

Effect of Pilates exercises on symptoms of irritable bowel syndrome in women: a randomized controlled trial

Doaa Mohammed Mahmoud Allam¹, Heba Ali Abdel Ghaffar², Amira Mostafa Elshamy³, Mohamed Abdelmotaal Safa⁴, Ahmad Mahdi Ahmad²

¹Department of Physical Therapy for Internal Medicine, Faculty of Physical Therapy, Kafr El-Sheikh University, Kafr el-Sheikh - Egypt

²Department of Physical Therapy for Cardiovascular and Respiratory Disorders, Faculty of Physical Therapy, Cairo University, Giza - Egypt

³Department of Medical Biochemistry, Faculty of Medicine, Tanta University, Tanta - Egypt

⁴Department of Internal Medicine, Faculty of Medicine, Tanta University, Tanta - Egypt

ABSTRACT

Objective: The treatment of irritable bowel syndrome (IBS) is challenging, calling for therapeutic strategies other than pharmacological treatment. Therefore, this study aimed to investigate the effects of Pilates exercises on IBS symptoms and severity, frequency of complete spontaneous bowel movements, fatigue, anxiety, depression, and body weight in women with IBS.

Methods: Sixty women with IBS, aged 20-45, completed this study. They were randomly assigned to two equal groups: a study group (n = 30) and a control group (n = 30). The study group received an 8-week Pilates exercise program (2 sessions per week) in addition to dietary advice, while the control group received dietary advice only. Inclusion criteria were women, IBS diagnosed based on Rome IV Diagnostic criteria, constipation-predominant IBS, and moderate to severe IBS. The outcome measures were the IBS severity scoring system (IBS-SSS), the frequency of complete spontaneous bowel movements, the modified fatigue impact scale (MFIS), hospital anxiety and depression (HADS) scale, and body weight (BW).

Results: The study group showed more significant improvements than the control group in total IBS-SSS score (Cohen d = 0.73, p < 0.001), frequency of complete spontaneous bowel movements (Cohen d = 0.50, p < 0.001), total MFIS score (Cohen d = 0.74, p < 0.001), anxiety (Cohen d = 0.56, p < 0.001), and depression (Cohen d = 0.64, p < 0.001). The study group also showed a significant reduction in body weight compared to baseline (p < 0.05). The control group showed significant improvements in all outcomes, except body weight, compared to baseline (p < 0.05).

Conclusion: Pilates exercises, used in addition to dietary advice, may significantly improve IBS symptoms and severity, frequency of complete spontaneous bowel movements, and alleviate fatigue, anxiety, and depression moderately more than dietary advice alone in women with constipation-predominant IBS. Nevertheless, dietary advice alone may also significantly improve these outcomes in this cohort.

Keywords: Anxiety/depression, Fatigue, Irritable bowel syndrome, Pilates exercises, Women

What is already known about this topic

- Pilates exercises can relieve symptoms of fatigue, anxiety, and depression in several populations.
- There is a gap in the literature concerning the potential effect of Pilates exercises on the gastrointestinal and extra-gastrointestinal symptoms of irritable bowel syndrome (IBS).

What this study adds

- This is the first study to reveal the effectiveness of adding Pilates exercises to dietary advice as a lifestyle therapy in women with IBS.
- Pilate exercises added to dietary advice may offer more relief for IBS symptoms and clinically meaningful changes in IBS severity than dietary advice alone in women.
- Pilate exercises with dietary advice may increase the frequency of complete spontaneous bowel movements and reduce fatigue, anxiety, and depression to a greater extent than dietary advice alone in women with IBS.

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Corresponding author:

Ahmad Mahdi

email: ahmed.mahdy@pt.cu.edu.eg

Introduction

The incidence of irritable bowel syndrome (IBS) is 4.1% worldwide (1), with women being more affected than men (2). IBS with constipation is the most prevalent subtype of IBS and most commonly affects women with overweight and obesity (3). Frequent abdominal pain and annoying bloating associated with irregular bowel habits are the most common symptoms accompanying IBS (4). The frequency and

extent of pain vary according to changes in bowel habits (4). Non-gastrointestinal symptoms such as fatigue, anxiety, and depression can also be present (5). The underlying cause of IBS is not yet clear but is known to be multifactorial, involving gut-brain axis dysfunction (6). Dysregulation of the gut-brain axis, a bidirectional pathway connecting the brain to the gut via the vagus nerve, may contribute to the perception of abdominal pain, discomfort, anxiety, and depression by the brain based on sensory input from the gut (3,7). Research has shown that managing IBS symptoms can be challenging (8). Since no established medical treatment can change IBS's natural course (9), management plans have recently focused on pathophysiology and symptom relief (10). Dietary intervention is the first target therapy to alleviate IBS symptoms, as consuming particular foods can exacerbate symptoms (11). Additionally, Pilates exercises can have a potential role in relieving extra-gastrointestinal symptoms such as fatigue, anxiety, and depression (12).

To our knowledge, no prior research has assessed Pilates exercises' effectiveness in managing patients with IBS. Thus, this study aimed to determine the effects of Pilates exercises in combination with dietary advice on IBS symptoms and severity, the frequency of complete spontaneous bowel movements, fatigue, anxiety and depression, and body weight compared to dietary advice alone in women with IBS. We hypothesized that Pilates exercises might influence the gastrointestinal symptoms of IBS based on the fact that they comprise a variety of postures combined with deep breathing, which can stimulate the vagal tone (13), thus optimizing the gastrointestinal tract (GIT) function and relieving constipation and associated symptoms. We also hypothesized that Pilates exercises might have positive effects on non-gastrointestinal symptoms of fatigue, anxiety, and depression associated with IBS based on two randomized trials in patients with multiple sclerosis (MS) (12) and post-menopausal women (14) and also based on a recent meta-analysis investigating the effect of Pilates exercises on depression in women with various medical conditions (e.g., MS, schizophrenia, chronic low back pain, type 2 diabetes, and breast cancer) (15). The results of this study may aid efforts targeting lifestyle approaches to improve the symptoms of IBS.

Methods

This study follows the CONSORT 2010 Statement Guidelines for reporting randomized controlled trials (16).

Study design and settings

This is a single-centered, parallel-group, randomized, controlled study. This study recruited patients by referral and continued from July 2023 to February 2024. The Ethics Committee of the senior author's institution approved the study's protocol (NO: P.T.REC/012/004218). This study has adhered to the Helsinki Declaration's guidelines. Patients provided informed consent before the beginning of the study. The study was prospectively registered at ClinicalTrials.gov (registration No.: NCT05832801), and no changes were made to the protocol after the study commenced.

Randomization and concealed allocation

A simple randomization was employed with a 1:1 allocation ratio using a randomization table created by a computer software program. The allocation sequence was hidden using opaque, sealed envelopes with sequential numbers. The participants and the allocator were unaware of the upcoming allocation.

Implementation and blinding

The randomization sequence was generated by a researcher who was not involved in study interventions. Enrollment and assignment of subjects were performed by the physiotherapist involved in study interventions. For practical considerations, the assessor of the outcomes was not blinded to the allocation of subjects. Also, both the subjects and therapist were not blinded either to the dietary advice or the Pilates exercises due to the nature of the interventions.

Subjects

Sixty women with irritable bowel syndrome were recruited for this study by referral from a physician. Eligibility criteria were as follows: women aged 20-45 (i.e., the most common age for developing IBS) (17), a body mass index of 25-34.9 kg/m² (i.e., IBS is mostly prevalent in overweight and obese subjects) (5,18), a diagnosis of IBS based on Rome IV Diagnostic criteria (4,19) constipation-predominant IBS established by a physician according to the Bristol stool form scale (20), and moderate-to-severe IBS (IBS severity score>174) (21). Exclusion criteria were organic gastrointestinal disorders, thyroid dysfunctions, concurrent cardiovascular, respiratory, renal, hepatic disorders, pregnancy, hematological disease, neurological/musculoskeletal problems, psychiatric disease, fibromyalgia, and previous history of stomach or intestinal excision. Eligible subjects were randomly assigned to a study group (Pilates and Dietary Advice) (n=30) and a control group (Dietary Advice) (n=30). Both groups received dietary advice without pharmacological treatment (e.g., laxatives).

Power analysis

A priori power analysis could not be performed due to the lack of similar studies in this research area. A post-hoc power analysis was conducted based on the total IBS-SSS score data from the present study using the G* Power software program (3.1.9.4). The post hoc power analysis revealed that 60 patients achieved 99% power at alpha = 0.05.

Evaluation

History taking and clinical evaluation

Thorough medical history-taking and clinical evaluation were performed for patient selection. The demographic, anthropometric, and clinical features of eligible patients were recorded at baseline. BMI was calculated at baseline

by dividing body weight in kilograms by height in meters squared (22).

Outcome measures

The primary outcome measure was the IBS symptom severity scoring system (IBS-SSS). The secondary outcome measures were the number of complete spontaneous bowel movements, the modified fatigue impact scale (MFIS), the hospital anxiety and depression (HADS) scale, and body weight (BW).

Irritable Bowel Syndrome Severity Scoring System (IBS-SSS)

The IBS-SSS is a valid and reliable patient-based measure that evaluates the severity of IBS symptoms through five clinically significant items over ten days (21), as follows: (1) frequency and (2) severity of abdominal pain; (3) degree of abdominal distention or tightness; (4) dissatisfaction with bowel habits; and (5) affection of IBS on quality of life. A greater score denotes worse conditions. Each item is rated on a visual analog scale (VAS) from 0 to 100, resulting in an overall score ranging from 0 to 500 (21). Based on the data collected, the IBS-SSS scores are divided into three categories: mild symptoms (from 75 to 174), moderate symptoms (from 175 to 299), and severe symptoms (from 300 to 500) (21). Additionally, a 95-point reduction in total IBS-SSS scores is clinically meaningful, indicating an improvement in symptoms (23).

Frequency of complete spontaneous bowel movements

Complete spontaneous bowel movement is defined as a sense of complete evacuation without laxatives, enemas, or suppositories on the day of the bowel movement or the preceding day [24]. A participant with a weekly complete spontaneous bowel movement frequency rate of three or more and an increase of one or more from baseline is considered a responder [24]. The patients reported the number of their complete spontaneous bowel movements per week at baseline and post-intervention. The minimal clinically important change in the number of complete spontaneous bowel movements is 1.3 times per week for subjects suffering from functional constipation treated with acupuncture (25).

Modified Fatigue Impact Scale (MFIS)

This questionnaire measures the impact of exhaustion on life in subjects experiencing fatigue-like symptoms (26). The Arabic version of the questionnaire was used (27). The 21 items in the MFIS are divided into three categories: physical (nine items), cognitive (10 items), and psychosocial (two items). For all items, participants rate their agreement using a 5-point Likert scale, where 0 means "never" and 4 means "almost always." The total score (0–84) comprises sub-scores for physical (0–36), cognitive (0–40), and psychosocial (0–8) functioning (26). A greater score is worse. The Arabic version of MFIS exhibited high reliability and concurrent validity in MS (27).

The Hospital Anxiety and Depression Scale (HADS)

To evaluate anxiety and depression, the Arabic version of the Hospital Anxiety and Depression Scale (HADS) was used (28). The Arabic version of HADS is a valid and reliable instrument (28). HADS has two subscales (i.e., anxiety and depression), and each subscale has 7 items. Each item is rated on a 4-point Likert scale (0-3) (29). Each subscale has a normal range of 0-7, a borderline range of 8-10, and a range denoting depression or anxiety of 11-21 (29). The minimal clinically important change is 1.17-2.13 for anxiety symptoms and 1.48-2.54 for depression symptoms (30).

Body weight

Body weight was measured at baseline and after 8 weeks.

Interventions

The interventions are reported following the TIDieR checklist (31).

Dietary/lifestyle advice

Dietary advice is an essential component in the management of IBS (32). Patients in both groups were instructed to follow dietary advice as per the guidelines from the National Institute for Health and Care Excellence (NICE) and the British Dietetic Association (BDA) (33-35) for 8 weeks. The dietary pieces of advice are outlined in Table 1. A physician provided dietary advice through one face-to-face interview in a private clinic at the beginning of the study, and patients were instructed to report their diet using diaries. Then, compliance with the dietary advice was assessed regularly by a physiotherapist who checked patients' diaries via the Watts-up application. All patients adhered to the dietary advice given. No modifications were made to the dietary advice throughout the study, as patients adhered well to the intervention.

TABLE 1 - Dietary advice

Dietary advice as per the guidelines from the National Institute for Health and Care Excellence (NICE) and the British Dietetic Association (BDA) (33-35).

Integrating a healthier eating habit, having food at the same time every day with regular intervals

Never eat too little or too much.

Staying properly hydrated

Preventing processed, fatty, and spicy food

Limiting caffeine, carbonated, and alcoholic drinks

Limiting fiber intake to soluble fibers starts with a low dose and builds up gradually.

Avoiding insoluble fibers, gas-producing foods like beans, and sweeteners

Awareness of dietary intolerance

An additional advice for increasing physical activity.



Exercise Intervention

Pilates exercises may stimulate the vagal tone, thus enhancing the GIT function (13), and have a role in relieving fatigue, anxiety, and depression (12). Patients in the study group received Pilates exercises and dietary advice for eight weeks. The Pilates exercise program, modified from the protocol by Silva et al. (36), is described in Table 2. A mat and a gymnastic Swiss ball for adults were used. Initially, patients received instructions on the exercises and YouTube's educational videos, as shown in Table 2. Then, an experienced physiotherapist guided the subjects in Pilates exercises through face-to-face sessions at a physiotherapy clinic. The sessions were scheduled two times per week for a total of 16 sessions. The sessions started with a 5-minute warm-up composed of

repeated sit-ups and back extensions on a Swiss ball and 1 set of 30 seconds of hamstring stretch, knee to chest, and global stretch for trunk and back. The session ended with a 5-minute cool-down period with the same activities as the warm-up. The total session lasted for 45-50 minutes. From the 1st to the 3rd week, patients performed each exercise for one set of 8 repetitions that reached 10 repetitions by the end of the 4th week. From the 5th to the 8th week, two sets of 10 repetitions were performed. At this time, exercises were personalized so that the patients who couldn't perform the two sets continually were allowed to rest for 3–5 minutes between sets. No adjustments were required, as every patient could complete the activities as directed. All patients in this group adhered to the scheduled sessions.

TABLE 2 - Pilates exercises prescription

Pilates exercises [modified from Silva et al. (36)]	Description
1-Swan	<ul style="list-style-type: none"> The subject lies prone with hands resting in the direction of the shoulders, Extends the elbows, maintaining the head in line with the spine and extending the trunk. Returns to the starting position. https://www.youtube.com/watch?v=hFoF-9UhJc
2-One leg up -down	<ul style="list-style-type: none"> The subject lies flat, arms outstretched alongside the body. Elevates the leg in extension with plantar flexion. Returns to the starting position https://www.youtube.com/watch?v=x06RH8Dig8g
3- Leg circles	<ul style="list-style-type: none"> The subject lies flat, arms outstretched alongside the body and supported on the ground. Elevates the leg in extension with plantar flexion. Makes circles with the leg https://www.youtube.com/watch?v=zeUW8LFUEPo
4-Single leg stretch	<ul style="list-style-type: none"> The subject lies flat and flexes the right leg as much as she can towards the chest by putting the left hand on the right knee and the right hand on the right ankle. Extends the left leg at a 30° angle. Alternates the leg slowly https://www.youtube.com/watch?v=dJWsTv3lhOo
5-Saw	<ul style="list-style-type: none"> The subject sits erect, with legs apart at hip width, and arms extended apart at shoulder height. Twists the spine to the left slowly from the waist. Moves the right arm towards the left foot and the left arm back at shoulder height. Returns to the original position and switches sides. https://www.youtube.com/watch?v=1XcU-WsTcaU
6-Side kicks: front and back	<ul style="list-style-type: none"> The subject assumes side lying, elbow flexed, and hand resting under the head. Keeps the upper leg aligned with the hips and slowly brings the extended leg forward. Returns to the starting position. https://www.youtube.com/watch?v=ZAhTD9Mitck
7-The hundred	<ul style="list-style-type: none"> The subject lies flat, elbow extended, with the shoulder, hips, and knees at 90°. Extends the knee at approximately 45°, with a slight bending of the trunk (removing the shoulder blades from the mat) and chin towards the chest. Returns to the starting position https://www.youtube.com/watch?v=HRsDeUrW1BA
8-Pelvic lift on the ball	<ul style="list-style-type: none"> The subject lies flat, legs straight, with heels on the ball. Squeezes the glutei and lifts the hips from the mat as high as possible. Returns to the starting position https://www.youtube.com/watch?v=Pxu5Mp6_ezc

Pilates exercises [modified from Silva et al. (36)]	Description
9-Sit-ups with the ball.	<ul style="list-style-type: none"> The subject lies flat while holding the ball over the head and legs at 45. Brings the ball toward the legs and hold it. Returns to the starting position https://www.youtube.com/watch?v=L0rZ6V_SB-U
10-Stretching on the ball for muscle relaxation.	<ul style="list-style-type: none"> The subject lies supine and prone on the ball in each position for 30 seconds. This was a part of cooling down. https://www.youtube.com/watch?v=7Lp5X9aazkg

Statistical analysis

Descriptive statistics were used to describe baseline patients’ characteristics (age, weight, height, BMI, IBS duration) as means ±SD. A two-way analysis of variance (ANOVA) was employed to compare outcome measures within and between groups. The chi-squared test was utilized to compare IBS-SSS severity categories between the groups after interventions. All statistical tests were set at a significance level of $p < 0.05$. Mean differences (MD) and 95% confidence interval (CI) were computed. The effect size was assessed by calculating the absolute mean changes from baseline (change scores) and the standardized mean difference between the two groups (Cohen d). Cohen d was interpreted as per Cohen [37], as $<0.2 =$ trivial effect; $0.2-0.49 =$ small effect; $0.5-0.79 =$ moderate effect; and $\geq 0.8 =$ large effect. The change scores were calculated by subtracting the pre-intervention mean

score from the post-intervention mean score. Mean percent changes were also calculated. Statistical Package for Social Sciences (SPSS) software version 24 was used for all analyses.

Results

Participants flow

Of 79 women with IBS, 15 did not fulfill the enrolment criteria, and 4 refused to participate. Sixty women with IBS were randomized to two groups: a study group (Pilates and Dietary Advice) (n = 30) and a control group (Dietary Advice) (n = 30). No losses occurred after randomization, and all participants in each group received the intended interventions and were included in the final analysis. The flow of participants can be seen in Figure 1. Eligible participants were recruited from July 2023 to February 2024.

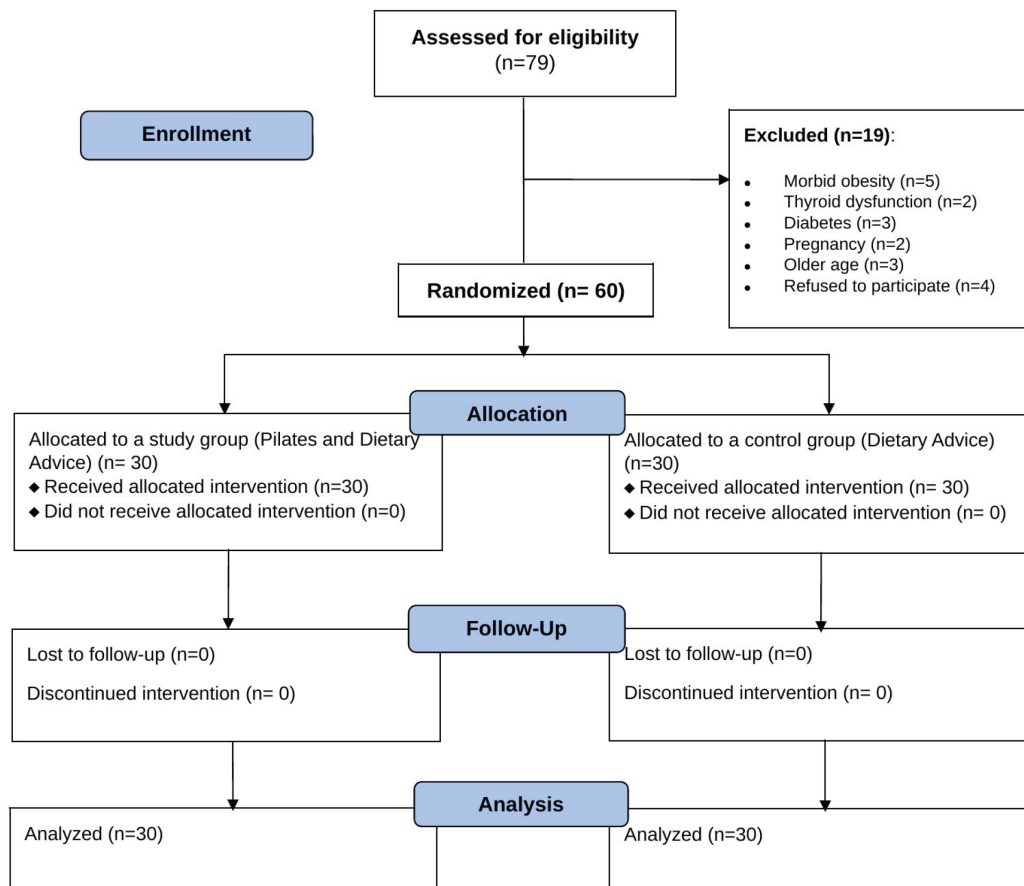


FIGURE 1 - Flowchart of the study.



Baseline data

The age and anthropometric and clinical characteristics of patients in the two groups are listed in Table 3.

Results of irritable bowel syndrome severity scoring system (IBS-SSS)

The total IBS-SSS displayed significant reductions in the study and control groups ($p < 0.001$) compared to the baseline (Table 4). However, the study group showed a more significant reduction in the total IBS-SSS score than the control group ($p < 0.001$), with a moderate effect size (Cohen $d = 0.73$) (Table 4). The percentage changes from baseline in total IBS-SSS were $\downarrow 66.75\%$ versus $\downarrow 38.28\%$ in the study and control groups, respectively (Table 4). Additionally, the severity of IBS was significantly lower in the study group than in the control group post-intervention ($p < 0.001$) (i.e., 30 mild cases and 0 moderate cases in the study group versus 16 mild cases and 14 moderate cases in the control group) (Table 4).

Frequency of complete spontaneous bowel movements

The mean values of the frequency of complete spontaneous bowel movements showed a significant increase in the study and control groups ($p < 0.001$) compared to the baseline (Table 5). However, the study group presented a more significant increase in the frequency of complete spontaneous bowel movements than the control group ($p < 0.001$) with a moderate effect size (Cohen $d = 0.5$) (Table 5). The percentage changes in the frequency of complete spontaneous bowel movements were $\uparrow 97.17\%$ versus $\uparrow 67.69\%$ in the study and control groups, respectively (Table 5).

Results of Modified Fatigue Impact Scale (MFIS)

The subscores of cognitive, physical, and psychosocial subscales of MFIS and the total score of MFIS reduced significantly in the study and control groups compared to baseline ($p < 0.001$) (Table 5). However, the study group showed significantly greater improvements in the MFIS total score ($p < 0.001$) than the control group with a moderate effect size (Cohen $d = 0.74$) (Table 5). The percentage changes in MFIS were $\downarrow 55.52\%$ versus $\downarrow 28.83\%$ in the study and control groups, respectively (Table 5).

Results of Hospital Anxiety and Depression Scale (HADS)

The mean values of anxiety and depression scores reduced significantly in the study and control groups compared to baseline ($p < 0.001$); however, the study group showed significantly more reductions in the mean scores of anxiety and depression with moderate effect sizes ($d = 0.56$, $d = 0.64$, respectively) than the control group ($p < 0.001$) (Table 5). The percent changes in anxiety were $\downarrow 53.45\%$ versus $\downarrow 27.64\%$ in the study and control groups, respectively; and in depression, they were $\downarrow 59.1\%$ versus $\downarrow 26.33\%$ in the study and control groups, respectively (Table 5).

Body weight (BW)

After interventions, BW displayed a significant reduction of 4.91% in the study group only ($p < 0.001$), with no significant difference between the two groups ($p = 0.17$) and trivial effect size (Cohen $d = 0.19$) (Table 5).

TABLE 3 - Baseline data for both groups

Variables	Study group (Pilates and Dietary Advice) ($n_1 = 30$)	Control group (Dietary Advice) ($n_2 = 30$)
Age (Years)	29.4 \pm 7.66	30.33 \pm 8.63
Body weight (kg)	77.15 \pm 11.16	77.63 \pm 9.85
Height (cm)	160.38 \pm 5.57	161.32 \pm 4.58
BMI (kg/m ²)	29.9 \pm 3.23	29.73 \pm 3.24
IBS Duration (Years)	7.38 \pm 5.95	7.22 \pm 5.98
Total IBS-SSS score	312.57 \pm 80.1	283.7 \pm 62.71
Severity		
Moderate	11 (36.66%)	17(56.66%)
Severe	19(63.33%)	13(43.33%)
Frequency of bowel movements	2.47 \pm 0.94	2.37 \pm 0.89
Modified fatigue impact scale	59.87 \pm 9.72	58.27 \pm 12.1
Anxiety	13.47 \pm 3.7	14 \pm 3.3
Depression	10.83 \pm 2.59	11.13 \pm 3.63

Data are expressed as Means \pm SD and frequencies (percent distribution). BMI: Body Mass Index; IBS: Irritable Bowel Syndrome; IBS-SSS: Irritable Bowel Syndrome Severity Scoring System

TABLE 4 - Results of IBS-SSS within and between groups

IBS-SSS		Study group (Pilates and Dietary Advice) (n ₁ = 30)	Control group (Dietary Advice) (n ₂ = 30)	MD	95% CI	Effect size Cohen d	p-value
Pain severity	Pre	59.63 ± 19.75	59 ± 16.01	0.63	(-8.66,9.93)	-	0.89
	Post	21.47±10.37	39.37±16.07	-17.9	(-24.91, -10.89)	0.67	<0.001**
	p-value	<0.001*	<0.001*				
	Change score	-38.16	-19.79				
	% Mean change	↓64%	↓33.27%				
Pain duration	Pre	66.33 ± 24.7	52.33±24.31	14	(1.33,26.67)	-	0.03**
	Post	15 ± 6.3	28.33±19.67	-13.3	(-20.99, -5.68)	0.46	0.001**
	p-value	<0.001*	<0.001*				
	Change score	-51.33	-24				
	% Mean change	↓77.39%	↓45.86%				
Abdominal distention	Pre	61.7 ± 24.03	42.23 ± 23.23	19.47	(7.25,31.68)	-	0.002**
	Post	18.87 ± 15.49	30.67 ± 21.54	-11.8	(-21.49, -2.1)	0.32	0.018**
	p-value	<0.001*	<0.001*				
	Change score	-42.83	-11.56				
	% Mean change	↓69.42%	↓27.37%				
Defecation satisfaction	Pre	64.6 ± 25.91	62.9 ± 22.09	1.7	(-10.74,14.14)	-	0.79
	Post	24.53±15.34	36.1±16.32	-11.5	(-19.75, -3.38)	0.36	0.006**
	p-value	<0.001*	<0.001*				
	Change score	-40.07	-26.8				
	% Mean change	↓62.03%	↓42.61%				
General QOL	Pre	71.2 ± 18.51	67.23 ± 19.99	3.97	(-5.99,13.92)	-	0.43
	Post	24.4 ± 9.07	40.63 ±17.62	-16.2	(-23.53, -8.94)	0.58	<0.001**
	p-value	<0.001*	<0.001*				
	Change score	-46.8	-26.6				
	% mean change	↓65.73%	↓39.57%				
Total score	Pre	312.57 ± 80.1	283.7 ± 62.71	28.87	(-8.31,66.04)	-	0.13
	Post	103.93 ± 27.95	175.10 ± 62.80	-71.1	(-96.53, -45.8)	0.73	<0.001**
	p-value	<0.001*	<0.001*				
	Change score	-208.64	-108.6				
	% mean change	↓66.75%	↓38.28%				
Severity (based on IBS-SSS total score)	Post	Mild	30 (100%)	16(53.33%)			<0.001¶
		Moderate	0 (0%)	14(46.66%)			

Data are expressed as Means ± SD, change scores and percent mean changes from baseline, and frequencies and percent distributions. IBS-SSS: Irritable Bowel Syndrome Severity Scoring System; QOL: Quality of life; MD: mean difference; CI: confidence interval. *Significant p-value (p < 0.05) based on the two-way ANOVA within-group comparison; **significant p-value (p < 0.05) based on the two-way ANOVA between-groups comparison; ¶ significant p-value (p < 0.05) based on Chi-square test.



TABLE 5 - Results of the frequency of bowel movements, MFIS, HADS, and body weight within and between groups

Outcomes		Study group (Pilates and Dietary Advice) (n ₁ = 30)	Control group (Dietary Advice) (n ₂ = 30)	MD	95% CI	Effect size Cohen d	p-value	
Frequency of bowel movements	Pre	2.47 ± 0.94	2.37 ± 0.89	0.1	(-0.37,0.57)	-	0.67	
	Post	4.87 ± 1.04	3.77 ± 1.44	1.1	(0.54,1.66)	0.5	<0.001**	
	p-value	<0.001*	<0.001*					
	Change score	2.4	1.4					
	% Mean change	↑97.17%	↑67.69%					
Modified fatigue impact scale (MFIS)	Cognitive	Pre	26.83 ± 5.87	26.37 ± 5.37	0.47	(-2.6,3.53)	-	0.76
		Post	12.83 ± 5.02	18.13 ± 6.12	-5.3	(-8.19, -2.41)	0.47	0.001**
		p-value	<0.001*	<0.001*				
		Change score	-14	-8.24				
		% Mean change	↓52.18%	↓31.25%				
	Physical	Pre	26.77 ± 5.19	26.53 ± 6	0.23	(-2.67,3.13)	-	0.87
		Post	11.83 ± 2.1	18.9 ± 4.44	-7.0	(-9.54, -4.6)	0.74	0.001**
		p-value	<0.001*	<0.001*				
		Change score	-14.94	-7.63				
		% Mean change	↓55.81%	↓28.76%				
	Psychosocial	Pre	5.83 ± 1.34	5.37 ± 1.54	0.47	(-0.28,1.2)	-	0.22
		Post	1.97 ± 1.38	4.3 ± 1.66	-2.3	(-3.12, -1.54)	0.78	<0.001**
		p-value	<0.001*	<0.001*				
		Change score	-3.86	-1.07				
		% Mean change	↓69.3%	↓19.93%				
	Total	Pre	59.87 ± 9.72	58.27 ± 12.1	1.6	(-4.07,7.27)	-	0.57
		Post	26.63 ± 9.48	41.47 ± 10.43	-14.8	(-19.98, -9.68)	0.74	<0.001**
		p-value	<0.001*	<0.001*				
		Change score	-33.23	-16.8				
		% Mean change	↓55.52%	↓28.83%				
Hospital Anxiety and Depression Scale (HADS)	Anxiety	Pre	13.47 ± 3.7	14 ± 3.3	-0.5	(-2.35,1.28)	-	0.56
		Post	6.27 ± 2.7	10.13 ± 3.94	-3.8	(-5.66, -2.08)	0.56	<0.001**
		p-value	<0.001*	<0.001*				
		Change score	-7.2	-3.87				
		% Mean change	↓53.45%	↓27.64%				
	Depression	Pre	10.83 ± 2.59	11.13 ± 3.63	-0.3	(-1.93,1.33)	-	0.71
		Post	4.43 ± 2.6	8.2 ± 3.27	-3.7	(-5.29, -2.24)	0.64	<0.001**
		p-value	<0.001*	<0.001*				
		Change score	-6.4	-2.93				
		% Mean change	↓59.1%	↓26.33%				
Body weight (kg)	Pre	77.15 ± 11.16	77.63 ± 9.85	-0.48	(-5.92, 4.96)	-	0.86	
	Post	73.36 ± 10.27	77.08 ± 10.24	-3.72	(-9.02, 1.57)	0.19	0.17	
	p-value	<0.001*	0.15					
	Change score	-3.79	-0.55					
	% Mean change	↓4.91%	↓0.71%					

Data are expressed as Mean ± SD and percent mean changes from baseline. MD: mean difference, CI: confidence interval; *Significant p-value (p < 0.05) based on the two-way ANOVA within-group comparison; **significant p-value (p < 0.05) based on the two-way ANOVA between-groups comparison



Discussion

The purpose of the study was to investigate the effect of Pilates exercises on IBS severity scoring system assessed by IBS-SSS, the number of complete spontaneous bowel movements, fatigue assessed by MFIS, anxiety, and depression assessed by HADS, and body weight (BW) in women with constipation-predominant IBS. To our knowledge, this study is the first randomized control trial that investigates the effectiveness of Pilates exercises in IBS. The main findings of this study are: (i) women with constipation-predominant IBS who received Pilates exercises in addition to dietary advice for IBS showed significantly greater improvements in IBS symptoms and severity as assessed by the IBS-SSS, with a moderate effect size in its total score, than their counterparts who received dietary advice only; (ii) Pilates exercises in combination with dietary advice led to a significantly higher frequency of complete spontaneous bowel movements, less fatigue as assessed by MFIS, and lower anxiety and depression levels as assessed by HADS with moderate effect sizes than dietary advice alone in women with constipation-predominant IBS, (iii) body weight was reduced significantly only following Pilates exercises and dietary advice compared to the baseline value.

This study showed that pilates exercises, in addition to dietary advice, showed more significant improvement in the IBS symptoms/severity assessed by IBS-SSS (i.e., pain duration, pain severity, abdominal distension, defecation satisfaction, and general QoL) than dietary advice alone. In a similar context, Fani et al. (38) revealed that six weeks of aerobic exercises significantly improved the severity of IBS symptoms. Interestingly, the change scores in total IBS-SSS scores in the study and control groups were 208.64 and 108.6 points, respectively, representing clinically important changes, as a 95-point reduction in total IBS-SSS scores is clinically meaningful (23). However, there was a difference in clinical significance in the improvements of IBS-SSS between the two groups in favor of the study group. This is because all patients in the study group had mild symptoms after the interventions, in contrast to 16 patients with mild symptoms and 14 patients with moderate symptoms in the control group post-intervention. Moreover, there was a significant difference with a moderate effect size in the improvement of IBS-SSS total score between the groups in favor of the study group (i.e., Cohen $d = 0.73$).

Another finding in this study was that the self-reported frequency of complete spontaneous bowel movements per week increased by a significantly greater degree in patients who received Pilates exercises and dietary advice than in patients who received dietary advice alone. This finding complements the previous findings in this study (i.e., the improvement in IBS symptoms and severity). Also, this study reveals the effectiveness of Pilates exercises in treating symptoms of constipation in our patients who had constipation-predominant IBS. In a similar context, Daley et al. (39) showed that exercise can significantly improve constipation symptoms compared to usual care in patients with IBS. Additionally, Gao et al. (40), in their systematic review, concluded that exercise can have a major role in alleviating constipation symptoms. The mechanism underlying the constipation-relieving effect of Pilates exercises is that Pilates has the advantage

of combining deep breathing with body movements, which can activate the vagal tone (13). Within this, Liu et al. (41) reported that 6 weeks of slow deep breathing exercises improved the number of bowel movements compared to the control group, which can be attributed to improvement in the parasympathetic activity in patients with constipation-predominant IBS. Worth noting is that Ai et al. (25) reported that a mean increase of ≥ 1.3 times/week in complete spontaneous bowel movement in patients with severe functional constipation treated with acupuncture suggests clinical significance. Given that the mean increases (change scores) in the frequency of complete spontaneous bowel movements were 2.4 and 1.4 times per week, the changes in this outcome may be of clinical importance in both groups. However, there was a significant difference with a moderate effect size in the improved frequency of complete spontaneous bowel movements between the groups in favor of the study group (Cohen $d = 0.50$).

The current study also showed that Pilates exercises and dietary advice improved overall fatigue symptoms (i.e., cognitive, physical, and psychosocial) compared to the baseline and dietary advice alone. In the present study, the mean changes (i.e., change scores) in total MFIS scores were 33.23 and 16.8 points in the study and control group, respectively. Alawami and Abdulla (42) reported that a mean change of 14.68 or more points in total MFIS score may indicate a minimal detectable change (MDC) in fatigue of clinical importance in patients with MS. Although this MDC in fatigue, assessed by MFIS, was investigated in MS, we think this threshold value may help interpret the changes in fatigue assessed by MFIS in response to our interventions. Nevertheless, there was a significant difference with a moderate effect size in the improvement of MFIS total score between groups in favor of the study group (Cohen $d = 0.74$).

Pilates exercises played a role in the enhancement of fatigue symptoms in patients with MS (12,43,44), healthy young female participants (45,46), post-menopausal women (14,47), and women with breast cancer (48). A recent meta-analysis reported that moderate aerobic exercises or combination training approaches for 2-10 weeks positively affected fatigue in subjects suffering from chronic conditions (49). In contrast, Johannesson et al. (50) demonstrated that moderate physical activity did not enhance fatigue symptoms in patients with IBS.

This study also showed that more significant improvements in anxiety and depression were found in the study group than in the control group. This finding can be supported by a recent systematic review by Ju et al. (15), which showed that Pilates exercises can be considered an additional treatment method for alleviating depression and anxiety symptoms in female patients. In addition, Pilates was effective in improving anxiety and depression symptoms in women with type 2 diabetes (51), middle-aged women with obesity (52), and post-menopausal women (53). On the other hand, some studies reported that Pilates exercises did not lead to any significant improvement in anxiety or depression in female patients with fibromyalgia (54) or dysmenorrhea (55). It is worth noting that changes in HADS anxiety symptoms of 1.17-2.13 points and in HADS depression symptoms



of 1.48-2.54 points were considered clinically important in patients with chronic pain (30). The change scores in HADS anxiety and depression symptoms in both groups in the present study were greater than those cut-off values, suggesting clinically meaningful improvements. However, there were significant differences with moderate effect sizes in the improvement of HADS anxiety symptoms (Cohen $d = 0.56$) and HADS depression symptoms (Cohen $d = 0.64$) between groups in favor of the study group.

The positive effects of Pilates on IBS symptoms, fatigue, anxiety, and depression may be explained based on the fact that Pilates can activate the parasympathetic nervous system and optimize the function of the hypothalamic-pituitary-adrenal axis, which regulates several body processes, including digestion, mood, and emotions, energy storage, and production (52,56,57). It should also be noted that the control group, which received dietary advice, only showed significant improvement in IBS symptoms, frequency of complete spontaneous bowel movements, anxiety, and depression compared to baseline. This may be because the diet they received could have modulated gut flora composition and function, thus optimizing the gut-brain axis pathway and reducing the brain's perception of abdominal pain, discomfort, and anxiety [58]. As such, it may be unsurprising that the patients who received both Pilates exercises and dietary advice experienced greater improvements in their IBS symptoms than those who received dietary advice alone, owing to the combined effects of both interventions.

The last finding in this study was that the study group showed a significant reduction in body weight compared to the baseline value. Pilates effectively reduced body weight in subjects with overweight or obesity (59,60), MS (44), young women (46), women with type 2 diabetes (51), and postmenopausal women (53). On the contrary, a study by Park et al. (52) reported that Pilates exercises did not cause any change in body weight in female participants with obesity. Also, the meta-analysis by Cavina et al. (61) reported that mat Pilates had no advantage over the control condition for reducing body weight in the general population. Interestingly, the mean percent change in body weight from baseline in the study group was approximately 4.91%, and this reduction could be of clinical relevance. It was shown that a weight reduction of 5% from baseline is "clinically meaningful" (62) and is associated with a decline of 13% in intra-hepatic triglycerides (63). Elevated triglyceride levels were found to exaggerate IBS symptoms (64).

Finally, this study has limitations, and its findings should be interpreted in that context. There was a lack of control over potential hormonal factors (e.g., effects of menstrual cycles or use of contraceptive pills). Also, the current study only included women with overweight and grade I obesity suffering from constipation-predominant IBS, which may limit the generalization of the results. Moreover, this study did not include abdominal circumference or other metrics of obesity. Nevertheless, the current study has several strengths. This study is the first to investigate the effectiveness of Pilates exercises in women with IBS. Additionally, a variety of patient-reported outcomes were used in this study to produce an extensive assessment of the patients

at baseline and in response to the interventions. Moreover, the results of this study may have practical applications for physiotherapists and healthcare providers interested in the complementary treatment of IBS.

Conclusion

When used in tandem with dietary advice, Pilates exercises may be an effective therapeutic intervention that could significantly reduce IBS symptoms and severity, increase the frequency of complete spontaneous bowel movements, reduce fatigue, and relieve anxiety and depression to a more moderate extent than dietary advice alone in women with IBS. However, dietary advice alone may also improve these outcomes in these patients.

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