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EXERCISE PHYSIOLOGY

Application of Pilates principles increases paraspinal muscle activation

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Summary *Objective:* To analyze the effect of Pilates principles on the EMG activity of abdominal and paraspinal muscles on stable and unstable surfaces.
Methods: Surface EMG data about the rectus abdominis (RA), iliocostalis (IL) and lumbar multifidus (MU) of 19 participants were collected while performing three repetitions of a crunch exercise in the following conditions: 1) with no Pilates technique and stable surface (nP + S); 2) with no Pilates technique and unstable surface (nP + U); 3) with Pilates technique and stable surface (P + S); 4) with Pilates and unstable surface (P + U). The EMG Fanalysis was conducted using a custom-made Matlab® 10.
Results: There was no condition effect in the RA iEMG with stable and unstable surfaces ($F_{(1,290)} = 0$ $p = 0.98$) and with and without principles ($F_{(1,290)} = 1.2$ $p = 0.27$). IL iEMG was higher for the stable surface condition ($F_{(1,290)} = 32.3$ $p < 0.001$) with Pilates principles ($F_{(1,290)} = 21.9$ $p < 0.001$). The MU iEMG was higher for the stable surface condition with and without Pilates principles ($F_{(1,290)} = 84.9$ $p < 0.001$).

Introduction

In 1920, Joseph Pilates (1880–1967) created a specific exercise method that was intended for rehabilitating soldiers injured during World War I. This exercise technique, the Pilates method, was based on a continuing focus on body awareness so that the self-perception of the body and kinesthesia would be improved during exercise. It has been suggested that this kind of approach during exercise might

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lead to a self-body awareness that would connect mind and body (Wells and Kolt, 2012; Latey, 2001).

Pilates-based exercises have been used for low back pain prevention or rehabilitation as this kind of conditioning exercise may activate the deep trunk muscles, providing greater spine stability (Muscolino and Cipriani, 2004). The current literature supports the notion that reductions in chronic low back pain after a bout of Pilates-based exercises may be obtained through improvements in postural control due to an increased muscular endurance strength and flexibility (Rydeard et al., 2006; Lim et al., 2011; Newell et al., 2012; Sekendiz et al., 2007; Kaesler et al., 2007).

Pilates practitioners believe that such an increased muscular endurance strength and flexibility and improved postural control may be a consequence of principles that include mental concentration, control, centering, flow, precision and breathing (Latey, 2001; Muscolino and Cipriani, 2004). For example, while centering increases spinal stability promoted by the co-contraction of antagonist muscles (Marques et al., 2012), controlling the forced expiration during the movement may recruit abdominal muscles (Neumann and Gill, 2002) and increase the activity of the lumbar-pelvic stabilizer muscles (Santos et al., 2010). Furthermore, combining self-control and centering may increase the biceps brachial activity and the electromyography (EMG) of co-activated muscles such as the multifidus, iliocostalis lumborum, rectus abdominis and internal oblique muscles (Rossi et al., 2013; Barbosa et al., 2013).

However, an important methodological aspect regarding Pilates studies (Marques et al., 2012; Neumann and Gill, 2002; Santos et al., 2010; Rossi et al., 2013; Barbosa et al., 2013) precludes a consistent understanding of the Pilates principles, as most studies have not included all the principles together when investigating Pilates-based exercises. Therefore, it is not possible to know whether positive effects on rehabilitation and physical fitness after a Pilates-based exercises program could be obtained without the application of the principles. In theory, it is necessary to include mental concentration, control, centering, flow, precision and breathing when evaluating the Pilates method's effectiveness (Di Lorenzo, 2011).

In contrast, a concurrent Pilates-based method suggested for rehabilitation purposes is the proprioceptive method. This method uses unstable surfaces such as a foam roller or gym ball to improve proprioceptive mechanisms, which are believed to be important for the effectiveness of rehabilitation during the Pilates program. For example, studies have suggested the effectiveness of using unstable surfaces and reported increases in the activation of abdominal and paravertebral muscles during crunch, pushup and single-legged hold exercises (Vera-Garcia et al., 2000; Kim et al., 2011; Marshall and Murphy, 2005; Escamilla et al., 2010; Sternlicht et al., 2007).

Therefore, the aim of this study was to investigate the effects of using Pilates principles on the electromyography activity of abdominal and paraspinal muscles during a crunch exercise on to the ground and using the foam roller. Due to controversial results, two hypotheses were formulated: There is a difference in the EMG activity of the rectus abdominis, iliocostalis and lumbar multifidus between the use and nonuse of Pilates principles during a crunch exercise; and there is a difference in the EMG activity of the rectus abdominis, iliocostalis and lumbar multifidus when the crunch exercise is done under a stable condition compared to when it is done under an unstable condition.

Materials and methods

Participants

Nineteen healthy women (25.6 $\pm$ 5 years old, body mass of 52 $\pm$ 6 kg, height of 162 $\pm$ 0.1 cm, and body mass index of 19.7 $\pm$ 2 kg/cm^2), not experienced with Pilates exercise, volunteered to take part in this crossover study. They were recruited from the university campus according to the following inclusion criteria: 1) absence of acute or chronic low back injury or prolonged back pain; 2) negative diagnosis of orthopedic, rheumatologic, neurologic and respiratory disorders; 3) absence of congenital or acquired anomalies in upper and lower limbs. After explaining the risks and benefits of the experimental procedures, participants signed a written informed consent. All the procedures were previously approved by the local Ethics Committee (15212313.3.0000.0029) and conducted in accordance with the Helsinki declaration.

Procedures and instruments

A 16-bit, four-channel surface electromyography system (EMGSystem®, 630C Brazil) measured the muscle activity at a sampling rate of 1 kHz, while the EMG signal was recorded by a specific software (EMGlab, EMGSystem®, Brazil). After skin exfoliation and cleaning (70% isoprolic alcohol), bipolar surface Ag/AgCl electrodes (Kendall-Meditrace 200®) were placed over the rectus abdominis (RA), iliocostalis (IL) and lumbar multifidus (MU) muscles, following the probable muscle fiber orientation. Electrodes were placed within a 4 cm inter-electrode distance and fixed by adhesive tape parallel to the muscle fibers. In order to ensure a reliable localization, the electrodes were placed according to the SENIAM (surface electromyography for the noninvasive assessment of muscles) according to the following description (Hermens et al., 2000): IL muscle, 6 cm lateral to the intervertebral space L2—L3; MU muscle, 2 cm lateral to the midline of the interspinous space L4—L5; and the principal muscle responsible for flexion of the trunk, the RA muscle, 2 cm lateral to the umbilicus.

Exercise protocol

Three repetitions of a crunch exercise were performed in four different conditions: 1) no Pilates technique and stable surface (nP + S); 2) no Pilates technique and unstable surface (nP + U); 3) Pilates technique and stable surface (P + S); 4) Pilates technique and unstable surface (P + U). A foam roller was used as an unstable surface and the exercises were performed in sequential order to avoid any influence from prior knowledge of the Pilates principles. The participants were familiarized with the crunch exercise execution according to the Pilates principles (mental