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Pilates exercise training vs. physical therapy for improving walking and balance in people with multiple sclerosis: a randomized controlled trial

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Abstract

Objective: Evaluate the effects of a Pilates exercise programme on walking and balance in people with multiple sclerosis and compare this exercise approach to conventional physical therapy sessions.
Design: Randomized controlled trial.
Setting: Multiple Sclerosis Center, Sheba Medical Center, Tel-Hashomer, Israel.
Subjects: Forty-five people with multiple sclerosis, 29 females, mean age (SD) was 43.2 (11.6) years; mean Expanded Disability Status Scale (S.D) was 4.3 (1.3).
Interventions: Participants received 12 weekly training sessions of either Pilates (n=22) or standardized physical therapy (n=23) in an outpatient basis.
Main measures: Spatio-temporal parameters of walking and posturography parameters during static stance. Functional tests included the Time Up and Go Test, 2 and 6-minute walk test, Functional Reach Test, Berg Balance Scale and the Four Square Step Test. In addition, the following self-report forms included the Multiple Sclerosis Walking Scale and Modified Fatigue Impact Scale.
Results: At the termination, both groups had significantly increased their walking speed (P=0.021) and mean step length (P=0.023). According to the 2-minute and 6-minute walking tests, both groups at the end of the intervention program had increased their walking speed. Mean (SD) increase in the Pilates and physical therapy groups were 39.1 (78.3) and 25.3 (67.2) meters, respectively. There was no effect of group X time in all instrumented and clinical balance and gait measures.
Conclusions: Pilates is a possible treatment option for people with multiple sclerosis in order to improve their walking and balance capabilities. However, this approach does not have any significant advantage over standardized physical therapy.

Keywords

Multiple sclerosis, gait, physical therapy, Pilates exercises, balance.

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Introduction

Balance and gait deficits are common in people with multiple sclerosis. These disabling deficits reduce mobility, independence, lead to falls and injuries and negatively affect quality of life.[1–3] Generally, physical interventions directed at improving balance and walking abilities have implemented various approaches, e.g. motor and sensory strategies,[4] Feldenkrais exercises,[5] robot-assisted gait training,[6] kickboxing,[7] sensory insoles,[8] Ai-Chi exercises,[9] Nintendo Wii games,[10] strength and aerobic training[11] and neuromuscular facilitation.[12,13]

A popular alternative rehabilitation method is Pilates exercise training. Pilates is a precise, controlled form of exercise using the stabilizing muscles of the body.[14] This type of training is based on a holistic approach where a correct execution of the six fundamental principles (concentration, control, centering, flowing movement, precision and breathing) increases body awareness with less ground impact and joint stress. Pilates exercises can also be performed at various intensity levels whereby the participant or patient may adjust the difficulty to their own level of conditioning.

Despite a lack of scientific evidence supporting the effectiveness of Pilates exercise training in different pathological populations, more and more professionals have been advocating its use as a treatment strategy in stroke survivors[15] and the elderly.[16] As a consequence, Pilates exercise training has recently been integrated into rehabilitation programs, both on an individual and group basis.

According to our literature investigation, only a few studies have examined this intervention strategy in the multiple sclerosis population.[17–20] Furthermore, previous reports have several limitations, thus precluding the ability to draw significant conclusions as to its efficacy on mobility. Nevertheless, according to Freeman et al.'s case report series in 2010, eight people with multiple sclerosis participants demonstrated a significant improvement between the baseline and intervention phases for the timed walk ($P = 0.019$), multiple sclerosis walking scale ($P = 0.041$) forward ($P = 0.015$) and lateral reach ($P = 0.012$).[17]

Therefore, the primary goal of the present randomized controlled study was to examine the effects of a 12-week Pilates exercise training program on gait and balance in people with multiple sclerosis and compare these results to those of a standard physical therapy intervention program.

Methods

The implemented study design was executed according to the rigor of the CONSORT guidelines[21] (Trial registration number ISR023213SMC). The randomized controlled study was a prospective, assessor blinded, parallel group performed at the Multiple Sclerosis Center, Sheba Medical Center, Tel-Hashomer, Israel, between June 2013 and May 2015. Potential participants were recruited via the Sheba Multiple Sclerosis Center's computerized database, a population-based registry documenting demographic and clinical data of all multiple sclerosis patients followed at the Sheba Medical Center, Tel-Hashomer, Israel from January 1, 1995 to date.

Potential participants learned of this study through e-mails and printed advertisements posted at the Sheba Multiple Sclerosis Center. The study team's contact details were provided to enable interested participants to further enquire and participate in the study. Under the Data Protection Act, no information regarding the participants was given to the Pilates study team. Interested participants were provided with an information pack describing the stud, supported by verbal information when requested.

Participants were screened for eligibility by the principal investigator, who obtained written informed consent from those who met the inclusion criteria. Inclusion criteria were: (1) diagnosis of definite relapsing-remitting multiple sclerosis according to the revised McDonald criteria;[22] (2) age range from 25-55 years; and (3) the Expanded Disability Status Scale score[23] ranging from 3.0 to 6.0. Additionally, in order to neutralize the effects of immune-modulatory medication, only patients receiving disease modifying drugs based on interferon beta-1a for at least 3 months, were recruited.

Exclusion criteria were (1) orthopedic disorders that could negatively affect mobility; (2) any medical condition contra-indicating participation in core stability exercises; (3) patients experiencing major depression or cognitive decline and incapable of performing Pilates exercises; (4) pregnancy; (5) blurred vision; (6) cardiovascular disorders; (7) in relapse or relapsed during the previous three months; (8) current or recent (within the past 6 months) participation in core stability exercises. Approval was obtained from the Sheba Medical Center Independent Ethics Committee prior to commencement of the study.

The sample size estimate was based on related studies examining the effects of Pilates on walking and balance capabilities in people with multiple sclerosis.[9–13] After consenting to participate and fulfilling the inclusion criteria, 50 participants were equally and randomly divided into one of the two groups; Pilates based core stability training and standardized physical therapy. A block randomization procedure was used with central concealment by numbered tickets placed in sealed opaque envelopes, organized by the study coordinator. The investigators opened the sealed envelopes sequentially only after the participant's name and other details were written on the appropriate envelope.

Randomization was performed one hour prior to the start of the baseline measurements by a physical therapist uninvolved in the assessment or treatment of the subjects. The intervention period of both groups was identical; 12 consecutive weeks, a single session per week, 30-minutes per session. Outcome measures were collected twice, at initiation of the intervention programs and at termination of the 12-week intervention period.

Three subjects from the Pilates group and two participants from the control group withdraw from the program within the first four weeks of the study period due to difficulties in arriving to the MS Center. Thus, data from 45 patients (29 females, 16 males; mean age (SD) 43.2 (11.6) years; mean EDSS (SD) 4.3 (1.3); mean disease duration (SD) 11.8 (6.9) years), were analyzed.

Intervention programs

The Pilates intervention program comprised 12 half-hour individualized face to face training sessions, delivered over 12 weeks, plus an individualized 15-minute daily home exercise program. Lessons were delivered by physical therapists certified in the Pilates method. The core stability exercises were selected from a basket of standardized exercises, each with three levels of difficulty appropriate for participants meeting the study's inclusion criteria. The exercises were designed to progressively challenge trunk control by gradually increasing the limb load and/or by reducing the base of support. Stretching was undertaken prior to or during these exercises to address any mal-alignments.

Where necessary, in the first instance, the instructor facilitated the movements with a "hands on" approach, progressing to a "hands off" approach. Activation of transversus abdominus in neutral spinal alignment was required for each starting position. Exercises progressed in response to the abilities of the individual. Each participant received written and diagrammatic instructions describing their 15-minute daily home exercise program. The selected intervention program has been recommended by therapists in a multiple sclerosis research group based in the United Kingdom.[24]

The Standardized physical therapy comprised twelve half-hour individualized face to face physiotherapy sessions, over a 12-week period, plus an individualized 15-minute daily home exercise program was provided to the patients in the control group. A standardized program of physiotherapy exercises aimed at improving trunk and pelvic stability, lower limb muscle length, strength, balance and control of movement, was used according to the Bobath concept. This exercise program is reflective of the general exercises typically undertaken within routine clinical practice.

Outcome measurements

All measurements were completed by an experienced physical therapist specialized in neurological rehabilitation, blinded to participant grouping. A research coordinator documented all training and examination sessions.

Clinical gait and balance tests included the Time Up and Go Test,[25] 2 and 6 minute walk test,[26] Functional Reach Test,[27] Berg Balance Scale[28] and the Four Square Step Test.[29] Additionally, the following self-report forms were collected: the Multiple Sclerosis Walking Scale:[30] a 12-item patient-rated index, questioning the perceived impact of multiple sclerosis on walking ability and the Modified Fatigue Impact Scale[31] which assesses the effects of fatigue in terms of physical, cognitive, and psychosocial functioning. Clinical tests were performed at the Department of Physical Therapy, Sheba Multiple Sclerosis Center.

Laboratory balance and gait spatio-temporal variables were obtained using the Zebris FDM-T Treadmill (zebris® Medical GmbH, Germany). The system consists of a computer controlled treadmill fitted with more than 10,000 miniature force sensors. As the subject stands/walks on the treadmill, the instantaneous force exerted by his feet (the so-called reactive-normal force) activates the sensors. Simultaneously, targeted software utilizes special algorithms to automatically group the activated sensors and form footprints. The system integrates all footprints and provides spatio-temporal parameters as well as graphic presentation of center of pressure trajectories within static stance and gait cycle.[32]

In terms of postural control measurements, each subject completed a sequence of three consecutive tests under two different task conditions (eyes open and eyes closed) with a 1-minute break between tasks. Each task was repeated three times, for 30 seconds, followed by a 30 second rest period. Posturography results are presented as the mean value of the three tests. As to the gait trial, following an adaptation phase, each participant was instructed to walk barefoot on the treadmill for one consecutive minute, at their comfort speed. Spatio-temporal parameters of gait included the following: velocity (cm/s), cadence (steps/min), step/stride time/length, single/double support (% gait cycle), stride width (cm). Gait and balance assessments were performed at the Institute of Motor Functions, Sheba Medical Center. Measurements were calculated by an experienced physical therapist specialized in neurological rehabilitation blinded to group allocation.

Data analysis was performed using IBM SPSS statistics software (Version 22.0 for Windows, SPSS Inc. NY, USA). Data was initially examined for normality violations, outliers, errors and missing values. Groups were compared at baseline using the t-test for independent samples for continuous variables and the chi-square test for categorical data. All outcome variables showed normal distribution; therefore, to test our hypothesis, we chose the repeated measure ANOVAs with a between-subject factor at 2 levels (the Pilates group vs. the standardized physical therapy group) and a within-subject factor at 2 levels (the time, pre-intervention, post intervention period). The interaction of group and time determined the efficacy of the Pilates training program on each of the outcome measures. A P-value in each case of $<.05$ was considered significant.

Results

A flow chart of the study is shown in Figure 1. Demographic and clinical data of the 45 subjects who fulfilled the study is presented in Table 1. All participants participated in at least 10 (out of the planned 12) exercise sessions. No significant differences in terms of baseline values were observed between the Pilates and control group. No adverse or harmful events were reported in both groups.

Table 2 shows the values of gait and postural control instrumented outcome parameters. In terms of posturography measures, both groups showed a main effect of time on reduction of the center of pressure path length ($F=3.278$, $P=0.034$) and sway rate with eyes open ($F=4.852$, $P=0.039$), indicating improved static balance control. Identical parameters performed with eyes closed were not significant.

At the termination of the intervention period, both groups increased their walking speed ($F=2.459$, $P=0.021$), mean step length ($F=4.261$, $P=0.023$) and mean single support phase ($F=5.695$, $P=0.008$). In addition, both groups decreased the mean step time ($F=4.206$, $P=0.009$) and time when both legs were in contact with the floor ($F=3.937$, $P=0.002$). No changes were observed in the cadence and stride width. There was no effect of group X time in all instrumented balance and gait measures.

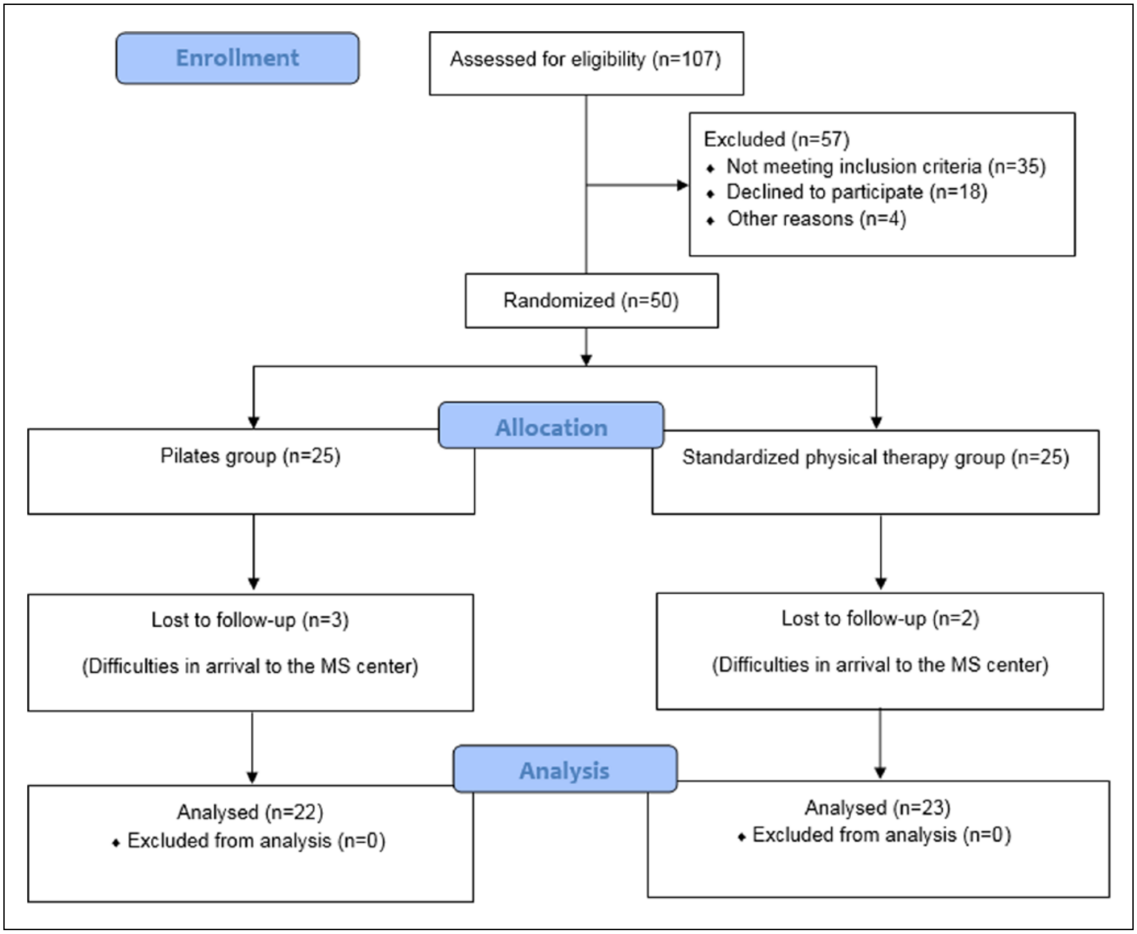

Figure 1. Study flowchart.

Table 3 presents the scores of clinical gait, balance measures and self-reported questionnaires. Improvements in both groups were demonstrated in 2 (out of 3) balance tests, the Functional Reach Test and Four Squre Step Test. No changes were found in the Berg Balance Scale. According to the 2-min and 6-min walking tests, both groups increased their walking speed at the end of the intervention program, F=2.391 (P=0.018); F=3.401, (P=0.017), respectively. Additionally, patients in both groups performed better on the Timed Up and Go Test (F=3.815, P=0.023). Based on the self-reported questionnaires, patients improved their walking abilities (Multiple Sclerosis Walking Scale, F=1.290, P=0.042) but there was no change in the level of perceived fatigue (P=0.226). In line with the gait and balance instrumented data, there were no main effect of time X groups in all walking and balance clinical tests.

Discussion

Our main findings indicated that a 12-week Pilates intervention program can improve mobility functions in moderately disabled people with multiple sclerosis. However, the improvements did not differ from those achieved through standardized physical therapy.

Apropos Pilates exercise training, our findings are in line with previous trials performed on

Table 1. Demographics and clinical characteristics of the study group.

Variable	Mean (S.D.)		*P*- Value
	Control (*n*=23)	Pilates (*n*=22)	
Age (years)	44.3 (6.6)	42.9 (7.2)	0.733
Gender			
Male	8	8	—
Female	14	15	—
Disease duration (years)	12.4 (5.7)	11.3 (6.9)	0.713
Height (cm)	167.4 (7.1)	168.1 (8.8)	0.459
Body mass (kg)	72.8 (11.4)	70.8 (12.5)	0.482
EDSS	4.6 (1.3)	4.1 (1.1)	0.627
Pyramidal	2.4 (0.9)	2.3 (0.8)	0.786
Cerebellar	1.8 (1.0)	1.7 (0.8)	0.641
Sensory	1.4 (1.0)	1.2 (1.0)	0.762

EDSS: Expanded Disability Status Scale.

different neurological populations[33] and the elderly. Recently, two systematic reviews reported on the effects of Pilates training on balance and gait performance in the elderly.[34,35] According to Barker et al.'s[35] meta-analysis (*n*=6 studies), when compared with non-active control groups, Pilates was shown to improve balance (standardized mean difference was 0.84) and reduce the number of falls (standardized mean difference was 0.84 -2.03). Similarly, Bullo et al.'s[34] review found that following Pilates exercise training, changes were observed in static balance (effect size was 0.34) and dynamic balance measures (effect size was 0.77).

As previously mentioned, improvements in the Pilates group were similar to those in the standardized physical therapy group. This observation can be viewed in several ways. On one hand, it could be argued that in cases where the aim is to improve walking and balance in people with multiple sclerosis, Pilates exercises do not have any specific advantages over physical therapy sessions. On the other hand, others may state that Pilates exercises are equally effective in improving gait and balance in people with multiple sclerosis in standardized physical therapy sessions.

A possible explanation for the similar effects may be connected with the health professionals who executed the intervention programs. In both the Pilates and physical therapy interventions, the specialists who carried out the sessions were physical therapists by profession. In fact, the Pilates instructors were actually physical therapists that in addition to their expert knowledge in neurorehabilitation were certified to teach Pilates.

We speculate that the "Physical therapist-Pilates" instructors unconsciously took advantage of their skills in neuro-rehabilitation and appropriately adjusted the intensity and difficulty of the Pilates exercises to those needing improvement in postural control and walking. We question whether the same results would have occurred if the intervention was taught by Pilates instructors with no experience in rehabilitation, resembling the situation in most community sport centers.

An additional explanation for the similarities observed between the groups relate to the study design. A major portion of both intervention programs included the patient's daily self-practicing drills at home. In this situation, we were unable to determine if the patients had performed the exercises precisely and consistently. We sense that several participants unintentionally practiced more (or less) than others, modified several

Table 2. Comparison of the instrumented balance and gait outcome measures.

Parameters	Pilates group (*n*=22)			Standardized physical therapy (*n*=23)			*F* (*P*-value) for time factor	*F* (*P*-value) for group X time factor
	Pre-intervention	Post-intervention	Mean difference	Pre-intervention	Post-intervention	Mean difference		
Posturography- eyes open								
CoP path length (mm)	323.9 (66.2)	290.5 (105.3)	−33.4 (62.4)	303.5 (79.5)	279.9 (68.4)	−25.4 (30.5)	3.278 (0.034)*	0.569 (0.226)
Sway rate (mm/s)	16.6 (5.3)	12.3 (5.5)	−4.3 (3.4)	16.9 (6.3)	13.6 (4.4)	−3.3 (3.4)	4.852 (0.039)*	0.897 (0.232)
Posturography- eyes closed								
CoP path length (mm)	382.9 (102.7)	369.1 (126.1)	−13.8 (78.0)	386.1 (102.9)	393.2 (176.5)	7.1 (132.4)	0.223 (0.589)	0.068 (0.648)
Sway rate (mm/s)	22.1 (16.3)	20.4 (10.8)	−1.7 (9.7)	23.4 (11.4)	22.9 (14.8)	−0.5 (8.9)	0.822 (0.639)	0.810 (0.496)
Spatio-temporal parameters of gait								
Velocity (km/h)	1.7 (0.4)	1.9 (0.4)	0.2 (0.3)	1.8 (0.5)	2.0 (0.3)	0.2 (0.3)	2.459 (0.021)*	0.871 (0.775)
Cadence (steps/min)	88.3 (12.4)	91.2 (15.3)	2.9 (10.5)	90.2 (11.4)	91.3 (9.7)	1.1 (6.8)	1.464 (0.223)	0.054 (0.865)
Mean Step time (s)	0.78 (0.03)	0.71 (0.02)	0.06 (0.02)	0.72 (0.07)	0.66 (0.05)	0.06 (0.06)	4.206 (0.009)*	0.980 (0.923)
Mean Step length (s)	32.0 (10.9)	36.0 (9.2)	4.0 (7.9)	33.9 (6.8)	37.3 (8.3)	3.4 (5.3)	4.261 (0.023)*	0.05 (0.887)
Mean Single support (%GC)	31.9 (3.5)	35.6 (2.7)	4.7 (2.2)	32.1 (3.1)	36.9 (5.5)	4.8 (3.8)	5.695 (0.008)*	0.08 (0.684)
Mean Double support (% GC)	43.9 (6.1)	39.6 (4.3)	−4.3 (3.8)	40.8 (4.2)	37.7 (5.3)	−3.1 (3.2)	3.937 (0.002)*	0.559 (0.694)
Mean Stride width (cm)	14.7 (1.1)	15.1 (2.7)	0.4 (1.0)	12.4 (2.9)	12.1 (2.7)	−0.3 (2.0)	0.142 (0.627)	0.011 (0.739)

Values are expressed as mean (S.D). **P*-Value <0.05.
CoP: Center of pressure; GC: Gait cycle.

Table 3. Comparison of clinical balance and gait tests and self-reported questionnaires.

Parameters	Pilates group (*n*=22)			Standardized physical therapy (*n*=23)			*F* (*P*-value) for time factor	*F* (*P*-value) for group X time factor
	Pre-intervention	Post-intervention	Mean difference	Pre-intervention	Post-intervention	Mean difference		
FRT (cm)	30.1 (5.0)	34.8 (6.9)	4.8 (4.1)	27.6 (6.4)	30.2 (4.9)	2.6 (3.2)	5.481 (0.003)*	1.173 (0.231)
BBT	46.8 (9.6)	47.9 (6.4)	1.1 (4.2)	43.3 (7.1)	44.6 (4.9)	1.3 (5.2)	1.541 (0.215)	1.794 (0.561)
FSST (s)	16.2 (7.0)	12.7 (6.4)	−4.5 (5.0)	14.2 (7.1)	11.7 (5.9)	−3.5 (6.1)	6.011 (0.031)*	1.250 (0.361)
TUG (s)	12.5 (3.5)	10.7 (3.3)	−1.8 (2.1)	11.6 (2.9)	9.9 (2.9)	−1.7 (2.1)	3.815 (0.023)*	0.710 (0.422)
2MWT (m)	139.3 (41.5)	153.8 (43.6)	14.5 (25.8)	135.7 (39.8)	147.9 (40.9)	12.7 (23.0)	2.391 (0.018)*	0.034 (0.872)
6MWT (m)	405.6 (125.8)	444.7 (89.7)	39.1 (78.3)	398.2 (105.3)	423.5 (119.2)	25.3 (67.2)	3.401 (0.017)*	1.231 (0.341)
MSWS-12	39.2 (12.7)	36.4 (11.8)	2.8 (6.3)	37.2 (10.5)	34.8 (11.9)	2.4 (5.9)	1.290 (0.042)*	0.002 (0.924)
MFIS	35.3 (21.6)	34.7 (19.5)	−0.6 (13.6)	30.4 (22.3)	28.7 (21.7)	−1.7 (16.9)	0.935 (0.683)	1.325 (0.226)

Values are expressed as mean (S.D). **P*-Value <0.05.
FRT: Functional reach test; BBT: Berg balance test; FSST: Four step square test; FES-I: Falls Efficacy Scale International; TUG: Timed up and go test; 2MWT: Two min walk test; 6MWT: Six min walk test; MSWS-12: Multiple sclerosis walking scale; MFIS: Modified Fatigue Impact Scale.

of the exercises or even trained using other exercises than those requested by the physiotherapists. This possibility could have diminished the differences between the two exercise groups.

An interesting issue worth noting concerns the frequency of the physical activity programs. In the current trial, we demonstrated that improvements in walking and balance in people with multiple sclerosis can be achieved in intervention programs consisting of a single weekly session. However, we underscore this finding with caution. Obviously, single exercise sessions are limited in their ability to change walking and balance unless they are reinforced by additional training at home. We speculate that patients who agreed to participate in the present trial (knowing that it involves exercise programs) had a positive perspective of physical activity. Consequently, compliance for the home exercise drills was probably high, contributing to the positive results.

We are aware that promoting exercise in the MS community is challenging and in many cases, depression and different cognitive aspects are barriers to physical activity.[36] Therefore, we fear that the participants in our trial may not totally reflect the majority of the multiple sclerosis population in terms of exercise participation. Despite these statements, we are fairly certain that with a positive approach to physical activity, improvements can be achieved in walking and balance abilities in people with multiple sclerosis even in programs consisting of a single weekly visit.

Our study has limitations. Firstly, the small sample size may have influenced certain variables and influenced the results. Secondly, due to the absence of a follow-up after completion of the Pilates and standardized physical therapy programs, the durability of the effect of the intervention could not be determined. Hence, further studies, including a long-term follow-up assessment, are needed to evaluate the long-term benefits of Pilates exercise training. Finally, although we carefully followed up with each patient during the intervention program, we could not ensure home exercise compliance.

In conclusion, this study presents an alternative rehabilitation program for people with multiple sclerosis. While to date no prospective randomized studies using Pilates for walking and balance rehabilitation in multiple sclerosis appear in the literature, this study shows that Pilates is a potential treatment option for people with multiple sclerosis to improve their walking and balance capabilities. However, this approach does not have any significant advantage over standardized physical therapy.

Clinical message

- Improvement in balance and mobility in people with multiple sclerosis was the same whether they received structured physiotherapy or a Pilates exercise programme over 12 weeks.

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