Artigo Original

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Effectiveness of pilates method for the posture and flexibility of women with hyperkyphosis

Eficácia do método pilates para a postura e flexibilidade em mulheres com hipercifose

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RESUMO: O objetivo do estudo foi avaliar a eficácia do método Pilates em melhorar a postura e a flexibilidade em mulheres com hipercifose. Foi conduzido um ensaio clínico, controlado e randomizado com 41 mulheres (média de idade= 59 ± 9 anos), divididas aleatoriamente em dois grupos: 22 no grupo de intervenção e 19 no grupo controle. As participantes passaram por dois conjuntos iguais de mensurações, antes e depois de um período de treinamento/ controle, que foram compostos por: características sociodemográficas e clínicas, peso, altura, índice de massa corporal (IMC), percentual de gordura corporal (três pregas cutâneas), razão quadril-cintura (medidas das circunferências). Além desses, o grau de cifose foi mensurado pelo ângulo de Cobb através de um exame radiológico (Raio-X) com o paciente em pé, a flexibilidade foi medida com um flexímetro e a postura analisada através de quatro fotografias (visão anterior, perfil direito e esquerdo e posterior) com o software Fisimetrix. Todas as medições foram realizadas pelo mesmo observador, que foi treinado e cegado quanto à alocação dos sujeitos. Os exercícios foram realizados duas vezes por semana (60 minutos cada aula) durante 30 semanas. Antes do estudo, os dois grupos não diferiram estatisticamente em nenhuma das características analisadas. Após o estudo foram detectadas diferenças significativas entre os dois grupos em termos de: ângulo da cifose torácica (grupo experimental= -8,0 ± 7,5 graus; grupo controle= -0,6 ± 3,4 graus; p <0,001), flexibilidade de todos os movimentos da região cervical e do tronco, IMC (p <0,001), percentual de gordura corporal (p <0,001) e todos os movimentos (p <0,05), com exceção da flexão anterior do tronco. Portanto, o método Pilates é eficaz em melhorar a postura e flexibilidade em mulheres mais velhas com hipercifose, bem como em reduzir a gordura corporal.

Palavras-chave: Treinamento; Cifose; Postura; Flexibilidade; Composição Corporal.

ABSTRACT: The aim of the study was to evaluate the effectiveness of the Pilates method in improving posture and flexibility in women with hyperkyphosis. A randomized controlled trial was performed with 41 women (mean age of 59 ± 9 years) randomized into two groups: 22 in the intervention group and 19 in the control group. Subjects undertook two equal sets of assessment, before and after a training/ control period, which comprised of sociodemografic and clinical characteristics, height, weight, body mass index (BMI), body fat percentage (three skin fold measurement), waist-hip ratio (circumference measurements). In addition to these, the degree of kyphosis was measured by the Cobb angle on a standing lateral radiograph, flexibility was measured with a fleximeter and posture assessment was carried out with the Fisimetrix software through four view photographs (front, right profile, left profile and back). All measurements were carried out by the same observer, who was trained and blinded with respect to the subjects' group allocation. The exercises were carried out twice a week (60-minute class) for 30 weeks. Before the study, the two groups did not differ statistically in terms of any of the characteristics analyzed. After the study, statistically significant differences were found between the two groups in terms of: kyphosis angle (experimental group = -8,0 ± 7,5 degrees; control group = -0,6 ± 3,4 degrees; p <0,001), flexibility of all cervical region and trunk movements, BMI (p <0,001), body fat percentage (p <0,001) e all body movements (p <0,05), except for trunk flexion. Therefore, the Pilates method is effective in improving posture and flexibility in women with hyperkyphosis as well as reducing body fat.

Key Words: Training; Kyphosis; Posture; Pliability; Body Composition.

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Introduction

In general, human posture undergoes modifications over the years and several factors may influence the maintenance and formation of the primary and secondary curves of the spine. In anatomical terms, thoracic kyphosis refers to the posterior primary curvature. In some people, this curvature maintains its mobility, while in others it becomes rigid and fixed[1]. After menopause, sedentary women may show a change in this curvature, increasing the kyphosis level (hyperkyphosis), altering the axial and pelvic alignment. In more severe cases, it can interfere with the pulmonary function and lead to an unbalanced gait, which can decrease daily living activities[2,3]. Additionally, in elderly people, hyperkyphosis is associated with difficulties in daily living activities and a decline in physical condition, resulting in impaired metabolic functions, which may lead to an increase in the mortality rate[4]. After the age of 55, the excessive curvature and forward positioning of the head causes a height decrease that ranges from 6% to 11%, besides increasing the fracture risk, independent from the bone mineral density[5,6].

Some studies show that physically active people have less chance of developing kyphosis, compared to sedentary people[2]. Back extension exercises as well as exercises involving a greater number of muscle groups may decrease the deformity or delay the deforming process, helping on the maintenance of good posture[2,7]. In this context, the Pilates method is said to be a movement reeducation technique composed of exercises deeply rooted in the human anatomy, able to restore and increase flexibility and muscle strength, improve breathing, correct posture and prevent injuries[1].

In the Pilates method, the main exercises aim to develop the strength of the extensor muscles of the back and abdomen, particularly the abdominal transverse, which refers to the center of strength and coordinates breathing and movement[8]. When the center of strength is weak, without stability and resistance, the movement in the body's distal portions is diminished, damaging the proximal portions and increasing the stress on joints and ligaments, thereby leading to degeneration. Through the neuromuscular control technique, there is an increase on the stability of this region, which leads to improvements in posture and movement control[1]. One of the most important elements in the application of this method is the observation of the correct pelvic alignment, which allows for the accurate performance of the movements and the stability of the lumbar region[1]. This stability and alignment leads to the alignment of the pelvis with the diaphragm, which further enhances the trunk stability. This facilitates the action of the abdominal transverse, oblique and multifidus muscles, which are the back stabilizers and act as its protectors, allowing freedom of movement[9,10]. Recent investigations have demonstrated that specific exercises for strengthening the multifidus and abdominal transverse may contribute to the reduction of lumbar back pain and the stability of all the spine segments[9,10].

Flexibility is limited by several factors: the shape of the articular surfaces, adhesions, contracture and scars on the soft tissues, and contraction components, ligaments, tendons and fascia[5]. In the Pilates method, exercises for flexibility are constantly carried out, mainly in the hip and trunk's extensor and flexor muscles.

In order to achieve total physical conditioning, Joseph Pilates conceived his method aiming to purify the bloodstream through oxygenation. When executing full inspirations and expirations, there is an increase in the efficiency of the gas exchange, bringing more energy and vitalizing the whole system[11]. The breathing technique is an important element for increasing oxygenation, as well as aiding the venous return and the action of the lumbar region stabilizer muscles. The pulmonary alterations caused by the normal aging process are mainly caused by the loss of elasticity of the pulmonary tissue and chest wall[2].

Despite the knowledge and the utilization of the Pilates method worldwide, methodologically adequate clinical trials proving the efficiency of this therapeutic method are still scarce. This study, therefore, aimed to evaluate the effectiveness of a physical training program utilizing the Pilates method in improving posture and flexibility in women with thoracic hyperkyphosis.

Material and Methods

Study design: randomized Controlled Trial; Sample: the volunteers were Caucasian women with a radiological diagnosis of hyperkyphosis. The participants were recruited from the city of Porto Alegre and its metropolitan region in the state of Rio Grande do Sul, Brazil. Recruitment was carried out via radio, newspapers and internet. This study was conducted from April 2009 to December 2010. The Research Ethics Committee of the Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS) approved the study (protocol no. 08/04448) and individual informed consents were obtained from all participants previous to their engagement.

Forty-one women over 45 years of age with hyperkyphosis (Cobb angle > 45º) were included in this study. The major exclusion criteria were: a body mass index >30, previous or actual engagement in Pilates' classes, a kyphosis angle smaller than 45º, and vertebrae compression fracture or some other spine disease detected by radiological diagnosis. Other reasons for excluding from the study were an attendance rate lower than 30% or engagement in another type of physical activity while in the research program.

Subjects undertook two equal sets of assessment, 30 weeks apart. All measurements took place at the PUCRS's Physical Activity Laboratory and at the Exercise Research Laboratory of the Universidade Federal do Rio Grande do Sul. Participants underwent laboratory tests, physical examination and interviews. The first set of assessments took place soon after subjects entered the study. After the first assessment was carried out subjects were randomly allocated into two groups: the experimental one (intervention) with 22 women and the control group with 19 women (no intervention; see Flow Diagram). No active or placebo intervention was prescribed for the control group. Controls were asked to carry on their normal activities for the next 30 weeks. The exercise group underwent a 30-week Pilates training period. At the end of the 30-week period, exercisers and controls underwent the second set of measurements. All measurements were carried out by the same observer, who was trained and blinded with respect to the subjects' group allocation.

Variables analyzed

Before and after the intervention, the following data were collected from all the participants:

Life style and clinical conditions

Data were gathered on daily consumption of alcohol, smoking, current engagement in any type of exercises, if on any kind of a diet, medication intake and any known disease or dysfunction.

Body mass index (BMI) was calculated by dividing weight (kg) by the squared height (m2). Body weight was measured using a scale (G. TEC, Oregon Scientific) and height was measured using a stadiometer (Cardiomed Seca).

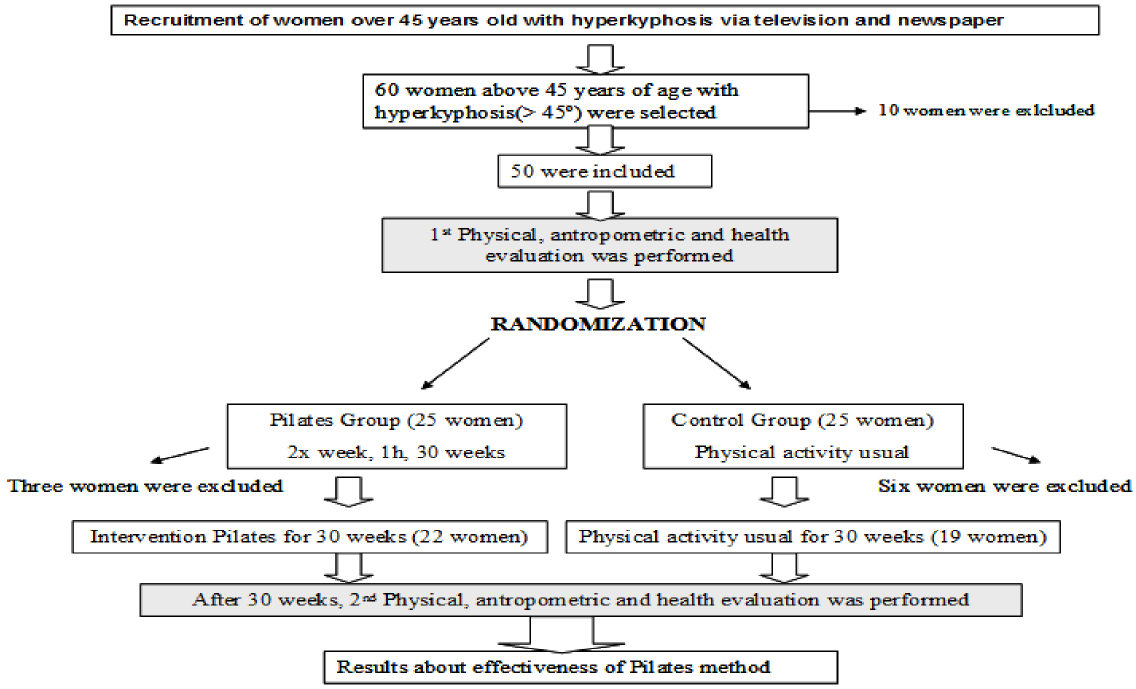
The body fat percentage was calculated by the measurement of skin folds – using a scientific plicometer (Cescorf) and a protocol for functional assessment (Jackson and Pollock) of three skinfolds (triceps, suprailiac and thigh). The absolute values of skinfold thickness used individually or as a sum of skinfolds are quite useful for determining the results obtained with training programs.

Waist-hip ratio was determined from the circumference measurements. A flexible metal tape (Sanny Medical) was used. The waist circumference was measured at the midpoint between the last rib and the iliac crest; the hip circumference was measured at the point of greatest gluteal protuberance.

Posture assessment was carried out by four view photographs (front, right profile, left profile and back). The posture analyses were carried out with the Fisimetrix software.

Flexibility was measured with a fleximeter (Fleximeter - Code Research Institute) using a flexibility protocol. The analysis was carried out using the angles of the cervical column (flexion, extension, and rotation and lateral flexion of both sides), hip (flexion, extension, abduction and adduction of right and left legs), shoulders

Flow Diagram



(flexion, extension, adduction and abduction of right and left sides) and trunk (flexion, extension and lateral flexion of the right and left sides).

The degree of kyphosis was measured by the Cobb angle taken from a standing lateral X-rays.

Training Protocol Study

Training was carried out in twice a week in 60-minute sessions, for a total of 30 weeks. Basic level Pilates method exercises were used. The degree of difficulty of the exercises was gradually increased and their focus was on keeping a neutral posture in different gravity orientations. Exercises were carried out in an open and closed sequence, with variations on the floor and devices. Training of all participants was provided by the same instructor.

Planning and periodization - Macro cycle

Three macro cycles were used as shown below.

- 1st Macro cycle - (6 weeks) - Period of neural adaptation; general exercises at the Pilates basic level and diaphragmatic deep breathing exercises.
- 2nd Macro cycle - (20 weeks) - Inclusion of specific exercises to strengthen and stretch. Strength: trunk extensors, latissimus dorsi, serratus anterior, rotator cuff and abdominal muscles. Stretching: chest, abdominal, intercostal, iliac-psoas, trapezius and cervical muscles. Throughout this period the series were maintained while the training resistance was increased with the use of springs and variations of the joint angles and distance.
- 3rd Macro cycle - (4 weeks): Maintenance of resistance, stretching and relaxation techniques.

This period involved exercises using specific devices of the method (Cadillac, Reformer, Wunda Chair, Wall Unit, Spine Corrector, Ladder Bar, Circles fit), as well as floor exercises without any device. The exercises applied were: (1) Reformer – scapular movement and stabilization, mermaid, footwork, running, bend and stretch, leg circles, frog, single thigh stretch, front rowing, arms pulling straps, long stretch, elephant, chest expansion, arm (internal rotation, external rotation, adduction, abduction), twist, straight forward, bicep curls, hip rolls[12]; (2) Cadillac and Wall – cat prep, roll-down, lat press, press down, press down with triceps, breathing, lat pull, scapula isolation, push-thru on back with roll up, swan, side arm pull, mermaid, leg press, bicep curls supine, midback series, back rowing press, font rowing preps, lower, middle, upper trap strengthener, chest expansion, bicep curls, tricep press, side arm work, snow angels, standing pull down, leg circles, walks, abduct top leg, adduct top leg, side stretch[12]; (3) WundaChair – footwork, hamstring press hips down, adductor press, ankle exercise, crossover press, standing leg press, forward step up, side step up, triceps press sitting, cat standing front, cat kneeling, cat standing back, horseback, elephant, swan, swan dive from floor, mermaid, mermaid kneeling[12]; (4) abdominal exercises were carried out on the floor, with the utilization of a thread-band and ball. For the extension trunk and stabilization of the pelvis, a half-moon was utilized (spine corrector)[12]. Besides the strengthening work, stretching exercises were applied for shortened muscle groups, with the utilization of a tonic-ball and Franklin ball.

Statistical analysis

Data were collected directly in a database developed for the study, in Access 2003, and analyzed using the SPSS program, version 17. The descriptive analysis was performed by frequencies, medians, means and standard deviations. Frequencies of the qualitative variables were compared between the groups using the chi-square test or Fisher's exact test (when an expected value was smaller than 5 it was obtained in the chi-square test). Student's t test for paired samples was used for comparing the means of quantitative variables before and after the intervention. The comparisons of the means of variables measured before the intervention and the mean differences (final values less the initial values) between the groups were carried out by Student's t test for independent samples, taking into consideration the equality of the variances determined by Levene's test. P less than 0.05 was considered significant.

Results

Forty-one women with a mean age of 59 ± 9 years (range= 45 to 78 years) were studied. The mean age, marital status, clinical and lifestyle characteristics were similar for the two groups (Table 1).

At the beginning of this study, the intervention and control groups did not differ in terms of height (Table 2). After the intervention, an increase of 1.1 cm was observed in the intervention group ($P<0.001$), which also showed a significant reduction in the Cobb angle (8 degrees; $P<0.001$), as shown in Table 2. No significant change was observed in the control group. BMI and percentage of body fat also showed significant differences ($P<0.001$) in both groups (Table 2). Nevertheless, these differences were in the opposite direction; they decreased in the intervention group and increased in the control group. In relation to the postural measures (Table 3) there was no significant difference between the groups before the training. In the intervention group, a reduction in the cervical-thoracic distance and an increase in height of the shoulder and scapula were observed, which was not seen in the control group (Table 3).

Concerning cervical and trunk flexibility (Table 4), the two groups were similar before the intervention. In the control group, a small reduction was found in all means, but without any statistical significance ($P>0.05$), except for neck lateral flexion to the left. The group that underwent Pilates training showed a significant improvement in the flexibility of all cervical and trunk movements. Comparing the means between the groups, before and after the intervention, significant differences ($P <0.05$) were found for all movements except trunk flexion, which showed only a tendency toward statistical significance ($P=0.066$) due to a large standard deviation.

The results of the hip flexibility are presented in Table 5. In the first evaluation, there was no significant difference between the two groups in any of the movements studied. For all movements, a significant improvement was observed only in the group submitted to the Pilates training program. The difference in flexibility change between the groups was significant ($P \leq 0.001$) for all hip movements.

Table 1. Demographic, clinical and lifestyle characteristics of the study population and the comparison between the intervention (n=22) and control (n=19) groups

Variable	Total Population N(%)	Groups Intervention N (%)	Control N (%)	*p*
Age Group (years)				
45-49	7 (17.1)	2 (9.1)	5 (26.3)	
50-54	11 (26.8)	8 (36.4)	3 (15.8)	
55-59	5 (12.2)	3 (13.6)	2 (10.5)	0.127&
60-64	10 (24.4)	7 (31.8)	3 (15.8)	
65 or more	8 (19.5)	2 (9.1)	6 (31.6)	
Marital Status				
single	9 (22.0)	4 (18.2)	5 (26.3)	
married	28 (68.3)	15 (68.2)	13 (68.4)	0.563&
divorced	2 (4.9)	2 (9.1)	0 (0.0)	
widowed	2 (4.9)	1 (4.5)	1 (5.3)	
Clinical conditions				
Hypertension	9 (22.0)	5 (22.7)	4 (21.1)	1.000$
Heart disease	3 (7.3)	1 (4.5)	2 (10.5)	0.588$
Asthma	6 (14.6)	1 (4.5)	5 (26.3)	0.080$
Thyroid diseases	5 (12.2)	2 (9.1)	3 (15.8)	0,649$
Diabetes	2 (4.9)	1 (4.5)	1 (5.3)	1.000$
Osteoporosis	6 (14.6)	4 (18.2)	2 (10.5)	0.668$
Orthopedic problems	10 (24.4)	4 (18.2)	6 (31.6)	0.469$
Back pain	26 (63.4)	13 (59.1)	13 (68.4)	0.536&
Stress	10 (24.4)	6 (27.3)	4 (21.1)	0.727$
Taking medication	27 (65.9)	13 (59.1)	14 (73.7)	0.326&
Lifestyle				
Daily consumption of alcohol*	11 (30.6)	6 (31.6)	5 (29.4)	0.888&
Smoker	11 (26.8)	6 (27.3)	5 (26.3)	0.945&
Currently doing exercises	14 (34.1)	8 (36.4)	6 (31.6)	0.747&
On some kind of diet	5 (12.2)	3 (13.6)	2 (10.5)	1.000$

& p-values calculated by Pearson's chi-square test.$ *p*-values calculated by Fisher's exact test.
* Only 36 women responded to this issue (19 of the intervention group and 17 of the control group)

Table 2. General comparison of anthropometric measurements and kyphosis angle measured in X-ray between the intervention (n=22) and control (n=19) groups, before and after the intervention period

Variable	Group Intervention m ± sd	Control m ± sd	*p*
Body weight (Kg)			
Before	64.54 ± 9.16	63.21 ± 12	0.693
After	63.28 ± 10.19	64.05 ± 11.01	---
p	0.090	0.064	---
Difference	-1.26 ± 3.33	0.84 ± 1.79	0.693
Height (m)			
Before	1.61 ± 0.07	1.60 ± 0.06	0.389
After	1.62 ± 0.07	1.59 ± 0.07	---
p	<0,001	0.110	---
Difference	0.01 ± 0.01	0.00 ± 0.01	**<0.001**
Body mass index (kg/m²)			
Before	24.83 ± 3.4	24.79 ± 4.17	0.978
After	23.95 ± 3.41	25.29 ± 3.94	---

p	0.009	0.007	---
Difference	-0.88 ± 1.42	0.49 ± 0.68	**0.001**
Fat percentage (%)			
Before	28.37 ± 4.50	28.83 ± 4.66	0.897
After	25.62 ± 4.93	28.61 ± 4.77	---
p	<0.001	0.663	---
Difference	-2.75 ± 2.44	-0.22 ± 2.08	**0.001**
Waist-hip ratio			
Before	0.85 ± 0.07	0.86 ± 0.05	0.715
After	0.81 ± 0.05	0.85 ± 0.05	---
p	0.001	0.501	---
Difference	-0.04 ± 0.05	-0.01 ± 0.06	0.075
Kyphosis angle (Cobb)			
Before	63.50 ± 9.78	58.83 ± 8.73	0.124
After	55.50 ± 11.97	58.22 ± 8.59	---
p	<0.001	0.454	---
Difference	-8.00 ± 7.50	-0.61 ± 3.38	**<0.001**

p-values calculated by Student's t test for independent sample comparisons between groups and for paired comparisons between before and after the intervention period.

Table 3. Comparison of the patients' postural measurements (four view photographs) between the intervention (n=22) and control (n=19) groups, before and after the intervention period

Variable	Group		*p*
	Intervention m ± sd	Control m ± sd	
Cervical-thoracic distance – right profile			
Before	9.81 ± 1.45	9.40 ± 1.80	0.427
After	7.53 ± 1.35	9.65 ± 1.76	---
p	<0.001	0.228	---
Difference	-2.28 ± 1.43	0.25 ± 0.83	**<0.001**
Cervical-thoracic distance – left profile			
Before	8.73 ± 1.35	8.80 ± 2.20	0.910
After	7.19 ± 1.38	9.10 ± 2.04	---
p	<0.001	0.439	---
Difference	-1.55 ± 1.67	0.30 ± 1.61	**0.001**
Height of right shoulder– back			
Before	130.27 ± 6.23	129.61 ± 6.00	0.736
After	132.64 ± 6.08	130.17 ± 5.89	---
p	<0.001	0.243	---
Difference	2.36 ± 2.52	0.56 ± 1.95	**0.017**
Height of left shoulder – back			
Before	131.82 ± 6.38	130.22 ± 6.13	0.428
After	133.64 ± 5.74	130.39 ± 6.00	---
p	0.002	0.729	---
Difference	1.82 ± 2.38	0.17 ± 2.01	**0.025**
Height of right scapula – back			
Before	117.86 ± 6.30	117.78 ± 6.12	0.966
After	121.59 ± 5.84	117.33 ± 7.30	---
p	0.001	0.594	---
Difference	3.73 ± 4.58	-0.44 ± 3.47	**0.003**
Height of left scapula – back			
Before	118.36 ± 6.30	118.22 ± 5.80	0.942
After	122.00 ± 5.83	118.00 ± 7.05	---
p	<0.001	0.760	---
Difference	3.64 ± 3.97	-0.22 ± 3.04	**0.002**

p-values calculated by the Student's t test for independent samples in comparisons between the groups, and for paired samples in comparisons between the groups, before and after the intervention period.

Table 4. Comparison of cervical and trunk flexibility measurements between the intervention (n=22) and control (n=19) groups, before and after the intervention period

Variable	**Group**		***p***
	Intervention m ± sd	**Control m ± sd**	
Cervical extension			
Before	49.45 ± 13.07	49.44 ± 17.76	0.998
After	58.05 ± 11.12	47.44 ± 13.35	---
p	0.013	0.560	---
Difference	8.59 ± 14.9	-2 ± 14.27	**0.028**
Cervical flexion			
Before	43.64 ± 13.8	49.83 ± 17.22	0.214
After	60.86 ± 10.51	44.78 ± 12.06	---
p	<0.001	0.340	---
Difference	17.23 ± 14.02	-5.06 ± 21.83	**<0.001**
Cervical rotation to the right			
Before	58.45 ± 12.04	56.00 ± 12.50	0.532
After	71.14 ± 7.77	52.78 ± 9.43	---
p	0.000	0.288	---
Difference	12.68 ± 9.63	-3.22 ± 12.47	**<0.001**
Cervical rotation to the left			
Before	58.18 ± 11.61	57.72 ± 13.03	0.907
After	71.50 ± 8.11	55.22 ± 9.88	---
p	<0.001	0.341	---
Difference	13.32 ± 13.16	-2.5 ± 10.82	**<0.001**
Cervical lateral flexion to the right			
Before	36.05 ± 10.66	33.06 ± 9.71	0.364
After	41.73 ± 8.00	30.11 ± 8.28	---
p	0.020	0.138	---
Difference	5.68 ± 10.58	-2.94 ± 8.03	**0.007**
Cervical lateral flexion to the left			
Before	33.27 ± 9.61	38.61 ± 8.27	0.071
After	42.86 ± 8.44	33.22 ± 8.39	---
p	0.001	0.014	---
Difference	9.59 ± 11.23	-5.39 ± 8.32	**<0.001**
Trunk flexion			
Before	111.86 ± 28.35	115.56 ± 31.18	0.697
After	127.59 ± 12.97	114.67 ± 18.16	---
p	0.007	0.904	---
Difference	15.73 ± 24.57	-0.89 ± 30.88	0.066
Trunk extension			
Before	20.73 ± 9.05	21.33 ± 7.14	0.818
After	24.59 ± 7.37	18.22 ± 5.53	---
p	0.079	0.052	---
Difference	3.86 ± 9.80	-3.11 ± 6.32	**0.013**
Trunk lateral flexion to the right			
Before	31.36 ± 11.84	34.94 ± 14.25	0.391
After	37.23 ± 8.44	29.17 ± 8.39	---
p	0.035	0.146	---
Difference	5.86 ± 12.19	-5.78 ± 16.10	**0.013**
Trunk lateral flexion to the left			
Before	31.77 ± 11.87	33.17 ± 11.45	0.709
After	38.64 ± 7.73	28.89 ± 8.37	---
p	0.030	0.139	---
Difference	6.86 ± 13.82	-4.28 ± 11.70	**0.010**

p-values calculated by Student's t test for independent samples in comparisons between the groups, and for paired samples in comparisons between the groups, before and after the intervention period

Table 5. Comparison of the hip flexibility measurements between the intervention (n=22) and control (n=19) groups, before and after the intervention period

Variable	**Group**	***p***

	Intervention m ± sd	Control m ± sd	
Flexion of the right hip			
Before	57.32 ± 20.86	69.61 ± 35.47	0.180
After	79.50 ± 13.16	62.67 ± 15.89	---
p	<0.001	0.261	---
Difference	22.18 ± 19.72	-6.94 ± 25.33	**<0.001**
Extension of the right hip			
Before	17.95 ± 9.84	23.94 ± 11.5	0.084
After	43.41 ± 12.74	22.89 ± 5.33	---
p	<0.001	0.657	---
Difference	25.45 ± 15.39	-1.06 ± 9.9	**<0.001**
Abduction of the right hip			
Before	50.45 ± 16.32	48.17 ± 17.29	0.670
After	68.5 ± 13.23	47.17 ± 14.47	---
p	<0.001	0.714	---
Difference	18.05 ± 15.28	-1 ± 11.37	**<0.001**
Adduction of the right hip			
Before	23.23 ± 9.14	22.94 ± 14.71	0.941
After	31.14 ± 7.14	21.44 ± 15.14	---
p	0.002	0.369	---
Difference	7.91 ± 10.28	-1.5 ± 6.9	**0.001**
Flexion of left hip			
Before	58.82 ± 19.81	69.17 ± 32.69	0.224
After	82.86 ± 10.28	61.17 ± 11.88	---
p	<0.001	0.245	---
Difference	24.05 ± 15.82	-8 ± 28.19	**<0.001**
Extension of the left hip			
Before	22.23 ± 11.22	23.72 ± 12.15	0.688
After	42.73 ± 13.47	22.39 ± 8.25	---
p	<0.001	0.454	---
Difference	20.5 ± 14.14	-1.33 ± 7.39	**<0.001**
Abduction of left hip			
Before	49.05 ± 13.56	50.56 ± 15.62	0.745
After	64.91 ± 12.87	50.61 ± 13.55	---
p	<0.001	0.981	---
Difference	15.86 ± 15.7	0.06 ± 9.52	**<0.001**
Adduction of left hip			
Before	24.91 ± 11.77	25.39 ± 12.36	0.901
After	31.86 ± 7.25	21.56 ± 10.66	---
p	0.001	0.094	---

Difference	6.95 ± 8.92	-3.83 ± 9.16	**0.001**

p-values calculated by Student's t test for independent samples in comparisons between the groups, and for paired samples in comparisons between the groups, before and after the intervention period

Discussion

The Pilates method is believed to improve posture and flexibility. Nevertheless, few studies are available to provide scientific support for this belief. Most previous studies were conducted in young subjects, and the effect of Pilates exercise on spinal posture and flexibility in older women remained unclear. We found few studies in the literature about the Pilates method and kyphosis in women, and only one on back posture and flexibility in older women[7].

In relation to posture, in our study a significant benefit with the utilization of Pilates method was observed, with a reduction in the kyphosis angle measured by X-rays, and the cervical-thoracic distance (observed in the profile photographs), beyond the elevation of the scapula and shoulders, also resulting in a small height gain. Thus, it evidences that the engagement in an exercise program with emphasis on strengthening the trunk extensor muscles aids the vertebral column realignment and may prevent the development of diseases or dysfunctions related to an impaired posture. These results are confirmed by those obtained from a longitudinal study of women in the menopause, for whom Pilates exercises were used to strengthen the back extensors and resulted in a 2.8º reduction in the kyphosis of some participants after a period of two years[13].

In another study, with the same age group population, a three month intervention with Pilates training produced results without statistical or clinical significance[7]. Considered as a method that involves a whole educational and physiological process, such as body perception, neural adaptation and movement control, this process may be slow regardless of age because of its complexity. According to the literature, the period of neural adaptation takes from four to eight weeks. Only after this period, the muscles are prepared for conditioning, with the application of exercises with greater intensity [8,9,14]. It is likely, therefore, that the 10 week training period adopted by Kuo et al.[7] was insufficient to produce the results shown by the two-year training used by Eiji and Mehesheed[13] and by our 30 week training. Another reason for the difference between the findings our study and those from Kuo et al.[7] may lie in the fact that all of our participants had kyphosis and theirs did not.

Flexibility is also a theme that has been approached in many studies on the Pilates method. It is said that, despite the fact that the aging process brings about various changes that result in limited flexibility, with the Pilates method an increase in joint range of motion can be observed, regardless of age. This was observed in our results obtained with older women, which demonstrate a significant improvement in cervical flexibility of the trunk and hip with Pilates training. In a study performed by La Touche et al.[15], it was suggested that these changes contributed to the promotion of posture and relief of pain and discomfort in the neck and lumbar areas. The authors reported that with the increasing mobility and mastery of these segments' motions, the movements become harmonious, precise and more secure.

Our study also corroborates the findings of Emery et al.[16], who performed a randomized clinical trial to determine the effect of a Pilates training program on arm-trunk posture, strength, flexibility and biomechanical patterns during a functional shoulder flexion task in 19 younger subjects (9 controls: 5 men; mean age = 28.6 ± 3.7 years; 10 experimental: 5 men, mean age = 33.1 ± 8.6 years). Their subjects were assessed twice, before and after a 12 week period, during which the experimental group was submitted to a Pilates training program (two 1-h sessions per week). After training, the subjects showed smaller static thoracic kyphosis during quiet sitting and greater abdominal strength. The experimental group also showed reduced posterior and mediolateral scapular displacements, greater upper thoracic extension and lumbar lateral flexion, as well as higher activity of the ipsilateral cervical spine erector, contralateral rhomboid muscles and lower activity of the ipsilateral lumbar spine erector during the shoulder flexion task. Regardless of the methodological differences between the two studies, such as the fact that in ours the Pilates training was performed only by women who were on average 30 years older than their subjects, who trained for a period of time almost three times longer than theirs, our subjects also improved on the results expected from the period of neural adaptation, reaching greater resistance gains and also maintenance of the lengthening of the skeletal muscle architecture resulting from their training program. So, even with an older sample, the Pilates method has proven effective in women decreasing their kyphosis and increasing their flexibility.

After the intervention, we found significant differences in BMI and fat percentage between the older women who performed the Pilates exercises and their controls. The plausible biological explanation is that aging may produce changes in the distribution of slow-twitch and fast-twitch muscle fibers, mainly because it is associated with increased fat mass due to an imbalance between fat deposition and fat mobilization, which ultimately results from an imbalance between energy intake and energy expenditure[17]. Thus, there is a decreased ability to mobilize fat[18]. To lose fat, moderate strength and endurance training is more effective than Pilates, although the Pilates method is considered more complex[19]. Notwithstanding, the group that underwent the intervention probably had a higher energy expenditure with the basic exercises. Going along with this reasoning, they also presented a significant reduction in the waist/hip ratio which, according to the literature, is highly predictive of chronic metabolic disease risk[19]. Most of the studies to evaluate the effect of Pilates exercise on BMI or body composition have been conducted in young subjects or in subjects that were already engaged in some physical activity, even so they have shown that Pilates holds promise as a means of reducing obesity[20]. In this case, the elderly population can also benefit from regular Pilates exercise, as shown by the results of the present study.

In the comparison of the skinfold measurements, there was a significant reduction in almost all measurements in the experimental group, in addition to the waist and hip circumferences. This suggests that changes in posture through exercises aimed chiefly at strengthening the muscle groups responsible for trunk stability, mainly the abdominals, which are constantly used in forced expiration and almost all body movements, are the ones that contributed to the changes in these measurements. It is suggested that the posture correction results in a better adipose tissue distribution[21].

Segal et al.[6] suggest that effects of Pilates training on body composition, health status, and posture are more limited and may be difficult to establish. They carried out an observational study to evaluate the effects of Pilates training on flexibility and body composition and showed that median fingertip-to-floor distance improved significantly from baseline, but no statistically significant changes were observed in trunk lean body mass, height, weight, or other body composition parameters[6]. Nonetheless, in the present study all of these measurements showed statistically significant improvements. The answer to these contradictory findings may lie in the quality of the training program, which in our case was tailored to the group of enrolled subjects and planned accordingly. This results show that multidimensional exercises, aimed at strengthening weak muscles and lengthening shortened ones, resulted in a neuromuscular balance and, consequently, in an increase in mobility of the vertebral column, resulting in harmonic and balanced action between agonist and antagonist muscles. The changes that occur with the application of the exercises and principles of the Pilates method stimulate body consciousness, the gravity center, movement control and the respiratory system[6,11].

Study Limitations

It is important to discuss some aspects related to our methodological design. We conducted a clinical trial that was not placebo-controlled, which can lead to bias in the implementation of the intervention, monitoring and final diagnosis. However, we tried to minimize these effects through blinding the examinations before and after the intervention with Pilates (lateral standing X-rays and photograph analysis with a specific software), which were carried out by the same observer, who was trained to do so and did not know to whom the measurements belonged to. In addition, the training of the women with kyphosis was performed by the same individual, who did not deal with either measurements taking, data registering or analysis. Furthermore, data were analyzed by a statistician blinded to the subjects' randomization. In an effort to minimize confounding variables, we studied subjects of similar age, physical activity engagement, diet and clinical characteristics. Despite the study's limitations, it opens perspectives for future research on the benefit of the Pilates method in musculoskeletal rehabilitation.

Conclusions

The results of this study demonstrate the effectiveness of Pilates in reducing the degree of kyphosis in women, reflected in the improved posture and flexibility. Moreover, the exercise method is also effective in reducing BMI and percentage of fat, which can have a major impact on cardiovascular disease prevention. In this sense, it seems that the Pilates method can have an important role in the prevention of or rehabilitation for musculoskeletal problems, as well as prevention of cardiovascular risk factors such as abdominal fat, which is highly prevalent in the elderly. In future investigations it would be important to assess the role of nutrition and usual exercise practice with Pilates training, as well as the role of this training method in the modulation of the hormonal biomarkers related to the accumulation of fat and muscle strength and performance.

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