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European Journal of Physical and Rehabilitation Medicine 2019 April;55(2):199-208
DOI: 10.23736/S1973-9087.18.04778-0

ORIGINAL ARTICLE

The effects of 10-week core stability training on balance in women with multiple sclerosis according to Expanded Disability Status Scale: a single-blinded randomized controlled trial

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ABSTRACT

BACKGROUND: The Expanded Disability Status Scale (EDSS) Score is one of the most extensively accepted clinical grading scales which used to the assessment of neurological impairment and disability in multiple sclerosis (MS).
AIM: The aim of this study was to analyse the effect of 10-week core stability training (CST) program on balance in women with relapsing-remitting MS according to EDSS Score.
DESIGN: A blind randomized controlled trial.
SETTING: The Department of Sports Injuries and Corrective Exercise at the Shahid Bahonar University of Kerman.
POPULATION: Sixty-nine MS women.
METHODS: They were randomly assigned into two groups as the intervention group and the control group. These groups were categorized into three subgroups according to the EDSS as follows: subgroup A (EDSS 2.5 to 3.5), subgroup B (EDSS 3.5 to 4.5), and subgroup C (EDSS 4.5 to 5.5). The intervention group performed a CST program for 10 weeks and to evaluate static and dynamic balance performance in pre-and post-tests, the Biodex Stability System (BSS) have been used. In addition, the participants' core muscle function was evaluated using the endurance and isometric muscle strength tests.
RESULTS: The results show a significant difference between post-test variables of the core muscles function, static and dynamic balances in interventional subgroups in comparison with the control subgroups. The improved balance order has been given as subgroup C > B > A.
CONCLUSIONS: The CST program could be suggested as an efficient clinical intervention for improving dynamic and static balance in the MS women due to the improvement of core muscle function, especially for the EDSS Score more than 3.5.
CLINICAL REHABILITATION IMPACT: The CST could be performed as an efficient clinical intervention for improving dynamic and static balance in MS women due to the improvement of core muscle function. The present protocol could be helpful for the patients with MS especially for the EDSS Score more than 3.5.

(*Cite this article as:* Amiri B, Sahebozamani M, Sedighi B. The effects of 10-week core stability training on balance in women with multiple sclerosis according to Expanded Disability Status Scale: a single-blinded randomized controlled trial. Eur J Phys Rehabil Med 2019;55:199-208. DOI: 10.23736/S1973-9087.18.04778-0)

KEY WORDS: Exercise; Postural balance; Multiple sclerosis.

Multiple sclerosis (MS) is a chronic and inflammatory disease with associated loss of axon and myelin.[1] The MS is defined as the most common human demyelinating disease.[2] The prevalence of MS has continued to increase worldwide during the past two decades,[3] that is more frequently diagnosed in women with ratios of 3 to 1 and in persons aged between 20 and 40 years.[4]

Its prevalence is 31.5/100,000 in Kerman province, and 57.3/100,000 populations in Kerman city with ratios of 3 to 1, female to male and average age at onset 28.35 years and average EDSS 4.5±1.9 on the Kurtzke's Disability Status Scale (4.83±1.9 in men and 4.26±1.8 in women, P=0.0035).[2]

The EDSS Score is one of the most extensively accepted clinical grading scales which used to the assessment of neurological impairment and disability in MS. This scoring system could be stratified patient's functional status such as the function of visual, brainstem, pyramidal, cerebellar, sensory, bowel/bladder and cerebral.[5] The various signs including visual disorders, pyramidal signs (such as muscle weakness and spasticity), sensory dysfunction, loss of coordination, cognitive disorders and balance disorders have been reported for the MS disease.[6] Instability or imbalance, which can result in falls and solemn injuries, are the most frequent problems faced by people with MS.[7] It is well-known that the ability of MS patients to maintain their body's center of gravity (COG) above its base of support (BOS) with minimal sway or the most control is usually disturbed.[8] The disturbed balance lead to the body response by increasing postural muscle tone through automatic postural responses while the most capable muscle output recovers balance and provides good stability can be found in the sensory inputs of CNS monitors.

A stable upright posture has been created by synergy effect between muscles of the limb and trunk. According to postural synergy, the coordinated arrangement of postural muscle activation employed in response to perturbation exists to simplify control of posture and movement.[9] One of the main elements of balancing, core stability is that defined as the ability to control the trunk to let the maximum transfer of torque to the terminal parts.[10, 11] The core is the corset of muscles that serve as a system to stabilize the trunk.[12] The principles of core stabilization are consisting of three relating elements: passive subsystem (bones, ligaments and the spinal column for structural support), active subsystem (muscles for movement), and neuromuscular control (coordination and conduction from nervous system).[13] Previous studies show that reduced trunk stability happens in MS patients. The deficits in standing balance, are reported with increased posture sway that increases with adding a dual task. Also, the posture sway has increased in the patients with sensory disorders. The transition from an upright position to the movement produce imbalance with problems in coordinating body parts due to the movement. Therefore, it appears that trunk stability improvement should be one of the main goals in rehabilitation for patients with MS.[14] The core exercises are taken widely in rehabilitation and a common reason patients referred to rehabilitation programs with the aim of improving trunk stability.[15, 16] During a core stabilization program, the muscles and the neuromuscular control, both are trained [13] also, CST regimen can increase the capability of power, strength, balance and proprioception. In theoretical, improving core stability have numerous benefits, which the evidence is developing in the research in recent years.[13] In this regard, Freeman *et al.* primarily explored the effects of CST on balance and mobility in people with MS and suggested that CST program might improve balance and mobility in ambulant people with MS.[10]

Considering the hypothesis that CST regimen can improve the balance in MS patient,[10] the exercise classification for these type of patients should be placed as a priority in their treatment programs. In this regard, EDSS is a scoring system to determine the class, type or stage of disease in MS patients. Also, the neurologists use of EDSS to follow the progression of disability related to MS.[17] Freeman *et al.* primarily explored the effects of CST on balance and mobility in people with MS and suggested that CST program might improve balance and mobility in ambulant people with MS. However, there is a lack of information about the exercise classification for patients with MS and in fact, the effect of CST regimen on balance and stability in MS patients according to EDSS scoring has not yet been scientifically evaluated. Also due to the high prevalence of MS disease in women and the gender differences in muscular endurance capacity that are related to physiological issues, this study was done on women only.[18-20] The present study aimed to explore the effect of CST on balance in women with MS according to EDSS.

Materials and methods

A blind randomized controlled trial has been conducted on 69 consecutive women who suffered MS. The mean age of all women was 31.61±5.03 years (range 23 to 40 years) with the diagnosis of relapsing-remitting MS with EDSS Score between 2.5 to 5.5 which confirmed by MS committee of Kerman University of Medical Sciences (In addition, patients were evaluated by the physician by using clinical tests such as the ability to maintain the upright position for 30 seconds, the ability to walk for 6 meters with or without an assistive device [21] and also by using self-report questionnaires, to determine EDSS and study eligibility). The study was adopted by the regional ethics committee (IR.KMU.REC.1394.121) and done pursuant to the Declaration of Helsinki. All the participants gave signed written informed consent about the participation in the study. In this study, the women with relapse of MS symptoms in the recent two months, history of orthopedic or rheumatologic perturbation within the last six months, history of musculoskeletal injury in previous six weeks, history of a brain stroke, pregnancy and also patients who have changed their drugs during the study were excluded. The selected participants were randomly assigned into two groups as the intervention group and the control group. Then, these groups categorized into three subgroups according to the EDSS as follow: subgroup A (EDSS 2.5 to 3.5), subgroup B (EDSS 3.5 to 4.5) and subgroup C (EDSS 4.5 to 5.5).

All measurements were performed at almost the same time of day in the same order at the beginning of the study (pre-test) and after 10 weeks (post-test). The study was performed at the department of sports injuries and corrective exercise at the Shahid Bahonar University of Kerman. Each participant took part in two phases of the experiment including familiarization and data collection. In the first phase, all of the participants underwent a familiarization session, about 1 to 2 hours before data collection and became familiar with the standard test and exercise techniques and how to correctly perform each task. In the second phase, participants filled questionnaire including personal and baseline characteristics before starting the exercise protocol. Body mass was measured using the calibrated digital scale and height was measured using a single stadiometer (SECA 769; SECA, Chino, CA, USA).

The participants' core muscle function was evaluated using the endurance tests (Sorenson Test, flexure endurance test, side bridge endurance test, plank)[22, 23] and isometric muscle strength tests (hip abduction, hip external rotation strength)[24] in pre- and post-test sessions. The main reasons for using these tests are resumed as follows: they are highly reliable (Sorenson Test: 0.98, flexure endurance test: 0.97, side bridge endurance test: 0.99, plank test: 0.99, hip abduction strength test: 0.84, hip external rotation strength test: 0.89),[25-27] cheap, fast and easy to perform. The isometric muscle strength tests were assessed using Nicholas hand-held dynamometer (Lafayette Instruments, Lafayette, IN, USA) and stabilization straps. The tests positions have been chosen using traditional manual muscle testing procedures and also previous studies methods.[28-30] For the endurance tests, the participants were taught to maintain the position for as long as possible until failure and the times were recorded using a stopwatch (in seconds).

The Biodex Stability System (BSS) was performed to assess the balance ability of the patients. The BSS (1/03V, SWPN, Biodex, NY, USA) measures the stability indexes containing overall (OA), antero-posterior (AP) and mediolateral (ML). This device uses a circular platform that can adjust to varying levels of difficulty ranging from level 12 (the most stable setting) to level 1 (the least stable setting). This platform is connected to a data saving computer and monitor.[31] The BSS has an interclass correlation coefficient ranging from r=0.60 to r=0.96 [31] and showed to be reliable. To begin, the participants were instructed to assume a bipedal stance on the BSS's locked platform with open eyes. In order to find the supporting foot position by the participants, the stability platform was unlocked to allow motion. Then, the platform was locked and the participant's foot position was recorded. This location was used as the reference and maintained in all trials. According to the standard software configuration, three trials of 20 seconds each at a stability level of 8 and three trials at the same time each at a stability level of 12 were calculated with 10-second rest between trials. The test evaluations were performed after 60-second rest for each participant between platform stability of 8 and 12. The static and dynamic balance were measured according to the OA, ML and AP indexes.

The training program for the intervention group was performed in a 60-minute session and have conducted 3 days a week for the following 10 weeks (from January to March 2015). Each session included 15 minutes warm-up (walking and stretching exercises), 30 minutes CST and 5 minutes cool-down (breathing, and relax the muscles). In this study, the modified Jeffrey core stabilization exercise program has been used. A general protocol has been derived from the finding of previously literature,[32, 33] while the exercises were progressed through Jeffrey's categorization [34] of progressive core stability training as a guide. The exercise program levels consist of the static contractions in a stable (level 1), training, static contractions in an unstable environment (level 2) and dynamic movements in the Swiss balls (Ball squat on wall, seated on Swiss ball, bridging on stability ball, stability ball crunches, seated on Swiss ball with abdominal draw, leg extension and arm flection, ball crunch with rotation, ball crunch with rotation with rotation with weighted ball, supine bridging on Swiss ball, bridging on stability ball, Sit-up on Swiss ball, abdominal draw in with feet on Swiss ball) as an unstable surface (level 3). The control groups received only conventional programs which provided by the MS committee of Kerman University of Medical Sciences and did not include training of balance function. This conventional treatment program was consisting basic activities (the stretching, range-of-motion exercises and breathing-enhanced upper-extremity exercises) and nursing cares. The experimental group also received the current (CST) program.

Statistical analysis

The collected data have been analyzed using IBM SPSS statistical software version 22.0. Continuous outcome measures were tested for normal distribution of data using the Shapiro-Wilk Test and equal variance was evaluated by the Levene Test. Repeated measures mixed ANOVA was applied to the data analysis of the endurance and isometric muscle strength tests and also, it was used to investigation the effects of CST training on stability indexes and compare the obtained results in between subgroups. Post hoc analysis by using Bonferroni adjustment was conducted; The P values of ≤0.05 were considered statistically significant.

Results

The flow diagram of the current study has been shown in Figure 1. In this study, 191 MS patients were evaluated for eligibility. After screening according to inclusion and exclusion criteria, 35 patients that did not meet the inclusion criteria were excluded and 156 patients remained. In order to investigate the effect of exercise therapy, 72 patients were randomly selected from the remaining 156 patients. The selected participants were randomly assigned into two groups as the intervention group (N.=36) and the control group (N.=36). Then, each of these groups were assigned into three subgroups according to the EDSS as follows: group A (EDSS 2.5 to 3.5), group B (EDSS 3.5 to 4.5), and group C (EDSS 4.5 to 5.5). As can be seen in Figure 1, three of the patients excluded from the study according to the criteria that explained in the methods section (lack of participation in post-test sessions, pregnancy and relapse of MS symptoms). Finally, the 35 patients in the intervention group (EDSS 2.5-3.5: 17 patients, EDSS 3.5-4.5: 10 patients and EDSS 4.5-5.5: 8 patients) and 34 patients in the control group (EDSS 2.5-3.5: 13 patients, EDSS 3.5-4.5: 11 patients and EDSS 4.5-5.5: 10 patients) have been analyzed for the following training effects.

Participant demographics including age, height and weight of the three groups have been represented in Table

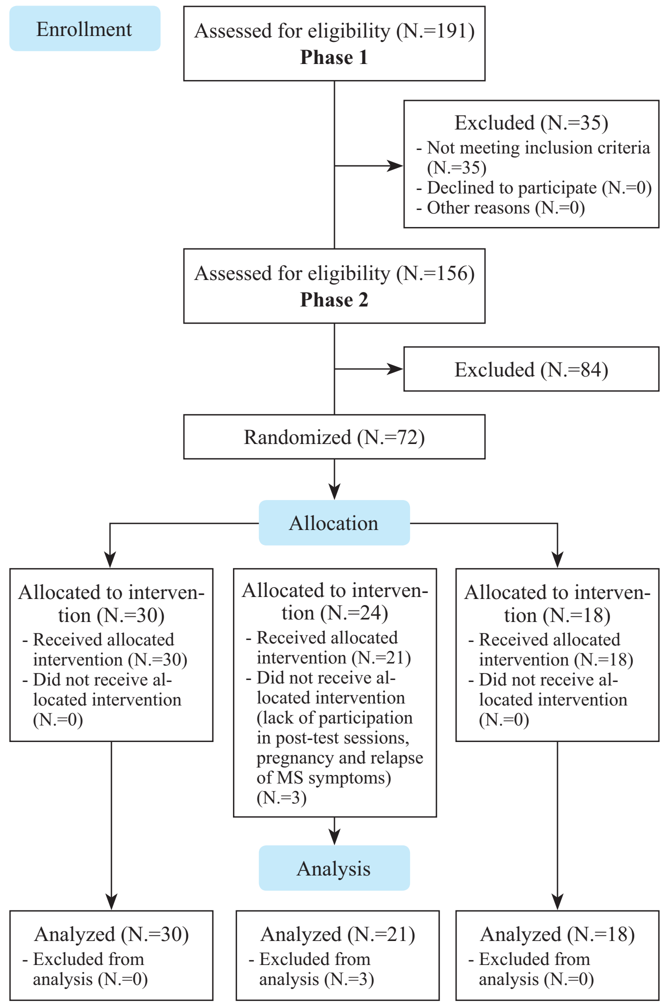

Figure 1.—Flow-diagram of the study protocol.

I. The obtained results show that characteristics variables were matched and there was no statistically significant difference between three groups of EDSS Score (P≥0.05). All patients had relapsing-remitting MS.

As can be seen in Table II, the mixed ANOVA indicated statistically significant differences in all of the variables of the core muscles function between pre-test and post-test sessions (P value <0.05) and also, significant interaction has been shown in all of the variables, between time (pre and post-test) and group according to EDSS. These results agree with those previously reported that improvements in core muscles function can be achieved by means of core training,[15, 33, 35-37] also, some studies reported impaired trunk muscles performance in patients with MS relation-

TABLE I.—*Baseline characteristics of the study participants (N.=69).*

Characteristic	Subgroup A EDSS: 2.5-3.5		Subgroup B EDSS: 3.5-4.5		Subgroup C EDSS: 4.5-5.5		P value
	Intervention N.=17	Control N.=13	Intervention N.=10	Control N.=11	Intervention N.=8	Control N.=10	
Age (year)	30.23±3.56	30.76±5.80	33.09±4.23	31.70±6.29	32.80±5.84	32.00±4.00	0.20
Height (cm)	161.15±4.45	160.88±4.41	161.54±4.03	160.60±4.67	160.00±4.87	161.87±6.03	0.20
Weight (kg)	66.84±12.99	65.64±13.53	66.45±13.02	65.90±9.74	65.90±8.70	63.62±15.50	0.20
EDSS	2.79±0.26	2.73±0.26	3.77±0.26	3.80±0.26	5.00±0.41	5.00±0.46	<0.001

ship to disability [38, 39] which the same exercise program had a greater effect on function of weaker muscles, these findings seem congruent.

Tables III, IV revealed that the mixed ANOVA indicated statistically significant differences in all of the stability indexes between pre-test and post-test sessions in three interventional subgroups during dynamic and static condition (P value <0.05). In addition, significant interaction has been shown in all of the stability indexes, between time (pre and post-test) and group according to EDSS. The obtained results indicate that trunk muscle function implicates in the control of posture according to the literature.[10, 40-43] Granacher *et al.* (2013) in a systematic review reported the correlations between the performance of

TABLE II.—*The results of the core muscles function in MS patients (repeated measures mixed ANOVA).*

Tests	Effect	value	F	Hypothesis df	Error df	Sig.	Partial η^2
Core endurance tests							
Sorenson Test	Time	0.656	33.017	1.000	63.000	0.000*	0.344
	Time*group	0.751	4.178	5.000	63.000	0.002*	0.249
Flexure endurance test	Time	0.529	56.108	1.000	63.000	0.000*	0.471
	Time*group	0.574	9.344	5.000	63.000	0.000*	0.426
Plank test	Time	0.644	34.901	1.000	63.000	0.000*	0.356
	Time*group	0.683	5.843	5.000	63.000	0.000*	0.317
Right lateral bridge test	Time	0.582	45.338	1.000	63.000	0.000*	0.418
	Time*group	0.642	7.030	5.000	63.000	0.000*	0.358
Left lateral bridge test	Time	0.503	62.292	1.000	63.000	0.000*	0.497
	Time*group	0.575	9.302	5.000	63.000	0.000*	0.425
Core strength tests							
Right hip abduction test	Time	0.235	204.815	1.000	63.000	0.000*	0.765
	Time*group	0.213	46.524	1.000	63.000	0.000*	0.787
Left hip abduction test	Time	0.311	139.544	1.000	63.000	0.000*	0.689
	Time*group	0.261	35.764	5.000	63.000	0.000*	0.739
Right hip external rotation test	Time	0.331	127.333	1.000	63.000	0.000*	0.669
	Time*group	0.247	38.510	5.000	63.000	0.000*	0.753
Left hip external rotation test	Time	0.328	128.982	1.000	63.000	0.000*	0.672
	Time*group	0.262	35.407	5.000	63.000	0.000*	0.738

*Significant changes (P<0.05).

TABLE III.—*The results of the static balance in MS patients (repeated measures mixed ANOVA).*

Stability Index	Effect	Value	F	Hypothesis df	Error df	Sig.	Partial η^2
AP	Time	0.221	222.079	1.000	63.000	*0.000	0.779
	Time*group	0.162	65.219	5.000	63.000	*0.000	0.838
ML	Time	0.284	159.194	1.000	63.000	*0.000	0.716
	Time*group	0.138	78.768	5.000	63.000	*0.000	0.862
O	Time	0.202	249.374	1.000	63.000	*0.000	0.798
	Time*group	0.128	85.896	5.000	63.000	*0.000	0.872

*Significant changes (P<0.05).

Table IV.—*The results of the dynamic balance in MS patients (repeated measures mixed ANOVA).*

Stability Index	Effect	Value	F	Hypothesis df	Error df	Sig.	Partial η²
AP	Time	0.189	270.890	1.000	63.000	*0.000	0.811
	Time*group	0.116	95.579	5.000	63.000	*0.000	0.884
ML	Time	0.605	41.139	1.000	63.000	*0.000	0.395
	Time*group	0.372	21.299	5.000	63.000	*0.000	0.628
O	Time	0.650	33.920	1.000	63.000	*0.000	0.350
	Time*group	0.419	17.445	5.000	63.000	*0.000	0.581

*Significant changes (P<0.05).

Table V.—*Differences in the static balance between the study groups.*

Stability index	Subgroup	Pre-test Mean±SD	Post-test Mean±SD	Intervention	Intervention	P value Intervention
AP	Intervention	1.25±0.42	0.66±0.25	-	0.002*	0.000*
	Control	1.36±0.39	1.50±0.36	0.037*	1.000	0.010*
	Intervention	0.99±0.60	2.23±0.60	0.002*	-	0.267
	Control	2±0.53	1.92±0.46	0.000*	0.823	1.000
	Intervention	1.25±0.27	2.91±0.26	0.000*	0.267	-
	Control	2.87±0.43	2.84±0.50	0.000*	0.000*	0.003*
ML	Intervention	0.92±0.43	0.63±0.31	-	0.659	0.000*
	Control	1.33±0.44	1.40±0.43	0.061*	1.000	0.076
	Intervention	0.91±0.56	1.52±0.90	0.659	-	0.021*
	Control	1.94±0.76	1.88±0.70	0.000*	0.064	1.000
	Intervention	1.15±0.27	2.99±0.23	0.000*	0.021*	-
	Control	3.14±0.68	2.93±0.61	0.000*	0.000*	0.005*
O	Intervention	1.22±0.40	0.61±0.19	-	0.019*	0.000*
	Control	1.28±0.42	1.31±0.40	0.222	1.000	0.000*
	Intervention	0.75±0.29	2.20±0.66	0.019*	-	0.012*
	Control	2.64±0.47	1.96±0.42	0.000*	0.062	1.000
	Intervention	1.24±0.27	3.10±0.28	0.000*	0.012*	-
	Control	3.16±0.70	2.86±0.56	0.000*	0.000*	0.001*

*Significant changes at P<0.05 between subgroups according to EDSS determined by *post-hoc* analysis using Bonferroni adjustment.
P value: for difference the static balance changes between subgroups according to EDSS.

trunk muscle and balance, additionally, they clear that core training program improves balance.

Tables V, VI show that there is a significant change between the subgroups according to EDSS in some of the balance parameters (AP, ML and OA); for example, in the static balance, there are significantly different between A, B and A, C intervention subgroups in AP and O stability indexes. Also, there are significantly different between A, C and B, C intervention subgroups in ML Stability Index and C, B in O Stability Index. In conjunction with dynamic balance, ANOVA Test shows significant difference between A, B and A, C intervention subgroups in AP and ML stability indexes. It can be concluded from our results that severely disabled patients derive more benefit in comparison with those who were less disabled. The present protocol was more effective in patients with the weaker balance due to having weaker muscles.

The percentage improvement was calculated based on Blanchard and Schwarz method as follows:[44]

$$\text{Percent improvement} = \frac{\text{Pre-test - post-test}}{\text{Pre-test}} \times 100$$

As documented, 50% or greater improvement in patients confirm a clinical improvement.[44] The percent improvement results show the ≥50% for the improvement of the intervention subgroup C in all indexes AP (57.04%), ML (61.54%) and OA (60%) in static condition and also in all indexes AP (62.71%), ML (65.44%) and OA (54.43%) in dynamic condition, the intervention subgroup B in 2 indexes AP (55.61%) and OA (65.91%) in static condition and in indexes AP (66.52%), and ML (50%) in dynamic condition also the intervention subgroup A only in index OA (50%) in static condition and in index AP (50.78%) in dynamic condition.

TABLE VI.—*Differences in the dynamic balance between the study groups.*

Stability Index	Subgroup	Pre-test Mean±SD	Post-test Mean±SD	Intervention	Intervention	P value Intervention
AP	Intervention	0.63±0.41	1.28±0.37	-	0.010*	0.000*
	Control	1.34±0.41	1.40±0.33	0.082	1.000	0.006*
	Intervention	0.76±0.31	2.27±0.63	0.010*	-	0.117*
	Control	2.06±0.47	1.92±0.43	0.000*	0.105	1.000
	Intervention	1.10±0.21	2.95±0.18	0.000*	0.056*	-
	Control	3.16±0.70	2.77±0.55	0.000*	0.000*	0.000*
ML	Intervention	0.82±0.31	1.22±0.39	-	0.015*	0.002*
	Control	1.45±0.49	1.28±0.43	0.692	1.000	0.397
	Intervention	1.10±0.54	2.20±0.66	0.015*	-	1.000
	Control	2.13±0.63	1.96±0.42	0.000*	0.736	1.000
	Intervention	0.94±0.30	2.72±0.35	0.002*	1.000	-
	Control	3.15±1.05	2.86±0.56	0.000*	0.000*	0.000*
O	Intervention	0.83±0.30	1.36±0.39	-	0.375	0.168
	Control	1.53±0.44	1.44±0.43	1.000	1.000	1.000
	Intervention	1.16±0.50	2.07±0.86	0.375	-	1.000
	Control	2.15±0.64	2.04±0.57	0.000*	0.814	1.000
	Intervention	1.08±0.35	2.37±0.95	0.168	1.000	-
	Control	3.10±1.09	2.70±0.77	0.000*	0.000*	0.001*

*Significant changes at $P<0.05$ between subgroups according to EDSS determined by *post-hoc* analysis using Bonferroni adjustment.
P value: for difference the dynamic balance changes between subgroups according to EDSS.

Also, a positive correlation between EDSS and the balance parameters improvement (AP, ML and OA) is observed. The balance is more significantly improved in the subgroups B and C in comparison with the subgroup A.

Discussion

The aim of this study was examination of the effect of 10-week CST program on the balance in women with MS according to EDSS Score. With respect to the measured parameters by BSS, the intervention group showed a significant improvement in the OA, AP and ML indexes in comparison with the control group. In general, these results indicate a positive effect of this program on the patient balance regarding the EDSS Score following 10-week exercise.

These findings indicate that the CST program improved balance which agrees with literature.[10, 41, 42] Freeman *et al.* provides preliminary evidence that this approach could be improved the balance and mobility in ambulant people with MS. They performed a replicated single-case series study on 8 MS patients who had EDSS Score of 4-6.5 to explore during the 8 weeks and stated that the development in balance and mobility may be related to the deep abdominal muscles which are responsible for the stabilization of the core area.[10] In the present study, the strength and endurance of the core muscles have been evaluated and we suggest the core stability and balance of patients who participated in CST program improved due to the improvement of the strength and endurance of core muscles.

The muscle weakness is among the most common symptoms and signs in MS patient which reducing muscle weakness introduce as a potentially important factor contributing to improving the balance.[45, 35] It is well-known that resistance strength training can be effective to increase muscle strength in people with MS.[35] Commonly, strength training programs promote an improvement in balance.[37] The present training program was designed to increase the endurance and strength of the core muscles that stabilize the trunk. This training program focused on trunk muscles (the deep stabilizers, rotators and flexors) which play a critical role in providing a postural stability.[46]

The balance has been improved due to facilitating coordinated local and global muscular activities.[15] According to previous research,[47] the rigid cylinder and a greater moment of inertia against body perturbation were created by the larger muscles of the core while providing a stable base for lower and upper extremity mobility.[41] The contraction of the abdominal muscles (the transverse abdominus, internal and external oblique and rectus abdominus) stabilize the spine and provide a stronger support base for lower extremity movement.[48] The trans*versus* abdominis contraction increased the intra-abdominal pressure and tenses the thoracolumbar fascia[24] which can be provided postural support before limb movements.[47] The activation of rectus abdominus muscle, obliques in specific patterns and limb movement have provided a postural support.[48]

The CST regiments can be improved the muscle activation patterns of trunk musculature and also the postural muscles in this area plays the most important role in balance improvement.[10, 15] Based on this suggestion, the development in balance approved that core strengthening have a positive effect on the balance. Similarly, another study showed a greater change in activation level of the muscles when subjects practice on unstable surface such as Swiss ball.[47]

Training in the unstable condition enhances movement specific effects via increasing activation of trunk musculature due to improving neuromuscular coordination.[24] In the present study, the similar improvements in the intervention group participants have been obtained due to specific movement on a Swiss ball, which consistent with previous study.[49]

The positive effects of this study that extend the results of other authors studying could be attributed to a blinded, randomized controlled trial design, the sufficient number of treatment sessions (30 sessions), supervised exercise, the bigger sample size, existence of comparison with other interventions and the variations in response to the intervention.

The present study is a closer evaluation of the balance of each patient due to the presence of specific causes such as EDSS which the differences in severity of muscle weakness concerning the EDSS Score[45] could be led to various improvements. The Balance improvements were observed in the interventional subgroups B and C. Participants who had poor EDSS seemed to have better improvement.

This can be justified by reference to the principle that CST can facilitate neuromuscular re-education, and concluded that present protocol is more effective in patients who their balance is weaker.

In the other hand, the strength development is dependent on the type and intensity of loading along with volume of the strength training.[50] In the current CST program, the activity of muscle groups, the muscle contraction type and the volume of strength training were similar in the intervention groups, therefore, it can be concluded that the differences in the obtained strength development was due to differences in the effect of exercise intensity.

Although the intensity of the exercises presented for each of the three groups was similar but perhaps the intensity of exercises has not been enough to influence balance in subgroup A subjects. Given that, perhaps, groups A was greater physical fitness compared to subgroups B and C, so group A subjects' need for higher intensity exercise for the effectiveness of training.

The present study results suggest that core muscle weakness is one impairment that can be a strength by a CST program, leading to improvement of balance control. Future investigations should clarify what aspect of core muscle performance will be more important to patient's balance improvement according to their EDSS Score.

Practical and clinical applications

One of the most effective therapies available to most patients with MS seems to be is exercise.[51-54] According to previous research work, it is found that many beneficial effects on disease signs occur during and right after an exercise therapy, while, every type of exercise will not work for every patient.[55-57] It is a challenge that exercises prescribed for the patients especially.[56, 58] However, there is a lack of information about the exercise classification for patients with MS. This is a promising finding, and future studies should further explore how the exercise classification can be designed and performed into rehabilitation programs to enhance the adherence and long-term effectiveness of training programs. This study provides practical implications for therapists who designed the training programs for patients with MS. This program can be gradually modified to be dedicated to the individuals with the different disability. Of course, all safety precautions must be checked and taken before training program design. The main clinical point of our study was that based on our knowledge, it was the first study showing that the same training program could have the different result on the balance in patients with MS according to EDSS due to core muscles different functions were significantly different More investigation for response to core stability training with different intensity is necessary so that therapists can target those most likely to benefit.

Limitations of the study

The limitations of the current investigation were included: 1) lack of long-term follow up in order to assess the maintenance of the beneficial effect of the training protocol; 2) all participants with the diagnosis of relapsing-remitting MS with EDSS Score between 2.5 to 5.5; 3) absence the studies that investigation of the effects of similar exercises on patients with EDSS Score between 2.5 to 5.5 for comparison with the present study; 4) the lack of balance outcome measurements such as Berg Balance Scale and fall-related questionnaires as fall's efficacy scale.

Conclusions

According to our results, it concluded that the CST can be performed as an efficient clinical intervention for improving dynamic and static balance in MS women due to the improvement of core muscle function. A significant difference between the mean of balance scores after the intervention in the three experimental subgroups in compared with the control subgroups was observed. The present protocol is helpful more efficiently for the patients with MS 4/5≤EDSS≤5/5 and 3/5≤EDSS<4/5 more than the patient with 2/5≤EDSS<3/5.

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Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Funding.—Authors gratefully acknowledge the Shahid Bahonar University of Kerman and Neurology Research Center of the Kerman University of Medicine Science for financial supports of this project.

Article first published online: January 2, 2018. - Manuscript accepted: January 2, 2018. - Manuscript revised: December 22, 2017. - Manuscript received: April 9, 2017.