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RANDOMISED CONTROLLED STUDY

The effectiveness of the Pilates method: Reducing the degree of non-structural scoliosis, and improving flexibility and pain in female college students

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Summary *Objective:* To evaluate the effectiveness of Pilates with regard to the degree of scoliosis, flexibility and pain.
Method: The study included 31 female students divided into two groups: a control group (CG = 11), which had no therapeutic intervention, and an experimental group (EG = 20), which underwent Pilates-based therapy. We used radiological goniometry measurements to assess the degree of scoliosis, standard goniometry measurements to determine the degree of flexibility and the scale of perceived pain using the Borg CR 10 to quantify the level of pain.
Results: The independent t test of the Cobb angle (t = - 2.317, $p = 0.028$), range of motion of trunk flexion ($t = 3.088$, $p = 0.004$) and pain ($t = -2.478$, $p = 0.019$) showed significant differences between the groups, with best values in the Pilates group. The dependent t test detected a significant decrease in the Cobb angle (Δ% = 38%, $t = 6.115$, $p = 0.0001$), a significant increase in trunk flexion (Δ% = 80%, $t = -7.977$, $p = 0.0001$) and a significant reduction

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in pain ($\Delta\% = 60\%$, $t = 7.102$, $p = 0.0001$) in the EG. No significant difference in Cobb angle ($t = 0.430$, $p = 0.676$), trunk flexion, ($t = 0.938$p $= 0.371$) or pain ($t = 0.896$, $p = 0.391$) was found for the CG.

Conclusion: The Pilates group was better than control group. The Pilates method showed a reduction in the degree of non-structural scoliosis, increased flexibility and decreased pain.

Introduction

Poor postural habits carried throughout life and the physical inactivity allowed by modern amenities are associated with asymmetric use of the body during functional activities. Over time, such musculoskeletal imbalance can cause changes in posture (Júnior and Tomaz, 2008).

Among orthopedic disorders, postural changes of the spine have the highest incidence (Kussuki et al., 2007). Scoliosis occurs at varying rates, depending on the population studied and the method of identification or magnitude of the curve, with a prevalence in the general population approaching 4%. This percentage represents about 30% of all cases of postural deviation (Bassani et al., 2008).

The high prevalence of postural defects in adults has reached a critical point. Many cases of back pain are related to poor posture or postural habits, which cause an imbalance between the effort required for work and activities of daily living and the functional capacity for performing these activities. (França et al., 2008). Poor postural habits lead the individual to grow accustomed to using the body in the wrong way. Such improper tendencies can lead to subsequent changes (e.g., concavity, kyphosis, scoliosis and herniated discs) and irreversible deformities (Cerchiari et al., 2005).

The literature describes various methods and therapeutic techniques that have been used to improve postural problems. These techniques include physical exercises, electrical stimulation of the muscles (either in isolation or in association with exercise), reorganization of phasic and tonic posturing, osteopathy, Global Postural Re-education (GPR) and isostretching, among others (Oliveiras and Souza, 2004).

One of the approaches currently used to promote muscle recovery is the Pilates method, which improves body awareness by working the body as a whole, using gravity and springs to increase resistance and aid with the execution of each movement (Rodrigues et al., 2010). This method (and the apparatus used during therapy sessions) was developed by Joseph Pilates and involves exercises that seek harmony between body and mind based on several principles: centering, control, precision, fluidity of movements, concentration and breathing (Anderson and Spector, 2000).

Training for the Pilates method involves conscious use of trunk muscles to stabilize the pelvic-lumbar region (Rydeard et al., 2006), and the method was designed to improve flexibility and overall body health by emphasizing strength, posture and coordination of movements with respiration (Segal et al., 2004).

The objective of this study was to assess the effectiveness of the Pilates method in the improvement of non-structural scoliosis, flexibility and the level of pain in the spine.

Materials and methods

Study type

This study used a randomized controlled design (Thomas et al., 2007).

Subjects

The patients included 31 physiotherapy students at a private university in the state of Maranhão (Brazil), all sedentary adult women who met the following inclusion criteria: age between 18 and 25 years, sedentary lifestyle, presence of non-structural dorso–lumbar scoliosis back with rightward convexity (SRC) or leftward convexity (SLC), muscle shortening of the posterior chain, pain in a segment of the vertebral column, psychomotor skills, availability (for 1 h twice a week) and willingness to participate in the study. The number of patients in the study depended on the voluntary interest and inclusion criteria.

Patient selection took place at the University Center of Maranhão (UniCeuma).

Patients were randomly assigned (01/15/2009) to one of two groups: an experimental group (EG, $n = 20$) that participated in a therapy program using the Pilates method and a control group (CG, $n = 11$) that did not undergo any therapeutic intervention. Randomization was performed using the ARRED (ALEATORY) function in Microsoft Office Excel 2003, which generates the number 0 or 1 for each sample. Patients with the number 0 were allocated to the CG, and those with the number 1 were assigned to the EG. The person who decided on the subject eligibility was concealed from the allocation list of subjects.

This study met the standards for the conduct of research with human beings according to all procedures of the Declaration of Helsinki (WMA, 2008) and was approved by the Ethics Research Committee of the Castelo Branco/Rio de Janeiro under study No. 0143/2008 on 11/10/2008.

Assessment procedures

Initially, the spine of each patient was inspected to detect the presence of dorso–lumbar scoliosis with rightward convexity or leftward convexity. We then performed the Adams test to determine whether the scoliosis was non-

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structural. For this procedure, each patient was placed in a standing position, barefoot and without a shirt, with limbs extended by performing a forward flexion of the trunk, and the presence or absence of a gibbosity was assessed (Costa et al., 2002).

Blinded radiographic imaging was then performed for both groups using an Emic EMERALD Model 130-3 (USA) instrument to confirm the presence of SRC or SLC. Furthermore, the degree of scoliosis was re-evaluated by measurement of the Cobb angle (Goldberg et al., 1995) by tracing a line parallel to the upper boundary of the top vertebra and another line on the bottom edge of the adjacent lower vertebra and measuring the angle with a goniometer (CARCI, Brazil). The intersection of these two lines determined the angle of deviation of the spine. The Cobb angle is used to make decisions regarding the progression of the curve, which is necessary to verify the effectiveness of treatment (Modi et al., 2009).

To evaluate shortening of the posterior muscle group, flexibility was assessed using a goniometer (CARCI, Brazil) and the goniometry protocol of the Team Laboratory of Biometry and Physiology of Stress (LABIFIE) of the Federal Rural University of Rio de Janeiro. Patients were seated with legs outstretched, and the goniometer was positioned along the sagittal plane, with its central axis at the greater trochanter and its fixed axle parallel to the surface of the femur. The spindle followed the movement of trunk flexion through the mid-axillary line. Patients were asked to perform a flexion of the trunk, and the degree of flexibility was measured in this position (Melegario et al., 2006).

Patients were also evaluated using a questionnaire based on the scale of perceived pain using the Borg CR 10 to quantify the level of pain in the spine both before and after treatment. This questionnaire includes a numerical scale from 0 to 10, where 0 is no pain and 10 is extremely strong pain. The patients selected the number that best represented their level of pain (Borg, 1982).

Measurements of flexibility, radiological goniometry and pain were performed by the same observer (not blinded) under similar conditions for all patients.

Intervention using the Pilates method

A protocol of therapeutic exercises based on the Pilates method was carried out twice a week for 60 min per session for three months. In this way, the study finished on April, 19 of 2009.

The protocol was divided into three steps: preparation (warming up, followed by stretching skills), specific exercises and returning to a relaxed position.

Preparation-Warm-up consisted of 8 min of walking at an intensity comfortable for each patient on an treadmill (YOZDA®, Brazil) or an elliptical machine (MOVIMENT®, Brazil). Walking was followed by stretching on the floor for 5 min (with 5 repetitions for each stretch). The patients were instructed to perform the following stretching steps.

- Spine forward stretching: the patient was seated on the floor, with her spine erect, and with her legs fully outstretched. The patients was requested to move her trunk forward, in a thoracic flexion movement. The goals of this movement were to stretch the posterior muscle chain and to mobilize the vertebral spine.
- Upper rolling: the patient was instructed to lie supine with her arms beside her body. The patient raised both legs, stretching these over her head until her toes touched the floor. Afterward, the patient unrolled her spine slowly, lowering vertebra by vertebra, without letting her legs touch the floor and maintaining a 90° angle with her body. The goals of this move are to stretch the posterior chain and to mobilize the spine as well as to strengthen the abdomen (i.e., the external oblique, rectus femoris and tensor fasciae latae).
- Child Position (Figure 1): From the four support position, the patient was requested to stretch her spine, pushing her hands against the floor with her arms stretched and lowering her spine such that the calf muscles approximate the gluteals. The goals of this movement was to stretch the thoracic paravertebral, lumbar and gluteal regions and to mobilize the vertebral spine.
- Forward leg pull: In a four support position, each patient with SLC was instructed to raise her the right arm and leg together, keeping her spine aligned and avoiding ankle rotation. Each patient who presented with SRC was guided to made the opposite movement. The goal of this movement is to stretch the concavity of the vertebral spine.

Specific exercises- Exercises were carried out with Swiss balls, FlexBall Quarks® (Brazil) and proper equipment (Cadillac, Reformer, Step Chair and Ladder-Barrel) used in the Pilates techniques of the *D & D Pilates* series (Brazil). For the first two weeks (4 consults), there was a period of individual adaptation, with movements coordinated with breathing, to promote the correct performance of the exercises and familiarization with the exercises used in the 24 Pilates sessions. This step involved the 12 exercises that are described below (10 repetitions each).

-Hip moviments with a large ball (65 cm diameter):

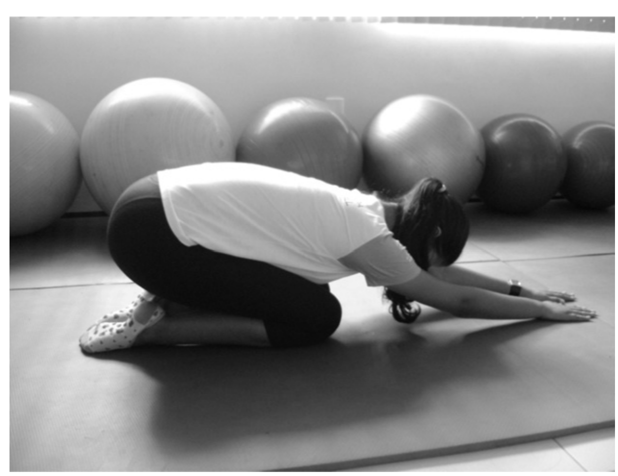

Figure 1 Child Position.

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Initial position- Lying down, with legs on the ball and the arms beside the body with the shoulders relaxed.

Sequence of movement- 1. Take a breath in the initial position. 2. Exhale, guide the navel toward the spine and gradually raise the pelvis from the floor until the body is aligned. 3. Breathe while keeping the pelvis raised. 4. Exhale while relaxing the chest, lowering vertebra by vertebra.

Goals- To strengthen the gluteal regions and to develop equilibrium.

-Inverted abdominal skills with a ball (55 cm diameter):

Initial position- Lying down, knees bent and the posterior part of the legs, thighs and heels pressed against the ball, with arms beside the body.

Sequence of movement- 1. Take a breath in the initial position. 2. Exhale while bringing the knees to the chest, lifting the ball off the floor. 3. Breathe and stay in the previous position. 4. Exhale and lower the ball to the floor.

Goals- To strengthen the infraabdominal region and the ischiotibial muscles.

-Rising into a seated position:

Initial position- Lying down position on the Ladder-Barrel equipment, elbows stretched, with hands holding a griptool and feet resting on the back of a chair.

Sequence of movement- 1. Breathe in the initial position. 2. Exhale, moving the chin toward the chest and lifting the shoulder blades off the barrel until in a seated position. 3. Breathe. 4. Exhale, returning to the initial position and unrolling the spine.

Goal- To strengthen rectus abdominis

-Lateral spine movement on a step chair with a spring of 0.1410 kgf positioned in the rings to provide major resistance (Figure 2):

Initial position- The patient sits laterally flexed with a hand on the movable bar.

Sequence of movement- 1. Breathe in the initial position. 2. Exhale, pushing the bar and, at the same time, guiding the opposite arm toward the head to make a lateral "C" with the spine. 3. Breathe. 4. Exhale while returning to the initial position.

Goal- To stretch lateral muscle chain according to the direction of the convexity of the scoliosis.

-Lateral spine movement (Figure 3):

Initial position- Standing laterally beside the Ladder-Barrel, with legs resting on the barrel in abduction with external rotation and hands holding a stick above the body.

Sequence of movement- 1. Breathe in the initial position. 2. Exhale, performing a lateral spine flexion according to the direction of convexity of the scoliosis. 3. Breathe. 4. Exhale, returning to the initial position.

Goal- To stretch the lateral muscle chain according to the direction of convexity of the scoliosis.

- Flexibility on the step chair with a spring of 0.1410 kgf positioned in the rings to provide major resistance (Figure 4):

Initial position- Standing on a ramp at 10° of inclination, facing the seat of the step chair, legs stretched out and hands on the step.

Sequence of movement- 1. Breathe in the initial position. 2. Exhale, pushing the step downward. 3. Breathe. 4. Exhale, returning to the initial position and unrolling the spine.

Goals- To mobilize the spine and to stretch the paravertebral thorax and lumbar regions.

-Series of supine leg stretches in the Cadillac with 2 springs of 0.0150 kgf, each situated in the superior and lateral rings of the equipment:

Initial position- Lying down position in the Cadillac, with feet in the handles, ankles flexed at 90° and superior limbs beside the body.

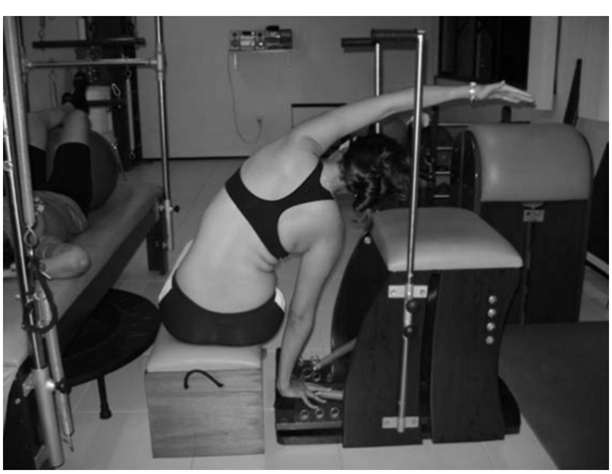

Figure 2 Movement performed in a step chair for the correction of SRC.

Figure 3 Movement held in the Ladder-Barrel for the correction of SLC.

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Figure 4 Movement performed on a step chair for a submaximal range of flexibility of the posterior muscular chain.

Sequence of movement- 1. Breathe in the initial position. 2. Exhale, extending the ankles, holding them together with knees extended. 3. Breathe. 4. Exhale, returning to the initial position.

Goals- To strengthen the gluteus maximus, ischiotibial muscles and ankle adductors.

-Leg extension in the Cadillac with 2 springs of 0.0150 kgf, each situated in the superior and lateral rings of the equipment:

Initial position- Lying down position in the Cadillac equipment, with feet in the rings, knees and hips bent at 90° and arms beside the body.

Sequence of movement- 1. Breathe in the initial position. 2. Exhale, extending the knees and hips, holding the ankles together. 3. Breathe. 4. Exhale, returning to the initial position.

Goals- To strengthen the gluteus maximus and quadriceps.

-Arms moving up and down in the Reformer with 2 springs of 0.0240 kgf, each positioned in the rings, with the force arm of the equipment set at maximal resistance:

Initial position- Lying down position in the Reformer, holding arm rings, with shoulders flexed to 90° and knees and hips maintained at 90° of flexion.

Sequence of movement- 1. Breathe in the initial position. 2. Exhale, performing an extension of the shoulders. 3. Breathe. 4. Exhale, returning to the initial position.

Goals- To strengthen dorsal muscle and major pectoral sections and posterior deltoid.

-Arms (triceps) in the Reformer with 2 springs of 0.0240 kgf, each positioned in the rings, with the force arm of the equipment set at maximal resistance.

Initial position- Lying down position in the Reformer, holding the rings in the hands, with the elbows flexed to 90° and knees and hips maintained at a flexion of 90°.

Sequence of movement- 1. Breathe in the initial position. 2. Exhale, performing an extension of the elbows. 3. Breathe. 4. Exhale, returning to the initial position.

Goals- To strengthen brachial triceps and anconeus muscles.

-Spine roll in the Cadillac, with 2 springs of 0.0150 kgf, each positioned in the superior rings of the equipment:

Initial position- Seated in the Cadillac, with feet resting on the lateral rods, holding the movable bar.

Sequence of movement- 1. Breathe in the initial position. 2. Exhale, perform an anterior flexion of the head toward the chest and then roll the spine slowly backward, mobilizing vertebra after vertebra, until lying down. 3. Breathe. 4. Exhale, perform anterior flexion of the head again and then slowly unroll the spine until lying down.

Goals- To improve mobility of the vertebral spine and to improve abdominal control.

-Extension of the spine in the Cadillac with 2 springs of 0.0150 kgf, each positioned in the superior rings of the equipment:

Initial position- Standing on the Cadillac, with hands on the fixed bar.

Sequence of movement- 1. Breathe in the initial position. 2. Exhale, rolling the cervical region and the spine forward, performing an anterior flexion of the spine to the maximal amplitude. 3. Breathe. 4. Exhale, returning to the initial position.

Goal- To stretch the posterior chain.

Returning to a relaxed position (relaxation with a ball 75 cm in diameter)- This procedure consisted of 3 movements, with 3 repetitions per movement, and lasted 5 min. Movements should be performed swiftly, to promote a state of relaxation. They are aimed at metabolic recovery and relaxation of the stimulated muscles and include three steps:

1. Patient lies down with her side on the ball, according to the direction of the convexity of the scoliosis.
2. Afterward, the patient lies down inclined on the ball, supported by the feet and hands.
3. Last, the patient lies down in an elevated position on the ball, keeping her feet resting on the floor and her superior limbs backward.

All exercises should be performed using kinetic chains that were mostly closed, providing overall strengthening of the chain rather than isolated muscles. The pelvis is held in a neutral stable position, in which the abdominal muscles are contracted, with specific recruitment of the transversus abdominis, a muscle essential for stabilization of the lumbar spine and neck when stretched (Gouveia & Gouveia, 2008). Movements are oriented according to the direction of convexity of scoliosis for each patient to improve the shortening of the posterior muscle group.

To control the intensity of the effort applied during exercise, we used the Perceived Exertion Scale (Perflex)

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(Dantas et al., 2008) in all training sessions. In the experimental group, the intensity of effort in all sessions was between 61 and 80, characterizing maximal intensity (flexing). The results were calculated as the final mean of each daily mean. The mean value of perceived exertion was found to be 69.2 (standard deviation [SD]: 7.5).

Patients were verbally guided and manually adjusted by the same physiotherapist, who asked them to maintain proper posture during the movements. Furthermore, patients performed the exercises without causing pain, adapting to the load and repeating the exercises according to their individual functional capacity.

The respiratory mechanics used during the movements were as follows: inspire completely, stop in the stabilized posture, increasingly expand the chest and exhale (returning to the initial position). The respiratory rate was coordinated with execution of the movement, and the end of the sequence was reached at the end of expiration.

The control group had weekly meetings with the researcher, who ensured that they maintained the desired conditions for this group.

Statistical analysis

To determine means and standard deviations of the responses of each patient group, we used descriptive statistics. For inferential statistics, we used 2 × 2 ANOVA with repeated measures, with the first factor being the group and the second factor (the repeated measures, pre and post-therapy) being the Cobb angle, degree of flexibility or pain level. In the case of a statistically significant interaction (pre- vs. post-therapy), we used t tests with unequal sample sizes (SPSS 18). The level of significance was set at 0.05. Statistical analysis was performed blind.

Results

The means and standard deviations of the Cobb angle, range of motion of trunk flexion and pain in the control and Pilates groups are shown in Table 1.

The independent t test of the Cobb angle ($t = -2.317$, $p = 0.028$), range of motion of trunk flexion ($t = 3.088$, $p = 0.004$) and pain ($t = -2.478$, $p = 0.019$) showed significant differences between the groups, with best values in the Pilates group. The dependent t test detected a significant decrease in the Cobb angle (Δ% = 38%, $t = 6.115$, $p = 0.0001$), a significant increase in trunk flexion (Δ% = 80%, $t = -7.977$, $p = 0.0001$) and a significant reduction in pain (Δ% = 60%, $t = 7.102$, $p = 0.0001$) in the EG (Figures 5, 6 and 7). No significant difference in Cobb angle ($t = 0.430$, $p = 0.676$), trunk flexion, ($t = 0.938$, $p = 0.371$) or pain ($t = 0.896$, $p = 0.391$) was found for the CG.

The effect size (the difference if the mean one group minus the mean of the other group divided by the SD; Cohen, 1969) was 0.65 for the Cobb angle, 1.1 for trunk flexion and 0.80 for pain.

Discussion

The main findings of this study were that Pilates exercises significantly decrease the degree of scoliosis, increase flexibility of the posterior muscular chain and reduce pain in the spine. These positive effects can be attributed to the nature of the movements, which obey the basic principles emphasized by the method. These movements were performed while seeking body awareness of muscle contractility by stabilizing the pelvis and lumbar spine, emphasizing perfect movements and maintenance of postural control.

These results agree with the study of Rydeard et al. (2006). In that study, patients participated in specific training for Pilates directed toward the mechanisms of neuromuscular control, which was effective in reducing pain and improving muscle function. This improvement occurred because of the effort to stabilize the transverse abdominal muscles, lumbar multifidus, diaphragm and pelvic floor, in addition to stabilization of the gluteus maximus muscles. These findings also agree with the work of Gouveia and Gouveia (2008), which emphasized the importance of the transverse abdominal muscle in stabilizing the spine during exercises of the abdominal wall, perhaps preventing or minimizing postural changes (such as scoliosis) and pain.

A study by Endleman and Critchley (2008) verified that the transverse abdominal muscles and internal oblique muscles were significantly thicker after training with the Pilates method, which activated the deep abdominal muscles. They

Table 1 Means and standard deviations of the Cobb angle, range of motion and pain score of the sedentary adult women in the control and Pilates groups.

Response variable	CG $n = 11$		EG $n = 20$	
	Pre	Post	Pre	Post
Cobb angle (°)	7.1 (2.8)	6.9 (3.1)[a]	7.6 (3.5)[b]	4.8 (2.0)[c,f]
Range of motion (°)	8.2 (5.2)	7.8 (5.5)[a]	9.5 (5.9)[b]	17.6 (9.6)[d,f]
Pain	4.4 (2.3)	3.8 (2.7)[a]	5.3 (1.5)[b]	1.8 (1.9)[e,f]

CG: Control group; EG: Experimental group.
[a] No significant differences pre and post-treatment in the control group ($p > 0.83$).
[b] No significant differences between groups ($p > 0.80$).
[c] The post hoc test detected a significant reduction of 38% in the grade of scoliosis for the Pilates group ($p = 0.0002$).
[d] The post hoc test detected a significant increase of 80% in trunk flexion for the Pilates group ($p = 0.0002$).
[e] The post hoc test detected a significant decrease of 60% in level of pain for the Pilates group ($p = 0.0002$).
[f] No significant differences between groups ($p > 0.11$).

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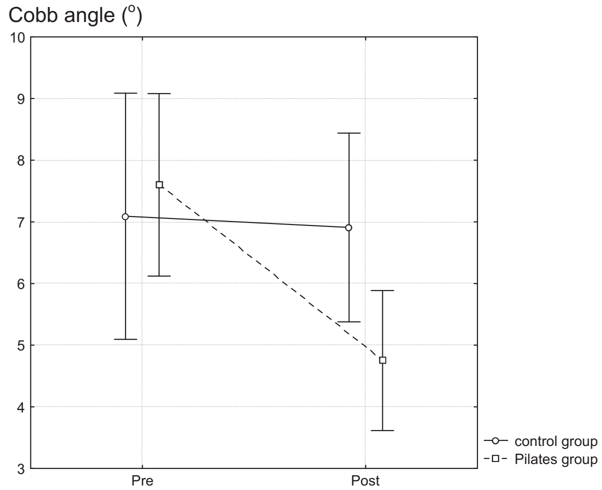

Figure 5 Cobb angles (degrees of non-structural scoliosis) in the control and Pilates groups before and after treatment.

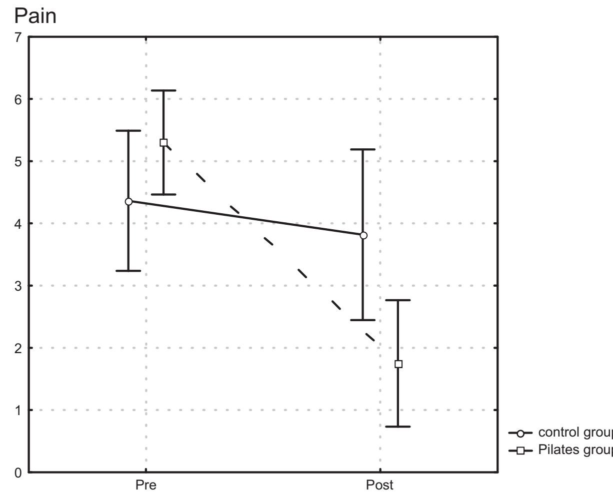

Figure 7 Pain in the control and Pilates groups before and after treatment.

suggested that this increase in thickness indicates increased muscle activity, which helped to stabilize or protect the spine. It is important to remember that, in our study, the movements carried out resulted in improvements in functional capacity on the whole. However, we did not directly evaluate this increase in capacity because the exercise intensity was progressively increased and adjusted to the performance of each patient to improve contractility of the required abdominal muscles, showing satisfactory results for the spine, flexibility and pain.

Strengthening the multifidus muscle and transverse abdominal muscles was also examined in a study conducted by Kofotolis and Kellis (2006) using a Proprioceptive Neuromuscular Facilitation (PNF) exercise program. They observed an improvement in muscle strength, endurance, trunk flexibility and chronic low back pain because the patterns of PNF exercises were based on a spiral, and performance of these exercises was in line with the topographical arrangement of the muscles used, as is true for Pilates training. The

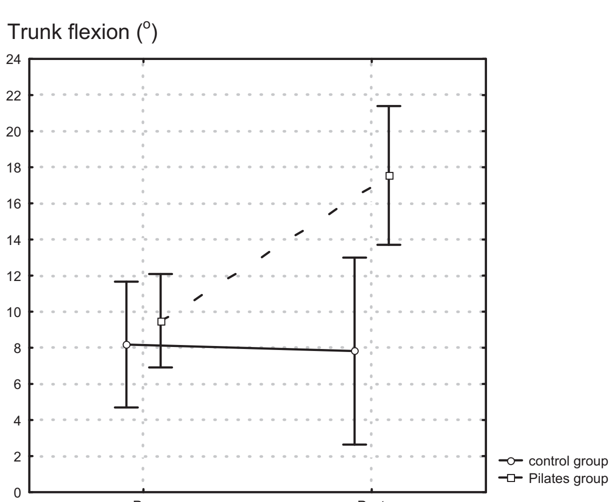

Figure 6 Range of motion bending the trunk for the control and Pilates groups before and after treatment.

performance of the movement patterns of PNF may be based on the specific muscles that are involved in the actions and movements used in various sports. As for PNF exercises, Pilates movements are performed using all types of muscle contraction (e.g., concentric, eccentric and isometric), establishing a progressive increase in muscular flexibility, recruitment and strength.

Blum (2002) explains that the problems associated with scoliosis can be caused by or occur as a result of body imbalance and "preferred" movement patterns. A weak or misaligned area can result in a propensity for compensation or the development of another area. Therefore, it is clear that the Pilates method leads to a rebalancing of the muscles. The symmetrical nature of Pilates exercises, is an excellent approach for rehabilitation therapy of patients who have muscle imbalances due to scoliosis.

The same focus on developing balance in the musculoskeletal system, combining flexibility, muscle contraction, body awareness and posture correction, was used in the study of Oliveiras and Souza (2004). With isostretching and osteopathic manipulation of the pelvis and the apex of the scoliotic curve, they observed a reduction of 66.7% in the degree of scoliotic curvature by measuring the Cobb angle from X-rays, and 16.7% of patients stabilized this curve. When comparing the initial and final observations, there was improvement in the standard posture of the patients.

The Pilates methods used in this study showed that when movements are executed with maximal precision, concentration and postural control, there can be extraordinary effects on the targeted muscle group. Satisfactory effects were also found by Sekendiz et al. (2007), who examined the effects of Pilates exercises on posterior chain flexibility in sedentary adult women by evaluating "sit and reach" ability. They showed a significant difference between measurements before (23.9 (7.5)) and after (31.1 (6.8)) intervention in the experimental group ($p < 0.001$). The control group values were 20.7 (8.3) in the period before intervention and 21.8 (9.4) after intervention, however the p value was not significant. The experimental group showed great improvement in the flexibility of the posterior chain compared to the control group, supporting the results of the present study.

The results of this study are important, given that none of the female university students, who were previously sedentary, found themselves limited at the completion of the treatment. They were able to carry out movements with increasing levels of difficulty, constantly emphasizing the use of stabilizing muscles of the trunk. These results show that patients with non-structural scoliosis can significantly improve muscle shortening of the posterior chain and subsequently reduce pain levels in the spine using the Pilates method.

However, there is a need for future studies to investigate the clinical course of these students for a longer period of time to verify the satisfactory effects of this treatment protocol.

Conclusion

We found that an exercise program using the Pilates method in female patients with non-structural scoliosis improved back pain and muscle shortening of the posterior chain. There was a reduction in the grade of scoliosis, increased flexibility and decreased levels of pain, all a result of the body awareness and postural control emphasized by this method.

There is a scarcity of randomized prospective studies comparing the effects of exercise using the Pilates method to treat scoliosis, flexibility and pain in the spine. This treatment protocol can be used, however, to minimize the degree of non-structural scoliosis, improve flexibility of the posterior muscular chain and reduce pain. Improvement in functional capacity could be analyzed because such improvement was observed as a direct result of increased flexibility and increased resistance to movements, supporting the effectiveness of Pilates exercises in the treatment of scoliosis and postural pain in the spine.

Although the results obtained in this study after training (38% improvement of scoliosis, 80% increased flexibility and 60% reduction in pain) were satisfactory, there are few studies showing the effects of therapeutic treatment using the Pilates method. It is hoped that further studies will also show the benefit of the Pilates method.

References

Anderson, B.D., Spector, A., 2000. Introduction to Pilates-based rehabilitation. Orthopaedic Physical Therapy Clinics of North America 9 (3), 395–410.

Bassani, E., Candaotti, C.T., Pasini, M., Melo, M., La Torre, M., 2008. Assessment of neuromuscular activation in individuals with scoliosis using surface electromyography. Revista Brasileira de Fisioterapia 12 (1), 13–19.

Blum, C.L., 2002. Chiropractic and pilates therapy for the treatment of adult scoliosis. Journal of Manipulative Physiological Therapeutics 25 (4), E3.

Borg, G.A., 1982. Psychophysical bases of perceived exertion. Medicine and Science in Sports and Exercise 14 (5), 377–381.

Cerchiari, P.A.R., Fujiwara, E., Pereira, T.G., Turchetti, V.A., 2005. Academic environment: the classroom accommodation and computer rooms of UNICAMP and its relation to the health of students. Revista Ciências do Ambiente on-line 1 (1), 13–19 (Portuguese).

Cohen, J., 1969. Statistical Power Analysis for Behavioral Sciences, second ed. Academic Press, New York.

Costa, A., Sousa, S.G., Oliveira, A., 2002. The pediatric scoliosi. Saúde Infantil 24 (1), 39–45 (Portuguese).

Dantas, E.H.M., Salomão, P.T., Vale, R.G.S., 2008. Scale of perceived exertion in the flexibility (PERFLEX): a dimensionless toolto evaluate the intensity. Fitness & Performance Journal 7 (5), 289–294.

Endleman, I., Critchley, D.J., 2008. Transversus abdominis and obliquus internus activity during pilates exercises: measurement with ultrasound scanning. Archives of Physical Medicine and Rehabilitation 89 (11), 2205–2212.

França, F.J.R., Burke, T.N., Claret, D.C., Marques, A.P., 2008. Spinal segmental stabilisation in low-back pain: a literature review and an exercise program. Revista Fisioterapia & Pesquisa 15 (2), 200–206 (Portuguese).

Goldberg, C.J., Dowling, F.E., Fogarty, E.E., Moore, D.P., 1995. Adolescent idiopathic scoliosis as developmental instability. Genética 96 (3), 247–255.

Gouveia, K.M.C., Gouveia, E.C., 2008. The transversus abdominis muscle and its function on the lumbar spine stabilization. Fisioterapia em Movimento 21 (3), 45–50 (Portuguese).

Junior, J.R., Tomaz, C., 2008. Effects of reeducation posture global by the method (RPG/RFL) of corretion posture and reequilibrum muscle. Fisioterapia em Movimento 21 (3), 127–137 (Portuguese).

Kofotolis, N., Kellis, E., 2006. Effects of two 4-week proprioceptive neuromuscular facilitation programs on muscle endurance, flexibility, and functional performance in women with chronic low back pain. Physical Therapy 86 (7), 1001–1012.

Kussuki, M.O.M., João, S.M.A., Cunha, A.C.P., 2007. Postural characterization of obese children spine between 7 and 10 years old. Fisioterapia em Movimento 20 (1), 77–84 (Portuguese).

Melegario, S.M., Simão, R., Vale, R.G.S., Batista, L.A., Novaes, J.S., 2006. The influence of the menstrual cycle on the flexibility in practitioners of gymnastics at fitness centers. Revista Brasileira de Medicina do Esporte 12 (3), 125–129 (Portuguese).

Modi, H.N., Chen, T., Suh, S.W., Mehta, S., 2009. Observer reliability between juvenile and adolescent idiopathic scoliosis in measurement of stable Cobb's angle. European Spine Journal 18, 52–58.

Oliveiras, A., Souza, D., 2004. Physiotherpy treatment for scoliosis through the techniques of iso-stretching and osteopathic manipulation. Terapia Manual 2 (3), 104–113 (in Portuguese).

Rodrigues, B.G.S., Cader, S.A., Torres, N.V.O., Oliveira, E.M., Dantas, E.H.M., 2010. Pilates method in personal autonomy, static balance and quality of life of elderly females. Journal of Bodywork & Movement Therapies 14 (2), 195–202.

Rydeard, R., Leger, A., Smith, D., 2006. Pilates-based therapeutic exercise: effect on subjects with nonspecific chronic low back pain and functional disability: a randomized controlled trial. Journal of Orthopaedic and Sports Physical Therapy 36 (7), 472–484.

Segal, N.A., Hein, J., Basford, J.R., 2004. The effects of Pilates training on flexibility and body composition: an observational study. Archives of Physical Medicine and Rehabilitation 85 (12), 1977–1981.

Sekendiz, B., Altun, O., Korkusuz, F., Akın, S., 2007. Effects of Pilates exercise on trunk strength, endurance and flexibility in sedentary adult females. Journal of Bodywork & Movement Therapies 11 (4), 318–326.

StatSoft, Inc, 2001. STATISTICA (Data Analysis Software System). Version 6. www.statsoft.com.

Thomas, J.R., Nelson, J.K., Silverman, S.J., 2007. Methods of Research in Physical Education. Artmed, Porto Alegre (Portuguese).

Wma - World Medical Association, 2008. Declaration of Helsinki. http://www.wma.net/e/policy/b3.htm (last accessed on 06/04/2008).

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