The Effect of Pilates on Quality of Sleep, Aerobic Capacity and Anaerobic Power in Premenopausal Women

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Sleep Sci 2024;17(1):e75–e81.

Abstract

Pilates is a holistic exercise focused on respiration, body control, and accuracy of movements, and it improves respiratory muscle strength, balance, quality of life, and overall physical performance. However, little is known about the effect of Pilates on sleep quality. The purpose of the present prospective observational study was to evaluate the effect of four months of Pilates training on the quality of sleep, aerobic capacity, and anaerobic power in premenopausal women. The sample consisted of 53 premenopausal women: one experimental group ($n = 40$) and one control group ($n = 13$). Participants in the experimental group received at least three one-hour sessions of Pilates exercise per week for 16 weeks. The two groups were similar at baseline. After 4 months of Pilates, the intervention group had significantly lower scores on the Athens Insomnia Scale, Epworth Sleepiness Scale, and autonomic arousal index compared to the baseline scores. The intervention group presented significant improvement in aerobic fitness, muscle strength, flexibility, balance, abdominal muscle endurance, as well as in the general health and social functioning subscales of the 36-Item Short Form Health Survey (SF-36). Pilates workouts appeared to improve sleep quality in premenopausal women, as well as the basic parameters of fitness and quality of life.

Keywords
- female
- quality of life
- physical examination
- sleep

Introduction

Pilates exercise was invented by Joseph Pilates in the 1920s. Its original name was "Contrology" because it places emphasis on the control of the body position and movement.[1] Exercises are floor-based, or involve the use of specialized equipment, which provides adjustable spring resistance. The traditional principles of Pilates exercise include centering (tightening of the "powerhouse" [trunk muscles]), concentration (cognitive attention while performing the exercises), control (postural management while performing the exercises), precision (accuracy of the exercise technique), and flow (smooth transition of movements within the exercise sequence).[2]

The Pilates method includes several stretching and strengthening exercises, which can be divided into two categories: mat Pilates, and exercises with the Pilates apparatus. The first set of exercises is performed on the ground, without

received August 24, 2022
accepted July 14, 2023

DOI https://doi.org/10.1055/s-0043-1776742.
ISSN 1984-0659.

any specific equipment, while Pilates apparatus includes exercises against resistance provided by springs and pulleys.[3]

Over the last few years, Pilates has become popular as a holistic exercise focused on respiration, body control, and accuracy of movements.[4] Current evidence suggests the positive effects of Pilates on respiratory muscle strength, balance, quality of life, and overall physical performance.[5] Moreover, in a recent systematic review and meta-analysis, it was found that Pilates is an alternative exercise to improve maximal oxygen uptake (VO_2max) values.[5]

The aim of the present study was to evaluate the effect on quality of sleep, aerobic capacity, and anaerobic power of four months of Pilates training in premenopausal women. Premenopausal women were selected in order to avoid vasomotor (hot flashes, night sweats, or both) and genitourinary symptoms associated with menopause, which affect most menopausal women, and could alter the results of the present study, including sleep quality and quality of life.[6,7]

Materials and Methods

Design

The present is a prospective observational study of pre- and postexercise measurement comparison with a control group that does not follow an exercise program.

Participants

The sample consisted of 53 premenopausal women, 40 of whom formed the intervention group, and 13 of them were the control group. Premenopausal women were those reporting normal length of menstrual cycle without any vasomotor or genitourinary symptoms. Also, the premenopausal period was defined as the period before women begin presenting signs of menopause, such as variable menstrual cycles ($\geq$ 7 days difference in the length of consecutive menstrual cycles), or amenorrhea for $\geq$ 60 days.[8]

We made a call of interest in a Pilates gym, to which 72 women responded; from the respondents, we selected 40 (55.5%) that fulfilled the enrollment criteria of the study. In addition, we also invited women to participate in the control group, and of them, we selected 13 that fulfilled the enrollment criteria, and were mainly not participating in systematic exercise. This was a convenience sample, based on personal preference for systematic Pilates exercise or not. The control group received exercise on demand, or according to their preference, but not systematically or under supervision.

The two groups, however, had similarities in somatometric characteristics. The participants did not have any specific ability, nor did they have any specific athletic profile. The inclusion criteria for the participants were: a) voluntary participation; b) being premenopausal; c) having a healthy physical condition, without contraindications to exercise by a doctor; d) exclusive performance of exercise through the ground Pilates method for the intervention group; e) body mass index (BMI) between 20 kg/m^2 and 30 kg/m^2; and f) no recent or current practice of physical exercise or sports activities. The exclusion criteria were: a) duration of the previous exercise; b) other exercises in parallel with this program (not allowed); c) pregnancy; d) serious health issues (such as cardiorespiratory, systemic, or musculoskeletal issues); e) prohibition of participation in Pilates exercises by the doctor; and f) taking medication.

Intervention: Pilates Program

Pilates training included at least 16 weeks (4 months) with at least 3 workout sessions per week. The training lasted 60 minutes. We started with 15 minutes of balance and proprioceptive exercises to strengthen joints and ligaments, and improve balance. During these exercises, the participants were in a standing position and trained all muscle groups in combination. The strength always began from the center of the body (powerhouse) and lasted 1 minute. Active recovery followed each exercise, with stretching of the muscle groups that we had worked on (►**Table 1**).

Then, from a stable position and based on the principles of coaching, the time and intensity of the exercises progressively increased. For 25 minutes, we chose exercises using the weight of the body and alternative instruments, with the weight not exceeding 1 kg (based on the principle of Pilates), while the heartbeats reached 150 b/min, thus improving along with the strengthening of the muscles and the aerobic capacity of the trainees. The duration of each exercise ranged from 1 to 3 minutes, with a break of 10 seconds, always followed by active recovery (stretching of the corresponding muscle group after each exercise). We worked with concentric and isometric exercises for the rectus and lateral abdominal muscles, lower transverse muscles, perineal muscles, cervical thoracic lumbar spine, arms, and legs. Strength

Table 1 Example of a daily workout session in a Pilates training program.

Type of exercise	Duration (min)	Exercise intensity (beats/min)
Balance and proprioceptive exercise	15	120
(1 min per drill with 10 s of recovery)		
Body weight and alternative instruments exercises	25	150
(1–3 min per drill with 10 s of recovery)		
Support exercises for the whole body and all muscle groups	10	160–180
(1–2 min per drill with 10 s of recovery)		
Full body stretching exercise	10	< 100

always started from the center of the body, whilst we aimed for a good lumbopelvic control. For the next 10 minutes, we were working with support exercises, from 1 to 2 minutes, for the whole body and all muscle groups, with active recovery at 160-180 b/min, thus exercising on anaerobic power. We always ended our Pilates workout with stretching (full body stretches) for the last 10 minutes, focusing on the lumbar spine. All exercises were performed free of charge, with alternative instruments (balls, ring, tires, and straps).

Instrumentation

The examined variables were muscle strength, aerobic capacity, anaerobic endurance (cardiorespiratory endurance), balance, flexibility, and quality of sleep, in premenopausal women. More specifically, the following tests were performed before and after the intervention:

- the Harvard Step test, which is a test of aerobic fitness. The participant steps up and down on the platform at a rate of 30 steps per minute (every 2 seconds) for 5 minutes or until exhaustion. Exhaustion is defined as when the participant cannot maintain the stepping rate for 15 seconds. The participant immediately sits down on completion of the test, and the total number of heartbeats is counted between 1 to 1.5 minutes after finishing, between 2 to 2.5 minutes, and between 3 to 3.5 minutes. The fitness index is equal to the following equation: (100 x test duration in seconds) divided by (2 x the sum of heartbeats in the recovery periods).[9]
- the Bosco Repeat Jump, which is a test for anaerobic power. The aim is to perform the highest number of jumps with maximum height in the set time. Jump height is calculated using a timing mat, which measures the time the feet are off the mat (flight time) and time on mat (contact time).[10]
- the Flamingo Balance Test for balance assessment. The participants stood upright on their fully stretched leg on a special wooden beam ($50 \times 3 \times 4$ cm), flexed the free leg at the knee, and gripped the foot with the hand on the same side. We recorded the number of falls that occurred in 1 minute of balancing.[11]
- the Sit and Reach test for flexibility assessment. The participants sat on the floor with their legs stretched out in front of them, with knees straight and feet flat against the front end of the test box. With the palms facing downwards, and the hands side by side, the participants reached forward along the measuring line, as far as possible. We recorded the nearest centimeter as the distance reached by the hand.[12]

For the assessment of sleep quality, the SOMNOcheck micro-CARDIO (Weinmann Emergency Medical Technology, Hamburg, Germany) was used, which was administered to each participant for overnight use at home. This device is routinely used by sleep units for screening patients against sleep apnea. Each participant was trained as far as the device usage was concerned, regarding both continuous overnight oximeter and pulse measurement, and nasal cannula for inspiration expiration recording. This machine is suitable for identifying apneas and hypopneas, awakenings and arousals, as well as desaturations for medical use.[13,14]

Moreover, insomnia was measured using the Athens Insomnia Scale (AIS)[15] and sleepiness (somnolence) was measured using the Epworth Sleepiness Scale (ESS).[16] The measurements were performed before and after the intervention in the intervention group.

Ethical Approval

The protocol was approved by the Ethics Committee of the Department of Nursing of National and Kapodistrian University of Athens (register number: 258-20/5/2019). The participants were informed in writing and orally about the purpose of the study, and their written consent was obtained. Personal data of the patients remained anonymous at all stages of the study.

Statistical Analysis

Data were analyzed using the IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, United States). Variables were tested for normality, and descriptive statistics (mean ± standard deviation [SD], frequencies) were reported. For the comparison between the control group and the intervention group, the t-test for independent samples and the Mann-Whitney test were performed. For the comparison between the pre- and postexercise measurements, the *t*-test for dependent samples and Wilcoxon test were performed. The alpha level was set at 0.05.

Results

The study sample consisted of 53 women, 13 of whom were the control group and 40 of whom the intervention group. ►**Table 2** presents the demographic characteristics

Table 2 Demographic characteristics of participants per group.

	Control group	Intervention group	
	$n = 13$	$n = 40$	*p*-value
Age (in years): mean(±standard deviation)	34.00(±6.38)	37.65(±8.28)	0.152
Smoking: *n* (%)			0.340
No	10 (76.9%)	25 (62.5%)	
Yes	3 (23.1%)	15 (37.5%)	
Body mass index (kg/m^2): mean(±standard deviation)	20.82(±2.09)	21.82(±2.46)	0.190

Table 3 AIS and ESS scores, AHI, AAI, and sleep characteristics in both groups and after 4 months in the intervention group.

	CG ($n = 13$)	IG ($n = 40$)		CG versus baseline IG	IG: baseline versus after	CG versus after IG
		Baseline	After			
	Mean(±SD)	Mean(±SD)	Mean(±SD)	*p*-value	*p*-value	*p*-value
AIS	2.54 (±0.88)	2.23 (±1.05)	1.73 (±0.75)	0.336	< 0.001	0.002
ESS	2.46 (±0.52)	2.68 (±0.97)	2.05 (±0.59)	0.454	< 0.001	0.031
AHI (apnea- hypopnea/hour ofsleep)	3.32(±2.15)	2.61(±1.95)	2.22(±1.52)	0.287	0.220	0.111
AI (apnea/hour of sleep)	1.06(±1.20)	0.69 (±0.72)	0.66 (±0.69)	0.107	0.432	0.087
HI (hypopnea/hour of sleep)	2.35 (±1.86)	2.20 (±1.59)	1.50 (±1.12)	0.286	0.241	0.24
OAHI/hour of sleep	0.79 (±0.71)	1.11 (±1.36)	0.83 (±0.84)	0.835	0.106	0.755
CAHI/hour of sleep	1.70 (±1.83)	1.41 (±1.18)	1.20 (±0.98)	0.868	0.358	0.914
Snoring	4.88 (±9.06)	7.36 (±4.34)	1.78 (±3.64)	0.091	0.766	0.090
AAI (arousals/hour of sleep)	28.32 (±13.30)	30.47 (±10.44)	26.09 (±7.80)	0.736	0.002	0.302
Respiratory AAI (arousals/ hour of sleep)	2.73 (±3.27)	3.16 (±5.81)	1.90(±1.41)	0.828	0.751	0.794
Non-respiratory AAI (arousals/ hour of sleep)	26.87 (±12.72)	27.85 (±11.01)	24.18(±7.57)	0.794	0.018	0.367
RERA	0.96 (±1.70)	0.49 (±0.83)	0.55 (±0.98)	0.801	0.974	0.850

Abbreviations: AAI, autonomic arousal index; AHI, apnea-hypopnea index; AI, apnea index; CAI, central apnea index; CG, control group; ESS, Epworth Sleepiness Scale; HI, hypopnea index; IG, intervention group; OAHI: obstructive apnea-hypopnea index; RERA, respiratory effort related arousal; SD, standard deviation.

of the study participants. The two groups had similarities regarding age, smoking habits, and BMI.

Quality of Sleep

At baseline, the two groups were similar regarding sleep quality, as assessed by the SOMNOcheck micro-CARDIO. Moreover, the AIS score (2.54 ± 0.88 versus 2.23 ± 1.05; p =0.336) and the Epworth score (2.46 ± 0.52 versus 2.68 ± 0.97; $p = 0.002$) did not differ between the control group and the intervention group at baseline.

After 4 months of Pilates, the intervention group had a significantly lower AIS score (1.73 ± 0.75 versus 2.23 ± 1.05; $p < 0.001$) and Epworth score (2.05 ± 0.59 versus. 2.68 ± 0.97; $p < 0.001$) than at baseline. Moreover, the autonomic arousal index (AAI) (26.09 ± 7.80 versus. 30.47 ± 10.44; $p = 0.002$) and the non-respiratory AAI (24.18 ± 7.57 versus 27.85 ± 11.01; $p = 0.018$) were significantly improved after 4 months of Pilates (►**Table 3**).

Muscle Strength, Aerobic Capacity, Anaerobic Endurance, Balance, Flexibility

At baseline, the two groups had similarities in the fitness index (Harvard Step test), the Six-Minute Walk test, Sit and Reach test, the Flamingo test, anaerobic power, muscle strength, and abdominal muscle endurance. After 4 months of Pilates, the intervention group presented significant improvement in the fitness index (Harvard Step test) (74.8 ± 11.2 versus 59.4 ± 9.66; $p < 0.001$), in the distance walked in the Six-Minute Walk test (935.00 ± 186.77 m versus 713.58 ± 183.59 m; $p < 0.001$), in muscle strength (25.91 ± 4.19 N versus 23.59 ± 3.83 N; $p < 0.001$), in flexibility (29.97 ± 6.56 cm versus 26.79 ± 6.64 cm; $p < 0.001$], in balance (2.23 ± 1.87 versus 4.20 ± 1.68; $p < 0.001$) and in abdominal muscle endurance (19.03 ± 2.75 versus 14.76 ± 2.91; $p < 0.001$) compared to the baseline values (►**Table 4**).

Quality of Life

After 4 months of Pilates, the intervention group presented significant improvement in the scores on the general health (79.05 ± 2.12 versus 76.13 ± 2.13; $p = 0.005$) and social functioning (88.75 ± 2.32 versus 84.38 ± 2.68; $p = 0.005$) subscales of the 36-Item Short Form Health Survey (SF-36) compared to the baseline values (►**Table 5**).

Discussion

The goal of the present study was to examine if the regular practice of Pilates exercises increases the quality of sleep and the general activity level in premenopausal women. The main findings are that the systematic Pilates exercise improves quality of sleep (arousals), ESS (somnolence), AIS (insomnia), quality of life, and general physical activity.

Our study showed that Pilates improved both insomnia and sleepiness, which is particularly important for good sleep. Similar results were found by Leopoldino et al.;[17] in their study, the level of sleepiness showed significant improvement after 12 weeks of Pilates.[17] The American Sleep Disorders Association has recognized physical activity as a

Table 4 Fitness Index, Six-Minute Walk test, Sit and Reach test, Flamingo test, anaerobic power, muscle strength, and abdominal muscle endurance in both groups at baseline and after 4 months.

	CG ($n = 13$)	IG ($n = 40$)		CG versus baseline IG	IG: baseline versus after	CG versus after IG
		Baseline	After			
	Mean (±SD)	Mean (±SD)	Mean (±SD)	*p*-value	*p*-value	*p*-value
Fitness Index (Harvard Step test)	64.1 (±8.83)	59.4 (±9.66)	74.8 (±11.2)	0.120	< 0.001	0.002
Six-Minute Walk test: distance in meters	835.6 (±249.1)	713.58 (±183.59)	935.00 (±186.77)	0.063	< 0.001	0.132
Bosco Repeat Jump	24.00 (±4.00)	23.73 (±3.90)	24.20 (±3.50)	0.701	0.084	> 0.999
Muscle strength (Newtons)	21.96 (±2.24)	23.59 (±3.83)	25.91 (±4.19)	0.154	< 0.001	0.002
Sit and Reach test (cm)	26.00 (±7.22)	26.79 (±6.64)	29.97 (±6.56)	0.926	< 0.001	0.093
Flamingo test (total number of falls or loss of balance in 60 seconds)	3.31 (±1.32)	4.20 (±1.68)	2.23 (±1.87)	0. 072	< 0.001	0.046
Abdominal muscle endurance (number of correctly performed folds in 30 seconds)	16.69 (±3.15)	14.76 (±2.91)	19.03 (±2.75)	0.087	< 0.001	0.007

Abbreviations: CG, Control group; IG, Intervention group; SD, standard deviation.

Table 5 Quality of life parameters in both groups and after 4 months in the intervention group.

Parameter	CG ($n = 13$)	IG ($n = 40$)		CG versus baseline IG	IG: baseline versus after	CG versus after IG
		Baseline	After			
	Mean (± SD)	Mean (± SD)	Mean (± SD)	*p*-value	*p*-value	Mean (± SD)
Physical functioning	93.9 (± 12.1)	93.38 (± 1.69)	93.18 (± 1.38)	0.739	0.491	0.377
Limiting roles due to physical health	78.9 (± 20.0)	91.25 (± 3.17)	90.63 (± 3.32)	0.010	0.317	0.013
Physical pain	93.1 (± 15.9)	83.50 (± 2.05)	84.44 (± 2.32)	0.006	0.572	0.008
General health	90.4 (± 11.4)	76.13 (± 2.13)	79.05 (± 2.12)	0.001	0.005	0.005
Emotional wellness	85.9 (± 15.4)	69.60 (± 2.85)	69.60 (± 2.85)	0.002	> 0.999	0.002
Social functioning	85.6 (± 15.18)	84.38 (± 2.68)	88.75 (± 2.32)	0.914	0.005	0.414
Limiting roles due to emotional problems	79.5 (± 21.7)	82.50 (± 4.77)	82.50 (± 4.77)	0.302	> 0.999	0.302
Energy - Fatigue	78.9 (± 12.4)	68.88 (± 2.13)	68.88 (± 2.13)	0.012	> 0.999	0.012

Abbreviations: CG, control group; IG, intervention group; SD, standard deviation.

nonpharmacological intervention that is highly effective for improving sleep patterns, enhancing the levels of daytime sleepiness,[17] increasing the levels of serotonin, the synchronization of the biological clock, and the indirect improvement in thermoregulation.[18]

In addition, systematic Pilates exercise improved the AAI, which is the most important factor to evaluate the quality of sleep. The less the awakenings during sleep, the better the quality of sleep. In a recent meta-analysis, the autjors[19] found that the Pilates group had significantly lowered the total score on the Pittsburgh Sleep Quality Index (PSQI) compared with the nonexercising control group, whereas no significant improvement in use of sleep medication was observed. Ashrafinia et al.[20] showed that Pilates exercises appeared to improve sleep quality in primigravida postpartum women. The intervention group showed a significant improvement in subjective sleep quality, sleep latency, daytime dysfunction, and total PSQI score ($p < 0.001$); however, there was no difference in sleep duration, habitual sleep efficiency, and sleep disturbance between the groups.[20]

Moreover, Pilates improves muscle strength, flexibility, balance, and abdominal muscle endurance in premenopausal women. Kloubec[2] demonstrated that in active middle-aged men and women, exposure to Pilates exercise for 12 weeks, for two 60-minute sessions per week, was enough to promote statistically significant increases in abdominal endurance, hamstring flexibility, and upper-body muscular endurance. Participants did not demonstrate improvements in either posture or balance when compared with the control group.[2]

In the present study, there was a significant improvement in the general health and social functioning subscales of the SF-36 in the Pilates group. These results are similar to other studies, which have reported that the Pilates method increased the ratings regarding general health, physical aspects, bodily pain, and functional capacity.[17,21]

A possible limitation of the present study is the relatively small number of participants; however, the results are clear, and the involvement of the control group for the baseline measurements strengthens the results of the study. Nevertheless, these results need to be further investigated.

Conclusions

Pilates exercises appeared to improve sleep quality (AAI, AIS, and ESS) in premenopausal women, as well as muscle strength, anaerobic fitness, anaerobic power, balance, flexibility, general health, and quality of life (SF-36).

Funding
The author(s) received no financial support for the research.

Conflict of Interests
The authors have no conflict of interests to declare.

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