scale | 4.06 ± 3.24 | 3.10 ± 3.40 | − 2.056 | 0.040 |
| Fatigue Severity Scale | 4.32 ± 1.32 | 3.76 ± 1.51 | − 2.014 | 0.044 |

*PwMS*, patients with multiple sclerosis; *HC*, healthy controls; *SD*, standard deviation; *HADS*, Hospital Anxiety and Depression Scale. Mann–Whitney *U* test was used

who expressed dysfunction according to the subjective test were found to be poor. The differences were significant for memory, fluency, and language domains (Table 4).

To determine which factors predict cognitive function, we made multivariate analyses in the PwMS group. All sociodemographic and clinical factors (age, sex, education, duration of diagnosis, type of MS, and mobility), subjective cognitive dysfunction (MSNQ), psychological factors (HADS anxiety and depression), and fatigue (fatigue severity and impact) were separately analyzed for association with the ACE-R score. Analysis showed there was a significant association between ACE-R and age ($p=0.021$), education ($p<0.001$), mobility ($p<0.001$), subjective cognitive dysfunction

**Table 3** Comparison of cognitive test scores among PwMS and HC groups

| Characteristics | PwMS ($n=60$) | | | HC ($n=60$) | | | *F* | *p* |
|---|---|---|---|---|---|---|---|---|
| | Mean | SE | 95% CI | Mean | SE | 95% CI | | |
| Attention and orientation | 14.89 | 0.28 | 14.38–15.44 | 15.83 | 0.28 | 15.28–16.38 | 5.580 | 0.020 |
| Memory | 13.02 | 0.52 | 11.99–14.06 | 15.33 | 0.52 | 14.29–16.37 | 9.537 | 0.003 |
| Fluency | 9.64 | 0.34 | 8.96–10.32 | 11.16 | 0.34 | 10.48–11.85 | 9.687 | 0.002 |
| Language | 21.02 | 0.43 | 20.17–21.87 | 22.95 | 0.43 | 22.09–23.80 | 9.792 | 0.002 |
| Visuospatial | 13.78 | 0.24 | 13.33–14.26 | 14.97 | 0.24 | 14.49–15.44 | 12.030 | 0.001 |
| MMSE | 23.95 | 0.39 | 23.19–24.72 | 26.83 | 0.39 | 26.07–27.59 | 27.220 | < 0.001 |
| ACE-R total | 72.39 | 1.42 | 69.58–75.21 | 80.27 | 1.42 | 77.46–83.09 | 15.103 | < 0.001 |

*PwMS*, patients with multiple sclerosis, *HC*, healthy controls; *SE*, standard error; *CI*, confidence interval; *MMSE*, Mini-Mental State Evaluation, *ACE-R*, Addenbrooke Cognitive Assessment Battery-Revised. General linear model (means adjusted for fatigue severity and fatigue impact)

**Table 4** Evaluation of ACE-R scores according to subjective cognitive dysfunction (MSNQ) in PwMS group

| Characteristics | MSNQ ≤ 22 (no dysfunction) ($n=40$) Mean ± SD | MSNQ > 22 (dysfunction) ($n=20$) Mean ± SD | $Z$ | $p$ |
|---|---|---|---|---|
| Attention and orientation | 15.02 ± 1.86 | 14.50 ± 3.17 | − 0.064 | 0.949 |
| Memory | 13.60 ± 3.92 | 11.20 ± 5.64 | − 2.329 | 0.020 |
| Fluency | 10.22 ± 2.44 | 7.95 ± 3.66 | − 2.195 | 0.028 |
| Language | 21.82 ± 3.31 | 19.00 ± 5.18 | − 2.050 | 0.040 |
| Visuospatial | 13.97 ± 2.01 | 13.15 ± 2.58 | − 1.183 | 0.237 |
| MMSE | 24.30 ± 3.13 | 22.90 ± 4.14 | − 1.201 | 0.230 |
| ACE-R total | 74.57 ± 9.84 | 66.05 ± 17.86 | − 1.562 | 0.118 |

*PwMS*, patients with multiple sclerosis; *SD*, standard deviation; *MMSE*, Mini-Mental State Evaluation; *ACE-R*, Addenbrooke Cognitive Assessment Battery-Revised; *MSNQ*, Multiple Sclerosis Neuropsychological Screening Questionnaire. Mann–Whitney *U* test was used

($p < 0.001$), anxiety ($p < 0.001$), depression ($p < 0.001$) and fatigue ($p = 0.004$). All parameters with a significance level < 0.01 were entered in a multivariable linear regression analysis (except for mobility, which did not fit the model). After this analysis, only education, depression (HADS-D), and fatigue (fatigue impact) remained significantly related to ACE-R (Table 5).

## Discussion

Cognitive impairment has become an increasingly important issue in MS in recent years because of its impact on social and economic issues and also the quality of life [9–11]. It is reported that cognitive impairment may occur in any stage of the disease, even in the early stages [4]. Previous studies have reported different prevalence rates in PwMS ranging from 20 to 77%, depending on the methodology (study design, sample characteristics, the cognitive test used in the study, etc.) [1, 3, 26]. The prevalence of cognitive impairment in Turkish RRMS patients was determined to be 53.7% in a national study in which a Brief Repeatable Battery of Neuropsychological Tests (BRB-N) was used [2]. In the present study, the ACE-R test was used to assess cognitive functioning. Although there are numerous batteries to assess cognitive functions, assessment is time-consuming and challenging to perform in daily practice. Therefore, we tried to choose a brief cognitive screening tool that is practical and does not require special competence in its use but can still reveal patients' cognitive problems. To date, ACE-R has been validated for screening mild cognitive impairment and used in different groups, such as elder people, patients with dementia, parkinsonian syndromes, stroke, HIV, and also MS [13, 20, 27–30].

Studies that compared PwMS with healthy controls reported that PwMS obtained worse scores from the cognitive tests [31, 32]. In our study, compared to healthy controls, PwMS had worse scores in all ACE-R test domains (attention/orientation, memory, verbal fluency, language, visuospatial, and total general cognitive functioning). The most impaired domains were fluency and memory domains, and the best-preserved one was attention. Earlier studies have similarly identified these domains to be affected by MS [3, 5–7, 13, 20]. Our study confirmed the results of previous studies. However, we have shown that results similar to previous studies can be obtained with the use of a short and practical scale called ACE-R, which has been used in only a limited number of studies in MS

**Table 5** Predictors of ACE-R total score in PwMS group

| Predictors | β | $t$ | $p$ | $F$ | Model ($p$) | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| Constant | 72.365 | 13.337 | < 0.001 | 17.664 | < 0.001 | 0.585 |
| Education | 0.398 | 3.948 | < 0.001 | | | |
| MSNQ | − 0.116 | − 1.155 | 0.253 | | | |
| Depression | − 0.245 | − 2.088 | 0.042 | | | |
| Anxiety | 0.034 | 0.333 | 0.740 | | | |
| Fatigue impact | − 0.258 | − 2.094 | 0.041 | | | |

*PwMS*, patients with multiple sclerosis; *ACE-R*, Addenbrooke Cognitive Assessment Battery-Revised; *MSNQ*, Multiple Sclerosis Neuropsychological Screening Questionnaire. Multivariable linear regression analysis was used

patients. However, it is also known that cognitive tests may not capture all cognitive functions. As the ACE-R does not assess information processing speed, it may be difficult to comment on information processing speed, which is reported as one of the most impaired cognitive functions in PwMS [ 12]. However, when the reported relationships between information processing speed and attention are taken into account [33], it can be thought that attention deficit can indirectly inform us about information processing speed.

Several factors have been suggested that play a role in the development of cognitive impairment in PwMS. These factors included age, sex, educational level, depression, pain, fatigue, location and extent of lesions, course, and duration of disease [2, 3, 7, 26]. In the present study, the analysis showed that age, education, mobility, anxiety, depression, and fatigue were associated with cognitive test scores. Age is a well-defined factor that may have a significant impact on cognitive functioning. The association of age with the ACE-R score found here is in line with previous findings [2, 34]. Another associate of cognitive function was mobility in our study. Our data are in line with the findings of previous studies reporting a correlation between disability and cognitive performance [2, 5, 6]. These findings show a need to monitor patients with advanced age, low education, and mobility problems more closely. Although the differences were not significant for all domains, the ACE-R scores of the patients who reported dysfunction according to the subjective test were also found to be poor. It is known that subjective and objective cognitive tests have no straightforward relationship, and perceived cognitive impairment may result from depression or fatigue. Self-reported cognitive dysfunction may denote changes in cognition, though the absence of subjective impairment does not imply objective cognitive impairment [34, 35]. A partial association of subjective dysfunction with ACE-R in our study indicates that objective cognitive measures are required to accurately identify cognitive impairment [34, 35].

In our study, education, depression, and fatigue were predictors of cognitive functioning. The model $R^2$ values showed that all the predictors accounted for 58.5% of the variance in cognitive functioning. Educational background is a surrogate for socioeconomic status used as a cognitive performance indicator in MS. Indicating low socioeconomic status, the low educational background may lead to an unhealthy lifestyle (i.e., physical inactivity, obesity), smoking [36], worse adherence to care [37], increased comorbidity, and other related factors, predisposing patients to detrimental effects of the burden of the disease [38]. As a source of intellectual enrichment, education attainment can enhance the cognitive reserve in MS patients [39]. Our findings were similar to the earlier studies reporting the positive effect of education on cognitive functions [2, 38, 39]. Our findings also confirm the widely recognized association of cognitive impairment with depression [5, 6, 40]. Whether depression is a risk factor or an early sign of cognitive dysfunction, it needs to be explored [34]. Another predictor of cognitive functioning, fatigue, is a common symptom of MS. It is not easy to distinguish whether fatigue is due to MS or depression. The subjective experience of problems in concentrating and logical thinking and cognitive fatigue lead to an actual reduction in test scores during or after a cognitively challenging task [35]. We found that fatigue has a negative effect on the outcome of cognitive tests, which was compatible with previous reports [6].

Some limitations of our study need to be mentioned. First, the study was performed on a relatively small population. The literature, however, includes several studies with the same objectives and with similar sample sizes. Second, cognitive functions could have been assessed by more sophisticated batteries. Although these tests can give a deeper understanding of a patient's cognitive function, they are mostly time-consuming and need competence, so their use in busy and resource-limited clinics is limited. Third, ACE-R does not assess information processing speed, which is one of the most frequently impaired functions in PwMS. However, it is a known fact that each test battery used to evaluate cognitive functions can only measure certain domains and each has its own limitations.

## Conclusion

This study demonstrated that, compared to healthy controls, patients with MS obtained lower scores in all ACE-R test domains, i.e., attention/orientation, memory, verbal fluency, language, visuospatial, and general cognitive functioning. The most impaired functions were memory and fluency, and the best preserved was visuospatial. Although many factors were associated with cognitive functions, particularly patients with low education levels, depression, or fatigue, should be monitored more closely. This study revealed impaired cognitive functioning in patients with multiple sclerosis, even without using sophisticated cognitive batteries. Routine assessment of MS patients with a cognitive screening test that is practical and does not require special competence can be suggested. Understanding cognitive dysfunction and its predictors in PwMS may enable healthcare providers to identify patients who might benefit from interventions to improve cognitive function.

**Author contribution** Concept: ZT; design: ZT; data collection: DB; data analysis: ZT; literature search: DB and ZT; manuscript writing: DB and ZT.

**Funding** This work was supported by the Scientific Research Projects Coordination Unit of Istanbul University-Cerrahpasa (Project No: BEK-2017–26529).

**Data availability** The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

## Declarations

**Conflict of interest** The authors declare no competing interests.

**Ethical approval** Ethical Board of the Istanbul Medeniyet University Goztepe Training and Research Hospital (30.12.2014, 2014/0178).

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