THE IMPACT OF PILATES EXERCISES ON THE POSTURAL ALIGNMENT OF HEALTHY ADULTS

EFEITO DOS EXERCÍCIOS DO MÉTODO PILATES NO ALINHAMENTO POSTURAL DE ADULTOS SAUDÁVEIS

EFECTO DE LOS EJERCICIOS DEL MÉTODO PILATES EN LA ALINEACIÓN POSTURAL DE ADULTOS SANOS

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ABSTRACT

Introduction: Exercises of Pilates method have been widely used to improve postural alignment. There is strong evidence favoring their use in improving flexibility and balance, as well as some evidence of improvement in muscle strength. However, the benefits related to posture are not well established. Objective: To investigate in healthy adults, the impact of the Pilates method in the postural alignment through some angles in the sagittal plane and the occurrence of pain before and after an exercise session, and after the completion of a 16-session program. Methods: This is a quasi-experimental study of pre and post-intervention type. Healthy adults (n = 37) interested in starting Pilates were evaluated for acute effects on posture after a Pilates session (n = 37) and after a 16-session program, for a period of 10 weeks (n = 13). Using the postural assessment software (SAPO), six angles were analyzed: head horizontal alignment (HHA), pelvis horizontal alignment (PHA), hip angle (HA), vertical alignment of the body (VAB), thoracic kyphosis (TK), and lumbar lordosis (LL). The occurrence of pain was investigated to control adverse effects. Results: Statistically significant ($p<0.05$) differences found after one session include increased HHA (left view), decreased VAB (left view) and TK (both side views). After 16 sessions, we observed an increase of HHA, and a decrease of TK, LL (both side views) and HA (right view). All the differences point to an improvement of postural alignment. A significant reduction of prevalence of pain was verified after the first session (40.5% vs. 13.5%; p=0.004) and after the full program (30.8% vs. 15.3%; p=0.02). Conclusions: Our results suggest that the Pilates method has a positive impact on postural alignment in healthy adults, besides being a safe exercise.

Keywords: exercise movement techniques; exercise; posture.

RESUMO

Introdução: Os exercícios do método Pilates têm sido amplamente utilizados com a finalidade de melhorar o alinhamento postural. Existem evidências científicas fortes que favorecem seu uso na melhora da flexibilidade e do equilíbrio, bem como alguma evidência de melhora da força muscular. Entretanto, os benefícios relacionados à postura não estão bem estabelecidos. Objetivo: Investigar, em adultos saudáveis, o impacto do método Pilates no alinhamento postural, por meio de alguns ângulos no plano sagital e da ocorrência de dor antes e após uma sessão de exercícios, e também após o término de um programa de 16 sessões. Métodos: Este é um estudo quase-experimental do tipo pré e pós-intervenção. Adultos saudáveis (n = 37) interessados em iniciar Pilates foram avaliados quanto aos efeitos agudos sobre a postura após uma sessão de Pilates (n = 37) e após um programa de 16 sessões, por um período de 10 semanas (n = 13). Usando o software para análise postural (SAPO), seis ângulos foram analisados: alinhamento horizontal da cabeça (AHC); alinhamento horizontal da pelve (AHP), ângulo do quadril (AQ), alinhamento vertical do corpo (AVC), cifose torácica (CT) e lordose lombar (LL). A ocorrência de dor foi investigada para controlar efeitos adversos. Resultados: Diferenças estatisticamente significativas ($p < 0,05$) encontradas após uma sessão incluem aumento do AHC (perfil esquerdo), redução do AVC (perfil esquerdo) e da CT (ambos os perfis). Depois de 16 sessões, foi observado aumento do AHC e redução da CT, LL (ambos os perfis) e AQ (perfil direito). Todas as diferenças encontradas apontam para a melhora do alinhamento postural. Uma redução significativa de prevalência de dor foi verificada após a primeira sessão (40,5% vs. 13,5%; $p = 0,004$) e após o programa completo (30,8% vs. 15,3%; $p = 0,02$). Conclusões: Nossos resultados sugerem que o método Pilates tem impacto positivo sobre o alinhamento postural de adultos saudáveis, além de ser um exercício físico seguro.

***Descritores**: técnicas de exercício e de movimento; exercício; postura.*

RESUMEN

Introducción: Los ejercicios del método Pilates se han utilizado ampliamente con el fin de mejorar la alineación postural. Hay una fuerte evidencia científica que favorece su uso para la mejora de la flexibilidad y el equilibrio, así como algunos indicios de mejora de la fuerza muscular. Sin embargo, los beneficios relacionados con la postura no están tan bien establecidos. Objetivo: Investigar en adultos sanos, el impacto del método de Pilates en la alineación postural a través de algunos ángulos en el plan sagital y en la aparición de dolor antes y después de una sesión de ejercicios, y también después de un programa de 16 sesiones. Métodos: Se trata de un estudio cuasi-experimental del tipo antes y después de la intervención. Se evaluaron adultos sanos (n = 37) interesados en iniciar Pilates para efectos agudos sobre la postura después de una sesión de Pilates (n = 37) y después de un programa de 16 sesiones durante 10 semanas (n = 13). Usando el software para el análisis postural (SAPO), se analizaron seis ángulos: alineación horizontal de la cabeza (AHC); alineación horizontal de la pelvis (AHP), el ángulo de cadera (AC), la alineación vertical

del cuerpo (AVC), cifosis torácica (CT) y la lordosis lumbar (LL). La aparición de dolor se investigó para controlar los efectos adversos. Resultados: Las diferencias estadísticamente significativas (p < 0,05) encontradas después de una sesión incluyen aumento de AHC (perfil izquierdo), reducción de la AVC (perfil izquierdo) y aumento de la CT (ambos perfiles). Después de 16 sesiones, se observó un aumento de la AHC y reducción de la CT, LL (ambos perfiles) y AC (perfil derecho). Todas las diferencias apuntan a la mejora de la alineación postural. Se observó una reducción significativa en la prevalencia del dolor después de la primera sesión (40,5% vs. 13,5% p = 0,004) y después del programa completo (30,8% vs. 15,3%, p = 0,02). Conclusiones: Nuestros resultados sugieren que el método Pilates tiene un impacto positivo sobre la alineación postural en adultos sanos, además de ser un ejercicio seguro.

***Descriptores**: técnicas de ejercicio con movimientos; ejercicio; postura.*

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INTRODUCTION

Pilates is a mind-body exercise approach requiring core stability, strength, flexibility, attention to muscle control, posture control and breathing. Exercises may be floor-based, but also include use of specialized equipment[1].The method is widely used by physical fitness and rehabilitation professionals,[2] aiming to ensure postural alignment during the execution of movements in functional positions[3]. Exercises also involve focused breathing and the activation of the central region of the body, especially the muscles located between the rib cage and the hips[4].

The Pilates method has been applied worldwide but its benefits are yet to be established for postural alignment, which is critical since one of the basesof this methods' theory is the posture control. There is strong evidence in the literature related to the effect of Pilates increasing flexibility and balance, and moderate evidence concerning the increase of muscle strength[5]. However, there are few reliable evidence concerning the benefits of the method to posture alignment in orthostatic position[6].

A study sought to determine the effect of a Pilates training program (1h session twice a week for 12 weeks) on arm-trunk posture, strength, flexibility and biomechanical patterns[7]. The results indicated that the Pilates training program was effective in improving abdominal strength and upper spine posture, as well as in stabilizing core posture when shoulder flexion movements were performed. In another report[8], researcher's recruited 34 adults aged 60 and over to participate in a study investigating saggital spinal posture after Pilates-based exercises. Results of their training indicated that immediately after the Pilates-based exercise program, older adults stood with slightly decreased thoracic flexion and sat with slightly increased lumbar extension. Improvements were also presented in a randomized controlled trial (RCT)with 74 adult women[6], both in head sagittal alignment and in pelvis frontal alignment. No adverse effect was controlled in this RCT and also no analysis was performed considering thoracic and lumbar angles in sagittal plane[6].

Even though the effects of Pilates method on postural alignment are not well established, many individuals seek this method to improve postural alignment[7-10]. Souza et al.[11] observed that most Pilates exercise practitioners (38.8%) shared the same goal: posture improvement. Furthermore, the same authors verified that most individuals (73.4%) who enrolled to an exercise program based on the Pilates method complained about pain or musculoskeletal discomfort. Since many individuals seeking Pilates exercises feel some kind of discomfort or musculoskeletal pain, even being healthy (with no chronic diseases), pain is an important variable to be controlled. In addition, it is also important to verify if the exercise is not being harmful to the individual who practices this type of exercise.

In light of such context, the aim of the present study was to investigate the impact of the Pilates method in the postural alignment analyzing six angles in the sagittal plane, before and after one training session, and after the completion of a 16 session program. In order to control for possible adverse effects, the occurrence of pain was also investigated.

METHODS

This is a quasi-experimental study, pre and post-intervention. Adults who were willing to start up the Pilates exercise method were included. In a first trial class, the subject was invited to participate in the study. Inclusion criteria were: age between 18 and 59 years (adults); being unfamiliar with the method, or not having practiced it for at least six months; and able to perform the proposed session sequence protocol. The exclusion criteria were: occurrence of any kind of musculoskeletal pain that would prevent the subject from completing the intervention; pregnant women; individuals under global postural reeducation treatment, surgery on the musculoskeletal system in the previous year, neurologic or osteomuscular disease, abnormal blood pressure and cancer. All subjects had a good general physical aptitude. Regarding the 16 sessions program, individuals that missed more than 2 weeks of classes, consecutively, were excluded. The acute effect was evaluated in 37 individuals: 29 (78.4%) females and 8 (21.6%) males, while 13 individuals finished the 16 sessions program: 11 (84.6%) females and 2 (15.4%) males.

To assess the 16 session program, all individuals that practiced Pilates twice a week and had not missed the sessions for a period exceeding 2 consecutive weeks were included. All participants signed an Informed Consent and the study was approved by the institutional ethics committee of Augusto Motta University Center - UNISUAM (CAAE: 04420412.6.0000.5235).

Evaluations were carried out on three occasions: before and after the first session, to verify the acute effect of a single session; and after the subject had completed 16 sessions, to verify the full program effect.

Before the first session, a questionnaire was filled out including personal information and anthropometric data. Pain/discomfort location and its intensity according to the Faces Scale were evaluated for several body locations[12]. It was assured that the pain was not related to the discomfort felt by stretching exercises.

Then, anatomical references were manually palpated and marked by a single evaluator, properly trained, using styrofoam balls and double-face adhesive tape. The evaluator was trained in palpatory anatomy and placement of anatomical markers. In addition, before the present data was collected, a pilot project was performed. The following anatomical landmarks were identified: in the anterior view, bilaterally, tragus, acromion, and anterior superior iliac spine (ASIS); in the side views bilaterally, the greater trochanter of the femur, knee joint line, and the lateral malleolus; and in the posterior view: posterior superior iliac spine (PSIS), bilaterally, and the spinous processes of C7 (seventh cervical vertebra), T12 (twelfth thoracic vertebra) and S1 (first sacral vertebra). Also, we observed the most convex point of the thoracic spine of each individual, and the spinous process was marked[13].

This marked process was filed in the subject's questionnaire, so that the same point could be used for the next photos. The most concave point of the lumbar spine was observed and the spinous process marked, and also filed in the subject's questionnaire. For the vertebral column, 25 mm styrofoam balls were used to better ensure the side view identification. For the remaining points, 15mm balls were used.

Postural alignment evaluation was carried out in sagittal plane. Postural analysis in three views (anterior, lateral and posterior), would generate many angles to be analyzed, which would require a very large sample to have statistical validity. Thus, we chose to analyze only the side view, with five angles. Some authors claim that the sagittal plane is the one that best reflects postural clinical evolution, since, on this plane, angle values differ from zero[14]. In addition, it has been reported that a good understanding of the principles of sagittal balance is vital to achieve satisfactory results when treating postural disorders. Even when addressing problems in the coronal plane, awareness of the sagittal balance is necessary to avoid future complications[15].

Table 1 and Figure 1 show the six evaluated measurements and their full description.

Postural assessment was carried out individually with Cyber Shot W570 (Sony, São Paulo, Brazil) digital camera, positioned 1m from the floor, on a tripod, 3m away from the subject. The zoom setting was 1.9x.

Women were instructed to wear tops and shorts, and men, Bermuda shorts. They were freely positioned on the millimeter paper (30 cm from a wall). The following verbal command was given: "Please stand on this paper in a comfortable position". The subject was then asked to flex his elbows, with the forearm in neutral position, to allow the visualization of the vertebral column markers. Next, the feet contour was drawn, to guarantee the same support basis in all photo records[16,17].

Table 1. Evaluated measurements in the lateral views and their abbreviations.

Angle	Description of the assessed angles
Head horizontal alignment HHA[11-15]	Angle formed between the line that links C7 and the tragus with a horizontal line. It is used to verify the head position in terms of protraction and retraction. It is always positive; the higher the angle value, the smaller the head protraction.
Pelvis horizontal alignment PHA[11,13,15,16]	Angle formed between the line that links ASIS and PSIS with a horizontal line. It is used to verify whether the pelvis is in anteversion (anterior inclination), or in retroversion (posterior inclination). It is always negative; the more negative, the larger the pelvic anteversion; the closer to zero, the greater the pelvic retroversion.
Hip angle HA[11, 13,15]	Angle formed between the line that links ASIS and the greater trochanter of the femur with the line that links the knee joint line to the greater trochanter of the femur. It is used to verify the position of the hip joint in relation to the flexion and extension. It is always negative; the more negative, the greater the hip tendency and extension; the closer to zero, the greater the tendency to hip flexion.
Vertical alignment of the body VAB[11,13,15,16]	Angle formed between the line that links the acromion and the lateral malleolus with a vertical line, and it reflects the anteroposterior inclination of the body. It is always positive; the higher the angle value, the greater the forward body inclination.
Thoracic Kyphosis TK[17,18]	Angle formed from the intersection of the lines that link the spinous processes of C7 and T12 with the most convex point of the thoracic spine. It is always positive; the higher the angle value, the smaller the thoracic kyphosis curvature.
Lumbar lordosis LL[17]	Angle formed from the intersection of the lines that link the spinous processes of T12 and S1 with the most convex point of the lumbar spine. It is always positive; the higher the angle value, the smaller the lumbar lordosis curvature.

All photos were transferred to the computer and analyzed with the SAPO software. SAPO is a free and simple software developed by researches in Brazil, in 2006, that is frequently used in this country. A study designed to estimate the accuracy of SAPO considered the software a reliable tool for postural assessment. Five blinded raters analyzed 88 pictures, and inter and intra-rater reliabilities were estimated using the intraclass correlation coefficient. Inter-rater reliability was excellent for 41% of the variables and very good for 35%. Ten percent of the variables had acceptable reliability, and 14% were defined as non-acceptable. For intra-rater reliability, 44.8% of the measurements were considered to be excellent, 23.5% were very good, 12.4% were acceptable and 19.3% were considered non-acceptable. Angular measurements had a mean error analysis of 0.11°[16]. Additionally, another study using SAPO for analysis found excellent interrater agreement (ICC> 0.90) for 28 variables (84.85%) and good agreement (0.80> ICC> 0.89) for 5 variables (15.15%)[18].

For comparisons, reference values for the angles measured in this study were obtained from a systematic review[19] that sought articles that employed SAPO as an evaluation tool on healthy adults.

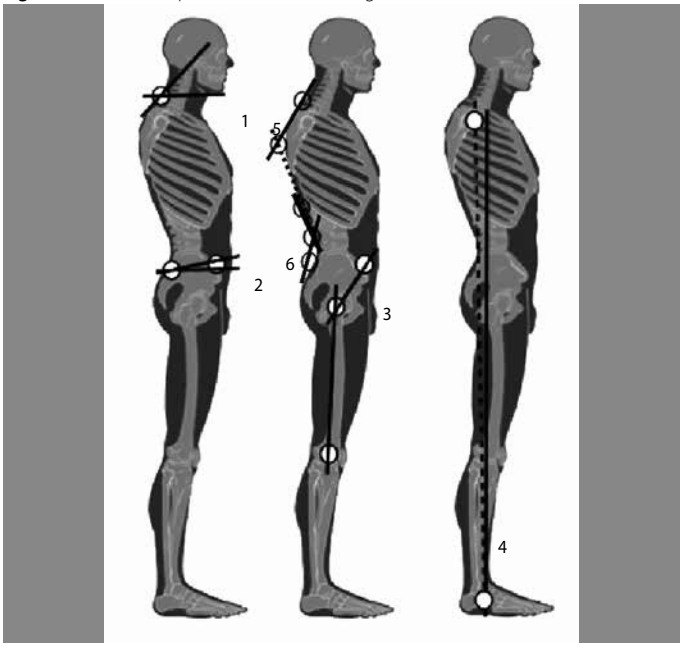
After the completion of the program, a post-intervention evaluation was scheduled for up to three days after the last session.

Session protocol

One-hour sessions were run by instructors from a Pilates Studio in Rio de Janeiro, Brazil, who were professionally trained in the method to accomplish the proposed session protocol. These instructors have professional training in the Pilates method by the same company (Metacorpus Studio Pilates), and before working at Studio underwent a 15-day training process. The exercises were mat- and equipment-based (Cadillac, Wall Unit, Combo Chair, Reformer and Ladder Barrel –Metacorpus Studio Pilates, Rio de Janeiro, Brazil).

Verbal commands and tactile guidelines were employed for conducting the sessions and correcting the performance of exercises. Different postures were used according to the subject's needs and objectives and to his/her performance throughout the sessions. Postural alignment, movement quality, the principles of centralization, control, concentration, precision, breathing and fluidity were always the focus. One set for each of the exercises with 10 repetitions was performed.

Figure 1. Anatomical points and obtained angles.



1. Head horizontal alignment 2.Pelvis horizontal alignment 3. Hip angle 4. Vertical alignment of the body 5.Thoracic kyphosis 6.Lumbar lordosis.

The first session comprised the following sequence:

1. Mobility and initial warm up stretching workouts
   a) 1 exercise for spine mobility
   b) 2 exercises for posterior chain stretching
2. Lower limbs strengthening
   a) 2 exercises for the quadriceps
   b) 1 exercise for the triceps surae
   c) 1 exercise for the hamstrings and gluteus
   d) 1 exercise for the hip adductor muscles
3. Abdominal toning (3 exercises)
4. Strengthening the upper limbs
   a) 2 exercises for the great dorsal muscle and biceps
   d) 1 exercise for the triceps and for the serratus anterior
   c) 1 exercise for the scapular adductors
5. Mobility exercises and final stretching
   a) 1 exercise for the spine mobility
   b) 2 exercise for stretching the posterior chain
6. Relaxing on the foam roller

The remaining sessions followed the same sequence: mobility and stretching, strengthening and new mobility and stretching, and final relaxation. However, according to the specific needs and objectives planned by the instructor for each individual, the exercises could vary concerning their amount for each muscle group. As each individual has different motor experiences, exercise progression during the sessions may vary, which makes it unfeasible to prescribe the same exercise series for everyone. According to the Brazilian Society of Sports Medicine, the emphasis for each individual varies according to their clinical condition and according to the objectives of each[20]. The subjects were instructed to report any musculoskeletal pain complaints when performing the exercises, which would be interrupted if there were any.

Statistical analysis

The data were analyzed by the R program for Windows 3.0.1[21] and described as median and interquartile range (IQR). For tables, we also included mean ± standard deviation for a better comprehension of the data. Two paired analyses were performed: the first one, to evaluate the effect of a session, and the second, to verify the effect of the 16 sessions program. In addition, an independent analysis was also carried out with the purpose of comparing the initial characteristics of the group that concluded the 16 sessions program (n=13) and the group that failed to complete the protocol (n=24). The Fisher test (independent analysis) and the McNemar test (paired analysis) were used for comparing the frequencies of the categorical variables. The paired Wilcoxon test was used to compare the pre and post-intervention angular values, and the non-paired test was used for the independent analysis, considering the significance level p ≤0. 05. Mixed effect linear models were used to study the association covariates age and abdominal circumference with the outcomes studied, since aging[22] and adiposity[23] seems to be associated with postural alignment.

RESULTS

The acute effect was evaluated in 37 individuals: 29 (78.4%) females and 8 (21.6%) males (Table 2). Only four (10.8%) were under physical therapy (electrotherapy techniques) and 18 (48.6%) claimed to practice some other type of physical exercise regularly. For pain or musculoskeletal discomfort, 35.1% of the subjects (n=13) presented some complaint, with a median intensity of 3 (IQR=2;4) –moderate pain, according to the Faces scale.

After the first session, there were significant increases of the HHAangle (left view) and TK angle (both side views). It could be also observed a reduction of the VAB angle (left view). These results point to an improvement of postural alignment (Table 3).

Immediately after the first session, only 13.5% of the subjects (n=5) reported pain, compared to 40.5% (n=15) at baseline (p=0.004; McNemar Test); the median intensity after the first session (2, IQR=2;2) was also lower compared to baseline (3,IQR=2;4).

Effect of the 16 session program

The effect of the Pilates method after the full 16 session program was evaluated in 13 individuals: 11 (84.6%) females and 2 (15.4%) males (Table 2). Among those, only two practiced other exercises regularly. None of the subjects started practicing any other physical exercise during the period of intervention. The remaining 24 individuals were excluded from this analysis due to the fact that they did not complete the program. It is noteworthy that these individuals did not present characteristics that statistically differed from the group that completed the protocol (n=13) (Table 2). The high number of individuals who didn't complete the program occurred because of faults in the classes for a period not exceeding two weeks (personal reasons involving travel, work, vacation, family problems); individuals that choose to practice only once a week were also excluded for the analysis after 16 classes. The dropouts did not affect the validity since there was no difference between groups.

Table 2. Distribution of demographic variables.

Variables	All the subjects (n=37)	Completed the program (n=13)	Did notcomplete the program (n=24)
Age (years)	35.2 ± 12.9 29.1 (26.2;48.4)	34.9 ± 14.1 27.6 (26.2;50.8)	35.4 ± 12.5 32.9 (26.4;41.5)
Weight (kg)	68.0 ± 12.9 66.2 (59.7;75.0)	63.9 ± 10.7 62.9 (56.7;70.4)	70.2 ± 13.7 68.2 (60.4;75.7)
Height (m)	1.70 ± 0.10 1.60 (1.60;1.70)	1.60 ± 0.10 1.60 (1.60;1.70)	1.70 ± 0.10 1.70 (1.60;1.70)
BMI (kg/m^2)	24.6 ± 3.2 23.8 (22.5;26.0)	23.7 ± 2.2 23.7 (22.3;24.3)	25.1 ± 3.6 24.5 (22.7;26.8)
Pain	13 (35.1)	4 (30.8)	9 (37.5)
AC (cm)	85.3 ± 9.7 84.0 (79.0;88.0)	83.3 ± 8.7 83.0 (76.0;87.0)	86.3 ± 10.2 84.8 (79;88.5)

Values expressed as mean ± standard deviation; and median (1st quartile; 3rd quartile), except for pain: counts (relative frequency, %); Wilcoxon's independenttest for continuous variables and Fisher's exacttest for categorical variables (occurrence of pain) when comparing subjects who completed the protocol with those who did not (p>0.05 for all the comparisons); BMI: body mass index; AC: abdominal circumference.

Table 3. Angles (in degrees) observed before and after the first session (n=37).

Angles	Before the session	After the session
HHA/R (º)	42.60 ± 4.10 42.90 (40.00;45.00)	43.40 ± 4.70 44.40 (41.00;46.80)
HHA/L (º)	43.80 ± 4.60 45.00 (41.00;46.80)	45.90 ± 4.70 46.40 (43.30;49.30)*
PHA/R (º)	-9.90 ± 4.40 -10.70 (-12.40;-7.90)	-10.70 ± 4.70 -10.80 (-14.20;-8.20)
PHA/L (º)	-9.90 ± 4.20 -10.10 (-12.00;-8.90)	-10.00 ± 4.20 -9.90 (-12.50;-7.90)
HA/R (º)	-4.60 ± 2.8 -4.30 (-6.10;-3.20)	-5.30 ± 3.90 -5.50 (-7.80;-2.10)
HA/L (º)	-6.80 ± 3.40 -6.30 (-8.80;-5.20)	-6.90 ± 3.70 -6.20 (-9.80;-4.10)
VAB/R (º)	2.30 ± 1.20 2.10 (1.50;3.30)	2.40 ± 1.10 2.50 (2.00;3.10)
VAB/L (º)	1.90 ± 1.30 1.80 (1.50;2.80)	1.40 ± 1.10 1.70 (0.70;2.10)*
TK/R (º)	154.10 ± 5.40 154.40 (150.30;157.50)	155.30 ± 5.20 155.10 (152.00;159.10)*
TK/L (º)	154.00 ± 5.30 154.70(149.80;157.60)	155.00 ± 5.20 155.80 (151.90;158.50)*
LL/R (º)	150.70 ± 10.80 151.90 (150.00;156.20)	151.00 ± 11.70 152.00 (144.50;157.80)
LL/L (º)	150.50 ± 11.30 151.60 (149.00;156.80)	151.30 ± 11.60 152.40 (144.70;157.60)

Values expressed as mean ± standard deviation; and median (1st quartile; 3rd quartile). R: right; L: left; * p < 0.05; paired Wilcoxon Test; HHA: head horizontal alignment; PHA: pelvis horizontal alignment; HA: hip angle; VAB: vertical alignment of the body; TK: thoracic kyphosis; LL: lumbar lordosis.

Compared to baseline, the 13 individuals who completed the program, showed statistically significant differences for the following aspects: increase of HHA, TK and LL angular values (right and left views); as well as reduction of the HA angular value (right view)(Table 4). From the initial assessment of 13 individuals, 11 reported having any factor in his posture that bother (84.61%) after the program. Only 2 continued referring some uncomfortable posture, indicating that the improvement of posture alignment had clinical significance in the group.

Musculoskeletal pain/discomfort was reported by 4 (30.8% from de 13 individuals) during initial assessment; and by only 2 (15.4%) after program completion, which represented a significant decrease (p=0.02). In this group the median of pain after the program was 2(IQR = 2;2), mild pain.

After applying mixed effect linear models, used to control the effect for other covariates, age and abdominal circumference remained in the final model. We observed - regarding acute effect - that the significant alterations in the angles HHA (left view), VAB (left view), TK (right view) were maintained. As for the 16 sessions program, after this same control, maintenance of the alterations to HHA, TK and LL (both side views) could also be observed. Thus, it could be noted that the most robust results were the benefits provided to the head position, vertical alignment of the body and to the spinal alignment.

DISCUSSION

Our results have pointed that the Pilates method has a positive impact on postural alignment of healthy adults, after one session, and after a program of 16 sessions, which means that analyzed angles showed values closer to what is considered as neutral postural alignment[19]. Since many individuals seek the Pilates method in order to improve posture[11], it was important to study whether this exercise brings postural benefits. When the study sample was asked, if there was something that bothered in their posture, 28 (75.7%) said yes, showing the relevance of this question. Also, some studies suggests a relationship between the presence of some postural abnormalities, that can be present in healthy subjects, and the incidence of pain, so it's important to see if the Pilates method is able to improve posture[24].

Table 4. Angles (in degrees) and abdominal circumference (in centimeters) observed: prior to the first session and after the 16 sessions (n=13).

Angles	Before the session	After the 16 sessions
HHA/R (º)	42.70 ± 4.00 43.10(40.00;45.00)	44.60 ± 4.10 44.40(43.60;46.60)*
HHA/L (º)	43.10 ± 4.30 43.20(40.50;46.20)	46.70 ± 3.40 47.20(45.00;48.00)*
PHA/R (º)	-8.90 ± 4.90 -11.10(-12.40;-5.70)	-10.00 ± 4.00 -11.00(-13.30;-8.60)
PHA/L (º)	-7.90 ± 5.10 -8.70(-10.10;-7.20)	-9.70 ± 4.60 -10.70(-13.40;-8.70)
HA/R (º)	-4.40 ± 2.90 -3.90(-5.00;-3.20)	-6.00 ± 2.60 -6.20(-7.70;-4..30)*
HA/L (º)	-6.60 ± 3.50 -6.50(-7.30;-5.60)	-6.80 ± 2.80 -7.20(-8.00;-6.20)
VAB/R (º)	2.00 ± 1.30 1.80(1.10;2.50)	1.60 ± 1.20 1.40(1.10;2.50)
VAB/L (º)	1.80 ± 1.30 1.70(0.90;3.00)	1.50 ± 1.00 1.20(0.90;2.20)
TK/R (º)	154.00 ± 5.10 154.40(150.60;156.80)	157.40 ± 4.90 157.40(154.50;160.00)*
TK/L (º)	153.70 ± 4.60 153.40(151.10;157.60)	157.20 ± 5.30 156.90(154.60;160.10)*
LL/R (º)	151.60 ± 11.10 152.40(145.70;154.20)	154.50 ± 9.10 155.20(153.40;161.00)*
LL/L (º)	151.90 ± 11.20 152.30(146.90;156.60)	154.50 ± 10.20 155.60(152.70;161.70)*
AC (cm)	83.30 ± 8.70 83.00(76.00;87.00)	80.10 ± 8.00 79.00(75.00;82.00)*

Values expressed as median (1st quartile; 3rd quartile); Paired Wilcoxon Test. * p< 0.05 when compared before the session and after 16 sessions; HHA: head horizontal alignment; PHA: pelvis horizontal alignment; HA: hip angle; VAB: vertical alignment of the body; TK: thoracic kyphosis; LL: lumbar lordosis; R: right; L=left; AC: abdominal circumference.

Subjects that did not complete the program were excluded because they missed two or more weeks of classes, consecutively, or because they practiced once a week, and not because they were feeling pain. The instructors were trained to ask their clients, every class, about pain or discomfort, and this has not been reported as a cause of failure or interruption of classes.

In the acute effect analysis, an increase of the angular value for the horizontal alignment of the head to the left side (HHA/L) was observed, indicating a reduced forward head posture[25] immediately after the session, to the left lateral view. The unilateral improvement may have occurred due to a certain level of head rotation, in the coronal plane; however, this plane was not investigated. After the 16 sessions, a significant increase of the angular value of the right and left HHA could be observed. Such increases reflect values closer to those considered as reference for this angle, which has a mean value of 51.42°(ranging from 43.80°and 54°)[19]. Positive results regarding head alignment in the sagittal plane have also been observed by Nunes Junior et al.[10], who evaluated the posture of individuals aged between 50 and 66 years old, who took part in a 36 session Pilates program, three times a week. Four of the five evaluated participants showed reduced forward head posture. Forward head position has been linked to musculoskeletal dysfunction and pain including craniofacial pain, headache, neckache, and shoulder pain[26].

In the analysis of VAB (left view), a significant acute reduction was observed. Reference values for this angle vary from 0.98°to 2.30°(mean1.73°)[19], and the higher the angle value, the more the body tilts forward. It can be inferred that there was an improvement of the vertical alignment of the body, in left side view, after the first Pilates session. The finding observed only for the left side may have occurred because of a greater protrusion of the shoulder to the right side; however, such analysis has not been included in this study.

There was a significant increase in the angular value of the TK (both side views) after a single Pilates session, which reflects a reduction in thoracic kyphosis. Kuo et al.[8] investigated the postural alterations of the spine, in the sagittal plane, in 34 healthy elderly individuals in standing and sitting positions, after a 10 week program of the Pilates method. The TK angle decreased, on average, 2.3°(p =0.002), immediately after the exercise program, when the subjects were evaluated in standing position. Such TK reduction immediately after the Pilates session is in accordance with our results regarding the acute effect.

In the same study, such alteration changed during the follow-up period, one week after the program had been completed. The TK angle had an increase of 0.9°, losing significance (p=0.119). In our study, the subjects were evaluated up to 3 days after the end of the 16 sessions program, at which point we observed a significant decrease of the TK. Benefits of the Pilates method regarding the decrease of TK have also been reported by Emery et al.[7], who observed the sitting posture of healthy individuals, after a 12 week Pilates program.

We have found an increase in the LL angular value (both side views) after the 16 sessions, which reflects a decrease of lumbar lordosis. Kuo et al.[8], nevertheless, did not observe any significant difference of LL in elderly individuals after a Pilates training period.

The positive effects for postural alignment can be attributed to the movements performed within the principles of the Pilates method, which implies body awareness improvement. Besides, there is the emphasis on the maintenance of postural alignment, seeking axial growth during all exercises. The improvement of postural alignment was still significant, even after controlling for potential confounders through mixed effect linear models. When the control was done by abdominal circumference and age, it was observed that there were postural benefits in the head

position, in the vertical alignment of the body and in the spinal alignment. These results are applicable to healthy subjects, so, further studies are required to check if the Pilates method is effective in improving posture in different populations and age groups.

Regarding pain, there was a significant reduction immediately after the first session, which suggests that the practice of Pilates is a safe procedure. Such results are in accordance with a study in which adult individuals submitted to a Pilates program did not report any serious side effects resulting from the exercises, and the rate of adverse events was very low[27]. It can be suggested that pain intensity was reduced immediately after the session. However, as it was not assessed a few hours after the session had finished, we cannot claim that this was a sustained effect.

The significant reduction in pain levels after 16 sessions suggests a possible beneficial effect of the technique in relation to reduction of musculoskeletal pain, as corroborate by a recent systematic review on chronic nonspecific low back pain[28]. Pilates method avoid positions that demand unnecessary muscle recruitment, which could cause early fatigue, reduction of stability and a damaged recovery period[4], which may explain why Pilates method is a kind of exercise that don't causes pain when well executed.

Despite the originality of the present study, one important limitation was that the effect of the Pilates method after the full 16 session program was evaluated in only 13 individual, a small sample size. In further studies we shouldhave a control group and larger samples. Besides, while the instructors selected exercises for each individual's posture, this study could not be replicated. Nevertheless, the instructors were trained to use the exercises of the method, thinking about individual's goals should achieve. The same muscle group can be worked in different ways, in the mat or equipment.

CONCLUSION

The study points that the Pilates method has a positive impact in the postural alignment of healthy adults, as measured either acutely after a single session or after a 16 session program. It is relevant to assess posture as it is a variable that individuals who seek the method want to improve. It also seems to be a safe method, as it did not lead to the occurrence or increase of musculoskeletal pain or discomfort. Even though more studies are necessary to confirm these results, specially randomized controlled trials, we believe that Pilates is a safe method and should be recommended for healthy individuals seeking posture improvement.

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