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RESEARCH ARTICLE

NECK MUSCLE ENDURANCE, TRUNK CONTROL, UPPER EXTREMITY FUNCTION AND MANUAL DEXTERITY IN PATIENTS WITH MULTIPLE SCLEROSIS

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ABSTRACT

Purpose: One of the most impacted regions is upper limb function, which lowers quality of life and involvement in daily living activities in patients with multiple sclerosis (PwMS). This study aimed to examine the relationship between function of upper extremity and manual dexterity with trunk control and neck muscle endurance in PwMS.
Materials and Methods: Thirty-one relapsing-remitting type PwMS and 30 healthy controls with matched ages and genders participated in the study. Trunk control was evaluated with the Trunk Impairment Scale (TIS); neck muscle endurance with the Extensor Endurance Test (EET) and Flexor Endurance Test (FET); upper extremity function and manual dexterity with the 9-Hole Peg Test (9-HPT) bilaterally, Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire, and Coin Rotation Test (CRT) bilaterally.
Results: TIS scores and EET times were lower, and dominant-nondominant 9-HPT times, DASH Questionnaire and dominant-nondominant CRT scores were higher in PwMS compared to healthy controls ($p<0.05$). Between the groups, there was no significant difference for FET times ($p>0.05$). In PwMS, FET times were only related to DASH Questionnaire scores, and EET times were related to DASH Questionnaire scores, nondominant 9-HPT times and CRT scores (r between -0.404 and -0.481; $p<0.05$). Except for some subparameters, TIS scores were related to 9-HPT and CRT times, and DASH Questionnaire scores (r between -0.401 and -0.767; $p<0.05$ for all).
Conclusion: Upper extremity function, manual dexterity, trunk control and neck muscle endurance, but not flexor muscle endurance, are affected in PwMS. In addition, neck muscle endurance, especially extensor neck muscle endurance, and trunk control seem to be related to upper extremity function and manual dexterity. Improving trunk control and neck muscle endurance may contribute to upper extremity function and manual dexterity in PwMS.
Keywords: Trunk control, neck muscle endurance, dexterity, upper extremity

INTRODUCTION

A wide range of neurological symptoms affect various functional systems, leading to different levels of disability in patients with multiple sclerosis (PwMS) (1). Upper limb function is one of the most affected areas in PwMS (2). Upper limb disability is caused by a combination of sensory and motor symptoms, which lowers quality of life and involvement in daily living activities. Upper limb disability can occur in the proximal and/or distal parts. Dysfunction in the distal upper extremity is referred to as dexterity impairment (3, 4). Bilateral dexterity deficit affects 75% of PwMS (5). Reduced quality of life, loss of employment, difficulty doing daily tasks, and medical expenses are all associated with poor dexterity (6, 7). Dexterity is a crucial sign of general activity and community involvement in PwMS (8). In addition, upper extremity dysfunction and decreased dexterity may also affect the ability to use walking aids (8).

It has been shown that trunk control is reduced, spinal posture is affected and even spinal mobility is reduced in PwMS (9). The trunk, which plays a complementary role in postural stabilization, controls limb movements by providing dynamic stabilization during task performance. It is thought that trunk stability is a prerequisite for upper extremity functions and trunk control has an effect on hand control. Optimal trunk control increases the strength and dexterity of the extremities (10, 11). It is known that trunk stability provides shoulder movement, and shoulder stability improves elbow, wrist, and finger movements (12). In addition, multifidus and transversus abdominis muscles are activated 50 milliseconds before shoulder movements in healthy individuals (13).

The muscles of the cervical region are an important part of the body's musculoskeletal system with kinesiologic and neurophysiologic contributions. Control of the posture and movement of the cervical region, stabilization of the spine, and orientation of the head and neck are the main functions of the cervical muscles (14-16). Since the cervical spine is one of the key sites of spinal proprioception, cervical pathologies can cause balance and posture problems (15, 17). The cervical spine also depends heavily on the neck muscles for physical support. The best possible coactivation of the dorsal and ventral neck muscles is necessary for maintaining proper neck position (16). PwMS have a decrease in muscle mechanical function, and this decrease tends to increase with the progression of the disease (18). We think that muscle mechanical function may be decreased in the neck region, which has a mechanical and functional relationship with the upper extremities in PwMS. In addition, decreased neck muscle endurance in PwMS may also be related to upper extremity and hand functions. To our knowledge, no one has previously invetigated neck muscle endurance in PwMS. When these relationships are demonstrated, the importance of trunk control and neck muscle endurance to contribute to upper extremity function and manual dexterity in PwMS will be better understood. Therefore, the primary aim of this study was to compare trunk control, neck muscular endurance, upper extremity function, and manual dexterity in PwMS with healthy controls. The secondary aim was to examine the relationship between trunk control and neck muscle endurance with upper extremity function and manual dexterity in PwMS.

MATERIALS AND METHODS

Study design

The research was planned as a cross-sectional study. Health Sciences University's Gülhane Faculty of Physiotherapy and Rehabilitation conducted this investigation between September 2023 and June 2024. The Health Sciences Ethics Committee of Ankara Yıldırım Beyazıt University approved the study (Date: 14.06.2023, Decision No: 06-271). All subjects gave their informed consent, and the study was carried out in compliance with the Declaration of Helsinki's tenets.

Participants

The diagnosis and follow-up of the relapsing-remitting type PwMS were by a neurologist, and the inclusion criteria for the patients in this study were (a) being diagnosed with MS according to 2017 McDonald criteria (b) not experiencing an MS attack within the previous three months (c) being between the ages of 18-65 (d) having a disability level between 0.5-4.5 according to the Expanded Disability Status Scale (mild to moderate disability) (e) having a cognitive level above 24 points according to the Mini Mental State Examination (MMSE) (f) not participating in a physiotherapy and rehabilitation program for the previous three months. Exclusion criteria were (a) corticosteroid use throughout the previous four weeks (b) being pregnant (c) having an orthopedic problem (spinal disc herniation, spinal deformities or other spinal pathologies, and orthopedic problems or biomechanical limitations related to the upper extremity) (d) having undergone surgery on the spine and upper extremity. The inclusion criteria for the healthy controls were (a) having a cognitive level above 24 points according to MMSE and (b) being between the ages of 18-65. The exclusion criteria for the healthy controls were (a) having undergone surgery on the spine and upper extremity and (b) having an orthopedic problem (spinal disc herniation, spinal deformities or other spinal pathologies, and orthopedic problems or biomechanical limitations related to the upper extremity).

Outcome measures

The sociodemographic information of all participants was recorded. The level of disability and cognitive status of the patients were evaluated by a neurologist. The evaluations were performed by the same physiotherapist in a well-lit and ventilated environment by taking safety precautions. A 2 min rest was given between measurements to avoid fatigue.

The Trunk Impairment Scale (TIS) was used to evaluate trunk control. The three components of the scale are coordination, dynamic sitting balance, and static sitting balance. For the starting position in all items, the participants are asked to sit with the thigh parallel to the floor, feet in full contact with the floor, knees at 90º flexion, hands and forearms supported on the thighs without back support. All items are repeated 3 times, and the best performance of the participant is recorded. The overall score is between 0 and 23, with higher scores signifying superior performance (19).

Neck muscle endurance was evaluated with the Flexor Endurance Test (FET) and Extensor Endurance Test (EET). The FET was conducted using the Harris et al. test protocol (20). The individual is placed in the hook-lying position (lying on your back with knees bent and feet flat on the floor) for the test. The assessor lays the left hand on the table slightly behind the occiput, positioning the participant's head in a mild upper neck flexion. Participants are instructed to tuck their chin in or hold their head up and lift their head from the assessor's hand while maintaining upper neck flexion. If the participant is unable to maintain this position, the test is terminated and the duration of the head hold is recorded in seconds. The Biering-Sorensen lumbar extensor test, as reported by Ljungquist et al., served as the model for the EET (21, 22). With their head above the end of the bed and their arms at their sides, the participant is supported while lying face down. To stabilize the upper thoracic spine, a strap is positioned at T6. A Velcro strap is secured around the head, and an inclinometer is attached over the occiput. The head strap is used to hang a weight of 2 kilograms. The participant's head is positioned in the neutral sagittal plane position and the test is initiated when the assessor lifts the support of the participant's head. The person is instructed to retract their chin and maintain a horizontal cervical spine. If, as determined by the inclinometer, the neck position deviates more than 5° from horizontal or the weight falls back to the floor, the test is over. The head hold's duration is in seconds.

The 9-Hole Peg Test (9-HPT) was used to evaluate upper extremity function. The test consists of a platform with 9 holes and 9 sticks. During the test, the platform is placed directly in front of the participants and is adjusted so that the bars are on the dominant hand side and the holes are on the nondominant hand side. The participants are asked to insert the rods into the board as fast as possible and then remove the rods one by one with the same hand. The test is performed for the nondominant hand using the same method. The test is performed twice for each side, and the total time is recorded in seconds (3).

Function and disability in upper extremity injuries were evaluated using the Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire. The first section of our study, which had 30 questions in total, was used. The first section included 21 questions about the participant's challenges with everyday living activities, 5 questions about symptoms (pain, activity-related pain, tingling, stiffness, weakness), and 4 questions about the patient's social function, employment, sleep, and self-confidence. The higher the score, the greater the disability (23).

The Coin Rotation Test (CRT) is a quick, low-cost, and simple way to measure coordinated, quick finger movements. For the test, a US nickel coin weighing 5,000 g, measuring 21.21 mm in diameter and 1.95 mm in thickness is used. Participants are instructed to rotate the coin between the thumb, index and middle fingers towards or away from them as quickly as possible, explaining that each 180° rotations is measured. During the test, if a participant drops the coin, the test is stopped and the test is repeated. The time taken by the participants to complete 20 rotations is recorded. Each hand is tested three times, and the three trials are averaged (6).

Statistical Analysis

To determine the sample size needed for the investigation, we used the G*Power software package (G*Power, Version 3.0.10, Franz Faul, Universität Kiel, Germany) (24). With a margin of error of 5% (a = 0.05), the correlation value and power of the study (1-β) were determined to be -0.708 (coefficient of correlation between the TIS and dominant 9-HPT) and 0.99, respectively, based on the computation performed using the research data, which included a total sample size of 31.

The Shapiro-Wilk test was used to check for data normality. Data that is normally distributed is presented using mean and standard deviation; data that is non-normally distributed is presented using median, and IQR25–75; and ordinal variables are presented using percentage and frequency. The Independent Samples T-Test and Mann-Whitney U-Test were used to evaluate intergroup differences. The Spearman correlation analysis was used to ascertain the relationship between the variables in the PwMS. Alpha was set at less than 0.05 for statistical significance.

RESULTS

Two of the 33 PwMS included in the study did not meet the inclusion criteria. Both patients had an MMSE score below 24. Therefore, 31 PwMS completed the study. All PwMS were relapsing-remitting type. In addition, all 30 healthy controls included in the study completed the study.

Table 1 lists the participants' demographics and disease characteristics. There was no difference between age, body weight, height, and gender in PwMS and healthy controls ($p>0.05$).

A significant difference was determined between the results of EET, TIS, DASH Questionnaire, dominant and nondominant 9-HPT and CRT in PwMS and healthy controls ($p<0.05$, Table 2). In terms of FET times, however, there was no significant difference between the groups ($p>0.05$, Table 2).

The FET times were negatively and moderately associated with the DASH Questionnaire scores, but not with the 9-HPT and CRT times in PwMS (Table 3).

Except for dominant 9-HPT and CRT times, EET times were negatively and moderately associated with DASH Questionnaire scores, nondominant 9-HPT and CRT times in PwMS (Table 3).

The TIS total scores and all of its subparameters showed a negative correlation between moderate and good levels in PwMS for both the dominant and nondominant 9-HPT times and DASH Questionnaire scores (Table 3).

There was no relationship between static sitting balance subparameter and dominant and nondominant CRT times and between the coordination subparameter and nondominant CRT times. All other subparameters and total TIS scores were associated with dominant and nondominant CRT times (Table 3).

DISCUSSION

It is shown that upper extremity function, manual dexterity, trunk control, and neck extensor endurance were affected in PwMS compared to healthy controls. Trunk control was associated with upper extremity function and manual dexterity. Extensor neck muscle endurance was associated with DASH Questionnaire, nondominant 9-HPT and CRT, whereas flexor muscle endurance was only associated with DASH Questionnaire.

In our study, it was shown that upper extremity function and dexterity were affected in PwMS. Ingram et al. showed that PwMS had decreased upper extremity function, dexterity, and muscle strength compared to healthy controls (25). Guclu-Gunduz et al. showed that PwMS had decreased upper extremity function and muscle strength compared to healthy controls (26). Over 50% of 205 PwMS in a research by Holper et al. indicated limitations or impairments pertaining to upper limb function (27).

Table 1. Demographic and clinical characteristics of PwMS and healthy controls

Characteristics	MS Group	Control group	p
Age, years X±SD	38.84 ± 9.71	38.60 ± 10.54	0.927
Body weight, kg X±SD	71.23 ± 14.57	72.67 ± 13.24	0.687
Height X±SD, cm	165.71 ± 10.43	166.77 ± 10.40	0.693
Gender, female/male n (%)	25 (80.6) / 6 (19.4)	19 (63.3) / 11 (36.7)	0.132
EDSS, score Median (IQR25-75)	2 (1-3)	-	-

$p<0.05$; MS: Multiple Sclerosis; BMI = Body Mass Index; EDSS: Expanded Disability Status Scale.

Table 2. Comparison of neck muscle endurance, trunk control, upper extremity function and manual dexterity test results of PwMS and healthy controls

		MS Group	Control Group	p
		Median (IQR25-75)	Median (IQR25-75)	
Trunk Impairment Scale	Static sitting balance	7 (6-7)	7 (7-7)	**0.002[a]**
	Dynamic sitting balance	4 (2-10)	10 (10-10)	**<0.001[a]**
	Coordination	6 (4-6)	6 (6-6)	**<0.001[a]**
	Total	17 (11-23)	23 (23-23)	**<0.001[a]**
9-Hole Peg Test	Dominant	23.13 (20.09-26.77)	17.96 (15.17-19.48)	**<0.001[a]**
	Nondominant	26.21 (21.96-28.65)	18.34 (16.78-21.28)	**<0.001[a]**
DASH Questionnaire		9.16 (0-21.66)	2 (0-7.25)	**0.031[a]**
Coin Rotation Test	Dominant	16.52 (14.13-20.30)	12.84 (11.21-14.63)	**<0.001[a]**
	Nondominant	17.37 (14.85-24.39)	15.21 (11.71-15.72)	**0.002[a]**
Neck Muscle Endurance Tests	Extensor endurance test	27.30 (14.12-53.84)	60.99 (45.91-6185)	**<0.001[a]**
		Mean ± SD	Mean ± SD	
	Flexor endurance test	26.76 ± 16.12	29.25 ± 14.83	0.533[b]

**p<0.05; MS: Multiple Sclerosis; a: Mann-Whitney U Test; b: Independent-Samples T Test; IQR: Interquartile range; X: Mean; SD: Standard Deviation; DASH Questionnaire: Disabilities of the Arm, Shoulder, and Hand Questionnaire.*

Table 3. The relationship between neck muscle endurance and trunk control with upper extremity function and manual dexterity in PwMS

		9-Hole Peg Test				DASH Questionnaire		Coin Rotation Test			
		Dominant		Nondominant				Dominant		Nondominant	
		r	p	r	p	r	p	r	p	r	p
Neck Muscle Endurance Tests	Flexor endurance test	-0.207	0.263	-0.275	0.134	-0.461	**0.009***	-0.249	0.176	-0.338	0.063
	Extensor endurance test	-0.325	0.075	-0.404	**0.024***	-0.409	**0.022***	-0.316	0.083	-0.481	**0.006***
Trunk Impairment Scale	Static sitting balance	-0.517	**0.003***	-0.597	**<0.001***	-0.605	**<0.001***	-0.279	0.128	-0.325	0.074
	Dynamic sitting balance	-0.687	**<0.001***	-0.729	**<0.001***	-0.440	**0.013***	-0.531	**0.002***	-0.459	**0.009***
	Coordination	-0.493	**0.005***	-0.607	**<0.001***	-0.401	**0.025***	-0.469	**0.008***	-0.257	0.163
	Total	-0.708	**<0.001***	-0.767	**<0.001***	-0.566	**0.001***	-0.549	**0.001***	-0.486	**0.006***

**p<0.05; DASH Questionnaire: Disabilities of the Arm, Shoulder, and Hand Questionnaire.*
The Spearman correlation analysis was used to ascertain the relationship between the variables.

Using the 9-HPT, an objective assessment of manual dexterity, Johansson et al. verified these high percentages of self-reported limitations and impairments in 219 PwMS; 76% of the patients included had manual dexterity disabilities (28). The results of these studies are consistent with the results of our study, which showed that upper extremity function and dexterity were affected in PwMS. Our study is remarkable in terms of evaluating the functions of both distal and proximal parts of the upper extremity together and showing that they are decreased in PwMS. In our study, decreased trunk control was also shown, and our results are consistent with the literature.

Ozkan et al. stated that trunk control and spinal mobility decreased and spinal posture was also affected in PwMS (29). Ozen et al. found that trunk control was weaker in PwMS compared to healthy controls. In addition, both flexor and extensor neck muscular endurance were evaluated in our study. Our study is the first study to evaluate neck muscular endurance in PwMS. In our study, it was shown that extensor neck muscle endurance decreased and flexor neck muscle endurance did not decrease statistically significantly. However, the mean duration of FET was 26.76 seconds in PwMS and 29.25 seconds in healthy controls. Although these results were not statistically significantly different, they suggest that neck flexor muscle endurance may be clinically affected in PwMS. The neck is the area of the body that connects the head and trunk. The cervical area is crucial for the posture control system's proprioceptive and vestibular input. The cervical region has a motor as well as a sensory function. It affects the stabilization of the spine, posture, and orientation of the cervical and head region (15, 17). For this reason, we think that neck muscle endurance evaluations should be included in the evaluation parameters from the early period.

Korkmaz et al. showed that decreased trunk control is associated with upper limb dysfunction in PwMS with relapsing-remitting type (30). Unlike this study, we used the CRT to evaluate rapid and coordinated finger movements in isolation in our study and showed that it was related to the TIS. Functional mobility and joint movements occur in distal body parts by providing stabilization in the proximal part of the trunk stability (31). These results suggest that trunk control in PwMS may affect not only the function of the proximal part of the upper extremity adjacent to the trunk, but also finger movements and function, which is the most extreme part of the upper limb. In another study conducted in PwMS, Ozkul et al. demonstrated the relationship between core muscle endurance and upper extremity function in PwMS (32). The relationship between upper extremity function and trunk control has also been investigated in many other disease groups (12, 33-35). Arslan et al. showed that upper extremity function is related to balance and trunk control in patients with stroke (33). In patients with acute cerebral infarction, Iso et al. showed a correlation between upper extremity function and trunk control ability in the first week following stroke (34). According to Miyake et al., shoulder stability improves elbow, wrist, and finger mobility, while trunk stability endures shoulder movement (12). Kim et al. showed that upper limb function test data exhibited moderate to strong correlations with trunk control ability in children with cerebral palsy (35). This evidences proves the trunk control's importance for upper-limb functionality and is consistent with our study. It is known that the muscles responsible for the control of the trunk are activated to provide stabilization before shoulder movements begin. We think that this stabilization of the proximal extremity contributes to function and manual dexterity. These results suggest that approaches aimed at increasing trunk control and stability can be added to rehabilitation practices aimed at increasing upper extremity function and manual dexterity, which are among the affected body parts in PwMS from the early period and significantly affect the patient's daily living activities and quality of life.

In addition to trunk control, the relationship between neck muscle endurance and upper extremity functionality and dexterity has been investigated in our study, and our study is the first study to investigate this relationship in PwMS. The results of our study showed that DASH scores were associated with both flexor and extensor neck muscle endurance, suggesting that decreased flexor and extensor muscle endurance may be related to upper extremity disability and dysfunction in PwMS. In addition to these results, the finding that extensor neck muscle endurance was associated with nondominant 9-HPT and CRT times suggests that neck extensor muscle endurance may be linked to manual dexterity and fast coordinated finger movements. We think that the flexor and especially extensor neck muscles around the cervical spine improve upper extremity function and dexterity both by contributing to trunk stabilisation and control by providing cervical stability and by leading to more proper upper extremity joint alignment by providing normal posture in the cervical region.

The strength of our study is that the upper extremity was evaluated in detail in terms of function and disability as well as manual dexterity. In addition, our study has some limitations. The first limitation of this study is that it was conducted in a single center. Multicenter studies allow for the expansion of the sample population and evaluation of the results with a larger sample size. Our second limitation is that the study cannot be generalised to PwMS with severe disability because we only included PwMS with mild to moderate disability. The third limitation of our study is that proprioception sensation of the trunk and cervical region was not evaluated. Considering the effectiveness of sensation on function, we think that there is a need for studies examining the relationship of proprioception sense of the trunk and cervical region with upper extremity function and dexterity in PwMS.

CONCLUSION

Upper extremity function, manual dexterity, trunk control and neck muscle endurance, but not flexor muscle endurance, are affected in PwMS. In addition, neck muscle endurance, especially extensor neck muscle endurance, and trunk control seem to be related to upper extremity function and manual dexterity. Improving trunk control and neck muscle endurance may contribute to upper extremity function and manual dexterity in PwMS.

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