Impact of Clinical Mat Pilates on Body Composition and Functional Indices in Female Patients With Multiple Sclerosis

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Abstract

Objectives: Muscle weakness, movement disorders and fatigue due to multiple sclerosis (MS) cause a decrease in balance and physical activity, which may be linked to the body composition. The purpose of our study was to investigate the effect of clinical mat Pilates on anthropometric variables, functional indices, and fatigue in females suffering from MS.

Materials and Methods: There were 30 female MS patients with mild to moderate disability, based on the McDonald criteria. They were randomly divided into 2 Pilates training (PT) and control (C) groups of equal size. The PT group followed the protocol of training 3d/wk for 8 weeks. The control group continued their routine life. Pre- and post-test of the variables in all the participants were done by one of the authors, who was blind to the groups. The anthropometric variables such as body weight (BW), body mass index (BMI), body circumferences (waist [WC], Hip [HC], mid-arm muscle [MAMC], and calf [CC]), waist to hip ratio (WHR), 7-site skinfold (chest, abdominal, thigh, triceps, subscapular, suprailiac, and midaxillary), fat percentage (FP), fat mass (FM), fat free mass (FFM), and body density (BD), functional indices consisting of balance, walking speed, endurance, and fatigue were accessed.

Results: Statistical analysis demonstrated a significant decrease in BW, BMI, WC, HC, MAMC, skin-folds of the chest, abdominal, triceps, suprailiac, FP, FM and fatigue and also increase in BD, balance, walking speed, and endurance in Pilates group ($P < 0.05$).

Conclusions: An 8-week mat Pilates program as non-pharmacological intervention may positively affect anthropometric variables, Functional indices and fatigue which may decline some of the outcomes of muscle weakness as one of MS complications.

Keywords: Body composition, Fatigue, Functional indices, Multiple sclerosis, Pilates

Introduction

Multiple sclerosis (MS) is an immune-mediated inflammatory disease of the central nervous system (CNS) (1). Loss of balance, movement disorders, and fatigue are the secondary symptoms which could lead to gradual functional limitations (1). In December 2011, Iranian Ministry of Health and Medical Education reported high prevalence of MS in Iran (n = 34 605, the prevalence rate= 45/100 000 of population), 77% of whom were women, and 70% of them were 20 to 40 years old(2), whereas in October 2013, the prevalence rate of the disease reported to be 72.1/100 000 (2), and in 2014, it reached 101.39/100 000 (3). The high prevalence and sharp increase in the incidence rate in the young population could lead to social and economic problems for the family and society (4), as most of the time it is associated with loss of balance and fatigue as the effective factors to derive functional limitations in

MS (5). These singes could contribute to muscle atrophy and decline of muscle strength which could lead to body composition changes (6), as it has been reported that the risk of developing body mass index (BMI) over 25 (kg.m^{-2}) is 2 times higher in MS subjects than in healthy subjects (7). There is a relationship between obesity and MS (8). Obesity as a stimulatory factor for inflammation contributes to the risk factor for MS, in which the hormones derived from adipocyte has been identified as a beginning and progression, and/or regulation factor in the immune response (9). These changes could be the positive feedbacks to expand functional limitations and fatigue in MS patients (10).

Clinical Pilates as a new practical rehabilitation method, which consists of stretch-power movements by controlling the speed and range of joint movement, deep breath, and concentration (11). Today, Pilates is

a popular and favorite exercise among women. There are numerous studies indicating the positive effect of Pilates training (PT) on body composition in healthy or elderly subjects (12,13). In addition, the improvement in functional indices and fatigue in MS patients following clinical PT was reported (14-16), whereas there is no research to investigate the effect of clinical Pilates on body composition and functional indices in MS patients. The prevalence of overweighting in MS patients due to lack of physical activity, and the ability to do PT in subjects with low functional indices drew our attention to select Pilates as the protocol of training and body composition as the main variable may indirectly manage the balance, physical capacity, and fatigue. We hypothesized that clinical mat pilates-based core stability can affect body composition, functional indices including balance, walking speed, endurance, and fatigue in female MS patients.

Materials and Methods
Subjects
This study was done between April and June 2015, under the auspices of Najafabad Branch, Islamic Azad University, and Goldasht Multiple Sclerosis Center. The participants were volunteers, who had enrolled in Goldasht Multiple Sclerosis Center. The inclusion criteria were being female and having MS with expanded disability status scale (EDSS) 2-6. The exclusion criteria were doing exercise during the last three months, back problems, pregnancy, epilepsy, and cancer. Thirty female patients (age= 33.00 ± 8.08 years, BW= 61.22 ± 12.17 kg, BMI= 24.52 ± 4.92 kg.m^{-2}) with definite MS based on the McDonald criteria (use of imagining to demonstrate the dissemination of CNS lesions which can be done by a single scan (17), with relapsing-remitting (RR) form of disease (EDSS = 2-6) (7) were enrolled in the study. The study design was a randomized controlled trial.

Instruments
Body Composition
The subject's height was measured without shoes by a portable wall-mounted ruler in the upright position (accuracy 0.1 cm). The body weight (BW) of the subject was recorded with light clothing by using a portable scale (Seca Vogel & Halke German model: 760 1029009). BMI (kg.m^{-2}) was calculated (18). Body circumferences consisting of the waist circumference (WC), hip circumference (HC), mild arm muscle circumferences (MAMC), and calf circumference (CC) were measured with a plastic measuring tape. WC was measured at the midpoint between the iliac crest and the margin of the lower rib. The maximum circumference of the buttocks was measured as HC, and waist to hip ratio (WHR) was calculated (18). The MAMC was measured at the midpoint between the elbow and shoulder. The maximum circumference of the calf was measured as CC. MAMC and CC girths were measured on the right side of the

body. The skinfold at chest, abdominal, thigh, triceps, subscapular, suprailiac, and midaxillary were measured (mm) by caliper (MK-60, Yagami, Japan) on the right side of the body. Fat percentage (FP) was calculated by Jackson/Pollock 7-site skinfold equation:

$$FP = 495/[1.097 - (0.00046971 *s) + (0.00000056 *s*s) - (0.00012828 *a)] -450$$

Fat mass (FM) was calculated by multiplying BW by the FP and fat-free mass (FFM) was calculated by subtracting FM from BW (18).

Body density (BD) was calculated by Jackson/Pollock 7-site skinfold equation:

$$BD = 1.097 - (0.00046971 *s) + (0.00000056 *s*s) - (0.00012828 *a)$$

s = sum of seven skinfolds (Chest, abdominal, thigh, triceps, subscapular, suprailiac, and midaxillary) mm, a = age (18).

Balance, Functional Indices, and Fatigue
The Berg balance scale was used to measure balance, which consisted of 14 items, through tasks such as sitting to standing, standing unsupported, sitting unsupported, standing to sitting, transfers, standing with eye closed, standing with feet together, reaching forward with outstretched arm, retrieving the object from the floor, turning to look behind, turning 360 degree, placing alternate foot on a stool, standing with one foot in front, standing with one foot (19).

Timed 10-Meter Walk Test (10MWT) was used to evaluate gait speed (walking speed) (20).

The Six Minute Walk Test (6MWT) was used to evaluate walking endurance by measuring the distance (meters) during 6 minutes of walking (21).

The Modified Fatigue Impact Scale (MFIS) was used to assess the fatigue (22).

All subjects were randomly divided into a PT (PT = 15) and a control group of equal size (C = 15). The Pilates group followed the protocol of training for 8 weeks. The control group continued their lifestyle. From the initial sample, 5 patients (PT = 2, C = 3) dropped out of the study.

Protocol of Pilates training
The PT group completed mat PT for 8 consecutive weeks based on the progressive program. The protocol of PT consisted of special exercises which were based on core stability with low to moderate intensity according to the ability of the patients participated in the study. The protocol of training was designed in a way to avoid exacerbation, hyperthermia, fatigue, and to maintain balance during training.

The duration of the protocol was 8 weeks which consisted of 3 days per week with 48 hours rest between each session. The training session began with 10 minutes of warm-up which consisted of 2 repetitions of breathing, imprint-release, supine spinal, head nods, shoulder shrugs, The main exercise was done for 30 to 40 minutes

and consisted of one to 2 sets of 10 repetitions of 100, 1 to 2 sets of 3-10 repetitions of roll up, roll down, single leg circle, (consisting of 10 seconds of exercise and 10 seconds of rest for 10 repetitions, and 30 seconds between each movement), and 60 seconds of rest between each set (each exercise took nearly 7 minutes) and cool down was done with a 10-minute duration like a warm-up (23-25).

Statistical Analysis

The relevant statistical analysis was performed using SPSS version 20.0. Descriptive analysis adopted for demographic and clinical characteristics was reported as mean ± standard deviation (SD). The Shapiro-Wilk test was used for determining the normality of the distributions ($P > 0.05$). Before the statistical analysis, the homogeneity of variances between the 2 groups before starting the protocol was shown by Levene test ($P > 0.05$). The analysis of covariance (ANCOVA) was used to assess the difference between the groups ($P < 0.05$).

Results

Twenty-five of the 30 patients recruited to our research completed the study. Demographic and clinical characteristics have been shown in Table 1.

No significant differences were in the baseline of age, BW, and BMI between PT and C groups. The baseline of all the variables in 2 (PT and C) groups has been demonstrated by the mean and SD and the comparison of the post-tests of 2 groups with pre-tests has been done by ANCOVA test ($P < 0.05$) which is demonstrated in Figures 1-6.

Figure 1 demonstrates the mean and standard deviation in pre- and post-training in both groups. The significant decreases in BW and FM were 2.68%, and 6.95%, respectively, whereas there was no significant change in FFM. The partial eta squared and observed power of the ANCOVA test were reported in BW 0.55, 0.99, FM 0.54, 0.99, and FFM 0.06, 0.05, respectively ($P < 0.05$).

Figure 2 demonstrates the mean and standard deviation in pre and post-training in both groups. The significant decreases in WC, HC, and MAMC were 3.1%, 3.69%, and 5.02%, respectively, whereas there was no significant change in the CC. The partial eta squared, and observed power of the ANCOVA test were reported in WC 0.60, 1.00, HC 0.60, 1.00, MAMC 0.53, 0.99 and CC 0.01, 0.05, respectively ($P < 0.05$).

Figure 3 demonstrates the mean and standard deviation in pre and post-training in both groups. The significant

Table 1. The Baseline Characteristics of the Subjects Who Completed the Study Protocol

Variables	Pilates Group (n=13)	Control Group (n=12)
Age (y)	34.46 ± 7.29	31.41 ± 8.89
BW (kg)	58.92 ± 12.02	63.70 ± 12.35
BMI (kg.m⁻²)	24.38 ± 5.36	24.66 ± 4.64

Abbreviations: BW, body weight; BMI, body mass index.

decreases in skinfold in the chest, abdominal, triceps, and suprailiac were 16.35%, 14.96%, 2.51%, and 4.25%, respectively, whereas there were no significant changes in the thigh, subaxillary, subscapular, respectively. The partial eta squared, and observed power of the ANCOVA test were reported in chest 0.31, 0.88, abdominal 0.31, 0.86, thigh 0.09, 0.29, triceps 0.15, 0.47, subscapula 0.09, 0.29, suprailiac 0.23, 0.70, subaxillary 0.11, 0.36, respectively ($P < 0.05$).
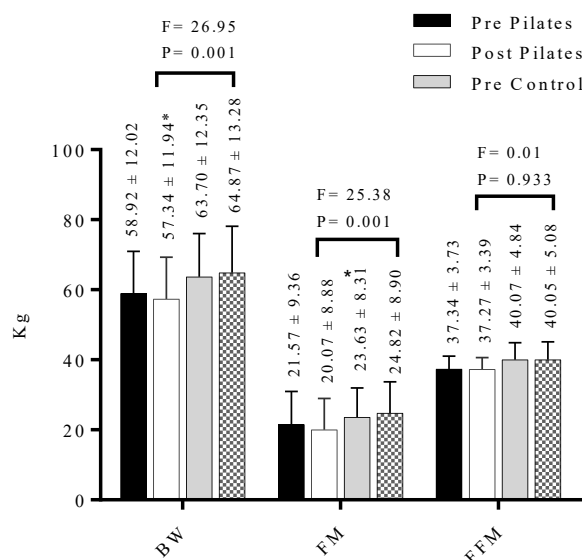

Figure 1. Mean and Standard Deviation Changes From Baseline and After 8-week PT in BW, FM, FFM. The ANCOVA test shows the difference of posttests between 2 groups with pretests in BW, FM. $P \leq 0.05$, * Significant change.
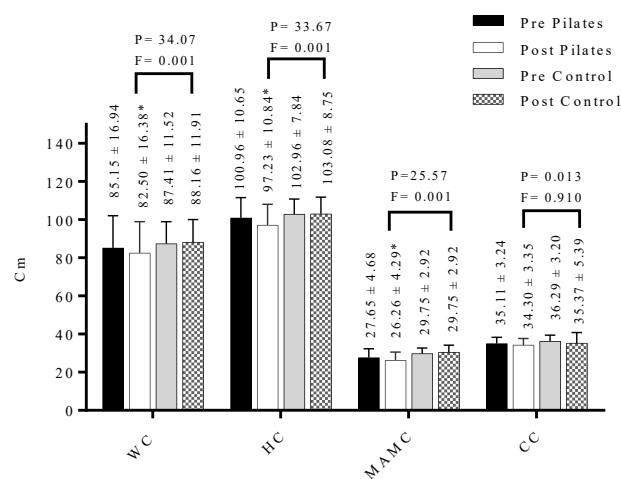BW, body weight; FM, fat mass; FFM, fat-free mass.

Figure 2. Mean and Standard Deviation Changes From Baseline and After 8-week PT in WC, HC, MAMC, CC. The ANCOVA test shows the difference of posttests between 2 groups with pretests in WC, HC, MAMC. $P \leq 0.05$, *Significant change.
WC, waist circumference; HC, hip circumference; MAMC, mid-arm muscle circumference; CC, calf circumferences.
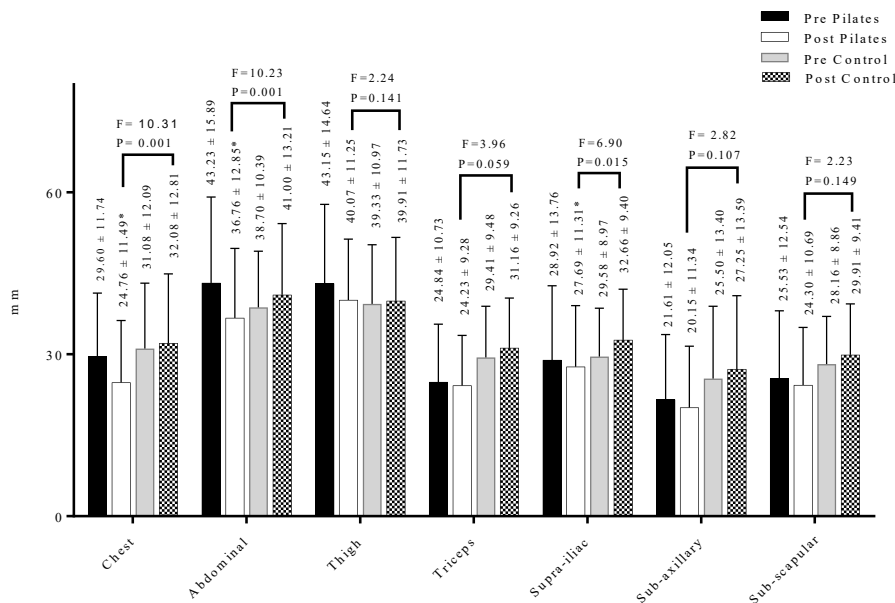
Figure 3. Mean and Standard Deviation Changes From Baseline and After 8-Week PT in Subcutaneous Adipose Layer Thickness in Chest, Abdominal, Thigh, Triceps, Suprailiac, Subaxillary, Subscapula. The ANCOVA test shows the difference of post-tests between 2 groups with pretests in Chest, Abdominal, Suprailiac. $P \leq 0.05$, * Significant change.

Figure 4 demonstrates the mean and SD in pre and post-training in both groups. The significant decrease in BMI was 4.43%. The partial eta squared, and observed power of the ANCOVA test were reported in BMI 0.60, 1.00, respectively ($P < 0.05$).

Figure 5 demonstrates the mean and SD in pre and post-training in both groups. There was no significant change in WHR. The partial eta squared and observed power of the ANCOVA test were reported in WHR 0.06, 0.20, respectively ($P < 0.05$).

Figure 6 demonstrates the mean and SD in pre and post-

training in both groups. The significant decrease in FP was 4.64%. The partial eta squared and observed power of the ANCOVA test were reported in FP 0.43, 0.97, respectively ($P < 0.05$).

Figure 7 demonstrates the mean and SD in pre and post-training in both groups. The significant increase in BD was 0.33%. The partial eta squared and observed power of the ANCOVA test were reported in BD 0.42, 0.97, respectively ($P < 0.05$).

Table 2 demonstrates the mean and SD before and after 8 weeks of clinical mat PT intervention by the ANCOVA
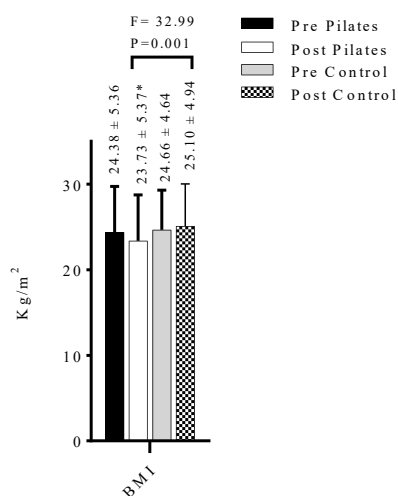

Figure 4. Mean and Standard Deviation Changes From Baseline and After 8-Week PT in BMI. The ANCOVA test shows the difference of posttests between 2 groups with pretests. $P \leq 0.05$, *Significant change. BMI, body mass index.
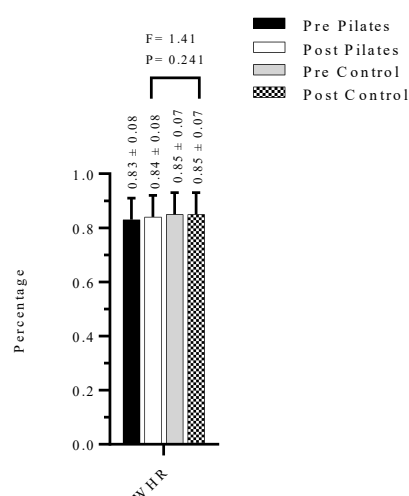

Figure 5. Mean and Standard Deviation Changes From Baseline and After 8-Week PT in WHR. The ANCOVA test shows no significant difference of posttests between 2 groups with pretests. $P \leq 0.05$. WHR, waist to hip ratio.
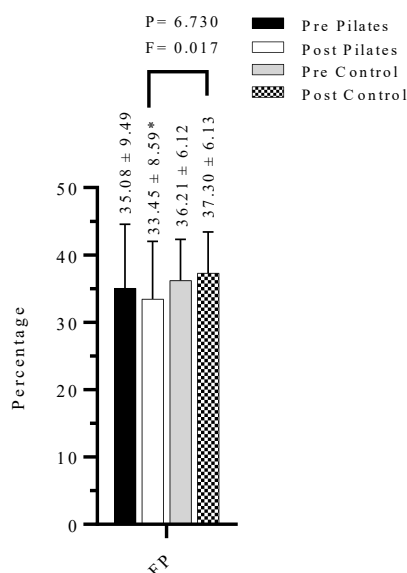
Figure 6. Mean and Standard Deviation Changes From Baseline and After 8-Week PT in FP. The ANCOVA test shows no significant difference of posttests between 2 groups with pretests. $P \leq 0.05$. FP, fat percentage.
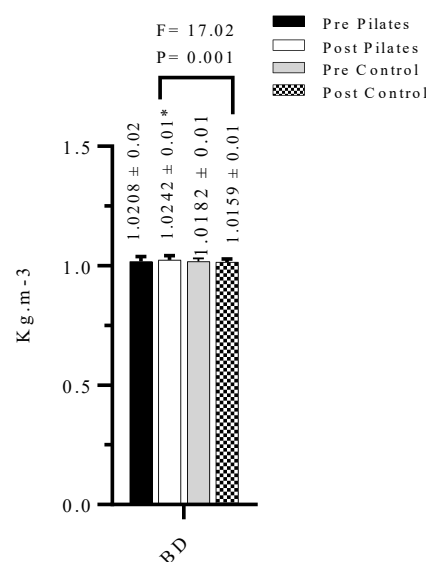

Figure 7. Mean and Standard Deviation Changes From Baseline and After 8-Week PT in BD. The ANCOVA test shows no significant difference of posttests between 2 groups with pretests. $P \leq 0.05$. BD, body density.

test in terms of the component s of functional indices, and fatigue in the subjects ($P < 0.05$).

Discussion

In our study, BW, BMI, WC, HC, MAMC, and some skinfold sites like chest, abdominal, triceps, suprailiac as effective variables in FP, FM significantly decreased, and BD significantly increased, whereas there was no significant change in WHR, CC, the skinfold of the thigh and subaxillary, and FFM ($P < 0.05$). Unfortunately, there is no report of the effect of Pilates on body composition in MS patients, but there are several studies investigating the effect of Pilates on body composition in healthy and elderly subjects (12,13,26,27). The significant reductions in BW and BMI following PT have been reported by Jago et al in healthy girls after 4 weeks (26), Cakmakci et al (13) and Savkin et al (12) in obese women after 8 weeks, and Vaquero-Cristobal et al in elderly women after 16-week PT (27), whereas Fourie et al (28), Segal et al (29), and Sekendiz et al (30) noted no significant changes in BW (28-30), and BMI (30) after completion of the Pilates program. The significant decrease in WC (12,31), and MAMC (31) after 8-week Pilates was reported, which were in line with our study results, but Jago et al noted no significant changes in the WC in healthy girls after 4-week Pilates (26). Cakmakci et al reported a significant decrease in WHR in obese women after 8-week Pilates (13), which was not in line with our results. There is a higher correlation between FP and WHR (32). Savkin et al (12) and Fourie et al (28) demonstrated that despite a significant decrease in FP and FM, there was no significant change in FFM after 8-week Pilates, which

were in line with our study. The significant decrease in FP, FM, and a significant increase in FFM were reported by Ruiz-Montero et al after 24-week Pilates-aerobic training (32), and Vaquero-Cristobal et al after 8-week Pilates (27). In addition, they reported a significant decrease in triceps, subscapular, suprailiac, abdominal, and sum of 6 skinfolds (27). These discrepancies in results of studies could be related to (*a*) the protocols of training, which were designed based on the physical fitness of subjects in each study, (*b*) the selected skinfolds to determine FP, FM, and FFM, and also (*c*) the equipment used to assess body composition which was different (such as skinfold calipers, hydrostatic weighing or dual-emission x-ray absorptiometry). The body composition as a non-invasive method gives us information concerning the distribution of tissues and indicators of the health risk and mortality (33). There is a vigorous relationship between BMI and sex-related FP in MS patients (34). Hedstrom et al referred that the risk of developing BMI more than 27 kg/m^2 in 20- year-old MS subjects is 2 times higher compared to the healthy subjects, which emphasizes the weight control in MS patients (7). Although the higher prevalence of overweight and obesity in MS, BMI has been reported, it has not been determined as a factor for disability in MS patient (35). Obesity could be a risk factor for MS (8), as leptin, a peptide hormone derived from adipocyte, plays an important role in the immune responses and inflammation (9). Kvistad et al reported the possible effect of BMI on Interferon-beta treatment response (36) could be one of the factors involved in weight managing in MS patients. Changing in muscle characteristics following the physical inactivity due to the decrease in FFM and fatigue

Table 2. The Mean and Standard Deviation Before and After Eight Weeks of Clinical Mat PT Intervention by the ANCOVA Test in Terms of the Functional Indices, and Fatigue in Subjects

Variables		Pre-test	Post-test	F	P	η	Observed Power
Sitting to standing	Pilates	2.00 ± 1.47	3.46 ± 1.33	5.32	0.031*	0.19	0.597
	Control	3.50 ± 1.00	3.16 ± 1.58				
Standing unsupported	Pilates	2.53 ± 1.71	3.46 ± 1.30	4.44	0.047*	0.16	0.52
	Control	3.33 ± 1.30	3.25 ± 1.42				
Sitting unsupported	Pilates	2.92 ± 1.55	3.58 ± 1.16	0.19	0.664	0.01	0.07
	Control	3.53 ± 1.12	3.83 ± 0.38				
Standing to sitting	Pilates	3.38 ± 1.19	3.53 ± 1.12	0.05	0.823	0.01	0.05
	Control	3.70 ± 0.86	3.66 ± 0.88				
Transfers	Pilates	3.30 ± 1.19	3.53 ± 1.12	1.64	0.213	0.06	0.23
	Control	3.58 ± 0.99	3.41 ± 1.37				
Standing with eye closed	Pilates	2.69 ± 1.37	3.38 ± 1.32	2.37	0.138	0.09	0.31
	Control	3.00 ± 1.80	3.08 ± 1.67				
Standing with feet together	Pilates	2.76 ± 1.30	3.61 ± 0.96	1.39	0.250	0.06	0.20
	Control	3.33 ± 1.15	3.50 ± 1.00				
Reaching forward with outstretched	Pilates	3.46 ± 0.96	3.69 ± 1.10	0.16	0.687	0.01	0.06
	Control	3.50 ± 1.00	3.58 ± 0.99				
Retrieving object from	Pilates	3.07 ± 1.25	3.69 ± 1.10	3.40	0.079	0.13	0.42
	Control	3.58 ± 1.16	3.41 ± 0.79				
Turning to look behind	Pilates	3.15 ± 1.28	3.69 ± 1.10	3.27	0.084	0.13	0.41
	Control	3.58 ± 0.79	3.50 ± 0.79				
Turning 360 degree	Pilates	2.84 ± 1.21	3.46 ± 1.05	0.47	0.497	0.21	0.10
	Control	3.33 ± 1.30	3.50 ± 1.16				
Placing alternate foot on stool	Pilates	1.69 ± 1.43	3.15 ± 1.51	13.32	0.001*	0.37	0.93
	Control	2.83 ± 1.58	2.75 ± 1.60				
Standing with one foot in front	Pilates	1.53 ± 1.61	3.30 ± 1.31	12.35	0.002*	0.36	0.91
	Control	2.75 ± 1.71	2.66 ± 1.72				
Standing on one foot	Pilates	1.38 ± 1.44	2.46 ± 1.76	6.84	0.016*	0.23	0.70
	Control	2.66 ± 1.61	2.66 ± 1.55				
Total (Balance Berg)	Pilates	3.25 ± 1.42	3.25 ± 1.42	11.13	0.003*	0.33	0.89
	Control	3.25 ± 1.42	3.25 ± 1.42				
Walking speed (min)	Pilates	0.88 ± 0.31	1.26 ± 0.33	10.38	0.000*	0.32	0.86
	Control	1.50 ± 0.49	1.32 ± 0.34				
Endurance (m)	Pilates	18.78 ± 6.15	22.28 ± 5.47	22.61	0.004*	0.50	0.99
	Control	20.00 ± 5.70	18.79 ± 6.59				
Fatigue	Pilates	10.00 ± 2.54	6.46 ± 3.35	80.21	0.000*	0.78	1.00
	Control	8.50 ± 4.29	10.50 ± 4.18				

Pilates group (n=13), Control group (n=12), *df* (1,22), $P < 0.05$.

are secondary parameters to decrease physical capacity and cause undesirable changes in body composition (37), which is another important factor involved in weight managing in MS patients.

The results of this research showed the significant improvement in variables of functional and physical indices such as balance, walking speed and endurance, and a significant decrease in fatigue in the training group.

In our study, the balance was accessed by using the Berg balance scale (consisting of 14 items) and it showed a significant improvement in the sitting to standing, standing unsupported, pacing an alternate foot on a stool, standing with one foot in front, standing on one foot items in front items in P group ($P < 0.05$). The improvement in balance in MS was reported by van der Linden et al (38) - the sitting stability- after 6-12-week, Soysal Tomruk et al

(16) following 10-week, and Kibar et al (39) after 8-week PT. The improvement in endurance in MS was reported by Kara et al (19), Kalron et al (14) and Kibar et al (39), and improvement in walking speed was reported by Freeman et al (40) and Karlon et al (14). Soysal Tomruk et al reported a significant decrease in fatigue after the 10-week modified clinical PT in MS patients (16), whereas Pahlevanzade et al noted no significant improvement in fatigue following 4 and 8-week PT in MS patients (41).

Although the body composition variables were not directly measured in other studies, the results showed PT, by affecting physical capacity (14,16,19,39-42), has caused development in balance (16,40,42) and managing the fatigue (16) in MS patients.

Muscle weakness and loss of balance are common in these patients. Performing clinical mat Pilates-based core stability caused a significant change in body composition that shows a significant decrease in FP as an ineffective tissue for balance and movement. The protocol of training in our study focused on core muscles exercises. Freeman et al for the first time introduced the specific core exercises as rehabilitation in MS patients (43). Strength or endurance of the trunk muscles following exercise is associated with sensory-motor control, which is more important than the increase of muscle mass, although the sensory-motor control was not measured directly in our study, the significant change in balance could justify this balance improvement (in sitting, standing, and walking) increases endurance and walking speed. The increased endurance could explain the decreased fatigue.

The difference in the results of these studies could be due to the differences in designing protocols such as a variety of applied exercises, instruments, intensity, duration of protocol, and differences subjects' characteristics such as age, sex, weight, and health condition, physical capacity (progressive immobility, lack of balance) and fatigue in MS patients could be the secondary reasons for the intensification of physical inactivity which could be regarded as the defining factor for body composition in MS patients.

Conclusions

The finding of this research indicated that 8-week mat Pilates program by managing anthropometric variables caused changes in some variables of body composition, which could help to increase physical capacity, balance and reduce fatigue as one of the important symptoms. However, in the control group, some anthropometric variables such as FP increased, which is associated with disorder movements. Pilates as an effective, safe, and economical method of training with minimal equipment with the practical approaches, and even executable at home that could be a suitable rehabilitation method for MS patients.

The interdisciplinarity of our research was the strong point of the study, and also it was the first study to investigate the effect of Pilates on body composition in people with MS.

The most important limitations in our study were the few participants as subjects, short duration of training, no utilization of advanced equipment to assess body composition and balance to reach accurate data, which must be put under consideration in future studies. .

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