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ORIGINAL ARTICLE

The effect of dual-tasking on functional mobility and manual dexterity in people with multiple sclerosis at different stages of disability

Çağrı Gülşen[1], Fatma Aydın[2], Fatih Söke[3], Bilge Koçer[2], Elvan Özcan Gülşen[4], Öznur Yilmaz[5], Selim Selçuk Çomoğlu[2]

[1]Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Osmangazi University, Eskişehir, Türkiye
[2]Department of Neurology, University of Health Sciences, Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, Türkiye
[3]Gülhane Faculty of Physiotherapy and Rehabilitation, University of Health Sciences, Ankara, Türkiye
[4]Department of Health Care Services, Yunus Emre Vocational School, Program in Geriatric Care, Anadolu University, Eskişehir, Türkiye
[5]Hacettepe University, Faculty of Physical Therapy and Rehabilitation, Ankara, Türkiye

ABSTRACT

Objectives: This study aimed to examine the effect of dual-tasking on functional mobility and manual dexterity in patients with multiple sclerosis (MS) at different stages of disability.

Patients and methods: Forty-five patients (18 males, 27 females; mean age: 39.0±10.7 years; range: 21 to 62 years) with MS, 15 in the very mild group (EDSS 0-1.5), 15 in the mild group (EDSS 2-3.5), and 15 in the moderate group (EDSS 4-6.5), were included in the cross-sectional study between July 2022 and September 2022. Fifteen healthy controls (6 males, 9 females; mean age: 38.2±13.4 years; range: 23 to 65 years) were recruited. The timed up and go (TUG) test and the nine-hole peg test (9HPT) were used to assess functional mobility and manual dexterity. The dual-task condition was carried out using the TUG test and the 9HPT as the single-task condition, combined with a serial sevens subtraction task.

Results: Dual-task scores for functional mobility and manual dexterity were significantly worse than single-task scores in all groups. The order of the magnitude of the dual-task effect (DTE) in functional mobility was as follows: healthy controls = patients with very mild MS = patients with mild MS < patients with moderate MS. In addition, the order of the magnitude of the DTE in both dominant and nondominant hand manual dexterity was as follows: healthy controls = patients with very mild MS < patients with mild MS < patients with moderate MS. The very mild group was similar to healthy controls in DTE on both functional mobility and manual dexterity.

Conclusion: The results suggest that dual-tasking has a negative effect on functional mobility and manual dexterity performance in patients with MS regardless of disability level. Also, the negative effect of dual-task begins to be evident at an earlier level of the disease in manual dexterity performance than in functional mobility performance.

Keywords: Disability level, dual-task, functional mobility, manual dexterity, multiple sclerosis.

Multiple sclerosis (MS) is a chronic demyelinating central nervous system disease characterized by loss of brain volume, neuronal damage, and dysfunction in neural pathways.[1] These dysfunctions in the nervous system lead to motor and cognitive impairments in patients with MS. It was reported that motor abilities such as walking, balance, and hand functions were largely impaired in patients with MS.[2-4] In addition, nearly 65% of the patients with MS have cognitive impairments.[5]

Patients with MS often face a decrease in performance when asked to perform a motor task concurrently with a cognitive task.[6] This decrease in performance caused by dual-tasking is called

Correspondence: Çağrı Gülşen, PT, PhD. Osmangazi Üniversitesi Sağlık Bilimleri Fakültesi, Fizyoterapi ve Rehabilitasyon Anabilim Dalı, 26040 Odunpazarı, Eskişehir, Türkiye
E-mail: fztcagri@gmail.com
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the dual-task effect (DTE).[7] The DTE occurs due to the limited attentional capacity of individuals.[8] Considering the motor and cognitive impairments in patients with MS, it was reported that the negative DTE was higher in patients with MS than in healthy subjects.[9]

Most activities of daily living require independent mobility.[10] Manual dexterity is also an important component of independence in activities of daily living.[11] Moreover, it was stated that most tasks in daily life were not performed as a single motor task but as a dual task, such as talking while walking.[12] Therefore, the effect of dual-tasking on functional activities in patients with MS has been a frequently studied topic in recent years.

Studies investigating the effects of dual-tasking in patients with MS mostly focused on functional activities such as walking.[13-16] In many of these studies, parameters such as walking speed, stride length, stride width were examined on a straight walking path of a certain length.[15,16] However, when the daily life activities of the patients were considered, functional mobility activities, including standing up, turning, and sitting, were performed more than walking on a straight walking path of a certain length.[17] In addition, as mentioned before, impairments in manual dexterity are frequently observed in patients with MS, and activities that require manual dexterity constitute an important part of daily living activities.[4,11] However, there is limited evidence in the literature regarding the effect of dual-tasking on manual dexterity in patients with MS.[18] In addition, most of the studies in the literature collectively evaluated patients with various disability levels.[13-15] Therefore, it is not possible to make an inference about the effect of dual-tasking in patients with different disability levels. However, it was reported that as the severity of the disease increased in patients with MS, the motor and cognitive impairments also became more severe.[19] Consequently, the effect of dual-tasking may be expected to be different in patients with different disabilities. Taking all these factors into account, this study aimed to examine the effect of dual-tasking on functional mobility and manual dexterity in patients with MS at different stages of disability.

PATIENTS AND METHODS

This cross-sectional study was conducted at the Ankara Dıskapı Yıldırım Beyazit Training and Research Hospital, Department of Neurology between July 2022 and September 2022. Fifty-two patients with relapsing-remitting MS were screened for eligibility. Five patients did not meet the inclusion criteria, and two declined to participate. The remaining 45 patients (18 males, 27 females; mean age: 39.0±10.7 years; range: 21 to 62 years) were divided into three groups according to the Expanded Disability Status Scale (EDSS) scores: the very mild disease group (EDSS scores between 0-1.5), the mild disease group (EDSS scores between 2-3.5), and the moderate disease group (EDSS scores between 4-6.5).[20] Additionally, 15 age-matched healthy participants (6 males, 9 females; mean age: 38.2±13.4 years; range: 23 to 65 years) were recruited through posters and social networks as a control group. All patients were diagnosed with MS by an experienced neurologist according to the revised McDonald criteria.[21] All patients were older than 18 years of age, had a Mini-Mental State Examination score ≥24[22] and EDSS score <7, and had no relapse or change in disease-modifying treatment at least one month prior to the study. Healthy controls were older than 18 years of age and had Mini-Mental State Examination scores ≥24. Patients with MS were excluded from the study if they had neurological disorders other than MS. Healthy controls were excluded if they had any neurological disorder. Patients with MS and healthy controls were excluded if they had pregnancy; presence of any other vestibular, orthopedic, or rheumatic problems that could hinder gait and stance; or a visual, hearing, or perceptual disorder. All the participants provided a written informed consent. The study protocol was approved by the Dışkapı Yıldırım Beyazıt Training and Research Hospital Clinical Research Ethics Committee (Date: 04.07.2022, No: 141/12). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Assessments were completed in a single session by an experienced physiotherapist. Three-minute resting periods were given between assessments to minimize fatigue effects. Functional mobility and manual dexterity assessments were completed in a single-task condition and a dual-task condition. The dual-task condition was carried out using the same motor task as the single-task condition but in combination with a serial sevens subtraction task from a randomly chosen number between 300 and 999 as a cognitive task. A different number was used for each dual-task assessment. Participants were asked to give their attention equally to the motor and the cognitive task.

TABLE 1
Demographic and clinical characteristics of the participants

	Very Mild			Mild			Moderate			Controls			
Variables	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			33.1±10.3			41.3±11.5			42.7±7.9			38.2±13.4	NS
Sex													NS
Female	8	53.3		9	60		10	66.7		9	60		
Male	7	46.7		6	40		5	33.3		6	40		
BMI (kg/m²)			24.12±2.78			25.65±4.20			26.19±3.90			25.30±4.30	NS
EDSS (score)			1.10±0.21			2.80±0.49			4.5±0.46			N/A	<0.001
Disease duration (year)			3.80±2.31			10.60±6.21			9.20±3.28			N/A	<0.001
Education level (%)													NS
Primary	1	6.7		2	13.3		3	20		2	13.3		
Secondary	1	6.7		0	0		2	13.3		1	6.7		
High school	5	33.3		4	26.7		4	26.7		3	20		
College	8	53.3		9	60		6	40		9	60		
Dominant hand (%)													NS
Right	13	86.7		14	93.3		14	93.3		14	93.3		
Left	2	13.3		1	6.7		1	6.7		1	6.7		

SD: Standard deviation; BMI: Body-mass index; EDSS: Expanded Disability Status Scale; p<0.05.

TABLE 2
Comparisons between single-task and dual-task scores

	Very mild			Mild			Moderate			Control		
	Single task	Dual task		Single task	Dual task		Single task	Dual task		Single task	Dual task	
	Mean±SD	Mean±SD	*p*	Mean±SD	Mean±SD	*p*	Mean±SD	Mean±SD	*p*	Mean±SD	Mean±SD	*p*
TUG (s)	6.27±0.90	10.11±2.66	0.001	7.79±1.27	12.72±3.55	0.001	11.58±3.17	23.28±5.59	0.001	5.98±1.15	8.96±1.65	0.001
9HPT Dominant (s)	18.98±4.01	23.15±4.41	0.001	24.73±4.92	33.80±7.29	0.001	34.94±7.68	56.17±10.78	0.001	17.27±3.46	20.54±3.89	0.001
9HPT Non-dominant (s)	23.47±4.74	31.61±6.14	0.001	29.76±6.07	48.76±11.78	0.001	40.72±7.08	81.34±9.68	0.001	19.85±3.51	23.90±4.19	0.001

SD: Standard deviation; TUG: The timed up and go test; 9HPT: The nine hole peg test; p<0.05.

The level of disability due to MS was assessed with the EDSS.[20] The EDSS is scored between 0 (normal neurological status) and 10 (death). A higher score indicates a higher level of disability.

Functional mobility was assessed with the timed up and go (TUG) test.[23] The TUG test required participants to rise up from a chair, walk 3 m, turn 180°, walk back 3 m to the chair, and sit down. The time taken to complete the test was recorded in seconds.

Manual dexterity was assessed with the nine-hole peg test (9HPT).[24] The 9HPT required participants to place nine pegs one at a time into the nine holes and then remove them as quickly as possible. Total time taken to insert and remove pegs with dominant and nondominant hands was recorded in seconds. The dominant hand of the participants was determined as the preferred hand for performing skillful and unimanual tasks such as writing.[25]

The DTE was calculated with the following equation: (dual-task performance-single-task performance)/(single-task performance)×100.[26]

Statistical analysis

The sample size was calculated using G*Power version 3.1 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany), based on previous data,[27] indicating that 15 participants were required for each of the four groups to achieve a significance level of 0.05 with a power of 0.90.

Data analysis was performed using IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Data were expressed as mean ± standard deviation or frequency (percentage). The Shapiro-Wilk test was used to evaluate distribution of the variables. Since most of the variables showed a nonnormal distribution, nonparametric methods were used in the analysis. The Wilcoxon signed-rank test was used to compare the single-task and dual-task performance of the participants. The Kruskal-Wallis test was used to compare the DTE between groups. If a statistically significant difference was observed in intergroup comparisons, Bonferroni-adjusted post hoc pairwise comparisons were conducted. A p-value <0.05 was considered statistically significant.

RESULTS

Demographic and clinical characteristics of the participants are given in Table 1. Comparisons

TABLE 3
Comparisons of patients with MS with different stages of disability and healthy controls in terms of the DTE

	Very Mild	Mild	Moderate	Controls	
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	*p*
DTE on TUG (%)	60.37±33.28	61.96±31.56	102.88±28.46	53.26±35.48	0.001
DTE on 9HPT dominant (%)	22.67±9.23	37.15±18.46	63.02±22.66	19.39±6.10	<0.001
DTE on 9HPT non-dominant (%)	36.01±20.61	64.44±28.08	104.35±36.47	21.40±18.56	<0.001

MS: Multiple sclerosis; DTE: Dual-task effect; DTE: The dual-task effect; TUG: The timed up and go test; 9HPT: The nine hole peg test; p<0.05.

TABLE 4
Pairwise comparisons

	DTE on TUG	DTE on 9HPT dominant	DTE on 9HPT non-dominant
	p	*p*	*p*
Very mild-mild	NS	0.005	0.006
Very mild-moderate	0.001	<0.001	<0.001
Very mild-controls	NS	NS	NS
Mild-moderate	0.002	0.001	0.003
Mild-controls	NS	0.001	<0.001
Moderate-controls	0.001	<0.001	<0.001

DTE: The dual-task effect; TUG: The timed up and go test; 9HPT: The nine hole peg test; p<0.008.

between single-task and dual-task scores are given in Table 2. Dual-task scores were significantly worse than single-task scores in all groups (p=0.001 for all).

Comparisons of patients with MS with different stages of disability and healthy controls in terms of the DTE are shown in Table 3. Significant differences were present between groups in terms of the DTE on TUG scores (p=0.001), the DTE on dominant hand 9HPT scores (p<0.001), and the DTE on nondominant hand 9HPT scores (p<0.001).

When pairwise comparisons were conducted (Table 4), there was similarity in the DTE on TUG scores between patients with very mild MS and controls (p=0.419), patients with mild MS and controls (p=0.351), and patients with very mild MS and patients with mild MS (p=0.820). However, the DTE on TUG scores in patients with moderate MS was significantly higher than patients with very mild MS (p=0.001), patients with mild MS (p=0.002), and controls (p<0.001).

There was also similarity in the DTE on dominant hand 9HPT scores between patients with very mild MS and controls (p=0.310). However, the DTE on dominant hand 9HPT scores in patients with mild MS was significantly higher than patients with very mild MS (p=0.005) and controls (p=0.001). In addition, the DTE on dominant hand 9HPT scores in patients with moderate MS was significantly higher than patients with very mild MS (p<0.001), patients with mild MS (p=0.001), and controls (p<0.001).

The DTE on nondominant hand 9HPT scores in patients with very mild MS and controls was also similar (p=0.011). However, the DTE on nondominant hand 9HPT scores in patients with mild MS was significantly higher than patients with very mild MS (p=0.006) and controls (p<0.001). In addition, the DTE on nondominant hand 9HPT scores in patients with moderate MS was significantly higher than patients with very mild MS (p<0.001), patients with mild MS (p=0.003), and controls (p<0.001).

DISCUSSION

This study examined the effect of dual-tasking on functional mobility and manual dexterity in patients with MS at different stages of disability. Overall, the results showed that dual-tasking had a negative effect on functional mobility and manual dexterity performances in patients with MS at all stages of disability, as well as in healthy controls.

This effect on functional mobility was similar in patients with MS with very mild and mild disability and healthy controls. However, DTE on functional mobility in patients with MS with moderate disability was higher than those with very mild and mild disability and healthy controls. In addition, DTE on dominant and nondominant hand manual dexterity were similar in patients with MS with very mild disability and healthy controls. On the other hand, DTE on dominant and nondominant hand manual dexterity in patients with MS with mild disability were higher than in patients with MS with very mild disability and healthy controls. However, patients with MS with moderate disability had the highest DTE on dominant and nn-dominant hand manual dexterity.

The results showed that dual tasking had a negative effect on functional mobility and manual dexterity performances in patients with MS at all stages of disability, as well as in healthy controls. To the best of our knowledge, the DTE on functional mobility has not been previously investigated in patients with MS. Most of the previous studies investigating the DTE focused on walking performance.[28] Therefore, no direct inferences can be drawn from previous reports. However, walking performance is one of the key components of functional mobility. Most of the previous studies investigating the DTE on walking performance in patients with MS found similar results to ours.[29,30] Furthermore, reviews of these studies suggested that the negative effect of dual-tasking on walking performance of patients with MS persisted in studies conducted on patients with different disability levels.[7] Therefore, it can be said that our results are in line with previous studies. Although there are few studies examining the DTE on upper extremity functions, particularly manual dexterity, in patients with MS, these studies reported similar results to ours.[18,30] The negative effect of dual tasking on walking performance can also be observed in healthy adults.[31] On the other hand, we could not identify any study that investigated the DTE on manual dexterity in healthy adults. Therefore, it was not possible to compare our results with previous findings. However, it can be concluded that mechanisms similar to dual-task walking may play a role in manual dexterity activities of healthy adults, and consequently, similar effects of dual-tasking can be observed in manual dexterity activities.

A novel finding of the present study was that the DTE on functional mobility in patients with MS with very mild disability, patients with MS with mild disability, and healthy controls was similar, and DTE on functional mobility was lower in these groups than in patients with MS with moderate disability. As mentioned before, it is not possible to compare the results with previous findings since there is no study investigating DTE on functional mobility in patients with MS. However, it was reported that EDSS scores of 4 and above required impaired mobility.[32] In addition, it was reported that walking required more cognitive function, such as executive function, in patients with mobility impairments.[33] Moreover, although the patients with MS included in the study were patients without cognitive impairment according to global cognitive assessments, it was reported that impairment in executive functions occurred more prominently in those with EDSS scores 4 and above.[34] Previous studies also demonstrated that executive functions were directly related to DTE.[35] In light of these results, we believe that the impaired mobility causing more cognitive load and decreased cognitive capacity may be the reason behind the higher DTE in patients with MS with moderate disability compared to the other groups.

Another novel finding of the current study was that, unlike functional mobility, the order of the magnitude of the DTE in both dominant and nondominant hand manual dexterity (healthy controls = patients with very mild MS < patients with mild MS < patients with moderate MS). It is known that even minimal disability accumulation in MS increased the risk of future progressive disease. There is limited evidence regarding the DTE on manual dexterity in patients with MS. A study conducted in mildly disabled patients with MS observed similar DTE on manual dexterity between patients with MS and controls.[18] However, a direct comparison with our findings was not possible since a different cognitive task was used in this study. To the best of our knowledge, there is no study investigating the DTE on manual dexterity in very mildly disabled patients with MS. However, it is known that patients with MS with EDSS scores ≤1.5 are not considered to have any physical disability,[20] explaining the similarity of patients with very mild MS and healthy controls in terms of DTE on manual dexterity. On the other hand, impairments in fine motor skills such as manual dexterity can be observed from the early stage of the disease.[24] In addition, impairments in manual dexterity become more prominent in the later stages of the disease.[36] Moreover, it is known that upper extremity skills

are more cognitively driven and create more cognitive load than gross motor activities, such as walking.[37] Therefore, our finding indicating that DTE on dexterity started to increase in earlier stages of the disease, unlike functional mobility, may be explained in the light of these results. This finding is also consistent with the results of studies on other neurological conditions such as Parkinson's disease.[38]

Our findings suggested that including dual-task performance in motor performance measurements may be useful for the early detection of motor-cognitive disorders in patients with MS. Similarly, in a previous study, the cerebellar activities of patients with MS were examined during dual tasks, and it was observed that there were affected regions in the cerebellum of these patients even in the early stages of the disease.[39] As a result of the study, it was concluded that patients were able to compensate for motor impairments originating from the affected areas in the cerebellum during single tasks, but these impairments were more pronounced during dual tasks. Our results also suggested that dual-task exercises should be added to the rehabilitation programs of patients with MS from the early stages of the disease. There is a lack of studies in the literature on the effects of dual-task training on manual dexterity. However, there is evidence that dual-task training has positive effects in terms of gait, balance, and DTE in patients with MS.[40]

There were several limitations to this study. First, all patients with MS were cognitively intact. Therefore, these results could be different in patients with MS with cognitive conditions. Moreover, although the participants were asked to give their attention equally to the motor and the cognitive task, the task prioritization of the participants during dual-tasking cannot be recorded. Thus, the effect of task prioritization on the results remains unclear. Additionally, there was no group with non-brain-derived disease (e.g., arthritis or congenital hip dislocation). Therefore, the results of our study cannot be generalized to such conditions. In addition, the mean age of the very mild group was lower than the other groups, although not statistically significant. Therefore, it should be considered that this nonsignificant difference may still have influenced the results. Lastly, the patients did not undergo a detailed cognitive assessment. Therefore, this should be taken into consideration when examining our findings.

In conclusion, cognitive-motor dual-tasking had a negative effect on functional mobility and manual dexterity performance in patients with MS, regardless of disability level. This negative effect became more prominent in moderately disabled patients with MS. However, the negative effect of dual-tasking begins to be evident at an earlier level of the disease in manual dexterity performance than in functional mobility performance.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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