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ARTICLE

Determination of five times-sit-to-stand test performance in patients with multiple sclerosis: validity and reliability

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ABSTRACT

Purpose/Aim: Although Five Times-Sit-To-Stand test (FTSST) performance is known to be a valid and reliable method in people with chronic stroke, Parkinson's disease, and balance disorder, it has not been widely studied in patients with Multiple sclerosis (MS). The main aim of this study was to evaluate validity and reliability of the FTSST in patients with MS.

Methods: The first outcome measure of the study was the FTSST, which was conducted by two different researchers. Secondary outcome measures were Biodex Stability System (BSS), 10-meter walk test, time up go test (TUG), EDSS scoring, Fatigue Severity Scale (FSS), Barthel Index, Quadriceps Muscle strength test, Functional Reach test. Intraclass correlation coefficient (ICC) was used for the validity and reliability of the FTSST, which was made by two different researchers, and Pearson Correlation Analysis was used to determine its relationship with other measurements.

Results: Interrater and test-retest reliability for the FTSST were excellent (Intraclass correlation coefficients of 0.98 and 0.99, respectively). A statistically significant correlation was found between all secondary outcome measures and FTSST ($p < 0.05$).

Conclusion: FTSST is considered to be a valid, reliable, easy, and rapid method for evaluating lower extremity muscle strength and balance in patients with MS.

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KEYWORDS
Multiple sclerosis; Five Times-Sit-to-Stand Test; reliability

Introduction

Multiple sclerosis (MS) has a complex etiology and is a disease characterised by demyelination of the central nervous system (CNS) (Confavreux and Compston 2006). MS, which is characterized by myelin sheath damage in the CNS, causes spasticity, tremor, sensory disorders, muscle weakness, depression, balance disorders, cognitive problems, sexual disorders, and bladder bowel problems and significantly affects the patient's quality of life (Confavreux et al. 2000; Lanzetta et al. 2004; Fletcher et al. 2009; Keller et al. 2012; Zhang 2012). In particular, weakening of the lower extremity muscles reduces the physical activity levels and ambulatory capacity of MS patients, and also, abnormalities in balance control enhance the risk of falling and reduce their quality of life (Lambert et al. 2001; Cattaneo et al. 2002; Ng et al. 2004; Cavanaugh et al. 2011). Thus, since it can cause many problems, it may be useful to establish an outcome measure that shows both lower extremity muscle strength and balance level in MS patients.

The Five Times-Sit-To-Stand Test (FTSST) performance today generally assesses lower extremity muscle strength (Bohannon et al. 1995; Lord et al. 2002). Some studies have shown that the FTSST is also associated with balance level (Lord et al. 2002; Ng 2010). It has been reported that FTSST is a positive predictor of balance level with a rate of 61% in patients with balance problems (Whitney et al. 2005). The FTSST is a useful measurement method for estimating the probability of recurrent falls, and individuals with a test >15 s were reported to be twice as likely to fall (Buatois et al. 2010). FTSST has high test–retest reliability when investigated in elderly individuals (ICC = 0.89–0.96) (Lord et al. 2002), Parkinson's disease patients (ICC = 0.76–0.99) (Duncan et al. 2011), and chronic stroke patients (ICC = 0.989–0.999) (Mong et al. 2010). Although there is only one study in the literature examining the validity and reliability of FTSST in patients with MS, we did not encounter ICC value in this study (Møller et al. 2012).

In investigating individuals with MS, the objectives of this study were: (1) To evaluate the intra-rater and test–retest reliability of the FTSST in MS, (2) to determineFTSST performance in people with MS, and (3) the relationship of FTSST with different variables.

Methods

Participants

Twenty-three volunteers diagnosed with MS included in the study. The population to be included in the study was individuals aged between 18 and 65 years, with an assistive device/standing independently, with EDSS ≤6.5. Patients

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with an incomplete diagnosis, who had an acute attack during the evaluation or treatment, and who had cardiovascular, respiratory, orthopaedic, psychiatric or other medical comorbidities were not included in the study.

Outcome measures

Five Times-Sit-To-Stand test (FTSST)

FTSST, participants were asked to sit and stand on a standard chair (42–45 cm) five times, with the hands and arms crossed on the chest. The test was started with the 'Start' command and the time to the end of the fifth repetition was recorded. Time was stopped when the hip touched the chair and documented as the participant's score (Guralnik et al. 1994).

The 10-meter walk test

The 10-meter walk test is a widely used tool for evaluating walking speed. Patients were walked the 10 m at corridor. Walking speeds were calculated by dividing 10 m by the elapsed time (Peters et al. 2013).

Functional reach test

The patient stands sideways at shoulder height, with her right arm not touching a tape measure attached to the wall. Arm in the forward functional reach test extend arm forward parallel to tape measure while flexion at 90°. Measure the distance between the shoulder and the tip of the third finger. Then, the maximum distance that he/she can extend her arm horizontally forward is measured. The difference between the two positions is calculated in cm keeps doing it (Hill et al. 1996).

Biodex stability system (BSS)

Postural balance was evaluated by tests using the Biodex stability system [(BSS) Biodex Inc., Shirley, NY]. BSS concur a mobile balance platform, the surface of which can be tilted up to 20° and linked to a computer software that allows the balance to be evaluated objectively. With this system, general stability, anteroposterior stability, mediolateral stability can be evaluated. The participants were informed about the tests and the procedures to be followed were explained, and three tests were performed for postural balance and risk of falling. Each test was applied for 20 sec (Cachupe et al. 2001).

EDSS. The most popular and comprehensively used tool for evaluating patients with MS is Kurtzke's Expanded Disability Status Scale (EDSS) (Kurtzke 1983). The EDSS is a clinician-applied evaluate scale that evaluates the functional systems of the CNS. EDSS is used to define disease advance in patients with MS and to evaluate the effectiveness of therapeutic interventions in clinical trials. Inadequacy in eight functional systems with this scale was measured and most of the scores in the functional system was evaluated between 0 and 6.0 on this scale showed normal neurological examination, up to 10 MS represents related death.

Fatigue Severity Scale (FSS)

Fatigue Severity Scale (FSS) was used to assess the fatigue level of patients with MS. Consisting of nine questions, this scale is scored between 1 and 7. The FSS was recorded by averaging the total score (Armutlu et al. 2007; Krupp et al. 1989).

Barthel index

The Barthel index was developed by Mahoney and Barthel and has been modified by Shah et al. The Turkish validity and reliability were performed by Küçükdeveci et al. (2000). It measures the patient's functional inability to perform 10 activities in daily life. These activities can be grouped according to self-care skills (grooming, dressing, incontinence, bathing and toilet use, and feeding) and mobility (transfer, climbing stairs, and ambulation). The total point ranges from 0–100. A higher score indicates independence level (McRae et al. 2002).

Time up go test (TUG)

TUG was applied to evaluate the functional capacity of patients with MS. For the test standard chair was used. First the patient was asked to sit. Then, to stand up and walk with regular steps at 3 m, the length of which is predetermined, and return to the chair at the end of 3 m. The walking time of the patient during the test was determined in seconds with a chronometer (Siggeirsdottir et al. 2002).

Quadriceps muscle strength

Quadriceps muscle strength was measured with a LaFayette brand digital hand dynamometer. The dynamometer was placed on the leg 1–2 cm above the malleolus and the patient was asked to extend the knee. After measuring twice in both knees, the best score was recorded (Kesilmiş and Manolya 2020).

Procedures

All participants gave written informed consent in compatible with the Declaration of Helsinki procedures. The study was started after the approval of the Kırşehir Ahi Evran University Clinical Research Ethics Committee (Decision: 2022-10/106). Demographic information, body mass index (BMI), height and weight of each participant were recorded. Tests and questionnaires were administered to the participants by two physiotherapists (AÖ., MC.) in a clinic prepared by taking all precautions. Two evluators synchronously applied two trials of FTSST for every participant. For the test-retest reliability, the same procedure was performed with seven days between test periods.

Data analysis

Statistical analysis was performed using SPSS version 24 software (SPSS Inc., Chicago, IL). The conformity of the variables to the normal distribution was examined using visual (histogram and probability graphs) and analytical methods

(Shapiro–Wilk tests). Descriptive analysis was given using the mean and standard deviation for normally distributed variables. Numbers and % were presented for nominal variables. Intraclass correlation coefficients (ICC) were used to determine inter-rater (ICC) and test–retest (ICC) reliability of the FTSST. ICC is classified as good (0.60–0.80) and excellent (0.80–1.0) (Pittenger 2003). In order to determine the concurrent validity of the five sit-stand tests, the relationship with other tests was evaluated with the Spearman correlation test. The degree of correlation was interpreted as low correlation between 0.05 and 0.4, moderate correlation between 0.4 and 0.7 and high correlation between 0.7 and 1.0 according to the correlation coefficient (Hayran 2011). The minimal detectable change (MDC) was calculated based on the standard error of measurement (SEM) conforming to the formula $MDC95 = 1.96*SEM*\sqrt{2}$. SEM was calculated to ensure the accuracy of the evaluation method with the formula $SEM = SD*\sqrt{(1\text{-}ICC)}$. Statistically significant level was accepted as $p < 0.05$.

Results

The characteristics of the data belonging to the demographic variables of the MS patients included in the study are given in Table 1.

The values of the variables (mean, SD, min–max) of the MS patients included in the study are given in Table 2.

The test–retest (ICC), Inter-rater (ICC) reliability of the MS patients included in the study are given in Table 3. When the test–retest result of the first evaluator was investigated, the result of the ICC value was found to be 0.99, and this result showed us that the FTSST in patients with MS was a perfect match in terms of test-retest. When we look at the compatibility (inter-rater) between the first and second raters, the result of the ICC value was found to be 0.98. Thus, it was observed that the inter-rater agreement was also excellent (Table 3).

The correlation results of the Biodex Stability Index, Functional Reach test, the 10-meter walk test, TUG, FSS, Barthel Index, EDSS, and Quadriceps muscle strength, which are frequently used in the clinic to determine the concurrent validity of the FTSST, are analysed in Table 4. According to this table, a positive, moderate statistical correlation was found between FTSST and Biodex Stability System (BSS) sub-parameters (dynamic ML, static ML) and TUG test ($p < 0.05$). A positive, high level statistical correlation was found between FTSST and BSS sub-parameters (Dynamic AP, Dynamic Overall, Static AP, Static Overall test), Functional Reach test, 10-meter walk test, FSS, Barthel Index, Quadriceps muscle strength (right, left) and EDSS ($p < 0.05$).

Table 1. Demographic characteristics of patients with MS included in the study.

		($n = 23$)			
		Mean	SD	Min	Max
Age (years)		50.1	10.8	31	67
Height (cm)		167.3	6.6	158	184
Weight (kg)		65.4	9.6	49	86
BMI (kg/m^2)		23.4	3.8	17.2	30.5
		n		(%)	
Gender	Male	11		47.8	
	Female	12		52.2	

SD: standard deviation; BMI: body mass index.

Table 2. Values of the variables of MS patients included in the study.

		($n = 23$)			
		Mean	SD	Min	Max
Biodex stability system	Dynamic Stability (AP)	4.66	2.71	0.90	8.40
	Dynamic Stability (ML)	2.65	2.36	0.60	7.10
	Dynamic Stability (Overall)	5.49	2.91	1.20	9.80
	Static Stability (AP)	2.98	1.93	0.40	6.20
	Static Stability (ML)	3.30	2.32	0.20	7.10
	Static Stability (Overall)	4.79	2.45	0.80	8.10
The 10-Meter Walk test		12.19	3.20	7.35	19.16
Time up Go test		14.95	3.14	8.76	19.91
FSS		6.01	1.60	1	7
Barthel Index		81.30	10.36	65	100
EDSS		3.57	1.31	1	5
Functional Reach test		13.33	4.66	5	21
Quadriceps Muscle Strength	Left	9.49	3.88	4.5	17
	Right	9.89	4.10	4	18.5
FTSST (1)	Test	16.07	4.06	9.95	22.08
	Retest	16.29	4.09	9.65	23.14
FTSST (2)	Test	15.82	3.91	9.01	20.88
	Retest	15.97	3.88	9.41	21.17

1: First evaluator; 2: Second evaluator; SD: Standard Deviation; FTSST: Five times-sit-to-stand test; EDSS: Expanded Disability Status Scale; AP: Anteroposterior; ML: Mediolateral; FSS: Fatigue Severity Scale

Discussion

Our study is one of the first to investigate the interrater and test–retest reliability of the FTSST in patients with MS. In line with the results obtained from the study, it was determined that the FTSST is a valid and reliable method in terms of inter-rater and test–retest.

Validity and reliability of the FTSST in patients with loss of balance and lower extremity muscle strength such as with Parkinson's disease (Duncan et al. 2011; ICC = 0.76–0.99), with the elderly (Lord et al. 2002; ICC = 0.89–0.96), and patients with chronic stroke (Mong et al. 2010; ICC = 0.989–0.999), high test–retest reliability was found. Consistent with the literature, our study found that the FTSST had excellent test-retest reliability in patients with MS.

Csuka and McCarty (Csuka and McCarty 1985) defined the sit-to-stand test as a tool for evaluating lower extremity muscle strength. However, some studies have indicated that the FTSST is not only associated with lower extremity muscle strength, but also with balance performance (Lord et al. 2002; Ng 2010). Therefore, it is widely used today in the evaluation of both lower extremity muscle strength and balance level. Our study supports the literature and a significant correlation was found between FTSST and Quadriceps muscle strength, which evaluates lower extremity muscle strength, and Biodex Stability Index, which determines balance level.

The TUG test is largely used to assess the decline in physical capacity and fall risk associated with ageing. There are many studies describing the relationship between the TUG test and hand grip strength, which reflects general body muscle strength (Bohannon 2012). In most of these studies, a significant negative correlation was found between TUG

Table 3. Inter-rater (ICC) and test–retest (ICC) reliability of the FTSST.

$n = 23$	Difference (mean ± SD)	Inter-rater (ICC $_{1,2}$) (95% CI)	Test–retest (ICC $_{1,1}$) (95% CI)	SEM	MDC_{95}
FTSST	0.21 ± 0.4	0.98 (0.96-0.99)	0.99 (0.98-0.99)	0.04	0.09

SD: standard deviation; FTSST: Five times-sit-to-stand test; ICC: intraclass correlation coefficient; SEM: standard error of measurement; MDC_{95}: minimum detectable change at the 95% confidence interval.

Table 4. The relationship between the FTSST and other tests.

		FTSST
Biodex stability system		
Dynamic stability (AP)	r	0.938
	p	**0.000***
Dynamic stability (ML)	r	0.681
	p	**0.000***
Dynamic stability (overall)	r	0.920
	p	**0.000***
Static stability (AP)	r	0.937
	p	**0.000***
Static stability (ML)	r	0.661
	p	**0.001***
Static stability (overall)	r	0.812
	p	**0.000***
Functional reach test	r	0.733
	p	**0.000***
The 10-meter walk test	r	0.969
	p	**0.000***
Time up go test	r	0.620
	p	**0.002***
FSS	r	−0.904
	p	**0.000***
Barthel index	r	0.832
	p	**0.000***
EDSS	r	−0.929
	p	**0.000***
Q muscle strength		
Left	r	−0.871
	p	**0.000***
Right	r	−0.812
	p	**0.000***

FTSST: Five Times-Sit-to-Stand test; EDSS: Expanded Disability Status Scale; AP: anteroposterior, ML: mediolateral, FSS: Fatigue Severity Scale, *: $p<0.05$

duration and hand grip strength, ranging from −0.20 to −0.57 (Kozicka and Kostka 2016; Lam et al. 2016; Yajima et al. 2016; Alonso et al. 2018; Pratama and Setiati 2018). In our study, a significant correlation was found between FTSST, which evaluates muscle strength, and TUG duration. It was not surprising to find similar results, as MS is associated with a similar loss of muscle strength due to ageing in healthy individuals.

Although the underlying mechanism is unknown, fatigue is most common in MS patients and leads to neurological and other symptoms of MS such as anxiety, cognitive dysfunction, pain, depression (White and Dressendorfer 2004; Motl 2014). In addition, health-related quality of life is decreased in MS patients. Decreased quality of life may be associated with impaired symptoms, gait and cognition in patients (Gallien et al. 2007). Dodd et al. gave Progressive Resistance Training (PRT) targeting lower extremity muscles to patients with MS for 10 weeks. According to the results of the study, they found that PRT improved muscle strength, quality of life, and fatigue (Dodd et al. 2011). In our study, it was revealed that the FTSST was related to the Barthel Index, which evaluated quality of life, and FSS, which evaluated fatigue.

People with MS often have reduced range of motion due to spasticity and prolonged immobilization (Halabchi et al. 2017). In their study, Cattaneo and Jonsdottir stated that lower extremity muscle strength was an independent predictor of Functional Reach test in patients with MS. They pointed that the reason for this is that muscle weakness may cause more forward bending (Cattaneo and Jonsdottir 2009). In parallel, we found a highly significant relationship between muscle strength and flexibility in patients with MS.

Exercise capacity is decreased in patients with MS. Gait tests are frequently used to determine exercise capacity in patients with MS. In patients with MS, impairments in walking capacity are generally observed with increased risk after limited mobility (Hansen et al. 2014). Broekmans et al. concluded that knee flexor and knee extensor strength were associated with better walking capacity (Broekmans et al. 2013). In another study, Thoumie et al. concluded that although walking capacity is more highly associated with the hamstring strength in MS patients, it is also associated with the Quadriceps strength (Thoumie et al. 2005).

Study limitations

This study has a limitation. Balance and lower extremity muscle strength performance were evaluated only in patients with MS. We think that many health problems may occur with age and how performance changes over time should be examined. It should be known that the values found as a result of this study are valid and reliable only in patients with MS.

Conclusions

In conclusion, the FTSST in patients with MS is a valid, reliable, understandable, and, easy method that can be used by clinicians and researchers. In addition, since the FTSST is a method that correlates with many MS symptoms, it can be an alternative, easy and understandable method for evaluating balance, muscle strength, and quality of life.

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