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EFFECTS OF STATIC AND FUNCTIONAL STRETCHING EXERCISES ON LOWER LIMB SPASTICITY AND FUNCTION IN PEOPLE WITH MULTIPLE SCLEROSIS: A RANDOMIZED CONTROLLED TRIAL

ORIGINAL ARTICLE

ABSTRACT

Purpose: Spasticity is a common problem among people with Multiple Sclerosis (MS). This study aimed to compare the effects of static stretching exercise (SSE) and functional stretching exercise (FSE) on lower limb spasticity, function, lower limb pain, active range of motion (ROM), and health-related quality of life (HRQOL) in patient with MS.

Methods: Twenty-six participants were randomly allocated into two groups. SSE group (n=12) completed a four-week (12 sessions) SSE of hamstrings, quadriceps, hip adductors and plantar flexors muscles. FSE group 2 (n=12) completed a four-week (12 sessions) FSE of the same muscles. The outcome measures were Modified Modified Ashworth Scale, Timed Up and Go Test, Timed 25 Foot Walk Test, active ROM assessment, Visual Analogue Scale, and EuroQoL 5-Dimension 5-Level questionnaire.

Results: In each group, decrease of spasticity, improvement of functional tests, decrease of pain, increase of ROM and increase of HRQOL were statistically significant compared to baseline ($p<0.05$). There were no significant differences between both groups in all variables before and after treatment ($p>0.05$). A strong correlation was found between decreased spasticity and functional improvement in the SSE group ($r=0.793$, $p=0.002$). In the FSE group, there were moderate correlations between decreased spasticity and increased ROM ($r=0.689$, $p=0.013$) and between increased ROM and functional improvement ($r=0.593$, $p=0.042$). There was also a strong correlation between decreased spasticity and increased HRQOL ($r=0.721$, $p=0.006$).

Conclusion: The regular four-weeks of SSE or FSE can decrease lower limb spasticity, improve function, decrease pain, increase active ROM and increase HRQOL in patients with MS.

Key Words: Mobility Limitation, Multiple Sclerosis, Muscle Spasticity, Muscle Stretching Exercises, Quality of Life.

MULTİPL SKLEROZLU BİREYLERDE STATİK VE FONKSİYONEL GERME EGZERSİZLERİNİN ALT EKSTREMİTE SPASTİSİTESİ VE FONKSİYONU ÜZERİNE ETKİLERİ: RANDOMİZE KONTROLLÜ BİR ÇALIŞMA

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Spastisite, Multipl Sklerozlu bireyler arasında yaygın bir sorundur. Bu çalışmanın amacı, Multipl Sklerozlu bireylerde statik germe (SG) ve fonksiyonel germenin (FG) alt ekstremite spastisitesi, fonksiyon, alt ekstremite ağrısı, aktif eklem hareket açıklığı (EHA) ve sağlıkla ilişkili yaşam kalitesi (SİYK) üzerine etkilerini karşılaştırmaktı.

Yöntem: Yirmi altı katılımcı randomize edilerek iki gruba ayrıldı. SG grubuna (n=12) 4 hafta (12 seans) hamstring, quadriseps, kalça adduktor ve plantar fleksor kaslarının statik germe egzersizleri uygulandı. FG grubuna (n=12) aynı kaslar için dört haftalık (12 seans) fonksiyonel germe egzersizleri uygulandı. Sonuç ölçümü olarak Modifiye Modifiye Ashworth Skalası, Zamanlı Kalk ve Yürü Testi, Zamanlı 25 Adım Yürüme Testi, aktif EHA değerlendirilmesi, Görsel Analog Skala ve Avrupa Yaşam Kalitesi Ölçeği-5 Boyut Anketi kullanıldı.

Sonuçlar: Her iki grupta da spastisitede azalma, fonksiyonel test sonuçlarında iyileşme, ağrıda azalma, EHA'nda e SİYK'nde meydana gelen artış başlangıç değerlerine kıyasla istatistiksel olarak anlamlıydı ($p<0,05$). Gruplar arasında, tüm değişkenlerde tedavi öncesi ve sonrası için anlamlı farklılık yoktu ($p>0,05$). SG grubunda spastisite azalma ve fonksiyonel iyileşme arasında güçlü bir korelasyon vardı ($r=0,793$, $p=0.002$). FG grubunda ise azalmış spastisite ile artmış EHA arasında ($r=0,689$, $p=0,013$) ve artmış EHA ile fonksiyonel iyileşme arasında ($r=0,593$, $p=0,042$) orta düzeyde korelasyon vardı. Azalan spastisite ile SİYK artışı arasında ise güçlü bir korelasyon vardı ($r=0,721$, $p=0,006$)

Tartışma: Düzenli olarak dört hafta boyunca uygulanan SG veya FG, multipl sklerozlu hastalarda alt ekstremite spastisitesini azaltabilir, fonksiyonu iyileştirebilir, ağrıyı azaltabilir, aktif EHA'nı ve SİYK'ni artırabilir.

Anahtar Kelimeler: Mobilite Limitasyonu, Multipl Skleroz, Kas Spastisitesi, Kas Germe Egzersizleri, Yaşam Kalitesi.

INTRODUCTION

Sixty to eighty percent of people with multiple sclerosis (PwMS) have spasticity (1,2). Spasticity was defined by Pandyan et al. as "Disordered sensorimotor control, resulting, resulting from an upper motor neuron lesion, presenting as intermittent or sustained involuntary activation of muscles" (3). Secondary changes in mechanical muscle fibers, collagen tissues, and tendon properties also contribute to spastic muscle tone, resulting in functional limitations in upper motor neuron lesions (4). Spasticity causes contracture of muscles and soft tissues, decreased range of motion (ROM) and pain; these components result in limb stiffness, impaired muscle balance, limited functional mobility, and decreased quality of life (2, 5, 6).

Stretching techniques prevent contractures, increase joint ROM, decrease limb stiffness and pain (7). These changes may contribute to improvement in functional movements and quality of life in PwMS (8). Static stretching exercises are generally recommended to reduce spasticity and increase flexibility in PwMS (9). Functional stretching is a therapist-assisted technique that specifically suggested to recover ROM and joint mobility. This technique is derived from normal daily activities and applied actively by patients in static or dynamic ways (10).

The results of some previous studies (11-17) have indicated positive effects of stretching on functional mobility, ambulation, balance, fatigue and quality of life in PwMS. However, in these studies, stretching exercises have been applied with other types of exercises such as balance, coordination, stability, strengthening or resistance exercises and particular parameters (i.e., stretching time, repetition, muscles) of the stretching program. In addition, the exact effects of stretching as an intervention on PwMS were unclear. Some other studies (18-20) studied the isolated stretching exercises effects on PwMS, but in these studies, stretching has been applied with anti-spasticity drugs, or parameters of the stretching program were unclear. Additionally, the effects of stretching exercises on clinical outcomes such as spasticity or functional mobility were not assessed.

However, stretching is recommended for PwMS, but also there is significant ambiguity about the type and its unique effects. Therefore, the primary aim was to compare the effects of static and functional stretching on lower limb spasticity and function in PwMS. Secondary aims were to compare two types of stretching on lower limb pain, active range of motion (ROM) and health-related quality of life (HRQOL) in PwMS, and to examine the relationship between outcomes.

METHODS

Study Design

This study was a single-center, single-blinded (only patients were blind to their treatment allocation), parallel, randomized, controlled trial investigating the effects of static stretching exercises (SSE) and functional stretching exercises (FSE) on lower limb spasticity, function, pain, active ROM and health-related quality of life in PwMS. Parameters related to the sample size calculation were taken from a similar study (12). The sample size was estimated as 11 (n=11 for each group) with an alpha of 0.05, 80% power and effect size of 1.2 using an equation. This study was conducted between September-December 2019 at Tehran MS Society Rehabilitation Center in Iran.

Written informed consent was obtained from all study participants. All participants were assessed at baseline for eligibility criteria by a physiotherapist (researcher). The participants who fulfilled inclusion criteria were then randomly allocated into either SSE (1) group and FSE (2) group; using random allocation rule (21) with 1:1 allocation ratio (placing 13 papers of 1 and 13 papers of two in a pocket and drawing them randomly) by an independent member of Tehran MS Society Rehabilitation Center.

Participants

The Medical Ethics Committee approved this study of the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran (Approval Date: 23.07.2019 and Approval Number: IR.USWR.REC.1398.051) and was registered with the Iranian Registry of Clinical Trial (Registration number: IRCT20190702044079N1). Thirty-four PwMS from the Tehran MS Society rehabilitation center were screened for eligibility criteria, and 26 PwMS were enrolled in the study following Helsinki's declaration. Inclusion criteria were specialist-confirmed MS (22), self-reported lower-extremity spasticity in daily activities with limb stiffness or muscle spasms or pain (Modified Modified Ashworth Scale score ≥1 in at least one of the assessed muscles), able to walk a minimum of 25 feet with or without assistive devices such as cane or walker. Exclusion criteria were participation in any yoga, Pilates or exercise programs, using medications used in the treatment of spasticity, Botox injections for lower limb (in the last six months), the use of an orthosis.

Interventions

Static stretching was in a passive form and performed by a physiotherapist (researcher). SSE include (23); static stretching of hamstrings in the supine position (hip flexion with knee locked in extension), quadriceps in the prone position (hip extension with full knee flexion and heel in contact with gluteal), hip adductors in the supine position (hip abduction with full knee extension) and plantar flexors muscles in the supine position (ankle dorsiflexion with the knee in full extension).

In the FSE group, the following exercises were supervised by a physiotherapist (researcher) and performed actively by participants (24):

Standing wedge plantar flexor stretch: Participant stood in front of a parallel bar, and held the bars for support, placed both feet onto a wedge with ankles are dorsiflexed. The patient then shifted his/her weight forward gradually while the knees were kept in extension.

Seated toe touch hamstring stretch: The participant sat on a chair in front of parallel bars. Both ankles were placed on the bar, which had been adjusted appropriately in height for the patient's safety and comfort; the patient then gradually reached as if to touch his toes.

Standing single leg quadriceps stretch: Participants stood in front of a parallel bar and held the bars for support while flexing the knee. Then placed his/her foot on a chair adjusted to an appropriate height and located behind the leg. This procedure was repeated for the other leg.

Standing hip adductors stretch by hip abduction: Participants stood in the parallel bar and hold onto the bars for support before abducting gradually both legs out to the side.

Each stretch maintained for 30 seconds and repeated three times with 15 seconds rests in both groups. After each stretching, participants were required to do five times active or active-assisted movements in the same direction of stretching in both groups. The intervention schedule for both groups was three times a week for four weeks, and each session took approximately 25-30 minutes. All participants completed their sessions individually in a separated timetable.

Measurements

The following outcomes were assessed at baseline and after a 4-week stretching program. Modified Modified Ashworth Scale (MMAS) was used to grade the spasticity level of hamstrings, quadriceps, hip adductors and plantar flexors (25). Functional mobility and dynamic balance were assessed using a timed up and go test (TUG) (26). Participant took the time to stand up from a chair at the height of 46 cm from the ground and walk 3 meters, turn around, and sit back down on the chair as fast as they could be measured in seconds by a stopwatch. Gait speed and gait capacity were measured using the Timed 25 Foot Walk Test (T25FWT) (27). Participants were asked to walk 25 feet as fast as possible, and the time taken to complete was recorded by stopwatch. Visual Analogue Scale (VAS) (28) was used to measure pain. Patients were asked to determine their general pain level in the lower limb on a 0–10 points scale in which 0 indicates no pain, and 10 indicates severe pain.

In a supine position, active hip flexion, abduction and ankle dorsiflexion ROM; and in prone position active hip extension ROM were assessed using a standard goniometer (Stainless Steel goniometer 20cm/180°, SAEHAN, Belgium) (29). The measurement was performed bilaterally. All ROM measurements were repeated two times, then we have averaged the first and second measurements of hip abduction, hip flexion, hip extension and ankle dorsiflexion. These new values were used for the statistical analyses.

European Quality of Life 5 Dimensions 5 Levels (EQ-5D-5L) questionnaire was allowed to use in this study and used to evaluate health-related quality of life (HRQOL) (30). Participants were required to describe their HRQOL in five dimensions: Mobility, Self-Care, Usual Activities, Pain/Discomfort, and Anxiety/Depression by choosing one of five response categories as no problems, slight problems, moderate problems, severe problems, and extreme problems. The EQ-VAS part recorded the patient's self-rated health on a vertical visual analogue scale (0-100 scale).

Statistical Analysis

For data analysis, SPSS version 17.0 (SPSS Inc., Chicago, USA) was used. Descriptive statistics (mean and standard deviation) were computed for all data. The Kolmogorov–Smirnov test was used to determine the normal distribution of variables. The ANOVA was applied to detect baseline differences between both groups, and the paired t-test was applied for comparing differences to baseline within the group. The ANCOVA was used to com-

Table 1: The Descriptive and Baseline Measures in Static and Functional Stretching Groups.

Variables		Static Stretching (n=12)	Functional Stretching (n=12)	p
Gender	**Female**	5	7	0.436
	Male	7	5	
Dominant Foot	**Right**	10	9	0.633
	Left	2	3	
Type of Disease	**PPMS**	1	-	0.764
	SPMS	6	6	
	RRMS	4	6	
	PRMS	1	-	
Age (years)		45.33±11.96	43.75±7.58	0.702
Weight (kg)		68.33±5.44	64.50±21.28	0.552
Height (cm)		168.58±8.96	164±6.99	0.177
Disease Duration (years)		13.42±7.90	18.42±5.48	0.085
MMAS (grade) Hamstrings		1 (0-2)	0 (0-2)	0.109
MMAS Quadriceps		1 (0-3)	0 (0-2)	0.107
MMAS Adductors		1 (0-2)	1 (0-1)	0.103
MMAS Plantar Flexors		2 (1-2)	2 (1-3)	1.000
TUG (s)		19.21±12.73	11.52±5.01	0.065
T25FWT (s)		12.50±8.72	8.40±3.33	0.142
Pain VAS (0-10 cm)		4.75±3.57	3.50±2.97	0.361
AROM (angle) Flexion	**R**	69.95±30.91	82.87±24.22	0.267
	L	76.75±26.12	87±21.77	0.308
AROM Extension	**R**	10.79±8.57	16.08±7.55	0.123
	L	9.41±7.14	14.91±7.82	0.086
AROM Abduction	**R**	33.62±14.96	39.91±12.58	0.277
	L	24.66±13.61	35.41±6.67	0.052
AROM Dorsi Flexion	**R**	26.08±8.76	32.04±14.30	0.232
	L	23.66±17.13	30.62±12.92	0.274
EQ-5D-5L		12.25±2.95	10±2.25	0.061
EQ-VAS (0-100)		65±19.42	74.58±14.21	0.182

Results expressed as mean±SD. MMAS results expressed as median (min-max). PPMS: Primary Progressive Multiple Sclerosis, SPMS: Secondary Progressive Multiple Sclerosis, RRMS: Relapsing-Remitting Multiple Sclerosis, PRMS: Progressive Relapsing Multiple Sclerosis, MMAS: Modified Modified Ashworth Scale, TUG: Timed Up and Go, T25FWT: Timed 25 Foot Walk Test, VAS: Visual Analogue Scale, AROM: Active Range of Motion, EQ-5D-5L: European Quality of Life 5 Dimensions 5 Levels, EQ-VAS: European Quality of Life Visual Analog Scale, R: Right, L: Left.

pare pre-post differences between both groups. The standardized treatment effect was calculated to compare static and functional stretching groups for pre-post differences. The Spearman rank test was used to quantify associations among the variables. Correlation coefficients(r) whose magnitudes were ≥0.7, 0.5-0.7, and ≤0.5 were considered as strong, moderate and weak correlation, respectively (31). A significant level was considered less than 0.05.

RESULTS

From the 26 PwMS that included in this study, two patients dropped out: one from the SSE group due to personal issues and one from the FSE group due to general pain; and 24 PwMS were included in the analysis. Twelve participants (7 men, 5 women; age=45.33±11.96 years) as the SSE group and 12 participants (5 men, 7 women; age= 43.75±7.58 years) as the FSE group participated in this study. Participants flow shown in Figure 1. The descriptive and baseline characteristic of participants have shown in Table 1.

There was no significant difference between the two groups for any data at the baseline (p>0.05). According to the results of paired t-test, which is shown in Table 2, there were significant improvements (p<0.05) in measured outcomes within both groups compared to baseline, except spasticity of hamstrings and quadriceps in the FSE group. There were no significant differences between both groups for all variables compared to baseline (p>0.05) (Table 3).

There was a strong correlation (r=0.793, p=0.002) between decreased spasticity of quadriceps and improved TUG in the SSE group. A strong correlation (r=0.733, p=0.007) was found between decreased spasticity of quadriceps and improved T25FWT in the SSE group. There was also a moderate correlation (r=0.662, p=0.019) between decreased spasticity of hip adductors and improved TUG in the SSE group. In the FSE group, a moderate correlation (r=0.689, p=0.013) was observed between decreased spasticity of hamstrings and increased right hip extension ROM. There was a moderate negative correlation (r=0.593, p=0.042)

Table 2: The Pre and Post Comparisons of Measured Variables in Static and Functional Stretching Groups.

Group Outcomes		Static Stretching (n=12)		Functional Stretching (n=12)	
		Mean Difference (95% CI)	p	Mean Difference (95% CI)	p
MMAS (grade) Hamstrings		-0.66 (-1.16--0.17)	**0.025***	-0.25 (-0.74 to 0.24)	0.275
MMAS Quadriceps		-0.75 (-1.17--0.32)	**0.005***	-0.41 (-0.84 to 0.1)	0.054
MMAS Adductors		-0.91 (-1.25--0.57)	**0.001***	-0.75 (-1.09 to -0.4)	<**0.001***
MMAS Plantar Flexors		-1.25 (-1.61--0.88)	**<0.001***	-1 (-1.36--0.63)	**<0.001***
TUG (s)		-3.83 (-5.62--2.04)	**0.007***	-2.1 (-3.89--0.31)	<**0.001***
T25FWT (s)		-2.23 (-3.41 to -1.06)	**0.006***	-1.74 (-2.92--0.57);	**0.003***
Pain VAS (0-10 cm)		-1.83 (-3.06 to -0.59)	**0.003***	-2 (-3.23--0.76);	**0.014***
AROM (angle) – Flexion	**R**	21.16 (12.88-29.44)	<**0.001***	16.45 (8.18-24.73)	**0.002***
	L	18.29 (12.56-24.01)	<**0.001***	12.70 (6.98-18.43)	<**0.001***
AROM-Extension	**R**	6.70 (2.93-10.48)	**0.001***	8.41 (4.64-12.19)	**0.002***
	L	8.54 (5-12.08)	**0.001***	7.75 (4.20-11.29)	<**0.001***
AROM-Abduction	**R**	14.29 (7.64-20.93)	**0.002***	13.83 (7.18- 20.48)	<**0.001***
	L	14.45 (10.25-18.66)	<**0.001***	8.54 (4.33-12.75)	<**0.001***
AROM-Dorsi Flexion	**R**	11.04 (6.52-15.56)	**0.002***	6.79 (2.27-11.31)	**0.001***
	L	14.62 (9.98-19.26)	<**0.001***	10.04 (5.39-14.68)	<**0.001***
EQ-5D-5L		-2.66 (-3.56--1.76)	<**0.001***	-2.5 (-3.4--1.6)	<**0.001***
EQ-VAS (0-100)		9.58 (3.78-15.38)	**0.024***	5.83 (0.34-11.63)	**0.002***

*p<0.05. CI: Confidence Intervals, MMAS: Modified Modified Ashworth Scale, TUG: Timed Up and Go, T25FWT: Timed 25 Foot Walk Test, VAS: Visual Analogue Scale, AROM: Active Range of Motion, EQ-5D-5L: European Quality of Life 5 Dimensions 5 Levels, EQ-VAS: European Quality of Life Visual Analog Scale, R: Right, L: Left.

Table 3: Comparison between Static and Functional Stretching Groups for Pre-Post Differences.

Outcomes		Standardized Treatment Effect*	p
MMAS (grade) Hamstring		0.50	0.728
MMAS Quadriceps		0.48	0.522
MMAS Adductors		0.28	0.212
MMAS Plantar Flexors		0.41	0.267
TUG (s)		0.57	0.756
T25FWT (s)		0.25	0.415
Pain VAS (0-10 cm)		0.08	0.303
AROM (angle)-Flexion	**R**	0.34	0.846
	L	0.58	0.324
AROM-Extension	**R**	0.27	0.142
	L	0.13	0.792
AROM-Abduction	**R**	0.04	0.527
	L	0.84	0.397
AROM-Dorsi Flexion	**R**	0.56	0.199
	L	0.59	0.204
EQ-5D-5L		0.10	0.271
EQ-VAS (0-100)		0.38	0.904

*The standardized treatment effect calculated as D=(Ms-Mf)/SDpooled, where Ms is the mean change score of the SSE group, Mf is the mean change score of the FFE group, and SDpooled=$\sqrt{[(SDs^2+SDf^2)/2]}$. MMAS: Modified Modified Ashworth Scale, TUG: Timed Up and Go, T25FWT: Timed 25 Foot Walk Test, VAS: Visual Analogue Scale, AROM: Active Range of Motion, EQ-5D-5L: European Quality of Life 5 Dimensions 5 Levels, EQ-VAS: European Quality of Life Visual Analogue Scale, R: Right, L: Left.

between left hip flexion ROM and TUG. There were also moderate negative correlations (r=0.592, p=0.043; r=0.586, p=0.045) between right and left ankle dorsiflexion ROM; and T25FWT, respectively. A strong correlation (r=0.721, p=0.006) was also observed between decreased spasticity of hip adductors and decreased EQ-5D-5L questionnaire score in the FSE group.

DISCUSSION

According to our results, the regular four-week static stretching or functional stretching exercises can decrease lower limb spasticity, improve lower limb function, decrease pain, increase active ROM and increase HRQOL in PwMS. However, there were no significant differences between static and functional stretching exercises for pre-post differences, but also there were: a strong correlation between decreased spasticity and functional improvement in the static stretching group; moderate correlations between decreased spasticity and increased ROM; and between increased ROM and functional improvement in the functional stretching group, and strong correlation between decreased spasticity and increased HRQOL in the functional stretching group.

In previous studies, stretching exercises were applied in combination with other types of exercise or other interventions without specific programs, while in this study, stretching exercises were considered a unique intervention in PwMS. Stretching exercises, according to autogenic inhibition, reciprocal inhibition, Golgi tendon organ, and muscle spindle mechanisms, can decrease the overactivity of the stretch reflex and spasticity in PwMS (32). Stretching exercises also decrease the stiffness of muscles and limbs and increase ROM in PwMS by remodeling in soft tissues and increasing muscle length. Therefore, these changes in muscles, joints, and limbs can improve functional mobility, decrease pain, and increase in HRQOL of PwMS (8, 9).

A limited number of studies show that the effects of stretching exercises, as the primary intervention, were investigated in PwMS. Ponzano et al. (20) compared static stretching with Pilates and resistance exercises in patients with relapsing-remitting MS, and their results indicated that static

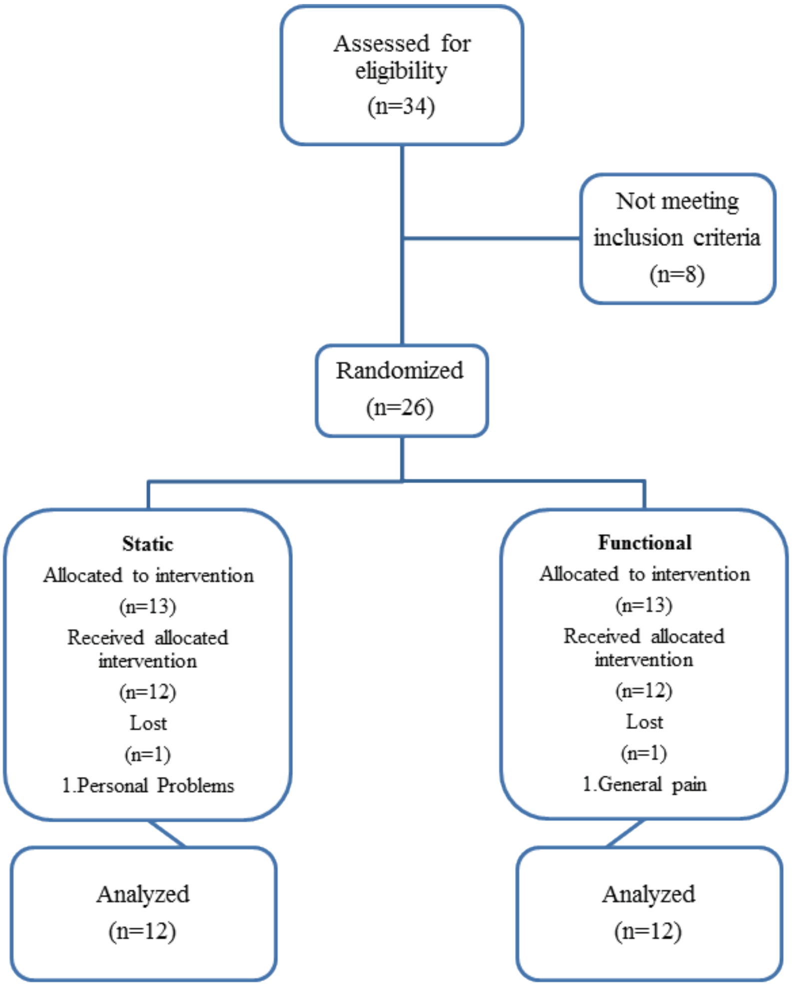

Figure 1: Flow Diagram of the Progress of Participants through the Study.

stretching improves balance and posture control. Ayaregar et al. (18) investigated stretching exercises on restless leg syndrome in PwMS, and their findings indicated a decrease in restless leg syndrome symptoms. In the current study, we measured different outcomes such as spasticity, functional mobility, ROM, pain and HRQOL.

In agreement with our results, Odeen et al. (33) showed that 30 minutes of passive stretching would increase active ROM in patients with spasticity [MS (n=5), spinal cord injury (n=3) and patients with paraparesis and hypertonia (n=2)].

Hugos et al. (19) explored the effectiveness of self-stretching exercises on spasticity scales (MAS and MS Spasticity Scale-88) and functional tests (TUG, T25FWT) of PwMS by single-blinded protocol. Although their findings indicated significant improvement in MS Spasticity Scale-88, there was no statistically significant improvement in MAS, TUG or T25FWT. The reason might be that four weeks of daily self-stretching at home was not enough to elicit any significant improvement in clinical spasticity measurements and functional tests. In contrast, according to our results, the four weeks of static stretching or functional stretching led to significant improvements in clinical and functional tests of PwMS.

This is the first study determining the unique effects of FSE as one specific intervention in PwMS. Our results demonstrated that functional stretching exercises could cause a significant decrease in lower limb spasticity, improve in function, a decrease in pain, an increase in active ROM and an increase in HRQOL of PwMS. Elshafey et al. (24) explored the effects of functional stretching on neural, mechanical and gait parameters in spastic diplegic children, and their results demonstrated significant improvement in all parameters. Ghasemi et al. (34) also showed that functional stretching could lead to functional improvement in chronic stroke patients. The FSE is suggested by Lederman et al. (10) as sensory-motor training to maintain, increase or recover ROM, enhancing motor learning and recovery. However, our results show a significant increase in ROM and indicated a moderate correlation between increased ROM and functional improvement in the FSE group.

Studies showed that limited functional mobility, loss of ROM, and decreased quality of life are spasticity consequences (6,35,36). Our results showed that there was a strong association between decreased spasticity and functional tests improvement in the SSE group. In our FSE group, there was a moderate correlation between decreased spasticity and recovered ROM. Also, there was a strong correlation between decreased spasticity and an increase in HRQOL. Our stretching protocol can potentially help reverse the limited functional mobility, loss of ROM and decrease in quality of life in PwMS. However, this study is preliminary to determine the unique effects of stretching exercises and shows the importance of stretching exercises as an essential intervention in comprehensive rehabilitation programs for PwMS. Stretching is a safe intervention and has fewer side effects than medications, and may increase medications' effects (37). Therefore, stretching can be considered as a recommended rehabilitation program for MS individuals with severe disabilities.

There were some limitations to this study. First, there was no opportunity to incorporate a follow-up period to examine the treatment's long-term effects. Second, a double-blinded condition would be ideal for reducing any internal bias in measurement. Third, it would be better for two different researchers to do the assessment and treatment to avoid any possible Pygmalion effect.

In conclusion, this study's central finding is that regular four-week static or functional stretching can decrease spasticity and pain and improve function, ROM, and health-related quality of life in people with multiple sclerosis. Static and functional stretching exercises by decreasing spasticity and increasing range of motion could lead to improvements in functional mobility of lower limbs, and through this could increase health-related quality of life in people with multiple sclerosis.

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Conflict of interest: None.

Ethical Approval: This study was approved by the Medical Ethics Committee of the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran (Approval Date: 23.07.2019 and Approval Number: IR.USWR.REC.1398.051).

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