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RESEARCH ARTICLE

Relationship Between Dual-task Walking and Cognitive Functions in Persons with Multiple Sclerosis

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Abstract

Objective: Dual-task performance assessment is a holistic approach that incorporates both motor and cognitive assessment. However, there is scarce data on the relationship between dual-task walking and cognitive functions in persons with multiple sclerosis (pwMS). The aim was to investigate the relationship between dual-task walking and cognitive functions in pwMS.

Materials and Methods: This study analyzed 156 patients (median age 35 years, 73.1% female). Timed Up and Go tests (TUG), with and without cognitive task (TUG), were performed to assess dual-task performance. Dual-task cost (DTC) was calculated. Cognitive information processing speed, visuospatial memory, and verbal memory were assessed using a Brief International Cognitive Assessment for MS (BICAMS).

Results: The DTC was 11.8%. The TUG-cog tests were moderately correlated with all subtests of BICAMS (r=-0.322 to -0.440). However, DTC has a significant but small correlation with cognitive tests (r=0.227-0.254). Disability level was the significant predictor of dual-task performance.

Conclusion: Our findings confirm that higher dual-task performance is significantly associated with better cognitive processing speed, visuospatial memory, and verbal memory in pwMS. This result may facilitate the use of dual-tasking paradigms in studies on cognitive impairment screening methods. However, such research undertakings should be supported by longitudinal studies.

Keywords: Multiple sclerosis, cognition, dual-task, cognitive-motor interference, walking

Introduction

Multiple sclerosis (MS) is a neurodegenerative condition of the central nervous system, mainly characterized by walking and cognitive impairment that begin in the early stages of the disease (1). Traditionally, these symptoms are evaluated and treated separately. However, when persons with MS (pwMS) are subjected to simultaneous evaluation for motor and cognitive performance, they often experience worsening in one or both tasks (2,3). This deterioration has been termed cognitive-motor interference (CMI), which can be quantified by calculating the percentage change between single-task and dual-task performance (4,5).

In recent years, there has been increasing interest in the clinical characteristics of CMI, its neural correlates and associated factors in pwMS, given that it has been considered a marker of daily life impairment. Although some neuroimaging studies suggest that there is increased activation in the prefrontal cortex and premotor cortex during dual tasking in pwMS, findings on whether pwMS have higher CMI than age-matched healthy controls are inconsistent (6-8). This may be due to the fact that varied dual-task paradigms have been used in studies or different baseline conditions of patients associated with diseases. Recently, Rooney et al. (9) summarized the findings in the literature on related clinical factors of dual-task in pwMS. They found that there were few studies on the relationship between dual-task and cognition, and that of these limited studies, majority focused on the correlation between processing speed and dual-task performance. Furthermore, the results arrived at in the studies were inconsistent (9).

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In this study, we aimed to investigate the association between cognitive-motor dual-task performance, cognitive functions and falls in pwMS using a larger sample than in the studies found in the literature. In addition, we aimed to explore the relationship between different domains of cognitive functions using an extensive cognitive battery.

Materials and Methods

The Dokuz Eylul University Ethics Board approved the study protocol (approval number: 2016/27-08, date: 20.10.2016). All participants provided their written consent after being fully informed.

Participants

The data were secondary outcomes of our previously published study (10). The inclusion criteria were diagnosis of MS according to the 2017 McDonald criteria (11), Expanded Disability Status Scale (EDSS) range was between 0 and 6.5, and age was between 18 and 65 years. Exclusion criteria were the following: relapse occurring within 30 days, neurological disease diagnosis other than MS, and severe cognitive impairment according to clinician judgments as to hindered understanding of test instructions.

Outcome Measures

Primary Outcome Measures

Dual-task Performance

The Timed Up and Go (TUG) test was performed with and without a cognitive task. The subject was instructed to stand up, walk three meters to a particular spot on the ground, turn around, and go back to the chair and sit (12). The activity, timed using a stopwatch, was ended when the participant was already sitting in the chair, with the total duration was noted. Each participant underwent the TUG test in the same standardized order, and they were instructed to use their regular mobility device and walk quickly but as safely as possible. Secondly, participants performed another TUG, this time with a cognitive task (i.e., TUG-cog). The cognitive task was serial subtraction by threes from a given starting number (between 20 and 100). Participants were instructed to execute both tasks at their best without prioritization. We reported single-task performance (TUG), absolute dual-task performance (TUG-cog), and dual-task cost (DTC). DTC was calculated by this formula:

DTC (%)=[(single-task performance - dual-task performance)/(single-task performance)]x100

The larger the minus value of the DTC, the higher is the DTC, meaning, worse dual-task performance.

Cognitive Functions

The Turkish version of the Brief International Cognitive Assessment for MS (BICAMS) was administered to measure cognitive functions. It includes three subtests: the oral version of the Symbol Digit Modalities Test (SDMT) that measures cognitive processing speed and sustained attention; the Brief Visuospatial Memory Test-Revised (BVMT-R) that assesses visuospatial memory; and the California Verbal Learning Test (CVLT-II) that assesses verbal memory (13).

Secondary Outcome Measures

Demographic and clinical information such as age, sex, disease duration, course of the disease and neurological disability level rated by EDSS were noted.

Timed-25 Foot Walking (T25FW) was used to assess gait speed on 7.62 m pathway (14). The perceived walking performance was evaluated using the 12-item MS Walking Scale (MSWS-12) (15).

Statistical Analysis

In order to analyze the data, IBM SPSS Statistics for Windows was used (Version 25.0. Armonk, NY: IBM Corp.). The Kolmogorov-Smirnov test and evaluation of the histogram and plots were utilized to determine the distribution of the data. The use of descriptive statistics yielded median and interquartile ranges since data did not show normal distribution. Spearman's rank correlation was calculated to determine the association between absolute dual-task performance, DTC and cognitive functions, and falls. Correlation coefficients between 0.1 and 0.29 were considered to be small, 0.3-0.49 to be moderate, and 0.5-1.0 to be strong (16). Hierarchical binary regression models were conducted to explain the relationship between cognitive functions and dual-task performance.

Results

Study Participants

In total, data from 156 subjects were analyzed in this study. The median EDSS score was 1.5. For majority of the subjects, the course of the disease was relapsing-remitting. The baseline demographics, clinical characteristics, and descriptives of outcome measures of participants are summarized in Table 1.

When the TUG was applied with the cognitive task, the duration increased from 6.78 to 7.69. The median DTC was 11.82%.

Correlations of Dual-task Performance with Cognitive Functions

Based on Spearman correlation analysis, absolute dual-task performance (i.e., TUG-cog) moderately correlated with all subtests of BICAMS (r=-0.322 to -0.440). However, DTC has a significant but small correlation with cognitive tests (r=0.227-0.254). Age and EDSS were strongly correlated with both TUG and TUG-cog. Age was weakly correlated with DTC but EDSS was found not to be correlated with DTC. Correlation coefficients are shown in Table 2.

Regression Analysis

Table 3 presents the hierarchical binary regression models to show the impact of age, disability level, and cognitive functions on absolute dual-task performance and DTC. In step 1, age and EDSS were entered, showing EDSS (β=0.58) to be significantly correlated with the TUG-cog (R2 =0.41). Step 2 included cognitive test outcomes in addition to age and EDSS, which yielded EDSS as the only variable significantly correlating with the TUG-cog that, in turn, explained 43% of the variance. The addition of cognitive tests explained an additional 2% of variance over age and disability level assessed by EDSS. For the DTC, no variable was found significant based on step 1 and step 2.

Table 1. Demographic and clinical characteristics of the participants

	Total (n=156)
Age (years)	35 (28.0-44.0)
Gender, n (%)	
Female	114 (73.1%)
Male	42 (26.9%)
EDSS (0-10)	1.5 (0-2.0)
Disease duration (years)	2 (2.0-11.37)
Clinical course of MS, n (%)	
Relapsing-remitting	144 (92.3%)
Secondary-progressive	9 (5.8%)
Primary-progressive	3 (1.9%)
TUG	6.78 (6.15-8.41)
TUG-cog	7.69 (6.64-10.55)
DTC	-11.82 [(-23.61)-(-4.74)]
T25FW	4.75 (4.34-5.65)
MSWS-12	17.0 (12.0-29.0)
SDMT	49.0 (41.0-56.0)
CVLT-II	53.0 (42.0-61.0)
BVMT-R	28.0 (22.0-31.0)

EDSS: Expanded Disability Status Scale, MS: Multiple sclerosis, TUG: Timed Up and Go test, TUG-cog: TUG cognitive, DTC: Dual-task cost, T25FW: Timed 25 Foot Walk, MSWS-12: Multiple Sclerosis Walking Scale-12, SDMT: Symbol Digit Modalities Test, CVLT-II: California Verbal Learning Test-Second Edition, BVMT-R: Brief visuospatial memory test-revised

Discussion

This study aimed to investigate the relationship between cognitive functions and dual-task walking performance in pwMS. Our findings suggest that (i) pwMS showed significant CMI (DTC: -11.8%); (ii) there was a statistically significant correlation between cognitive tests and dual-task performance; and (iii) disability level assessed by EDSS was the only significant determinant factor on absolute dual-task performance in pwMS.

Previous studies that investigated the relationship between dual-task performance and cognitive functions the mechanism underlying CMI in pwMS (9,17). Our study found that absolute dual-task performance was moderately correlated, while motor DTC was insignificantly correlated, with cognitive functions. Our results are consistent with the findings of Prosperini et al. (18) who assessed dual-task performance during static postural control task with Stroop task. Prosperini et al. (18) also found a higher correlation between SDMT and absolute dual-task performance than DTC (r=-0.481 and -0.242, respectively). In another study, Motl et al. (19) did not find a correlation with all parameters of gait but they found a significant correlation between SDMT and DTC of speed (r=-0.32). In their study, verbal fluency task was applied during a short walking distance test (19). Recently, Veldkamp et al. (20) assessed the relationship between cognition and dual-task performance with different cognitive and motor task combinations. They observed that SDMT was a factor associated with dual-task performance in less challenging walking conditions (20). Some studies do not support findings of a significant relationship between SDMT and dual-task performance, though (21,22). However, none of these studies employed a motor test containing functional mobility tasks (i.e., TUG) as we used in this study. Despite the methodological heterogeneity in the literature, the association of better processing speed with higher dual-task performance is increasingly supported by investigations on the relationship between dual-task performance and cognitive functioning. However, further studies are needed to confirm these findings.

Our findings show significant association between disability level and absolute dual-task performance but not DTC. In the systematic review of Rooney et al. (9), no correlation between

Table 2. Correlation coefficients between variables

	TUG	TUG-cog	DTC
SDMT	-0.407**	-0.440**	0.254*
CVLT-II	-0.266*	-0.322**	0.233*
BVMT-R	-0.337**	-0.343**	0.227*
Age	0.533**	0.529**	-0.194*
EDSS	0.603**	0.535**	-0.057

$^{*}p<0.05$, $^{**}p<0.001$

1
0.5
0.3
0.1
0
-0.1
-0.3
-0.5
-1

TUG: Timed Up and Go test, DTC: Dual-task cost, SDMT: Symbol Digit Modalities Test, CVLT-II: California Verbal Learning Test-Second Edition, BVMT-R: Brief visuospatial memory test-revised, EDSS: Expanded Disability Status Scale, TUG-cog: TUG cognitive

Table 3. Regression analysis

		B	SEB	β	R^2	ΔR^2	p
Absolute dual-task performance (TUG-cog)	Step 1				0.41	0.41	0.794
	Age	0.12	0.08	0.12			
	EDSS	3.77	0.48	0.58*			
	Step 2				0.43	0.02	0.083
	Age	0.08	0.08	0.08			
	EDSS	3.64	0.50	0.56*			
	SDMT	-0.12	0.08	-0.12			
	CVLT-II	-0.06	0.08	-0.07			
	BVMT-R	0.06	0.14	0.04			
DTC	Step 1				0.001	0.001	0.386
	Age	-0.19	0.61	-0.03			
	EDSS	0.83	3.79	0.02			
	Step 2				0.043	0.042	0.207
	Age	0.04	0.64	0.006			
	EDSS	-0.10	3.94	-0.003			
	SDMT	0.49	0.65	0.09			
	CVLT-II	1.09	0.59	0.19			
	BVMT-R	-1.89	1.13	-0.18			

*$p<0.05$, TUG: Timed Up and Go test, DTC: Dual-task cost, SDMT: Symbol Digit Modalities Test, CVLT-II: California Verbal Learning Test-Second Edition, BVMT-R: Brief visuospatial memory test-revised, EDSS: Expanded Disability Status Scale, TUG-cog: TUG cognitive

DTC and EDSS was found in most of the studies. However, due to the methodological heterogeneity of the studies, no firm conclusions could be drawn about the relationship between disability level and dual-task performance in pwMS. Nonetheless, some studies show that a higher disability level is associated with lower dual-task performance (19,23) but such findings should be confirmed by future studies involving participants having different disability levels and the use of different motor-cognitive tasks.

We found a correlation between dual-task performance in different domains of cognition with similar magnitude. To the best of our knowledge, there is no other study that examined this relationship using the BICAMS battery, which is valid for pwMS and includes different cognitive domains. This study showed that in addition to cognitive processing speed, verbal memory and visuospatial memory are also associated with dual-task performance in pwMS.

Study Limitations

Although our study includes a relatively larger sample size compared to studies found in the literature, some limitations should be noted. Firstly, we mostly included patients with mild disability, which affects the generalizability of our results to persons with moderate and severe disability. Secondly, we evaluated dual-task performance using the TUG test with a cognitive task. Although the evaluation is reflective of daily life functionality as it includes many activities that are undertaken in everyday living, such as sitting, walking, and turning, the limitation is that it is a short-term test. Additionally, there is no test-retest reliability study on TUG with the cognitive task in pwMS. Furthermore, since its reliability is low, we did not assess cognitive DTC. Lastly, we also did not assess gait parameters by instrumented gait analysis methods. In future studies, we recommend measuring the dual-task performance during different TUG tasks with the use of wearable sensors.

Conclusion

Our results confirm that higher dual-task performance is significantly associated with better cognitive processing speed, visuospatial memory, and verbal memory in pwMS. This finding may facilitate the use of dual-tasking paradigms in research on cognitive impairment screening methods. However, such investigations should be supported by longitudinal studies.

Ethics

Ethics Committee Approval: The Dokuz Eylul University Ethics Board approved the study protocol (approval number: 2016/27-08, date: 20.10.2016).

Informed Consent: All participants provided their written consent after being fully informed.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: S.O., Concept: Z.A., P.Y., H.K., S.O., Design: Z.A., P.Y., H.K., S.O., Data Collection or Processing: Z.A., P.Y., H.K., S.O., Analysis or Interpretation: Z.A., P.Y., H.K., S.O., Literature Search: Z.A., P.Y., H.K., S.O., Writing: Z.A.

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