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ORIGINAL RESEARCH

Muscle Activation During Pilates Exercises in Participants With Chronic Nonspecific Low Back Pain: A Cross-Sectional Case-Control Study

Naiane Teixeira Bastos de Oliveira, MS,[a] Sandra Maria Sbeghen Ferreira Freitas, PhD,[a] Fernanda Ferreira Fuhro, MS,[a] Maurício Antônio da Luz, Jr, MS,[b] Cesar Ferreira Amorim, PhD,[a] Cristina Maria Nunes Cabral, PhD[a]

From the [a]Master's and Doctoral Program in Physical Therapy, Universidade Cidade de São Paulo, São Paulo SP; and [b]Department of Physical Therapy, Universidade Paulista, São Paulo SP, Brazil.

Abstract

Objective: To determine the amplitude of the electromyographic activity of trunk muscles during Pilates exercises in women with and without chronic low back pain (LBP).

Design: Case-control study.

Setting: University physical therapy clinic.

Participants: Women (N=60) divided into an LBP group and a control group.

Interventions: Not applicable.

Main Outcome Measures: Amplitude of the electromyographic activity (root mean square values) of the gluteus maximus and external oblique muscles collected during 3 Pilates exercises: Shoulder Bridge performed on the mat, and Hip Roll and Breathing performed in equipment. Pain intensity was assessed in the LBP group.

Results: The amplitude of the electromyographic activity was similar between groups ($P \geq .05$). For both groups, the amplitude of the gluteus maximus was higher in the Shoulder Bridge exercise compared with the Hip Roll with 2 springs (control group: mean difference [MD]=.18; 95% confidence interval [CI], .05−.41; LBP group: MD=.29; 95% CI, .16−.31) and the Breathing exercise (control group: MD=−.40; 95% CI, −.55 to −.26; LBP group: MD=−.36; 95% CI, −.52 to −.20). The amplitude of the external oblique muscle was higher in the Shoulder Bridge compared with the Hip Roll with 2 springs (control group: MD=.13; 95% CI, .05−.21; LBP group: MD=.18; 95% CI, .03−.33). Pain intensity increased after exercises, but this increase was lower for the mat exercises.

Conclusions: Similar muscle activation between groups was found. The findings suggest that mat exercises caused less pain and a greater difference in the amplitude of muscle activation compared with the equipment-based exercises.

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Chronic low back pain (LBP) is a symptom with a very high prevalence. A systematic review[1] showed a prevalence of 38% for people who had LBP at some point in their lives. One of the most effective treatments for chronic LBP is exercise because it reduces pain and disability.[2] Physical therapists have been using Pilates-based exercises in rehabilitation programs[3] to treat chronic LBP. However, the selection criteria for some of the variables, such as the type of exercise and the springs, are still subjective[4] because of the scarcity of studies on the subject.

Several clinical trials[5-15] have been conducted to verify the effectiveness of the Pilates method for improving LBP symptoms. Nevertheless, the studies[4,16-31] that included a biomechanical assessment, in particular studies evaluating the amplitude of muscle activation during Pilates, did not provide sufficient evidence to guide clinical practice in the treatment of patients with chronic LBP. A systematic review[32] highlighted that the electromyographic activity of the lumbar extensors and abdominal

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muscles during Pilates exercises had only been evaluated in healthy subjects and suggested that this assessment be done in patients with LBP. To date, only 1 study[20] evaluated muscle activation during the powerhouse (ie, isometric contraction of the lumbar stabilizers) in patients with chronic LBP compared with healthy subjects. However, this study did not correspond to the suggestion of the systematic review[32] because it did not provide biomechanical information about the main Pilates exercises in order to clarify how they work and how to use them to treat patients with chronic LBP.

Therefore, the objective of the present study was to compare the amplitude of the electromyographic activity of the gluteus maximus and external oblique muscles during Pilates exercises in women with and without LBP. We hypothesized that women with LBP would have lower electromyographic activity than women without LBP.

Methods

Study design and setting

Data of this cross-sectional case-control study were collected between August 2012 and October 2013 in a university physical therapy clinic.

Participants

We evaluated women with and without LBP, aged between 18 and 60 years, who walked independently and did not practice regular physical activity.[33] The participants included in the LBP group had to have nonspecific chronic LBP lasting >3 months, and the participants included in the control group did not have chronic LBP. The age, height, and body mass index were matched between the groups. The contraindications for physical exercise were evaluated with the Physical Activity Readiness Questionnaire, which can identify through a positive response the participants who need prior clinical evaluation and authorization.[34] The exclusion criteria for both groups were as follows: (1) previous experience with the Pilates method; (2) pregnancy; (3) prior surgery in the spine, upper or lower limbs; (4) history of spinal fracture; (5) inflammatory, rheumatic, or neurologic disorders; (6) uncontrolled systemic metabolic disease; (7) herniated disk; (8) tumors; (9) infection; (10) osteoporosis; (11) structural deformity; and (12) physical therapy treatment for chronic LBP in the last 6 months.[5,6] All participants signed an informed consent form to take part in the study, which was approved by the research ethics committee of the university (process no. 0056.0186.000-11).

Sample calculation

The sample size calculation was performed in G*Power version 3.1,[a] based on a pilot study with 4 participants from the LBP group and 8 from the control group. We used the mean and SD of the normalized root mean square value of the right and left external oblique muscles during the Shoulder Bridge exercise to determine a difference between groups of .65. For the LBP group, the mean ± SD muscle activation was 1.22±.10, and for the control group, 1.14±.14. Considering a statistical power of 80% and an alpha of 5%, the sample size was determined to be 30 participants per group.

List of abbreviations:

LBP **low back pain**

Data collection: procedure and equipment

On the first day of assessment, the participants received basic instruction on the Pilates technique and training on the activation of the powerhouse, which is the isometric contraction of the pelvic floor muscles, pelvic and lumbar stabilizers at exhalation during diaphragmatic breathing.[35] On the same day, there was a training session to familiarize the participants with the proposed exercises.

Muscle activation was recorded on the second day of evaluation, which took place at least 2 days after the first evaluation. We used an electromyographic device with 16-bit analog-to-digital converter[b] connected to an electrogoniometer[b] and to the WinDaq Data Acquisition program[c] with a sampling frequency of 2000Hz per channel. Data were acquired using a fourth-order Butterworth bandpass filter with a cutoff frequency of 20 to 500Hz, noise <3μV, impedance of $10^9\Omega$, and common mode rejection >100dB. The electrogoniometer (with accuracy of 0.1°) was also used to determine the onset and termination of each repetition of the exercise.

Silver−silver chloride (Ag-AgCl) bipolar surface electrodes[d] preamplified with 20× gain were used with shielded cable and pressure clips coupled to disposable electrodes. Before electrode placement, the skin was shaved (when necessary) and cleansed with alcohol. The electrodes were placed 2cm apart over the muscle belly, along the direction of the muscle fibers.[36] To capture the electromyographic signal, all recommended procedures[37] were strictly followed. The reference electrode was placed over the spinous process of C7. For the gluteus maximus, the electrodes were placed bilaterally midway between the sacral vertebrae and the greater trochanter, facing toward the line from the superior posterior iliac spine to the posterior medial face of the thigh.[38] For the external oblique muscle, the electrodes were placed bilaterally midway between the anterior superior iliac spine and the lowest point of the costal margin (at the level of L3).[39] These muscles were chosen because they are superficial, easy to assess using electromyography, and represent the hip extensors and lumbar flexors, recruited in the performed exercises.

The electrogoniometer was placed on the hip joint as a way to synchronize the capture of electromyographic activity and determine the analysis interval of the electromyographic signals. Before placement, the electrogoniometer was calibrated with the acquisition system using a universal goniometer. Two angles of the hip joint were used for calibration: 0° and 90°. The goniometer was placed with its central axis over the greater trochanter of the femur, with the fixed arm on the lateral line of the trunk and the moving arm on the lateral line of the thigh aligned with the center of the lateral condyle of the femur. After placement of the electrodes and electrogoniometer, the participants were instructed on the performance of each of the Pilates exercises.

Exercises

The exercises performed were the Shoulder Bridge on the mat, the Hip Roll with 1 spring or 2 springs on the Reformer,[e] and the Breathing exercise on the Cadillac.[e] These exercises were chosen because they activate the stabilizing muscles of the lumbar spine and they are the most commonly used in the treatment of patients with chronic LBP. During the exercises, the evaluator instructed the participants through the following verbal command: “Inhale