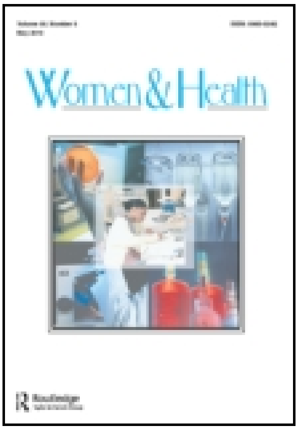

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Does Pilates-Based Exercise Improve Postural Alignment in Adult Women?

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Does Pilates-Based Exercise Improve Postural Alignment in Adult Women?

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A randomized, controlled trial was conducted to determine the effect of Pilates-based exercise on postural alignment. Seventy-four adult women (mean age ± SD, 34.9 ± 16.4 years) were randomized to a Pilates-based mat class (n = 40) or a control group (n = 34). Pilates-based exercise participants were taught the Initial Mat of Body Control Pilates for 6 months, twice a week, for 60 minutes per session; the control group received no exercise intervention. Repeated measurements were performed at baseline, 3 months, and 6 months of the frontal alignment of the thoracolumbar spine, shoulder, and pelvis, and sagittal alignment of the head and pelvis. No differences were found in either group, over time, on frontal alignment of the thoracolumbar spine and pelvis. The experimental group showed significant improvements in frontal alignment of the shoulder and sagittal alignment of the head and pelvis at 6 months. The Pilates-based exercise enhanced some parameters of

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the postural alignment of women, as measured by frontal alignment of the shoulder and sagittal alignment of the head and pelvis. The significant improvement in sagittal alignment of the head may imply that 6 months of Pilates-based exercise enhances sagittal alignment of the cervical or thoracic spine.

KEYWORDS *Pilates method, RCT, posture*

INTRODUCTION

The Pilates method of exercise is a popular mind-body program that has been widely acknowledged. Created by Joseph Pilates, this method was designed to improve one's posture by uniformly developing all muscles, with minimum use of energy and maximum pleasure (Pilates, 1934).

A new systematic review concluded that the Pilates method of exercise requires core stability, strength, and flexibility and involves attention to muscle control, posture, and breathing (Wells, Kolt, & Bialocerkowski, 2012). The core stability is the key to postural stability (Smith & Smith, 2005), contributing to the optimal lumbar-pelvic stabilization needed for daily activities and function (McGil & Cholewicki, 2001). This increased core muscle strength improves spinal stabilization and promotes efficient use of the extremities (Bryan & Hawson, 2003; Muscolino & Cipriani, 2004b). Strengthening and stretching exercises promote balance, skeletal alignment, and consequently postural realignment (Hrysomallis & Goodman, 2001). The attention used in the Pilates method of exercise refers to cognitive concentration required to perform an exercise (Latey, 2001), through verbal cues, body awareness, and imagery practice (Lange et al., 2000).

Sedentary habits, ergonomically inadequate work equipment, and lack of body awareness may be responsible for postural misalignments. While the ideal postural alignment is associated with pain-free movement, postural misalignment is associated with musculoskeletal symptoms (Tsuji et al., 2002; Yip, Chiu, & Poon, 2008; Emami et al., 2007). Aging is also related with gradual loss of postural alignment (Kuo, Tully, & Galea, 2009; Boyle, Milne, & Singer, 2002; Vialle et al., 2005). To prevent postural misalignment, intervention programs based on core stability (Kuo et al., 2009), strength/stretch (Katzman et al., 2007; Carpes, Reinehr, & Mota, 2008), and cognitive attention (Greendale et al., 2009) are usually used.

Despite the popularity of the Pilates method of exercise and claims of improving postural alignment, few randomized controlled trials have been conducted to measure its effect on postural alignment in healthy adults. The studies that have been published have had conflicting results. Improvements in thoracic kyphosis were reported in 34 healthy older adults after 10 weeks of Pilates mat work (Kuo et al., 2009) and in 19 healthy adults after 12 weeks of Pilates mat work and apparatus training (Emery et al., 2009). In pelvic alignment, improvements were found in 29 dance students after 7 weeks of Pilates mat work and apparatus training (Fitt, Sturman, & McClain-Smith, 1993). Alternatively, no differences in postural alignment were observed in 11 healthy adult females after 10 weeks of Pilates mat work (Donahoe-Fillmore et al., 2007). Also, no improvements were found in postural alignment in 50 healthy adults after 12 weeks of Pilates on mat, although the evaluated area was not specified (Kloubec, 2010). A recent systematic review in a healthy population reported inconclusive evidence to support the effectiveness of the Pilates method of exercise in improving postural alignment. According to those authors, more randomized controlled trials are clearly needed using high quality methods to minimize bias (Cruz-Ferreira, Fernandes, Laranjo, et al., 2011).

To overcome the shortcomings of the extant literature, researchers conducted a randomized, controlled trial to investigate the effectiveness of a Pilates-based exercise (PBE) program on the postural alignment of healthy women.

METHODS

Participants

An approval from the Ethics Committee of the University of Évora, Portugal, was obtained for the protocol to conduct this study. Recruitment procedures were reported previously (Cruz-Ferreira, Fernandes, Gomes, et al., 2011) and targeted healthy women aged 25–55 years, to provide a wide age range of adult women, who were users of the University's electronic mail system. Community participants were recruited using materials posted in local trade and public offices. Exclusion criteria were pregnancy; contraindications to exercise from cardiovascular, neuromuscular, or neurological disorders; structural spine deformity; previous experience in PBE; or regular physical exercise during the previous year. Written informed consent was obtained from all participants before their study enrollment. A registered nurse, blinded to group allocation, screened and consented eligible participants. Eighty Caucasian participants met the selection criteria for inclusion in the study, and fourteen were excluded. The participants included were randomly assigned into one of two groups containing 40 participants each: a PBE group and a control group (CG). Randomization was administered by an honest broker using a table of random numbers, and the allocation was concealed (Figure 1). Six participants of the CG dropped out of the study due to personal issues ($n = 3$), pregnancy ($n = 1$), and sudden illness ($n = 2$). The final sample was composed of 74 participants, 40 in the PBE group and 34 in the CG.

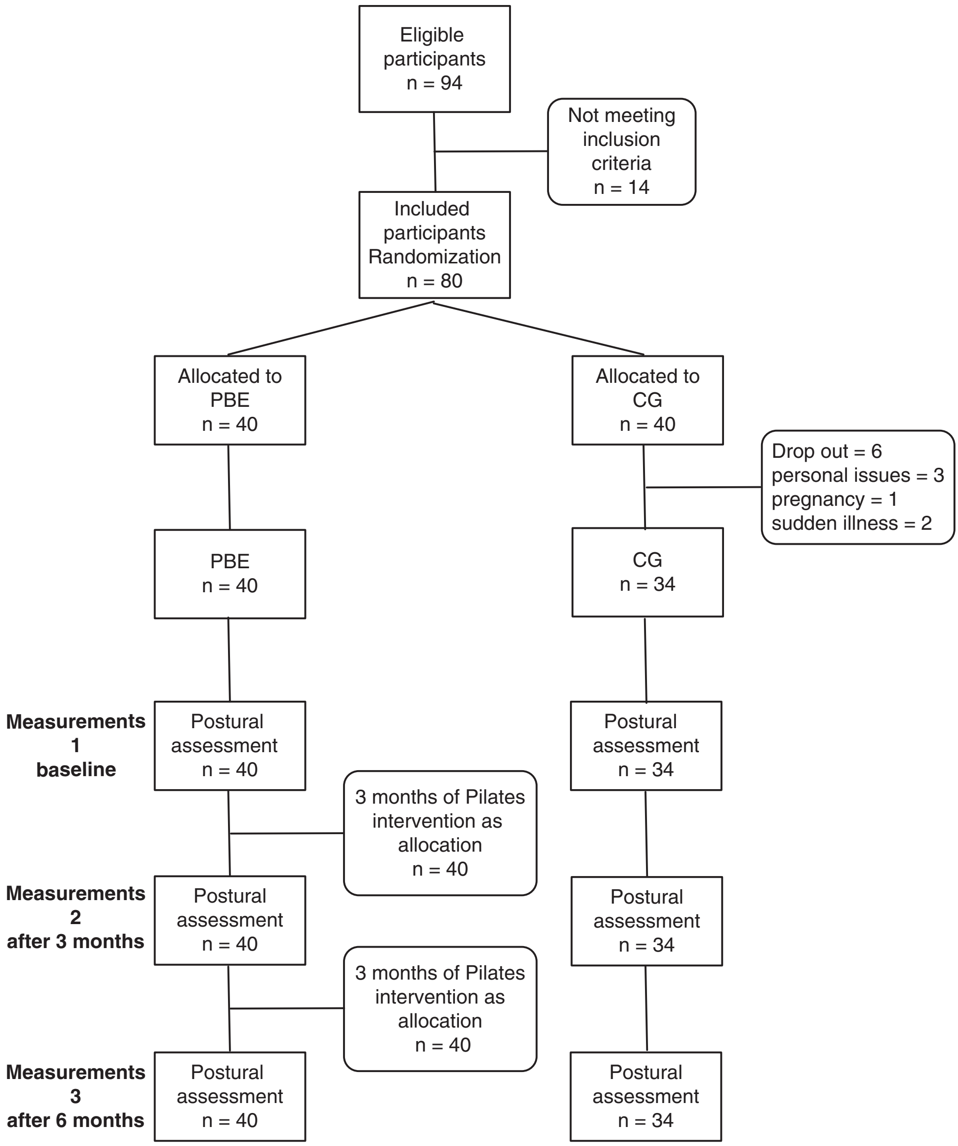


FIGURE 1 Flowchart of participants in the trial.

Intervention

The PBE and data collection sessions were held at the research institution. The principal investigator, certified in Body Control Pilates®, designed and instructed the PBE program tailored to the study's time frame. The class format followed the Body Control Pilates® program designed to prepare the participants to perform the 34 mat exercises safely as originally created by Joseph Pilates. Due to the 6-month study time frame and the Pilates-naïve participants, the PBE program was the Initial Mat. The Initial Mat focuses on alignment and awareness, breathing and release, pelvic stability, scapular stability, spinal movements, and stretches and release. All exercises were conducted in progressively more difficult sequences. For example, weight training was introduced when the participants were able to maintain a neutral spine and pelvis. Individual limitations were respected, and new exercises were introduced when participants mastered the previous ones. Each exercise was demonstrated with verbal, visual, and kinesthetic cues. The classroom had no mirrors, and the instructor provided feedback by intensifying the demonstrations and emphasizing the most frequently made mistakes. Props included a cushion, mat, tennis ball, stretch band, pole, and hand-held weights between 1 and 2 kg.

The PBE group attended 6 months of PBE classes, twice a week on non-consecutive days for 60 minutes per session. They were instructed not to perform any exercises at home during the study. The CG did not receive PBE or any other exercise training, and they were instructed to maintain their existing levels of physical activity.

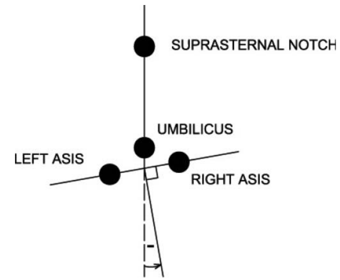
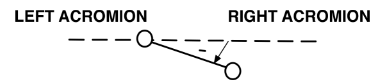
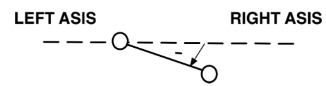
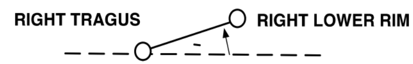
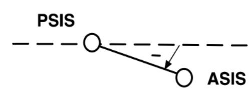
Women & Health 2013.53:597-611.

Outcome Measurements

The participants were tested at baseline and after 3 and 6 months. For postural assessment, the participants wore tight-fitting underwear or a swimsuit. To identify the anatomical landmarks, nine reflector sphere markers were attached to the left tragus, the right lower rim of the right orbital cavity, the left and right midpoint of the lateral surface of the acromion, the left and right anterior superior iliac spine, the right posterior superior iliac spine, the suprasternal notch, and the umbilicus. Postural measurements were taken in the frontal and sagittal planes. The following outcomes were evaluated: frontal alignment (FA) of thoracolumbar spine (suprasternal notch, umbilicus, left and right anterior superior iliac spine), FA of the shoulder (left and right acromions) (Ferreira et al., 2011), FA of the pelvis (left and right anterior superior iliac spine) (Ferreira et al., 2011), sagittal alignment (SA) of the head (right tragus and right lower rim), and SA of the pelvis (right posterior superior iliac spine and right anterior superior iliac spine) (Ferreira et al., 2011) (Table 1). Different anatomical points are usually used to measure the same angle (Ferreira et al., 2011; Fernández-de-las-Peñas et al., 2007; Harman, Hubley-Kozey, & Butler, 2005; Kuo et al., 2009). In this study, new anatomical points were used to assess the FA of the thoracolumbar spine and SA of the head.

Participants were instructed to stand for 10 seconds, assuming a comfortable erect spine. The participants' asymptomatic concept of comfortable erect posture was constant, representing their true postural alignment (Bulock-Saxton, 1993). The anterior and right lateral views were videotaped. The tripod-mounted video camera was placed 2.5 m on a perpendicular

TABLE 1 Description of Outcomes Measures

	Outcomes	Description	Graphic	Values
Frontal alignment	Thoracolumbar spine	Angle between suprasternal notch and umbilicus and the line of both ASIS.		Zero degrees: aligned vertically. Negative values: lateral flexion to the right. Positive values: lateral flexion to the left.
	Shoulder	Angle between left acromion and right acromion and horizontal.		Zero degrees: aligned horizontally. Negative values: tilt to right. Positive values: tilt to left.
	Pelvis	Angle between left ASIS and right ASIS and horizontal.		
Sagittal alignment	Head	Angle between the line of the right lower rim of the orbital cavity and the right tragus and horizontal.		Zero degrees: aligned horizontally. Negative values: right lower rim of the orbital cavity superior to tragus. Positive values: right lower rim of the orbital cavity inferior to tragus.
	Pelvis	Angle between the line of right ASIS and right PSIS and horizontal.		Zero degrees: aligned horizontally. Negative values: anterior tilt. Positive values: posterior tilt.

ASIS = left and right anterior superior iliac spine; PSIS = right posterior superior iliac spine.

line from the back wall and 80 cm above the floor. One plumb line was suspended from the ceiling to provide a vertical reference. To calculate the planar angles, the 2DLT method and Matlab version R2009_b software (MathWorks, Inc: MA-EUA) routines were used. An assessor blinded to the participants' group assignment marked anatomical landmarks at each point measure and analyzed the videotapes. Intra-class correlation coefficients between measurements by the same rater of marker placement ranged from 0.722 to 0.996 (SEM = 0.08° to 0.7°).

Demographic characteristics

To characterize all the participants, weight, height, waist circumference, body mass index (BMI), and physical activity were evaluated at baseline. Weight (kg), height (cm), and waist circumference (cm) were measured using standardized procedures (Lohman, Roche, & Martorell, 1988) and by means of an electronic scale (Secca Bella 840), stadiometer (Secca 770), and a measuring tape (Secca 201), respectively. BMI was calculated as weight in kilograms divided by the square of height in meters. Physical activity (MET min/week) was assessed using the short form International Physical Activity Questionnaire (IPAQ, 2005; Craig et al., 2003). This outcome was expressed as the sum of metabolic expenditure spent on vigorous-intensity and moderate-intensity activities and walking for at least 10 consecutive minutes.

Statistical Analysis

Statistical analyses were computed using SPSS software, version 17.0 (SPSS Inc., Chicago, IL). The level of significance was set at $p < .05$. Intra-class correlation coefficients were calculated. The independent *t*-test was applied to assess differences in continuous variables between the groups at baseline. Repeated measures (ANOVA) were used to compare the outcome variables between groups (PBE and CG) and among measured time points (baseline, 3, and 6 months), with baseline scores used as the covariate, followed by the Bonferroni post hoc test. The assumptions of these statistical tests were met. Effect sizes are reported as partial eta-squared (ηp^2), with the following cut-off values: [.01, .059] [.06, .139] and $\geq$ .014 for small, medium, and large effects, respectively (Cohen, 1988).

RESULTS

The two groups at baseline were similar in age, weight, height, BMI, and weekly physical activity (Table 2), so that no baseline covariates other than initial anatomical measurements were controlled in the longitudinal analyses. Verbal confirmation was received from both groups that they did not change their physical activity and did not practice home exercises during the study.

TABLE 2 Participant Characteristics

Participant characteristics	PBE $n = 40$	CG $n = 34$	p
Age (years)	41.8 ± 20.6	38.6 ± 8.2	.74
Weight (kg)	65.0 ± 9.9	64.3 ± 7.6	.75
Height (cm)	160 ± .09	161 ± .06	.35
BMI (kg/m^2)	25.8 ± 5.0	24.7 ± 2.9	.25
IPAQ (MET min/week)	2,146 ± 2,647	2,959 ± 4,292	.32

Note. Values are mean ± standard deviation (SD).
IPAQ = International Physical Activity Questionnaire–Short Form.

At baseline, the independent *t*-test revealed no significant differences between the groups in any postural outcome measure (Table 3). The results of ANOVA indicated that while no significant interaction effect was found on inter-group analysis in FA of the thoracolumbar spine ($p = .473$; $\eta p^2 = 0.007$) and pelvis ($p = .864$; ηp^2 0.001) and SA of the pelvis ($p = .606$; $\eta p^2 = 0.004$), significant differences were observed at 6 months in FA of the shoulder ($p = .014$; $\eta p^2 = 0.083$) and SA of the head ($p = .000$; $\eta p^2 = 0.163$). Initially in FA, the right shoulder was lower than the left, and after 6 months the shoulders were almost horizontally aligned in the PBE group. In addition, at baseline in SA the right lower rim of the orbital cavity was superior to the tragus, and at the end of the study they approached being horizontally aligned. In FA of shoulder and in SA of the head, the mean values (standard deviation) changed from −1.17° (2.38) to 0.13° (1.81) and from −14.71° (9.06) to −3.45° (6.49), respectively.

The results of the repeated measures ANOVA showed a significant main effect of time in the PBE group on FA of the shoulder and SA of the head and pelvis (Table 4). In FA of the shoulder and sagittal alignment of the pelvis, the PBE group had significant changes between baseline and 3 months ($p < .001$; $p = .007$) and between baseline and 6 months ($p < .001$; $p = .004$). Furthermore, the PBE group had significant differences in SA of the head between baseline and 6 months ($p < .001$) and between 3 and 6 months ($p < .001$). No significant differences were observed in CG for the three time points measures for all outcomes.

DISCUSSION

The results of this study provided evidence to support the effectiveness of PBE as a means of improving FA of the shoulder and SA of the head and pelvis in adult women when practiced 2 hours per week for 6 months.

The present findings may be due to the nature of PBE, as illustrated in published research reports. PBE has been shown to promote changes in habitual posture by enhancing spinal (Kuo et al., 2009; Smith & Smith, 2005; Muscolino & Cipriani, 2004a), scapular (Lange et al., 2000), and joint

TABLE 3 Inter-Group Analysis of Postural Outcomes

	Baseline			3 Months			6 Months		
Outcomes	PBE	CG	*p*	PBE	CG	*p*	PBE	CG	*p*
Frontal alignment of the thoracolumbar spine	−0.45 (1.85)	−0.20 (1.36)	.230	−0.03 (1.78)	−0.20 (1.18)	.633	−0.37 (1.93)	−0.87 (1.54)	.561
Frontal alignment of the shoulder	−1.17 (2.38)	−0.89 (2.73)	.634	0.32 (1.99)	−0.41 (2.95)	.018*	0.13 (1.81)	−0.48 (2.93)	.042*
Frontal alignment of the pelvis	−1.62 (2.60)	−0.43 (2.69)	.058	−1.00 (1.78)	−0.01 (2.67)	.295	−0.87 (2.35)	−0.86 (3.58)	.308
Sagittal alignment of the head	−14.71 (9.06)	−16.83 (10.50)	.354	−16.08 (10.12)	−18.62 (10.55)	.448	−3.45 (6.49)	−16.47 (11.97)	.001*
Sagittal alignment of the pelvis	−7.52 (4.32)	−5.47 (7.12)	.133	−3.79 (6.45)	−3.67 (8.14)	.617	−4.27 (5.04)	−4.17 (7.39)	.539

Note. Values are in degrees, expressed as mean (standard deviation).
*$p < .05$.

TABLE 4 Intra-Group Analysis of Postural Outcomes

Outcomes			Mean differences (°) (95% CI)	p
Frontal alignment of thoracolumbar spine	PBE	B to P1	−0.5 (−1.0 *to* 0.2)	0.216
		B to P2	−0.1 (−0.8 *to* 0.6)	1.000
		P1 to P2	0.4 (−0.5 *to* 1.2)	0.992
	CG	B to P1	−0.6 (−1.3 *to* − 0.0)	0.067
		B to P2	−0.3 (−1.1 *to* 0.4)	0.794
		P1 to P2	0.3 (−1.2 *to* 0.7)	1.000
Frontal alignment of the shoulder	PBE	B to P1	−1.5 (−2.1 *to* − 0.8)	< 0.001*
		B to P2	−1.3 (−1.9 *to* − 0.6)	< 0.001*
		P1 to P2	0.2 (−0.4 *to* 0.8)	1.000
	CG	B to P1	−0.5 (−1.2 *to* 0.2)	0.213
		B to P2	−0.5 (−1.6 *to* 0.3)	0.332
		P1 to P2	0.1 (−0.6 *to* 0.7)	1.000
Frontal alignment of the pelvis	PBE	B to P1	−0.3 (−1.1 *to* 0.5)	1.000
		P1 to P2	−0.5 (−1.5 *to* 0.5)	0.697
		P1 to P2	−0.2 (−1.3 *to* 0.9)	1,000
	CG	B to P1	−0.8 (−1.6 *to* 0.4)	0.068
		B to P2	0.1 (−1.0 *to* 1.3)	1.000
		P1 to P2	0.9 (−0.3 *to* 2.2)	0.197
Sagittal alignment of the head	PBE	B to P1	0.8 (−3.0 *to* 4.5)	1.000
		B to P2	−11.9 (−15.3 *to* − 8.5)	< 0.001*
		P1 to P2	−12.6 (−16.2 *to* − 9.1)	< 0.001*
	CG	B to P1	2.5 (−1.6 *to* 6.6)	0.417
		B to P2	0.3 (−3.3 *to* 4.0)	1.000
		P1 to P2	−2.2 (−6.0 *to* 1.7)	0.523
Sagittal alignment of the pelvis	PBE	B to P1	−3.4 (−6.0 *to* − 0.8)	0.007*
		B to P2	−2.9 (−5.0 *to* − 0.8)	0.004*
		P1 to P2	0.5 (−2.4 *to* 3.3)	1.000
	CG	B to P1	−2.2 (−5.1 *to* 0.6)	0.185
		B to P2	−1.7 (−4.0 *to* 0.6)	0.224
		P1 to P2	0.5 (−2.6 *to* 3.6)	1.000

B = baseline; P1 = 3 months; P2 = 6 months.
*$p < .05$.

flexibility (Smith & Smith, 2005; Bryan & Hawson, 2003); strengthening musculature (Kuo et al., 2009; Bryan & Hawson, 2003), namely the core muscles (Smith & Smith, 2005; Segal, Hein, & Basford, 2004; Muscolino & Cipriani, 2004a, 2004b), the shoulder girdle (Bryan & Hawson, 2003; Lange et al., 2000), and lumbar muscles (Bernardo & Nagle, 2006); decreasing erosion and joint stress (Muscolino & Cipriani, 2004b), automatic and superfluous movements (Petrofsky et al., 2005), needless tension and muscle contractions (McMillan, Proteau, & Lébe, 1998); promoting muscle length and/or strength (Latey, 2001; Smith & Smith, 2005), muscle balance and symmetry (Bryan & Hawson, 2003), body awareness (Kuo et al., 2009) and joint proprioception (Bryan & Hawson, 2003). Possibly, the verbal cues and imagery practice, a feature of the PBE (Lange et al., 2000), can also clarify these positive results.

Women & Health 2013.53:597-611.

The researchers' conclusions concur with those of other investigators who demonstrated that PBE can be effective in enhancing postural alignment in healthy populations (Emery et al., 2009; McMillan et al., 1998; Parrot, 1993; Fitt et al., 1993; Kuo et al., 2009), although none of these studies investigated the effectiveness of PBE in FA of thoracolumbar spine and pelvis. To the researchers' knowledge, no studies have measured the effects of an exercise program on these outcomes. It is likely that the duration and/or frequency of the intervention have been reduced to promote significant changes in these outcomes.

At baseline, the participants' left shoulders were higher than their right shoulders. After 3 months, positive significant changes were observed, and after the Pilates intervention, the shoulders were close to horizontal and relatively level. Furthermore, a medium effect size was observed ($\eta p^2 = 0.083$). These findings may have been the result of enhanced shoulder girdle strength and stability promoted by PBE. Such development may be due to improved self-awareness of reducing unnecessary movement patterns and aligning body segments, thus contributing to improved motor control and postural shoulder alignment.

Initially, the participants showed hip anteversion, and at the end of 3 and 6 months, SA of the pelvis were progressively more horizontally aligned in the PBE group. These findings are similar to those of Fitt and colleagues (1993). Dance students, after 7 weeks of habitual dance training, supervised Pilates mat work, and individual work on the apparatus and mat, improved their sagittal pelvic alignment as measured with a chalkboard. In contrast, Donahoe-Fillmore and colleagues (2007) found that after 10 weeks of general postural education and unsupervised Pilates mat work, no changes were observed in SA of the pelvis in healthy adult females as measured with a postural grid. The current study used supervised PBE, a different type of PBE, and a valid and reliable postural assessment, as compared to Dohahoe-Filmore and colleagues (2007), which may explain the contradictory findings. It is important to emphasize this finding because radiological studies show that the pelvis determines the SA of the spine while standing (Boulay et al., 2006; Legaye et al., 1998). Kuo and colleagues (2009) also found that the antero-posterior tilt of the pelvis was significantly associated with the sagittal angle of the lumbar spine.

At the onset of the trial, the position of the head was tilted upward. Three months was not enough to produce positive results in this variable; however, after 6 months of PBE, SA of the head was improved. The comparison of data for this outcome was difficult because many anatomical points have been used to measure it, namely the angle formed between C7, ear lobe, and horizontal (Ferreira et al., 2011); and between C7, tragus, and horizontal (Fernández-de-las-Peñas et al., 2007). Despite the anatomical marks that the current researchers used being different from those of Harman and colleagues (2005), the results were consistent. Harman and colleagues (2005) concluded that 10 weeks of a strengthening and stretching exercise program did not improve sagittal head alignment in healthy adults.

Sagittal misalignment of the head was evident (14.7° and 16.8° in PBE group and CG, respectively) at baseline, probably due the lack of postural self-awareness. This poor head posture led to successive corrections to improve it through kinestesic, verbal and/or visual cues, and imagery practice. Several cognitive strategies were also used as tactile sensations, mental images, descriptions of daily situations, and mental representation of gesture. Perhaps this goal, present in all sessions, could explain the large effect size ($\eta p^2 = 0.163$). This result indicated that participants titled their head downward (by 11.26° after 6 months), possibly due to enhanced SA of the cervical or thoracic spine. Importantly, a slight improvement in thoracic kyphosis in healthy older adults was found after 10 weeks of supervised PBE mat work (Kuo et al., 2009) and in healthy adults after 12 weeks of private PBE mat work and apparatus training (Emery et al., 2009).

Good posture is an essential indicator of health (McEvoy & Grimmer, 2005) and an important goal of therapists and physicians, among others. These findings suggest that the Pilates method can be used to improve the alignment of certain body segments in adult women. However, to compare the effectiveness of PBE in posture, further studies are needed that investigate these or other posture outcomes.

The limitations of this study included the relatively small sample size; the limited generalizability of the results due to the use of a university sample and thus the non-representative nature of the study sample; the Pilates instructor being the principal investigator; the PBE taught in this study perhaps not being similar to the methods used in other postural studies; multiple statistical comparisons possibly resulting in type I errors (i.e., statistically significant differences by chance alone); and the anatomical points used to measure the FA of thoracolumbar spine and the SA of the head being different from those used in other studies, which limits the comparison of the results in these variables.

CONCLUSIONS

This study demonstrated that PBE enhanced the postural alignment of healthy women, as measured by FA of shoulder and SA of the head and pelvis. The large improvement in SA of the head could imply that 6 months of PBE enhances SA of the cervical or thoracic spine. Because PBE have positive benefits on some postural alignment measures in healthy women, further research should compare PBE to other exercise programs, and measurements should be obtained as a follow-up to determine the lasting effects of the PBE on postural changes.

Women & Health 2013.53:597-611.

REFERENCES

Bernardo, L. M., and E. F. Nagle. 2006. Does Pilates training benefit dancers? An appraisal of Pilates research literature. *J Dance Med Sci* 10(1):46–50.

Boulay, C., C. Tardieu, J. Hecquet, C. Benaim, B. Mouilleseaux, C. Marty, et al. 2006. Sagittal alignment of spine and pelvis regulated by pelvic incidence: Standard values and prediction of lordosis. *Eur Spine J* 15(4):415–22.

Boyle, J. J. W., N. N. Milne, and K. P. Singer. 2002. Influence of age on cervicothoracic spinal curvature: An ex vivo radiographic survey. *Clin Biomech* 17:361–7.

Bryan, M., and S. Hawson. 2003. The benefits of Pilates exercise in orthopaedic rehabilitation. *Techniq Orthopaed* 18(1):126–9.

Bulock-Saxton, J. 1993. Postural alignment in standing: A repeatability study. *Austral Physiother* 39(1):25–9.

Carpes, F. P., F. B. Reinehr, and C. B. Mota. 2008. Effects of a program for trunk strength and stability on pain, low back and pelvis kinematics, and body balance: A pilot study. *J Bodywork Movement Ther* 12:22–30.

Cohen, J. 1988. *Statistical power analysis for the behavioral sciences*. 2nd ed. Hillsdale, NJ: L. Erlbaum Associates.

Craig, C. L., A. L. Marshall, M. Sjostrom, A. E. Bauman, M. L. Booth, B. E. Ainsworth, et al. 2003. International Physical Activity Questionnaire: 12-country reliability and validity. *Med Sci Sports Exer* 35(8):1381–95.

Cruz-Ferreira, A., J. Fernandes, D. Gomes, L. M. Bernardo, B. D. Kirkcaldy, T. M. Barbosa, and A. Silva. 2011. Effects of Pilates-based exercise on life satisfaction, physical self-concept and health status in adult women. *Women Health* 51(3):240–55.

Cruz-Ferreira, A., J. Fernandes, L. Laranjo, L. M. Bernardo, and A. Silva. 2011. A systematic review of the effects of Pilates method of exercise in healthy people. *Arch Phys Med Rehabil* 92(12):2071–81.

Donahoe-Fillmore, B., N. M. Hanahan, M. L. Mescher, D. E. Clapp, N. R. Addison, and C. R. Weston. 2007. The effects of a home Pilates program on muscle performance and posture in healthy females: A pilot study. *J Women Health Phys Ther* 31(2):6.

Emami, M. J., M. H. Ghahramani, F. Abdinejad, and H. Namazi. 2007. Q-angle: An invaluable parameter for evaluation of anterior knee pain. *Arch Iran Med* 10(1):24–6.

Emery, K., S. De Serres, A. McMillan, and J. Côté. 2009. The effects of a Pilates training program on arm-trunk posture and movement. *Clin Biomech* 25:124–30.

Fernández-de-las-Peñas, C., C. Alonso-Blanco, M. L. Cuadrado, and J. A. Pareia. 2007. Neck mobility and forward head posture are not related to headache parameters in chronic tension-type headache. *Cephalagia* 27:158–64.

Ferreira, E. A., M. Duarte, E. P. Maldonado, A. A. Bersanetti, and A. P. Marques. 2011. Quantitative assessment of postural alignment in young adults based on photographs of anterior, posterior, and lateral views. *J Manip Physiol Ther* 34(6):371–80.

Fitt, S., J. Sturman, and S. McClain-Smith. 1993. Effects of Pilates-based conditioning on strength, alignment, and range of motion in university ballet and modern dance majors. *Kinesiol Med Dance* 16(1):36–51.

Women & Health 2013.53:597-611.

Greendale, G. A., M. H. Huang, A. S. Karlamangla, L. Seeger, and S. Crawford. 2009. Yoga decreases kyphosis in senior women and men with adult-onset hyperkyphosis: Results of a randomized controlled trial. *J Am Geriatr Soc* 57(9):1569–79.

Harman, K., C. L. Hubley-Kozey, and H. Butler. 2005. Efectiveness of an exercise program to improve forward head posture in normal adults: A randomized, controlled 10-week trial. *J Manual Manipulative Ther* 13(3):163–76.

Hrysomallis, C., and C. Goodman. 2001. A review of resistance exercise and posture realignment. *J Strength Conditioning Res* 15(3):385–90.

Katzman, W. B., D. E. Sellmeyer, A. L. Stewart, L. Wanek, and K. A. Hamel. 2007. Changes in flexed posture, muscoloskeletal impairments, and physical performance after group exercise in community-dwelling older women. *Arch Phys Med Rehab* 88(2):192–9.

Kloubec, J. A. 2010. Pilates for improvement of muscle endurance, flexibility, balance,and posture. *J Strength Cond Res* 24(3):661–7.

Kuo, Y. L., E. A. Tully, and M. P. Galea. 2009. Sagittal spinal posture after Pilates-based exercise in healthy older adults. *Spine* 34(10):1046–51.

Lange, C., V. B. Unnithan, E. Larkam, and P. M. Latta. 2000. Maximizing the benefits of Pilates-inspired exercise for learning functional motor skills. *J Bodywork Movement Ther* 4(2):99–108.

Latey, P. 2001. The Pilates method: History and philosophy. *J Bodywork Movement Ther* 5(4):275–82.

Legaye, J., G. Duval-Beaupere, J. Hecquet, and C. Marty. 1998. Pelvic incidence: A fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. *Eur Spine J* 7(2):99–103.

Lohman, T. G., A. F. Roche, and R. Martorell. 1988. *Anthropometric standardization reference manual*. Champaing, IL: H. K. Books.

McEvoy, M. P., and K. Grimmer. 2005. Reliability of upright posture measurements in primary school children. *BMC Musculoskel Disord* 6:35.

McGil, S. M., and J. Cholewicki. 2001. Biomechanical basis for stability: An explanation to enhance clinical utility. *J Orthop Sports Phys Ther* 31:96–100.

McMillan, A., L. Proteau, and R. Lébe. 1998. The effect of Pilates-based training on dancers' dynamic posture. *J Dance Med Sci* 2(3):101–7.

Muscolino, J. E., and S. Cipriani. 2004a. Pilates and the "powerhouse"—I. *J Bodywork Movement Ther* 8:15–24.

Muscolino, J. E., and S. Cipriani. 2004b. Pilates and the "powerhouse"—II. *J Bodywork Movement Ther* 8:122–130.

Parrot, A. 1993. The effects of Pilates technique and aerobic conditiong on dancers' technique and aesthetic. *Kinesiol Med Dance* 15(2):45–64.

Petrofsky, J., A. Morris, J. Bonacci, A. Hanson, R. Jorritsma, and J. Hill. 2005. Muscle use during exercise: A comparison of conventional weight equipment to Pilates with or without a resistive exercse device. *J Appl Res* 5(1):160–73.

Pilates, J. 1934. *Your health* (reprinted in 1988). Incline Village, NV: Presentation Dynamics.

Segal, N. A., J. Hein, and J. R. Basford. 2004. The effects of Pilates training on flexibility and body composition: An observational study. *Arch Phys Med Rehabil* 85(12):1977–81.

Women & Health 2013.53:597-611.

Smith, K., and E. Smith. 2005. Integrating pilates-based core strengthening into older adult fitness programs implications for practice. *Topics Geriatr Rehab* 21(1):57–67.

Tsuji, T., Y. Matsuyama, M. Goto, Y. Yimin, K. Sato, Y. Hasegawa, and N. Ishiguro. 2002. Knee-spine syndrome: Correlation between sacral inclination and patello-femoral joint pain. *J Orthop Sci* 7:519–23.

Vialle, R., N. Levassor, L. Rillardon, A. Templier, W. Skalli, and P. Guigui. 2005. Radiographic analysis of the sagital alignment and balance of the spine in asymptomatic subjects. *J Bone Joint Surg* 87:260–7.

Wells, C., G. S. Kolt, and A. Bialocerkowski. 2012. Defining Pilates exercise: A systematic review. *Complement Ther Med* 20(4):253–62.

Yip, C. H., T. T. Chiu, and A. T. Poon. 2008. The relation between head posture and severity and disability of patients with neck pain. *Man Ther* 13:148–54.

Women & Health 2013.53:597-611.