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ARTICLE

The Effect of Yoga Exercises on Fatigue, Balance, Muscle Strength and Neurological Disorders in Women with Multiple Sclerosis

Nazarian Alibagher[1*], Azar Aghyari[2], Shahin Asgari[3]

[1] Assisstant Professor in Sports Injuries and Corrective exercises, University of Payame-Noor, Tehran, Iran
[2] Associated Professor in sport injuries and Corrective exercises, University of Payame Noor, Tehran, Iran
[3] Master of Sciences in Sports Injuries and Corrective exercises, University of Payame-Noor, Tehran, Iran.

[*]Corresponding Author: Alibagher Nazarian. Email: a.bnazarian@pnu.ac.ir
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ABSTRACT: The aim of this study was to investigate the effect of yoga exercises on fatigue, balance, muscle strength and neurological disorders in women with multiple sclerosis.

This was a semi-experimental study, for this purpose, pre and post-test study design (experimental group and control group) were used. 42 women with MS in Khomein city participated in this study and divided into two control (age: 33.3±6.2, height: 164.6±4.4, weight: 71.1± 7.3 and BMI: 26.4±2.9) and experimental group (age: 38.3±4.5, height: 160.8±7, weight: 68.5±14/6 and BMI: 26.4±4.8). The exercises were based on cognitive therapy based on mindfulness and yoga exercises, which was an 8-week program (3 sessions of 60 minutes per week). A quesinnaire, Berg balance test, Standing stork test, Tug, chair test and neurological disorders test were used to collect data. Kolmogorov Smirnov, dependent and independent t test, and Cohen's D test were used in the SPSSV25 software environment to analys data. Level of significant was 0.05.

The findings of this study showed that yoga exercises leads to reduce fatigue level($P\leq0.05$), improve static and dynamic balance ($P\leq0.05$), increase lower body muscle strength ($P\leq0.05$) and leads to decrese neurological disorders ($P\leq0.05$) in women with MSm($P\leq0.05$).

In conclusion it can sugusted to trainers and MS patients' authorities to utilize this method in to minimiz balance problems, improve strength, endurance and also nurological disorders of affected individuals. Thi sapproach can be considered as a new method in their rehabilitation exercise program.

KEYWORDS: Yoga, Fatigue, Balance, MS, Women.

1 Introduction

Multiple Sclerosis (MS) is recognized as the most common non-traumatic cause of disability among young adults, posing significant economic and psychological burdens on patients, their families, and society (1). Globally, the average prevalence of MS is 33 per 100,000 people, but regional studies conducted in Iran report much higher rates (over 75 per 100,000 people). MS is a chronic inflammatory disease of the central nervous system, characterized by damage to the myelin sheath of neurons, leading to injury to axons and myelin, and affecting sensory, motor, and cognitive functions (2). The disease causes inflammation in both white and gray matter of the central nervous system and primarily affects young adults aged 20-45 years (3). One of the key features of MS is its unpredictability, as patients face a challenging treatment regimen, unpleasant symptoms, adverse drug effects, and physical disabilities. The prevalence of MS in women is reported to be three times higher than in men (4,5). Various strategies are recommended to cope with these symptoms, including medication, patient education, lifestyle changes, appropriate physical activity, relaxation techniques, stress reduction, ergonomic adjustments, balanced diet, improved sleep quality, and avoiding environmental challenges (6). Symptoms of MS may range from mild (such as tingling in limbs) to severe (such as limb paralysis, which may appear suddenly or over several years). However, symptoms vary among individuals and are unpredictable (7).

Common symptoms of MS include fatigue, balance disorders, spasticity, motor weakness, and visual problems (8). Since the exact cause of MS is still unknown, factors such as genetics, abnormal immune system activity, viral infections, changes in climate, proximity to the equator, vitamin D deficiency, smoking, and psychological stress are believed to play significant roles in the onset of the disease (9). Approximately 75% to 90% of MS patients report fatigue, and 55% of them consider fatigue as one of the worst symptoms. Furthermore, 85% of patients report walking impairment as a primary issue. By 15 years from the onset of MS, nearly half of the patients require assistance for walking, and 10% become wheelchair-dependent (10). Early muscle fatigue, balance issues, reduced muscle strength, visual impairment, bladder dysfunction, loss of muscle control, numbness, tingling, sensory and motor impairment are among the most common symptoms of MS (11). Studies have shown that muscle fatigue leads to increased postural sway, decreased ability to maintain balance, and impaired proprioception (12,13).

Another significant issue faced by MS patients is balance impairment. Balance is a complex state that dynamically prevents falls and can be defined in two ways: static and dynamic. Static balance refers to the ability to maintain the center of gravity within a stable base, while dynamic balance involves maintaining control of the center of pressure during walking or other movements. Impairment in balance control is a critical risk factor for falls in MS patients. This impairment is characterized by increased sway during stationary positions, delayed postural responses to perturbations, and reduced ability to maintain stability. Research from countries like Sweden, the United States, the United Kingdom, and Australia has shown that 56% of MS patients have experienced falls at least once, and 37% have fallen multiple times, leading to a reduction in daily activities and, ultimately, a decreased quality of life (14).

Additionally, MS patients experience muscle weakness. Muscle strength is a crucial component of physical fitness related to health and plays a significant role in daily activities and sports performance. Research has shown that many MS patients suffer from functional impairments due to reduced lower body strength (15). Disruptions in neural conduction within the nervous system are associated with functional impairments and syndromes such as muscle weakness, cognitive impairments, sensory disturbances, and decreased control of posture and gait performance (16). Qazaq et al. (2019) examined the effectiveness of a mindfulness-based stress reduction program on the quality of life and fatigue severity in women with MS,

finding significant differences in various quality-of-life subscales such as physical functioning, role limitations due to physical and mental health issues, and fatigue severity between the experimental and control groups (17).

Research has shown the benefits of yoga and meditation, such as increased body awareness, muscle tension release, improved coordination and balance, increased flexibility and strength, fatigue management, enhanced circulation, and respiratory function (18). However, there has been ongoing debate regarding the effects of exercise on MS, with the belief that exercise may exacerbate symptoms and fatigue. Despite this, exercise is now widely recognized as safe and effective for MS patients, even having potential benefits for clinical outcomes. Yoga, in particular, is considered a beneficial mind-body intervention and has been widely reported as highly satisfying for MS patients. However, there are limited studies exploring the effects of yoga exercises on fatigue, balance, muscle strength, and neurological disorders in individuals with MS. Therefore, the results of this research are expected to provide valuable insights into the impact of yoga exercises on fatigue, balance, muscle strength, and neurological disorders in women aged 45-20 with MS, helping to delay the gradual loss of mobility and ease in daily activities for these patients.

2 Methods

This study is a quasi-experimental research, utilizing a pre-test and post-test design with experimental and control groups. The statistical population consisted of all women diagnosed with MS in Khomein city, affiliated with welfare services and sports for patients with disabilities through the Sports and Youth Organization and Seka Rehabilitation Center. Using G*Power software (power 0.95, degree of freedom 53, significance level 0.05), a sample of 42 individuals were selected and divided into two groups of 21 participants(experimental and control groups). Six participants withdrew from the study due to personal reasons and inability to fully execute the training protocol.

Inclusion and Exclusion Criteria:

•**Inclusion criteria**: MS diagnosis by a specialist, being in relapse-remission stage, not dependent on a wheelchair, age between 20 to 45 years.

•**Exclusion criteria**: Non-participation in yoga and meditation sessions before and during the study for two consecutive sessions or three non-consecutive sessions, presence of severe or chronic disorders such as severe depression during sessions, and inability to complete exercises.

Implementation Method:

The research began with a public call for participation in collaboration with the Khomein Welfare and Rehabilitation Department. Objectives, research timeline, and collaboration details were communicated to participants. Individuals willing to participate registered, and written informed consent was obtained. All participants completed questionnaires and initial training related to research and tests. Participants were selected based on inclusion criteria, followed by an 8-week yoga program (3 sessions per week, 60 minutes each) for the experimental group, while the control group maintained no exercise regimen. After the intervention, an individual evaluation session was conducted, following a pre-determined schedule for post-test assessment. This study received ethical approval from the university with code IR.PNU.REC.1402.190.

Measurement Tools:

•**Height Measurement**: Used a seca stadiometer (accuracy 0.1 cm) without shoes, in a standing position.

•**Weight Measurement**: Used a calibrated seca scale (accuracy 0.1 kg) with minimal clothing.

•**Berg Balance Scale (BBS)**: A clinical test assessing static and dynamic balance, especially in neurological patients. This gold-standard test for functional balance includes 14 balance tasks with scores ranging from 0 to 40. A score ≤ 40 indicates the need for walking assistance, while a score > 40 indicates independence in walking.

•**Fatigue Severity Scale (FSS)**: Used to measure fatigue in MS patients, consisting of 9 questions rated on a 7-point Likert scale. Scores range from 1 (strongly disagree) to 7 (strongly agree), with a total score calculated by dividing the sum of scores by 9. Higher scores indicate greater fatigue.

•**Dynamic Balance Test**: Time Up and Go Test (TUG): The participant stands up from a chair, walks 3 meters, and returns. Completing the test in 10 seconds or less indicates normal neurological health and independence in balance and motor skills.

•**Static Balance Test:** Flamingo Test: The participant stands barefoot on a flat surface with one foot placed next to the knee of the standing leg. Maintaining this position while lifting the heel of the supporting foot to stand on toes assesses static balance.

•**Muscle Strength**: Lower limb muscle strength was assessed using a sit-to-stand test. Participants performed as many sit-to-stand movements as possible within a 30-second period. Performance was recorded based on the number of movements, with reliability scores of 0.92 for women and 0.84 for men.

This research provides a comprehensive analysis of the impact of an 8-week yoga intervention on balance, fatigue, and muscle strength among MS patients.

Table 1. Yoga Training Protocol

Lying exercises for strengthening muscles	**General exercises for strengthening muscles**	**Warming up (7-10 minutes)**
(4-10 repetitions)	(4-10 repetitions)	(4-10 repetitions)
Leg Lift stretch Leg Lock Pose Locust Pose Bow Pose Cobra Pose Simple Supine twisting	Bridge Upward-Facing DogSun Salutation Shoulder Stand Plow Pose	fish Pose Shoulder movements Lifting legs with sit-ups Chest lift with sit-ups (hold up to 6 breaths) Leg sliding together Lifting the pelvis off the ground Spine mobility Spine stretching
Stretching exercises for strengthening the lower body muscles 4o mini	**Standing exercises for strengthening muscles**	**sitting exercises for strengthening muscles**
Garland Pose Plank Lunge Chaturanga Head to Knee	Mountain Pose Side Bend Standing Dancer Pose Simple Triangle Pose Ninety Degree Triangle Pose Virabhadrasana 1/2/3	Correct Seated Position Butterfly Pose Seated Teacher Pose Cow Pose Half Boat Pose Full Back Stretch

	Standing Forward Bend Wide Leg Forward Bend Eagle Pose	Head-to-Knee Forward Bend Half Lord of the Fishes Pose

Data analysis

For data analysis, both descriptive (mean, standard deviation, frequencies, etc.) and inferential statistical methods were employed. The statistical analyses were conducted using SPSS version 25, at a significance level of 0.05.

Statistical Methods:

1. **Descriptive Statistics:**
   - Mean
   - Standard Deviation
   - Frequencies
   - Other relevant descriptive statistics.
2. **Inferential Statistics:**

Kolmogorov-Smirnov Test was used to assess the normality of data.

Independent and dependent t-test were used to test hypotheses related to the research.

These analyses helped in evaluating the effectiveness of the yoga intervention on balance, fatigue, and muscle strength among MS patients.

3 Results

In table 1 anthropometeric indexes of subject are shown, also descriptive and inferential results mentiond in the following tables.

Table 2. Antropometeric indexes of groups(Mesn±SD)

Variable / Groups	**BMI** (kg/m^2)	**Weight (kg)**	**Height (cm)**	**Age (yr)**
Control	26.4±2.9	71.1±7.3	164.6±4.4	37.3 ± 6.2
Experimental	26.4±4.8	68.5±1.6	160.8±7	38.3±5.5

Table 3. Descriptive and inferential results of variable measurments in the differents groups(Mesn±SD)

Variable		**Pre**	**Post**	**t Dependen**	**Sig.**
Fatigue	Control	55.2 ±5	55.1±5.3	0.204	0.841
	Experimental	53.7 ±6.5	46±4.5	8.660	0.000
Static Balance (s)	Control	12.37 (2)	12.5(2.1)	-1.222	0.236
	Experimental	15.6 (9.5)	21.2(13.8)	-4.060	0.001
Dynamic Bakancce (s)	Control	11.8 (1.2)	11.7(1.3)	0.613	0.547
	Experimental	12.5 (3.5)	10.2(2.9)	10.4	0.000

Muscle Strength (number)	Control	8.8 (1.5)	8.9(1.5)	-0.491	0.629
	Experimental	9.8 (2.4)	14.9(2.7)	-16.1	0.000

Table 3 shows that the level of fatigue in the control group participants in the post-test has significantly decreased compared to the pre-test. Additionally, the levels of static balance, dynamic balance, and lower limb muscle strength have shown a significant improvement ($p \leq 0.05$).

Table 4. Results of Independent t-Test for Fatigue, Static Balance, Dynamic Balance, and Lower Limb Muscle Strength in Post-Test for Different Groups

Variable		**Independent t**			**Leven Test**
	Df	**t**	**Sig.**	**F**	**Sig.**
Fatigue	40	4.9	0.000	0.6	0.428
Static Balance (s)	40	-2.8	0.007	0.3	0.476
Dynamic Bakancce (s)	40	2.06	0.045	1.5	0.072
Muscle Strength (number)	40	-8.5	0.000	3.1	0.059

The information regarding the test of equality of variances for the measured variables is presented in Table 4. Additionally, according to Table 4, the results of the independent t-test indicate that there are significant differences between the two groups in terms of fatigue, static balance, dynamic balance, and muscle strength. These differences are in favor of the experimental group ($p \leq 0.05$).

4. Discussion and Conclusion

Based on the results of the research, yoga exercises had a significant impact on reducing fatigue among participants. This finding aligns with the results of Ilbighi et al. (2019) and Bastians et al. (2016) (23,24). Yoga, like any other physical activity, increases energy levels and, by promoting stretching in both lower and upper limbs, can help reduce muscle contractions, improving flexibility and physical readiness. Additionally, it can enhance the body's metabolism, leading to better blood circulation, oxygenation, and muscle nourishment, ultimately reducing fatigue and muscle weakness while improving the nervous system (25). Given that fatigue is one of the most common symptoms and complications of MS, it is essential for caregivers and healthcare professionals to consider non-invasive and accessible methods like exercise and activities such as yoga for management.

Furthermore, the increasing prevalence of MS in Iran and the importance of managing fatigue in these patients highlight the need for effective non-pharmacological approaches. Since pharmaceutical methods impose significant financial burdens on both individuals and society while having numerous side effects, patients who are informed about the benefits of non-pharmacological methods like exercise and yoga can make meaningful strides toward reducing fatigue and improving their quality of life.

Regarding balance, the results of the research demonstrated that yoga exercises had a significant impact on the static and dynamic balance of women aged 45-20 years with MS, leading to noticeable improvements in their balance. This finding aligns with the results of Ebasriyanik et al. (2021) (26). For individuals with MS, as their mobility decreases over time, they experience impairments in movement patterns and reliance on affected limbs, resulting in reduced sensory inputs and, ultimately, disrupted sensory-motor integration. These factors limit balance and functional mobility. In contrast, engaging in physical exercises can enhance somatosensory, visual, and vestibular information, ultimately improving sensory-motor integration in the central nervous system and promoting appropriate muscle synergies and increased postural control. Thus, yoga exercises improve both dynamic and static balance through a systems theory approach, emphasizing the coordination of the nervous, muscular, and skeletal systems. For maintaining balance in both static and dynamic states, it is essential to integrate sensory data to recognize body positioning in space and for the musculoskeletal system to generate appropriate forces. According to this theory, the central nervous system, using inputs from the visual, vestibular, and proprioceptive systems (including joint position and peripheral sense), becomes aware of the body's center of gravity relative to gravity and stable support surfaces, providing appropriate motor responses through pre-programmed movement patterns. Consequently, yoga exercises, by enhancing these systems and strengthening core muscles (such as the transverse abdominis, multifidus, and pelvic floor muscles), can improve balance and postural stability in daily activities.

Additionally, the results of the research showed that yoga exercises have a significant impact on the muscular strength of women aged 45-20 years with MS, leading to a noticeable improvement in patients' muscle strength. This finding aligns with the results of Serbaz and colleagues (2020) (28). Increasing muscular strength in individuals with MS is beneficial because these individuals experience varying degrees of fatigue due to the disease, leading to a reduction in daily activities and subsequent muscle atrophy. Through strength training exercises, muscle strength in MS patients is increased, preventing atrophy and muscle weakness, likely enhancing their daily activity levels. Furthermore, initial adaptations to strength training are more neurogenic than muscular, highlighting the importance of these positive neurological changes in individuals with neurological disorders. These neurological benefits from physical activity likely result in positive functional outcomes, although it is important to note that these results may be influenced by the severity of pre-existing plaques (29). Since most individuals with MS, including women, are at higher risk for other conditions such as osteoporosis due to inactivity, resistance training has a profound impact on the quality of life and mobility of older MS patients. Consequently, it is expected that resistance training programs will improve muscular strength, muscular endurance, and overall mobility capacity in MS patients. Thus, resistance exercises could be considered an effective intervention strategy for improving the mobility performance of MS patients with moderate disability. Additionally, improvements in muscles capable of adapting to additional loads may enhance general physical fitness and motor performance in MS patients with moderate disability. Furthermore, according to research findings, yoga significantly increases thalamic GABA levels, which has beneficial effects such as mood enhancement and anxiety reduction in participants. Additionally, studies have shown that yoga has positive effects in reducing the frequency and severity of various types of tension headaches (30).

Based on the findings, it was evident that selected yoga exercises significantly reduce fatigue, improve balance, enhance muscular strength, and reduce neurological impairments in MS patients. Therefore, yoga training should be recommended to trainers and professionals working with MS patients as a method to

minimize balance issues, enhance patients' strength and endurance, and improve the neurological condition of individuals with MS. It can serve as a novel approach in their rehabilitation exercise programs.

Compliance with ethical guidelines:

Ethical principles in this research, including obtaining consent for participation in tests and receiv-ing approval from the ethics committee, have been followed.

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Author's Contribution:

Conceptualization, methodology, investigation, writing and editing: correspondin author, data collecting and analysis: coworkers, Review the article: corresponding author and coworkers.

Conflict of interest:

The authors declared no conflict of interest.

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