DOI: 10.590/1809-2950/12658022032015

Effects of the Pilates method on lung function, thoracoabdominal mobility and respiratory muscle strength: non-randomized placebo-controlled clinical trial

Efeitos do método Pilates sobre a função pulmonar, a mobilidade toracoabdominal e a força muscular respiratória: ensaio clínico não randomizado, placebo-controlado

Efectos del método Pilates sobre la función pulmonar, movilidad toracoabdominal y fuerza muscular respiratoria: ensayo clínico no randomizado, placebo-controlado

Letícia Tiziotto de Jesus[1], Letícia Baltieri[2], Luana Gomes de Oliveira[1], Liliane Rodrigues Angeli[3], Silvia Patrícia Antonio[4], Eli Maria Pazzianotto-Forti[5]

ABSTRACT | The Pilates method can be an effective tool for the physical therapist during rehabilitation, because it has varied benefits and few contraindications. Although widely practiced by the population, the literature is scarce about the benefits related to the respiratory system. The purpose of this study was to evaluate the influence of the Pilates method on lung function, thoracoabdominal mobility, respiratory muscle strength and anthropometric characteristics in healthy women. This is a non-randomized placebo-controlled clinical trial with 21 volunteers, who were allocated for convenience in two groups: Pilates with 11 female volunteers, aged 33.18±8.08 years, subjected to the Pilates method twice a week for three months; and Control with 10 female volunteers, aged 31.70±7.39 years that remained three months without regular physical exercises. All of them were submitted to the anthropometric evaluation, physical activity Baecke questionnaire, spirometry lung function, thoracoabdominal mobility by cirtometry and respiratory muscle strength by measures of the maximum respiratory pressure obtained by means of a manovacuometer. All volunteers were evaluated prior to insertion in the groups and revaluated after three months. In the Pilates group, there was significant increase in recreational physical activity, total of the physical activity questionnaire, mobility in the three levels (axillary, xiphoid and abdominal) of the respiratory, inspiratory and expiratory muscle strength, and significant reduction in waist circumference (WC) ($p<0.05$) after three months of intervention. However, except for leisure physical activity and total of the physical activity questionnaire, when compared, significant differences were not detected between groups ($p\geq0.05$). As to the lung function, significant differences were not detected ($p\geq0.05$) in the groups and between them. It is concluded that, after the practice of the Pilates method, there was improvement in leisure physical activity, thoracoabdominal mobility, respiratory muscle strength and waist circumference reduction, however, in comparison with the control group, the Pilates method did not show relevant changes in pulmonary function, thoracoabdominal mobility, respiratory muscle strength and anthropometric characteristics in healthy women that did not perform physical activities.

Keywords | Exercise Movement Techniques; Physical Therapy Modalities; Spirometry; Muscle Strength.

RESUMO | O método Pilates pode ser uma ferramenta eficaz para o fisioterapeuta na reabilitação, pois apresenta benefícios variados e poucas contraindicações. Embora largamente praticado pela população, a literatura é escassa quanto aos seus benefícios relacionados ao sistema

[1]Degree in Physiotherapy, Undergraduate Research Program FAPIC, Universidade Metodista de Piracicaba (UNIMEP) – Piracicaba (SP), Brazil.
[2]Graduate Program in Surgery Sciences, Universidade Estadual de Campinas (UNICAMP) – Campinas (SP), Brazil.
[3]Clínica Spazio Corpus Pilates – Piracicaba (SP), Brazil.
[4]Clínica Fisiocap – Capivari (SP), Brazil.
[5]Undergraduate Program in Physiotherapy, Master´s Program in Physiotheraphy, and Graduate Program in Human Movement Sciences of Universidade Metodista de Piracicaba (UNIMEP) – Piracicaba (SP), Brazil.

Mailing address: Eli Maria Pazzianotto-Forti – Rodovia do Açúcar, km 156 – CEP 13400 911 – Piracicaba (SP), Brazil.
E-mail: empforti@unimep.br – Phone: +55 19 3124 1558
Presentation: Nov. 2013 – Accepted for publication: Aug. 2015 – Financing sources: Fundo de Apoio à Pesquisa de Iniciação Científica (FAPIC) of Universidade Metodista de Piracicaba. – Conflicts of interest: nothing to declare – Approval of Ethics Committee – Protocol no. 03/11

respiratório. O objetivo deste estudo foi avaliar a influência do método Pilates sobre a função pulmonar, mobilidade toracoabdominal, força muscular respiratória e características antropométricas em mulheres saudáveis. Trata-se de um ensaio clínico não randomizado, placebo-controlado com 21 voluntárias, que foram alocadas por conveniência em dois grupos: Pilates com 11 voluntárias, com idade de 33,18±8,08 anos, submetidas ao método Pilates duas vezes por semana durante três meses e Controle com 10 voluntárias, com idade de 31,70±7,39 anos que permaneceram três meses sem a realização de exercícios físicos regulares. Todas foram submetidas à avaliação antropométrica, questionário de atividade física de Baecke, função pulmonar por espirometria, mobilidade toracoabdominal por cirtometria e força muscular respiratória pelas medidas das pressões respiratórias máximas obtidas por meio de um manovacuômetro. Todas as voluntárias foram avaliadas antes da inserção nos grupos e reavaliadas após três meses. No Grupo Pilates houve aumento significativo da atividade física de lazer e no total do questionário de atividade física, aumento da mobilidade nos três níveis (axilar, xifoidiano e abdominal), da força muscular respiratória, tanto inspiratória como expiratória, bem como redução significativa da circunferência da cintura (CC) (p<0,05), após três meses de intervenção. Entretanto, com exceção da atividade física de lazer e no total do questionário de atividade física, quando comparados os grupos, não foram constatadas diferenças significativas (p>0,05). Para a função pulmonar, não foram constatadas diferenças significativas (p>0,05) entre os grupos e tampouco entre seus integrantes. Conclui-se que, após a prática do método Pilates, houve melhora na atividade física de lazer, mobilidade toracoabdominal, força muscular respiratória e redução da circunferência da cintura. No entanto, em comparação ao Grupo Controle, o método Pilates não promoveu alterações relevantes na função pulmonar, mobilidade toracoabdominal, força muscular respiratória e características antropométricas de mulheres saudáveis que não realizaram programa de exercício físico.
Descritores | Técnicas de Exercício e de Movimento; Modalidades de Fisioterapia; Espirometria; Força Muscular.

RESUMEN | El método Pilates puede ser una herramienta eficaz para el fisioterapeuta en la rehabilitación, pues presenta algunos beneficios y pocas contraindicaciones. Aunque ampliamente practicado por la población, la literatura es escasa acerca de los beneficios relacionados al sistema respiratorio. El objetivo de este estudio fue evaluar la influencia del método Pilates sobre la función pulmonar, movilidad toracoabdominal, fuerza muscular respiratoria y características antropométricas en mujeres saludables. Se trata de un ensayo clínico no randomizado, placebo-controlado con 21 voluntarias, que fueron divididas por conveniencia en dos grupos: Pilates con 11 voluntarias, con edades de 33,18±8,08 años, sometidas al método Pilates dos veces a la semana durante tres meses y Control con 10 voluntarias, con edades de 31,70±7,39 que permanecieron tres meses sin ejercicios físicos regulares. Todas fueron sometidas a la evaluación antropométrica, cuestionario de actividad física de Baecke, función pulmonar por espirometría, movilidad toracoabdominal por cirtometría y fuerza muscular respiratoria por las medidas de las presiones respiratorias máximas obtenidas por medio de un manovacuómetro. Todas las voluntarias fueron evaluadas antes de la inserción en los grupos y revaluadas después de tres meses. En el grupo Pilates hubo aumento significativo de la actividad física recreativa y en el cuestionario total de actividad física hubo aumento de la movilidad en los tres niveles (axilar, del xifoides y abdominal) de la fuerza muscular respiratoria, tanto inspiratoria como espiratoria, así como la reducción significativa de la circunferencia de la cintura (CC) (p<0,05) después de tres meses de intervención. Sin embargo, con excepción de la actividad física de recreación y en el total del cuestionario de actividad física, en comparación con los grupos, no fueron detectadas diferencias significativas (p≥0,05). No se constató diferencias significativas (p≥0,05) entre los grupos y sus integrantes para la función pulmonar. Se concluye que después de la práctica del método Pilates hubo mejoría en la actividad física de recreación, movilidad toracoabdominal, fuerza muscular respiratoria y reducción de la circunferencia de la cintura. Sin embargo, en comparación con el Grupo Control, el método Pilates no promovió alteraciones relevantes en la función pulmonar, movilidad toracoabdominal, fuerza muscular respiratoria y características antropométricas de mujeres saludables que no realizaron programas de ejercicios físicos.
Palabras clave | Técnicas de Ejercicio con Movimientos; Modalidades de Fisioterapia; Espirometría; Fuerza Muscular.

INTRODUCTION

Like other skeletal muscles, respiratory muscles respond to stimuli through physical training[1,2]. For this purpose, regular practice of physical exercises is recommended[3].

One of the goals of the Pilates method is muscle balance, so that muscle groups interact with strength

and flexibility, breathing coordination, intense abdominal muscle strengthening, among others, different from other forms of exercises aimed at muscular hypertrophy[4]. Studies confirm the efficacy of the method to correct posture[5], flexibility[6], muscle strengthening[7], rehabilitation[8], and physical conditioning programs[9,10]. However, the literature is scarce when it comes to show the effectiveness of Pilates method on the responses of the respiratory muscular mechanics and pulmonary function.

According to Wells et al.[11] the fundament traditionally known of the Pilates method is breath control. During the exercises, the stabilization goal of the spine, promotes intense recruitment of the abdominal transverse muscle and internal oblique muscle, especially upon the association of breathing control and the trunk flexion movement[12].

The breathing standard used in the Pilates method is known as "lateral breathing", that is, prevents the expansion of the abdominal region during inspirations. Using predominantly the chest and ribcage muscles, favoring the lateral expansion of the ribcage, increases the room for pulmonary expansion[13,14] and thus, influence lung volumes in healthy individuals practitioners of the method[15].

Until now, there are no studies in the consulted literature that investigate the effects of method on the respiratory system and, becomes relevant to the investigation of the influence of the Pilates method on such system, since it has been used as a physiotherapy complement and also as respiratory physiotherapy, due to the important focus on breathing control.

We have the hypothesis that the application of the Pilates method can promote gains in lung function, thoracoabdominal mobility and respiratory muscle strength in healthy subjects and changes in anthropometric characteristics especially regarding the distribution of body fat.

Therefore, the objective of this study was to evaluate the effects of the Pilates Method on lung function, thoracoabdominal mobility, respiratory muscle strength and body fat distribution.

METHODOLOGY

This study is a clinical essay, with a single protocol, applied in more than one location and, therefore, carried out by more than one investigator. It was approved by the Research Ethics Committee of the Universidade Metodista de Piracicaba (UNIMEP), under protocol 03/11, registered in ClinicalTrials with the identifier NCT01841385 and held in Pilates clinics in the region. The clinics that had a physical therapist with specific training in the method were selected and invited to participate in the study. After acceptance, the meeting with the professionals for the method standardization and program progress was held, and then, a formal invitation was sent to beginner students in their clinics and also the volunteers directly in community, through posters and formal invitation. The participants performed the practice of the method at no charge, regardless of location. Those with availability to perform the exercises program proposed by three consecutive months composed the Pilates Group and the others, the Control Group.

Women aged between 25 and 55 years were included, with body mass index (BMI) ≤29kg/m^2, non-smokers or non-drinkers, not without any abnormalities of the cardiovascular, respiratory or neuromuscular system. Women with crippling diseases, pregnant, or with understanding failures were excluded for the performance of tests and exercises that did not show regularity in training sessions (Pilates group) or who began any program of physical activity during the studied period (Control group).

Experimental protocol

The volunteers formed two groups:

a) Pilates Group (n=16): those who were not performing any form of regular exercise, supervised or not for at least a year, and who had not practiced the Pilates method before, but that would start the activities with the Pilates method after initial evaluation, being reevaluated after three months. For the protocol of the Pilates method, the exercises have been applied in the ground and in equipment, with gradual load progression. The equipment used were: Cadillac, Reformer, Chair and Ladder Barrel. Most exercises performed on the ground and on equipment were: teaser, horse back in the ladder barrel, rollover, tendon stretch on the reformer, push-throught (seated front) in Cadillac, modified splitsside using elastic band on the Reformer, and modified sidearm twist using extension box on

the Chair. The intervention with the method had regularity of two weekly sessions lasting one hour, during 12 weeks, totaling 24 sessions. After the initial assessments, the volunteers became familiar with the therapeutic method for the purpose of adaptation and learning of the movements, with a session, the total number of sessions is not included. The exercise program started from a pre-established protocol and there was individualized progression of load and number of sets and repetitions, every 4 weeks.

b) Control Group (n=13): those who were not performing any form of regular exercise, supervised or not for at least a year, and who had not practiced the Pilates method before, and that remained in this lifestyle, during the study period. Every 30 days the volunteers of this group were contacted by telephone so that the researcher obtained information about maintenance of the absence of the practice of physical exercises by the volunteers.

All the volunteers were evaluated by a single researcher, and the evaluation consisted of anamnesis with clinical history and data collection such as: age, body mass, height, BMI, waist circumference (WC) and hip circumference (HC), waist circumference and hip circumference ratio (WHR) and neck circumference (NC), in addition to the usual physical activity assessment (PAA) by Baecke et al. questionnaire[16], validated in Brazil by Florindo and Latorre[17]. For this study, the PAA scores in the last 12 months were used: for leisure physical exercises (LPE) with four questions and, for leisure and locomotion activities (LLA) with four questions.

Pulmonary function

For the assessment of lung volumes, flows and capacity a computerized spirometer (Microquark; Cosmed, Rome, Italy) was used, according to the American standards American ThoracicSociety and EuropeanRespiratorySociety (ATS/ERS)[18] and guidelines for pulmonary function[19]. The volunteers were directed to perform the maneuvers of slow vital capacity (SVC) and forced vital capacity (FVC) and maximum voluntary ventilation (MVV). The curves were analyzed according to the provided criteria of acceptability and reproducibility praised by literature[18,19].

Thoracoabdominal mobility

Thoracoabdominal mobility was measured by means of cirtometry, in the standing position, by the same evaluator, in axillary, xiphoid and abdominal levels, being held three times at each level, with the use of a measuring tape, after a maximum inspiration and expiration. The difference between the highest value obtained from the inspiration and the smaller value of the expiration was the thoracic and abdominal mobility for each one of the levels.

Respiratory muscle strength

Respiratory muscle strength was evaluated by means of the maximum respiratory pressure, through an analog manovacuometer (Criticalmed®), with operating range of ±300cmH_2O, equipped with a nozzle adapter containing a hole of 2mm diameter, acting as a relief valve[20].

The maximum inspiratory pressure (IPmax) was measured from a maximum expiration (residual volume). The maximum expiratory pressure (EPmax) was measured from a maximum inspiration (residual volume). Each effort was sustained for at least two seconds, with 45 second intervals between each maneuver.

To minimize the learning effect, five measurements were performed and the difference between them should be up to 10%. It was considered the highest value obtained for analysis.

Statistical analysis

The SPSS program version 13.0 was used. For checking normality, Shapiro-Wilk test was used. For intragroup analysis, the absolute values were used and Student's t-test (related samples) was carried out for data parametric data. The Wilcoxon test was used for nonparametric data. For the comparison of the data between groups, the differences of values between the pre- and post-treatment were used. The Student's t-test (independent samples) was carried out for parametric data, while the Mann-Whitney test was employed for data nonparametric data. The statistical significance level of 5% was adopted.

The calculation of the size of the sample was carried out by a pilot study, with the IPmax variable of the Pilates group. For the calculation, it was used the average of the difference, considering the movements before and after applying the treatment and the standard deviation of

the difference. The Student's t-test was employed for two related samples, adopting a statistical power of 80% and an alpha of 0.05. Thus, a number of 10 volunteers per group was determined.

RESULTS

Of the 29 volunteers evaluated, eight were excluded during the study (five claimed personal reasons, one began doing physical activities and two did not show up for reevaluation), with 21 volunteers, being 11 in the Pilates Group and 10 in the Control Group (Figure 1).

The data of initial characteristics and distribution of groups, such as age and anthropometric measurements are shown in Table 1. There is homogeneity of the groups in relation to the first evaluation characteristics: age, height, BMI and body weight.

Table 2 list the values of both circles and results of the Baecke questionnaire about physical activity. On intragroup analysis of the Pilates group, we noticed a reduction of WC and increase of the score for leisure physical activity, and consequently, of the total score of the questionnaire of physical activity. In the Control group, there was no significant difference for any of the variables. On comparison between the Control and Pilates groups, there was significant increase in the variable of the leisure physical activity, obtained through the Baecke questionnaire. However significant differences were not detected in relation to WC when comparing the two groups.

Regarding pulmonary function, we did not detect intra-group significant differences in spirometric measures, however, there was significant increase in thoracoabdominal mobility in three levels and respiratory muscle strength (IPmax and EPmax) for the Pilates group. When the groups were compared using the difference between the first and second evaluation, there was no significant difference (Table 3).

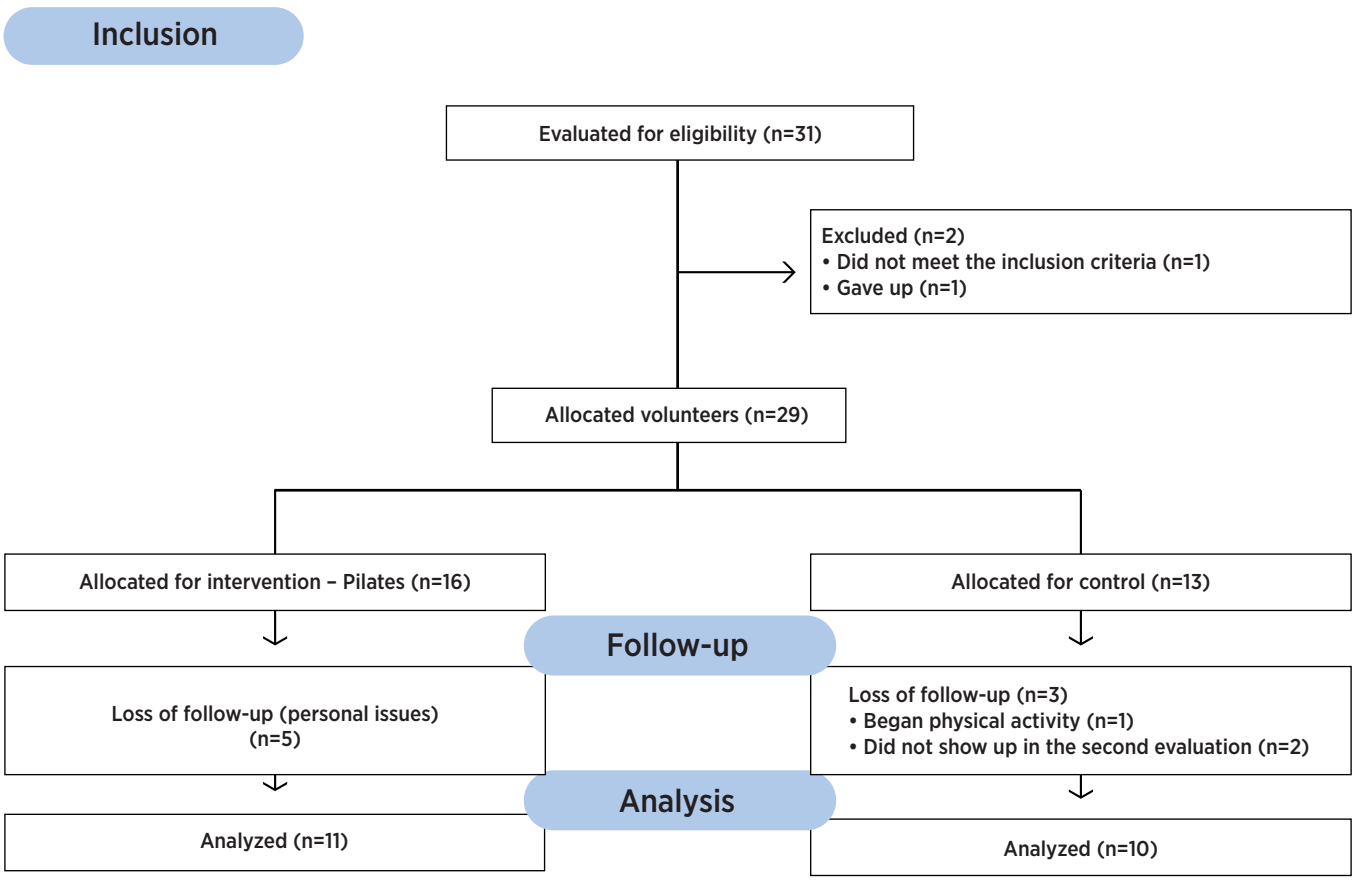

Figure 1. Flowchart of participants' distribution

Table 1. Age and anthropometric characteristics of the Pilates group and Control group, at the beginning of the study, expressed as mean and standard deviation

	Pilates (n=11)	Control (n=10)	p-value [95%CI] between groups
Age (years)	33.18±8.08	31.70±7.39	0.67 [-8.5;5.61]
Height (m)	1.63±0.05	1.64±0.06	0.66 [-0.03;0.06]
Body mass (kg)	55.86±6.94	60.85±13.18	0.62
BMI (kg/m^2)	21.17±3.16	22.56±3.62	0.36 [-1.7;4.4]

BMI: body mass index; 95%CI: confidence interval at 95%

Table 2. Anthropometrical variables, circumferences, and scores of regular leisure physical activity and locomotion of the Pilates group and Control group of the pre- and post-intervention, expressed as mean and standard deviation, pre- and post- differences, as well as the p-value and the 95% confidence interval (95%CI) of the intra-group analysis and between groups

	Pilates (n=11)				Control (n=10)				p-value [95%CI] between groups
	Before	After	Difference before-after	p-value [95%CI] intragroup	Pre-	Post-	Pre- and post-difference	p-value [95%CI] intragroup	
WC (cm)	81.3±7.60	78.5±8.38	↓ 2.77	0.038	84.5±10.9	84±11.04	↓ 0.48	0.85 [-5.1;6.0]	0.41 [-8.0;3.5]
HC (cm)	97.1±6.95	96.02±7.1	↓ 1.13	0.38 [-1.6;3.8]	98.3±13.8	98.9±8.87	↑ 0.61	0.81 [-6.4;5.2]	0.53 [-7.5;4.0]
WHR	0.83±0.05	0.82±0.06	↓ 0.01	0.33 [-0.01;0.05]	0.86±0.14	0.85±0.07	↓ 0.01	0.75 [-0.07;0.10]	0.9 [-0.08;0.08]
NC (cm)	31.4±2.17	31.1±1.71	↓ 0.37	0.37 [-0.53;1.27]	31.8±1.92	31.8±1.84	↓ 0.03	0.86 [-0.3;0.40]	0.46 [-1.29;0.6]
AFL	1.95±0.31	2.43±0.32	↑ 0.47	0.002 [-0.73;-0.2]	2.45±0.50	2.35±0.46	↓ 0.10	0.57	0.008 [0.17;0.9]
LLA	1.30±0.64	1.52±0.82	↑ 0.22	0.38 [-0.78;0.32]	1.8±0.39	1.72±0.72	↓ 0.075	0.80 [-0.59;0.74]	0.44 [-0.5;1.1]
TOTAL	3.25±0.69	3.95±0.79	↑ 0.70	0.02	4.25±0.55	4.07±0.91	↓ 0.17	0.65 [-0.68;1.03]	0.07 [-0.08;1.8]

WC: waist circumference; HC: hip circumference; WHR: waist-hip relation; NC: neck circumference; AFL: leisure physical activity; LLA: leisure activity and locomotion

Table 3. Measures of the variables lung function, thoracoabdominal mobility and respiratory muscle strength of both groups, in the pre- and post-intervention, expressed as mean and standard deviation, pre- and post- differences, as well as the p-value and the 95% confidence interval (95%CI) of the intra-group analysis and between the groups

	Pilates (n=11)				Control (n=10)				p-value [95%CI] between groups
	Before	After	Pre- and post-difference	p-value [95%CI] intragroup	Before	After	Pre- and post-difference	p-value [95%CI] intragroup	
Pulmonary function									
SVC (%P)	94.5±16.4	98.5±12.2	↑ 4.07	0.13 [-9.5;1.4]	97.36±14.1	100.95±19.6	↑ 3.59	0.26 [-10.4;3.2]	0.9 [-7.6;8.5]
ERV (L)	0.73±0.2	0.89±0.4	↑ 0.16	0.18 [-0.4;0.08]	0.93±0.3	0.80±0.3	↓ 0.13	0.25 [-0.11;0.3]	0.07 [-0.03;0.6]
IRV (L)	1.94±0.6	1.78±0.5	↓ 0.16	0.38 [-0.2;0.5]	1.87±0.6	2.13±0.5	↑ 0.26	0.21 [-0.6;0.1]	0.12 [-0.9;0.12]
CVF (%P)	94.8±13.6	95.37±10.5	↑ 0.55	0.71 [-3.7;2.6]	99.08±15.9	101.24±16.4	↑ 2.16	0.054 [-4.3;0.05]	0.37 [-5.3;2.09]
FEV_1 (%P)	98.1±16.9	101.5±13.5	↑ 3.38	0.10 [-7.5;0.78]	102.26±14.5	102.65±14.3	↑ 0.39	0.70 [-2.6;1.8]	0.18 [-1.5;7.57]
FEFP (%P)	95.9±30.5	96.78±31.1	↑ 0.85	0.81 [-8.7;7.01]	98.37±19.4	106.26±23.9	↑ 7.89	0.06 [-16.2;0.4]	0.18 [-17.7;3.6]
MVV (%P)	85.8±21.5	86.85±20.8	↑ 1.01	0.54 [-4.6;2.58]	91.01±16.8	93.35±18.1	↑ 2.34	0.38 [-8.1;3.4]	0.66 [-7.5;4.9]

continues...

Table 3. Continuation

	Pilates (n=11)				Control (n=10)				p-value [95%CI] between groups
	Before	After	Pre- and post-difference	p-value [95%CI] intragroup	Before	After	Pre- and post-difference	p-value [95%CI] intragroup	
Thoracoabdominal mobility									
Axillary (cm)	7.35±2.0	8.73±2.0	↑ 1.37	0.007	6.95±2.0	8.33±2.1	↑ 1.38	0.05	0.99 [-2.3;2.3]
Xiphoid (cm)	6.52±2.1	8.37±1.7	↑ 1.85	0.005 [-3.0;-0.67]	7.05±2.8	8.27±1.8	↑ 1.22	0.26 [-3.5;1.1]	0.57 [-1.7;2.9]
Abdominal (cm)	4.05±2.2	5.94±1.8	↑ 1.89	0.02 [-3.48;-0.2]	4.38±2.0	5.55±0.8	↑ 1.17	0.12 [-2.7;0.4]	0.48 [-1.3;2.8]
Respiratory muscle strength									
IPmax (cmH_2O)	-72.7±21.6	-82.2±26.2	↑ 9.55	0.009 [2.9;16.1]	-67.50±16.7	-70.00±17.8	↑ 2.50	0.52 [-6.1;11.1]	0.15 [-17.0;2.9]
EPmax (cmH_2O)	85.4±19.4	104.1±22.8	↑ 18.64	0.001 [-27.6;-9.6]	77.50±21.6	87.00±12.7	↑ 9.50	0.05 [-34.2;-0.08]	0.13 [-2.9;21.2]

Absolute values and percentage of predicted (% P). SVC: slow vital capacity, ERV: expiratory reserve volume, IRV: inspiratory reserve volume, FVC: forced vital capacity, FEV_1: forced expiratory volume in one second, FEFP: forced expiratory flow peak, MVV: maximum voluntary ventilation; IPmax.: maximum inspiratory pressure, EPmax.: maximum expiratory pressure

DISCUSSION

The main results of this study demonstrated increase in the axillary, xiphoid and abdominal mobility, respiratory muscle strength, WC reduction and score increase in physical activity questionnaire in the group that practiced the Pilates method twice a week for 12 weeks, totaling 24 sessions, but when the two groups in the final evaluation were compared, there was no difference between them. However, it was possible to demonstrate improvement in the score of the usual physical activity in the Pilates group when compared to the Control group.

The positive results found for volunteers of the Pilates group can be assigned to one of the guiding principles of the Pilates method: breathing. According to Craig[21], breathing is the primary factor at the beginning of the movement, as it provides the organization of the trunk recruiting the deep stabilizers muscles of the spine in pelvic support.

In accordance with the principles of the Pilates method, the abdominal musculature is responsible for the dynamic stabilization of the trunk[22]. This stabilization during exercises is part of the principle of centralization, also known as "powerhouse", being one of the most important principles of the Pilates method.

Probably, this guiding principle allowed the recruitment of the trunk muscles, abdominal wall and diaphragm, which resulted in the improvement of the thoracoabdominal mobility and increase of the respiratory muscle strength observed in this study.

The integrity of the thoracoabdominal mobility during breathing movements is critical to the proper respiratory mechanics[23]. The improvement of the thoracic and abdominal mobility found in this study, particularly in the Pilates group, might be attributed to improved flexibility of the trunk.

Studies demonstrate the effectiveness of Pilates for the correction of postural changes[5], increased strength[7] and flexbility[6,9]. These benefits can justify the gaining of mobility by volunteers, with reduction of possible respiratory muscle shortenings or enhancement of the stretching of these muscles contributing to an efficient respiratory mechanics. The increased thoracoabdominal mobility was also confirmed with the method of Global Postural Reeducation (GPR)[24]. The authors attribute this fact both to treatment duration (8 weeks) and for the duration of each stretching session (30 minutes). It is interesting to note that even with the higher duration of the treatment (12 weeks) and session (60 minutes), it has not been possible to highlight differences in mobility compared to the Control group.

Improvement of the muscle strength, flexibility, posture, motor skills and life quality were also benefits of the Pilates method according to Guimarães et al.[25], who studied the application of the method for older adults.

In addition to thoracoabdominal mobility, it was possible to evidence in this study the increase in respiratory muscle strength with regular sessions of Pilates method, since the breathing principle of the method requires a maximum expiration during the exercises. This maximum expiration is accomplished by the following muscles: rectus abdominis, external and internal oblique and transversus abdominis. Some studies have shown activation of these muscles during Pilates exercises, primarily of the following muscles: rectus abdominis[26], multifidus and external oblique[27].

Possibly, in this study, the activation of these muscles culminated in increasing expiratory muscle strength. Although the expiratory muscle strength gain is relevant we were unable to conclude that this occurred due to the Pilates method because there was no difference regarding the Control group in the second evaluation.

However it is worth mentioning that Dorado et al.[28] observed that, in healthy and inactive women, the Pilates method is effective in strengthening the muscles of the abdominal wall due to the hypertrophy of these muscles, particularly of the rectus abdominis.

In addition, the pelvic retroversions performed during Pilates exercises put the diaphragm muscle (main inspiratory muscle) in a stretching position, due to its insertion. Di Alencar et al.[29] reported that stretching also results in increased muscle strength, which in this study may be a factor to increase inspiratory muscle strength.

Other muscles that participate in inspiration, in addition to the diaphragm, are also involved in the Pilates exercises, and can be strengthened, assisting in increasing the inspiratory force. An increase in respiratory muscle strength was also observed in practitioners of other methods, such as Yoga[30,31], GPR[24] and Kabat[2].

According to Doijad and Surdi[31], the Yoga postures involve Isometric Contraction which is known to increase skeletal muscle strength. Thus, Yoga training improves strength and also the resistance of the inspiratory and expiratory muscles. We can infer that the postures used by the Pilates method, as well as the method association to the breathing may have contributed to the increased strength of the respiratory muscles. Moreno et al.[24] report that the stretchings present in the GPR method may have favored an increase in the length of the sarcomeres and a more effective contraction, which was reflected in the increase of the maximum respiratory pressures and so, in the strength of respiratory muscles.

Barbosa et al.[12] studied the behavior of expiratory muscles, i.e. rectus abdominis muscles, upper and lower fibres, transversus abdominis and internal oblique using surface electromyography during the movement of trunk flexion in two times. One of them performed the breathing method of Pilates, and the other performed normal breathing. It was possible to observe a greater level of activation amplitude of transversus abdominis muscles, internal oblique and during flexion of the trunk associated with typical Pilates breathing. These electromyographic findings of the study of Barbosa et al.[12] can help to justify the increased expiratory muscle strength of female practitioners of the Pilates method of this study.

Thus, it appears that the expiratory muscle strength increased by 17.9% and inspiratory muscle strength increased 11.59% in the Pilates group, while the control group increased 10.91 percent and 3.57%, respectively.

Although all the benefits related to respiratory muscle strength have been found in the group that practiced the Pilates method, we still were not able to identify the effectiveness of the method applied to the respiratory system since, in general, the Pilates group showed similarity to the Control group in relation to respiratory muscle strength and thoracic mobility.

The beneficial results of the Pilates method in relation to the increase of respiratory muscle strength should be further investigated, since they can benefit individuals presenting respiratory muscle dysfunction or even need for the maintenance of respiratory muscle integrity, as it usually occurs with elderly persons[32].

However, about the effects of the Pilates method on pulmonary function, studies are scarce in the literature. In this study, the measures of lung function did not show major changes, which was expected, since all the volunteers are healthy, with spirometry values above 80% of the predicted, meaning normal pulmonary function[18]. Such findings were similar to the ones observed by Godoy et al.[30] both in individuals who practiced yoga, as in individuals who performed aerobic activity for three months.

Doijad et al.[31], reported an increase of CVF and MVV shortly after yoga practice. According to the authors, the yoga postures and breath employed during the method promote strengthening and endurance of the respiratory muscles and indicate better performance on spirometric manoeuvres of MVV and CVF. Even though Yoga is a different method, it is similar to Pilates with regard to the breathing focus during the exercise. Probably we have not reached the same results as in the study of Doijad et al.[31], the frequency of sessions was higher. The study volunteers performed 6 sessions a week, while the weekly frequency in the present study was twice. In the totality of the program, 24 sessions were held in this study against 72 sessions in this study. The number of sessions of Pilates method might have been a fundamental factor for the lack of significant difference between the PilatesGroup and the Control group in this study.

WC reduction is clinically relevant, because it is an anthropometric indicator that confirms the abdominal obesity, and if associated with overweight, exposes the persons involved in metabolic syndrome to cardiovascular risks, increasing the death risk[33]. According to the World Health Organization (WHO)[34] values of WC equal to or greater than 80cm are considered indications of risk for developing cardiovascular diseases. It is worth noting that the volunteers of the Pilates group finished the exercise program without risk indications (WC=78.56±8.38), while the control group remained in the range of cardiovascular risk (WC=84.07±11.04). There is no doubt that regular physical activity contributes to the balance between the energy consumed in the form of food and spent due to exercises[35] promoting the maintenance or reduction of body weight. In this study, it was not possible to identify significant changes in relation to body weight and BMI, since the volunteers studied were classified as eutrophic and also most of them were in the age group least prone to weight gain.

The increase in leisure physical activity score demonstrates a change in the routine of the volunteers of the Pilates group in relation to the practice of physical exercises, being of great importance for the health and life quality.

Health benefits from the regular practice of physical exercises are vast. The study of Matsudo et al.[36] mentions that the physical exercise presents benefits both in physical and cognitive appearance, and also in the psychological and social appearance, as well as promotes the control of body weight, decrease of the body fat, promotes muscle hypertrophy, increase of the muscle strength, and improves flexibility. All these benefits have great value to the improvement of quality of life and health of individuals and should be emphasized. The Pilates Method in addition to promoting physical health can also bring positive feelings of pleasure, satisfaction and well being [37]. This can justify the increased habitual physical activity in this study and change in lifestyle.

Finally, in this study the results obtained are for healthy and eutrophic people, which even without performing physical activity, maintains the integrity of respiratory muscle strength, thoracic mobility and anthropometric characteristics. We suggest that further studies are conducted investigating the Pilates Method as a resource in the treatment of respiratory disorders and also that the weekly frequency is more often than two times a week.

Some limitations were identified in this study: non-randomization of volunteers, the completion of the study in more than one location and more than one method instructor with possible influence of the environment and empathy between student/instructor, the fact that the Pilates Group had sought the method on its own initiative might have provided better results due to the dedication and motivation to practice physical exercises.

CONCLUSION

According to the above and within the experimental conditions used, it is concluded that, after 24 sessions of practice of the Pilates method, there was improvement in leisure physical activity, thoracoabdominal mobility, respiratory muscle strength and waist circumference reduction, however, in comparison with the Control group, the Pilates method did not show relevant changes in pulmonary function, thoracoabdominal mobility, respiratory muscle strength and anthropometric characteristics in healthy women that did not perform physical activities.

We suggest follow-up beyond the 24 sessions of the method to better identify the benefits. We also suggest that studies in populations with respiratory dysfunction are carried out.

REFERENCES

1. Derenne JP, Macklem PT, Roussos C. The respiratory muscles: mecanics, control, and pathophysiology. Am Rev Respir Dis. 1978;118(1):119-33.
2. Moreno MA, Silva E, Gonçalves M. O efeito das técnicas de facilitação neuromuscular proprioceptiva – método Kabat – nas pressões respiratórias máximas. Fisioter Mov. 2005;18(2):53-61.
3. Goya KM, Siqueira LT, Costa RA, Gallinaro AL, Gonçalves CR, Carvalho JF. Regular physical activity preserves the lung function in patients with ankylosing spondylitis without previous lung alterations. Rev Bras Reumatol. 2009;49(2):132-35.
4. Panelli C, De Marco A. Método Pilates de condicionamento do corpo: um programa para toda vida. 2a ed. São Paulo: Phorte. 2009.
5. Blum CL. Chiropractic and Pilates therapy for the treatment of adult scoliosis. J Manipulative Physiol Ther. 2002;25(4):E3.
6. Bertolla F, Baroni BM, Junior ECPL, Oltramari JD. Effects of a training program using the Pilates method in flexibility of sub-20 indoor soccer athletes. Rev Bras Med Esporte. 2007;13(4):222-6.

7. Kolyniak IEG, Cavalcanti SMB, Aoki MS. Isokinetic valuation of the musculature involved in trunk flexion and extension: Pilates method effect. Rev Bras Med Esporte. 2004;10(6):491-3.
8. La Touche R, Escalante K, Linares MT. Treating non-specific chronic low back pain through the Pilates Method. J Bodyw Mov Ther. 2008;12:364-70.
9. Segal NA, Hein J, Basford JR. The effects of Pilates training on flexibility and body composition: an observational study. Arch Phys Med Rehabil. 2004;85(12):1977-81.
10. Jago R,Jonker ML, Missaghian M, Baranowski T. Effect of 4 weeks of Pilates on the body composition of young girls. Prev Med. 2006;42(3):177-80.
11. Wells C, Kolt GS, Bialocerkowski A. Defining Pilates exercise: a systematic review. Complement Ther Med. 2012;20(4),253-62.
12. Barbosa AWC, Guedes CA, Bonifácio DN, Silva AF, Martins FLM, Barbosa MCSA, et al. The Pilates breathing technique increases the electromyographic amplitude level of the deep abdominal muscles in untrained people. J Bodyw Mov Ther. 2015;19(1):57-61.
13. Menezes AS. The complete guide to Joseph H. Pilates' techniques of physical conditioning: applying the principles of body control. Salt Lake City: Hunter House; 2000.
14. Blount T, McKenzie E. Pilates básico. São Paulo: Manole; 2006.
15. Cancelliero-Gaiad KM, Ike D, Pantoni CBF, Borghi-Silva A, Costa D. Respiratory pattern of diaphragmatic breathing and pilates breathing in COPD subjects. Braz J PhysTher. 2014;18(4):291-9.
16. Baecke JA, Burema J, Frijters JE. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am J Clin Nutr. 1982;36:936-42.
17. Florindo AA, Latorre MRDO. Validação do questionário e reprodutibilidade de Baecke de avaliação da atividade física habitual em homens adultos. Rev Bras Med Esporte. 2003;9:121-8.
18. ATS/ERS. Task Force: Standardisation of lung function testing. Standardisation of Spirometry. Eur Respir J. 2005;26:319-38.
19. Pereira CAC. Directives for pulmonary function tests. J Pneumol. 2002; 28(3):1-82.
20. Black LF, Hyatt RE. Maximal respiratory pressures: normal values and relationship to age and sex. Am Rev Respir Dis. 1969;99(5):696-702.
21. Craig C. Pilates com a bola. São Paulo. Phorte. 2003.
22. Araújo PCS, Sá KN. Atividade eletromiográfica durante exercícios de estabilização dinâmica do tronco. Rev Ciênc Méd Biol. 2011;10(1):7-13.
23. Jamami M, Pires VA, Oishi J, Costa D. Efeitos da intervenção fisioterápica na reabilitação pulmonar de pacientes com doença pulmonar obstrutiva crônica (DPOC). Rev Fisioter Univ São Paulo. 1999;6(2):140-53.
24. Moreno MA, Catai AM, Teodori RM, Borges BLA, Cesar MC, Silva E. Effect of a muscle stretching program using the Global Postural Re-education method on respiratory muscle strength and thoracoabdominal mobility of sedentary young males. J Bras Pneumol. 2007;33(6):679-86.
25. Guimarães ACA, de Azevedo SF, Simas JPN, Machado Z, Jonck VTF. The effect of Pilates method on elderly flexibility Fisioter Mov. 2014;27(2):181-8.
26. Souza EF, Cantergi D, Mendonça A, Kennedy C, Loss JF. Electromyographicanalysis of the rectus femoris and rectus abdominis muscles during performance of the hundred and teaser pilates exercises. Rev Bras Med Esporte. 2012;18(2):105-8.
27. Loss JF, Melo MO, Rosa CH, Santos AB, La Torre M, Silva YO. Electrical activity of external oblique and multifidus muscles during the hip flexion-extension exercise performed in the Cadillac with different adjustments of springs and individual positions. Rev Bras Fisioter. 2010;14(6):510-7.
28. Dorado C, Calbet JA. Lopez-Gordillo A, Alayon S, Sanchis-Moysi J. Marked effects of pilates on the abdominal muscles: a longitudinal magnetic resonance imaging study. Med Sci Sports Exerc. 2012;44(8):1589-94.
29. Di Alencar TAM, Matias KFS. Princípios fisiológicos do aquecimento e alongamento muscular na atividade esportiva. Rev Bras Med Esporte. 2010;16(3):230-4.
30. Godoy DV, Bringhenti RL, Severa A, Gasperi R, Poli LV. Yoga versus aerobic activity: effects on spirometry results and maximal inspiratory pressure. J Bras Pneumol. 2006;32(2):130-5.
31. Doijad VP, Surdi AD. Effect of short term yoga practice on pulmonary function tests. Indian Journal of Basic & Applied Medical Research. 2012;1:226-30.
32. Kim J, Sapienza CM. Implications of expiratory muscle strength training for rehabilitation of the elderly: tutorial. J Rehabil Res Dev. 2005;42(2):211-24.
33. Rezende FAC, Rosado LEFPL, Ribeiro RCL, Vidigal FC, Vasques A. CJ, Bonard IS, et al. Body mass index and waist circumference: association with cardiovascular risk factors. Arq Bras Cardiol. 2006;87(6):666-71.
34. World Health Organization. Waist Circumference and Waist-Hip Ratio. Report. Geneva, 2008. Disponível em: http://apps.who.int/iris/bitstream/10665/44583/1/9789241501491_eng.pdf.
35. Trombetta, I.C; Exercício físico e dieta hipocalórica para o paciente obeso: vantagens e desvantagens. Rev Bras Hipertens. 2003;10:130-3.
36. Matsudo SM, Matsudo VKR, Barros N, Turíbio L. Efeitos benéficos da atividade física na aptidão física e saúde mental durante o processo de envelhecimento. Rev Bras Ativ Fís Saúde. 2000;5(2):60-76.
37. Souza M., Vieira C. Who are the people looking for the Pilates method? J Bodyw Mov Ther. 2006;10:328-34.