ELECTROMYOGRAPHIC ANALYSIS OF THE RECTUS FEMORIS AND RECTUS ABDOMINIS MUSCLES DURING PERFORMANCE OF THE HUNDRED AND TEASER PILATES EXERCISES

LOCOMOTOR APPARATUS IN EXERCISE AND SPORTS

ORIGINAL ARTICLE

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ABSTRACT

The literature has shown that small modifications in a Pilates method exercise may change the muscles activation pattern. Moreover, few studies have evaluated Pilates' exercises from the kinesiology point of view. Therefore, this study aimed to compare a couple of exercises performed on the mat and in apparatus regarding electric activation of acting muscle groups. Eleven healthy Pilates trained women took part in the study. Electromyographic data were collected from the rectus femoris and rectus abdominis muscles, right and left portions, while keeping the isometric posture of the hundred on mat, hundred on the Reformer apparatus, teaser on mat and teaser on the Cadillac apparatus exercises. The five central seconds of each execution normalized by maximum voluntary contraction were analyzed. Statistical analysis showed difference between the muscle group's activation that was higher for the rectus femoris, and interaction between muscle and exercise, where rectus femoris muscle's electric activation was higher on the hundred exercise performed on mat and *Reformer* and *rectus* abdominis muscle's electric activation was higher on teaser performed in the Cadillac apparatus. Based on the study results, it may be stated that: (i) when compared the hundred (on mat and Reformer) and teaser (on mat and Cadillac) exercises were compared, no difference was found between them regarding rectus abdominis and rectus femoris muscles' activation; (ii) when muscle groups were compared, the rectus femoris presented higher activation levels on the hundred exercise performed on mat and Reformer, while rectus abdominis presented higher activation during the teaser exercise performed on Cadillac.

Keywords: biomechanics, applied kinesiology, abdomen.

INTRODUCTION

The Pilates method has been widely used in rehabilitation and physical fitness, and it be performed on mat (*mat* Pilates) or in apparatus which allow that elastic resistance be used as resistive load[1]. Many of the exercises performed on mat are used very similarly in the apparatus, being the overload of the springs the only difference. The Pilates exercises and their possible variations choice is many times defined from informally transmitted guidance by the method's instructors. Since there is a large number of possibilities and indications, analyses of the Pilates exercise have been quite relevant[2].

The literature has been studying the exercises in the Pilates method many times comparing them with those classically performed in body building trainings[3], or even with other examples of physical activity, such as *yoga*[4] and *tai chi chuan*[5]. Nonetheless, the comparison between exercises performed on mat and in the apparatus has been little explored. In one of the few comparisons between exercises found in the literature, Sacco *et al.*[6] analyzed exercises in the mat *versus* apparatus situations, pointing out differences under a biomechanical analysis perspective, but without assessing the electrical activation of the musculature.

Common Pilates exercises, such as the *hundred* and the *teaser*, may be performed similarly on mat or with the aid of apparatus. These two exercises are performed at dorsal decubitus. The *hundred* is characterized by the maintenance of hip and trunk flexion, keeping lower limbs with no contact with the ground, which lets only the low back in touch with the ground, while the arms perform an oscillation movement. When performed in apparatus, the individual may be challenged by the elastic resistance on his/her hands. The *teaser* exercise may be dynamic or isometric. When it is isometric, the performer keeps hip flexed, and legs and trunk lifted. When it is performed in an apparatus, the individual may use the elastic resistance with aid or not of overload.

Considering also that slight alterations in one exercise of the Pilates method may alter the muscular activation pattern[7,8] and that studies which evaluate Pilates exercises from the kinesiological viewpoint are still scarce (electrical activity of the involved muscles), the aim of this study was to compare two exercises (*hundred* and *teaser)* performed on mat and in the apparatus concerning the electrical activation of the acting muscular groups.

METHODS

Sample

11 healthy women (aged 29.6 ± 7.97 years, weight of 62.3 ± 4.1kg, height of 158.1 ± 4.7cm, BMI of 24.6 ± 1.1%) Pilates' practitioners for at least six months participatedin the study. According to the resolution 196/96 of the National Board of Health, all participants were informed about the research before agreeing on participating and signed a Free Clarified Consent Form.

Equipment

An electromyograph of four channels, common rejection mode of 110db (at 60Hz), entrance impedance of the system of 100 Gohm-sand A/D converter of 14 bits (Miotool 400, Miotec) was used for electromyography data collection. The sign was collected with a sample frequency of 2,000Hz per channel.

Electromyography

The skin was prepared with shaving, abrasion and sanitation. Pairs of Ag/AgCl surface electrodes with 22mm diameter Kendall, Meditrace – 100) were bilaterally placed on the surface of the rectus abdominis and rectus femor is muscles on each leg. The distance between electrodes was of 20mm. The skin preparation and electrodes placement of the rectus femoris followed recommendation of the Seniam project[9]. The electrodes positioning on the rectus abdominis musculature followed recommendations of specific literature[10]. The reference electrode was positioned on the medial side of the right tibia. Aiming to compare the signs derived from the monitored muscles, two maximum voluntary contractions were performed (MVC) for the rectus abdominis and two MVC for the recturs femor is, both at dorsal decubitus, with duration of five seconds. The individuals were verbally encouraged to try to perform twice the trunk flexion movement and twice the hip flexion movement for performance of the MVCs, randomly performed. Velcro strips were used on three sites to stabilize the individual: i) at the xiphoid process level, ii) at the thigh medial portion, and iii) close to the knees[10]. The MVC with highest value in each situation was used for normalization of the electromyographic signs.

Protocol

The *hundred* exercise was performed on mat and in the *Reformer* apparatus, while the *teaser* was on mat and in the *Cadillac* apparatus[11]. The position kept for the *hundred* exercise may be seen in figure 1. Both on mat and in the *Reformer*, the lower limbs are kept without contact with the plane by the maintenance of a light hip flexion. The cervical and upper part of the thoracic spine also performs flexion, not being in contact with the plane, so that the upper limbs are suspended in a position approximately parallel to the plane. In the *hundred* exercise only the low back and the lower part of the thoracic spine are in contact with the ground, while the arms perform an oscillation movement.

The position kept for the *teaser* exercise may be seen in figure 2. Both on mat and in the *Cadillac* apparatus, there is maintenance of a hip flexion angle close to 90 degrees. The angulation of the lower limbs in relation to the plane is around 45 degrees, while the upper limbs are kept approximately parallel to the lower limbs. Due to the characteristics of the exercise, in the *teaser* hip flexion is more emphasized than in the *hundred* exercise, while the back flexion is minimized. In this exercise the low back is kept without contact with the support surface, on which only the gluteal region is in touch with the plane.

All situations (*hundred* on mat and in apparatus, *teaser* on mat and in apparatus) were considered isometric from the point of view of the monitored muscles, with the volunteer keeping her head, cervical and thoracic spine, as well as lower limbs with no contact with the ground, through the maintenance of a simultaneous hip and back flexion.

Each participant, starting from rest in dorsal decubitus, kept posture of each one of the exercises (figures 1 and 2), on mat or in the apparatus, returning to original position in 15 seconds. The five central seconds were considered for analysis, eliminating hence the concentric actions to reach the positioning and eccentric during the return to the starting position. The exercises were randomly performed for each participant and at least five minutes of interval between was kept. Since in the *hundred* exercise there is bombing of the arms series (shoulder flexo-extension movements of small amplitude) while posture is kept, it was asked to the volunteers to perform them in a rhythmic manner, but the frequency of the wrists was not controlled, allowing that each individual performed it according to their practice.

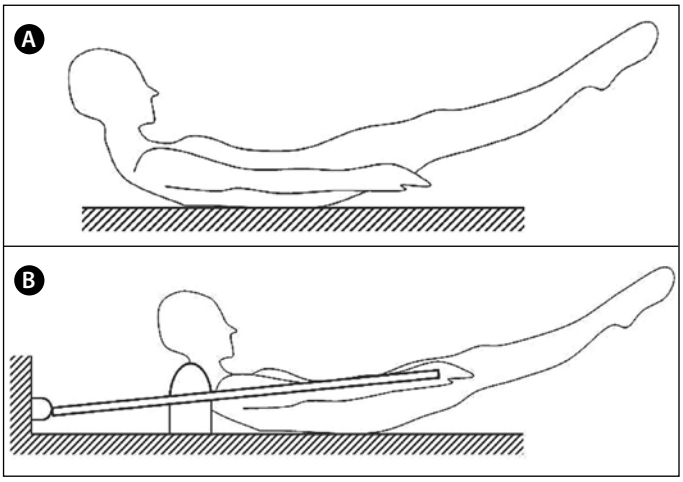

Figure 1.Scheme of the *hundred* on mat(A) and in the *Reformer* exercises (B).

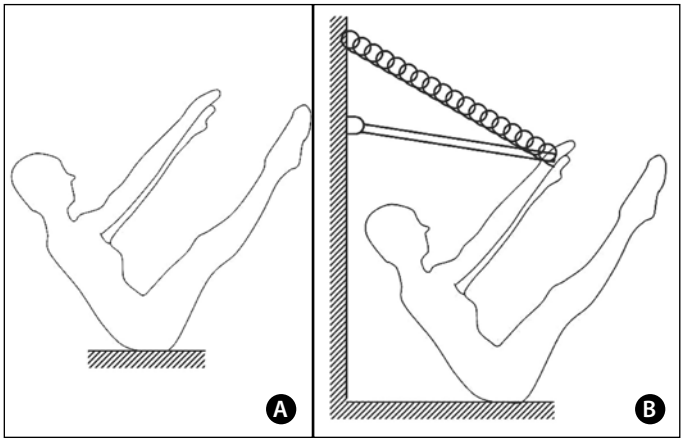

Figure 2. Scheme of the *teaser* on mat(a) and in the *Cadillac* exercises (b).

DATA ANALYSIS

The electromyographic data were processed in the SAD32 software (version 2.61.07mp, 2002). A digital Butterworth pass band filter of third order with cutoff frequency between 20 and 500Hz was used. The central part of the performance of each exercise was cut and the *root mean square* (RMS) value referring to five seconds of the phase considered isometric was obtained. This value was normalized by the RMS value of the MVC of highest amplitude.

A *t* test was used for statistical analysis to verify the difference of activation between the right and left portions of the rectus abdominis muscle and between the two legs of the rectus femoris muscle. As there were not differences between the activation of the right and left sides, a simple arithmetic mean was performed to represent the "muscular group". Two-way ANOVA was used (muscular group

and exercise) to verify differences in the electric activation in the different situations. Whenever necessary, Bonferroni *post hoc* was used. Significance level in all tests was of $p < 0.05$.

RESULTS

Significant difference was not found ($p > 0.05$) between the right and left sides, neither for the rectus abdominis portions nor for the rectus femoris muscles, which enabled grouping of the muscular portions. TFor analysis of the situation the RF muscle (rectus femoris: result of the mean of the right and left sides) and the RA muscle (rectus abdominis: result of the mean of the right and left portions) were considered.

Thus, considering the two muscles (RF and RA), difference has not been found between exercises ($F(3.72)=0.493$, $p=0,689$, $\omega^2= -0.012$), which means that there is not higher demand of any of the exercises when the joint activity of the analyzed muscles is considered. On the other hand, there was difference between the muscles ($F(1.72)=19.128$, $p<0.001$, $\omega^2 = 0.146$), where, in mean, the rectus femoris was more recruited in the analyzed exercises (table 1). There was also significant interaction between muscles and exercises ($F(3.72)=10.122$, $p<0.001$, $\omega^2 = 0.221$), indicating that the difference found between the muscles is dependent on the performed exercise (figure 3).

Table 1. Mean of the electric activation of the rectus femoris and rectus abdominis muscles considering all the exercises (mean and standard error).

Muscle groupr*	Activation (%CVM)
Rectus femoris	56.28 (3.50)
Rectus abdominis	39.42 (2.74)

* Significant difference between the muscles ($p < 0.05$).

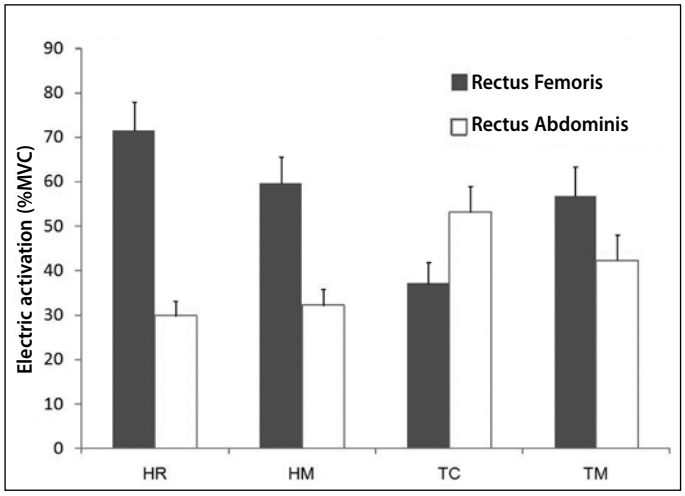

Figure 3. Mean and standard error of the activation of each muscle in the different exercises:*hundred Reformer* (HR), *hundred mat* (HM), *teaser Cadillac* (TC) and *teaser Mat* (TM).
* Significant difference between the muscles in the same exercise ($p < 0.05$).

DISCUSSION

In this study the electric activation of the rectus abdominis and rectus femoris muscles was compared during the *hundred* exercise on mat and in the *Reformer*, and the *teaser* exercise on mat and in the *Cadillac* apparatus, of the Pilates method. In the initial analysis the comparison of the electric activation of the muscles between the right and left sides did not present differences, which enabled the grouping of the muscles of each side of the body. This symmetry in the electromyography is corroborated by data in the literature, in which Rutkowska-Kucharska*et al.*[12] found symmetry in the electric activation of trunk muscles during the performance of different abdominal exercises.

Considering the muscular right and left portions grouped, the statistical analysis identified significant difference in the electric activation between the muscles of different exercises, as well as dependence of the exercise for activation of the RF and RA muscles. However, difference has not been verified between the exercises when activation of the muscular groups together was considered.

The greater activation of the RF group in comparison to the RA group in the *hundred*, exercise, both in the *Reformer* and on mat, may be related to the fact that the low back is rested on mat during the exercise, simultaneously to the great resistance torque offered by the lower limbs in these exercises. Corroborating this statement, Sacco *et al.*[6], when evaluating the *hundred* exercise on the *mat* and in the *Reformer and Cadillac* apparatus, showed that the torque of the lower limbs was always higher, both on mat and in the apparatus. Although strength and electromyography cannot be directly related, it is reasonable to suppose that greater resistance torque demands higher electric activation of the involved musculature[13].

In the *teaser* exercise in the *Cadillac*, higher activation of the RA compared to the RF may be associated with the elastic resistance of the apparatus. In that case, lower activation of the RA group could be expected, since apparently, the hand grip would help in the maintenance of posture. Nevertheless, the elastic resistance which is connected to this grip would stop the upper part of the body, generating an extensor torque in the hip joint, which tends to increase the recruiting of the abdominal musculature. Moreover, the demand on the RF is minimized in that case, since the resistance torque offered by the lower limbs is reduced due to the more vertical legs position, which has also been evidenced by Sacco *et al.*[6].

Outside the Pilates environment, Duncan[14] compared the electric activation of the rectus abdominis muscle in different abdominal exercises, including the traditional one, in which the low back is kept on mat and only the thoracic spine lifts, with the 'jack knife' exercise, in which the entire back is lifted from the ground, including the low back. Greater activation of the abdominal musculature during the jack knife compared with the traditional exercise was found, which agrees with the results of this study.

On mat, Esco *et al.*[15]evaluated the electric activation of different groups of muscles during the performance of many exercises, including the *hundred* and *teaser*. These authors did not present the result of a statistical comparison between the muscles of each exercise or between exercises, but by the activation percentage data presented, rectus abdominis and rectus femoris had apparently similar activation. On the other hand, comparing the activation between exercises, both muscles had activation about 40% higher in the *teaser* than in the *hundred* on mat. In this study though, the rectus abdominis activation was significantly higher than in the rectus femoris in the *hundred* on mat, while there was not difference between the muscles in the *teaser*.

Within an applied context, these results can be used as a reference parameter when some emphasis on a given muscular group is expected.Thus, the *hundred*, should be the chosen exercise when the

intention was greater activation of the rectus femoris muscle, both on mat and in the apparatus, while when wish is to obtain greater demand on the rectus abdominis muscle, the *teaser* in the *Cadillac apparatus* should be the exercise to be performed. Regardless of the choice, the level of activation of the assessed muscles is sufficient to provide physical fitness[15]. It is worth mentioning that only the rectus femoris and rectus abdominis muscles were evaluated. There may be some other occasional differences, in case other muscular groups are evaluated. In that perspective, new studies in which other muscles are monitored during the performance of these exercises should be carried out.

CONCLUSION

The rectus femoris muscular group presented higher activation levels in the *hundred* exercises performed on mat and in the *Reformer*, while the rectus abdominis muscular group presented higher activation during the *teaser* exercise performed in the *Cadillac*. In either of the exercises the activation levels are sufficient to provide physical fitness.

All authors have declared the reis not any potential conflict of interests concerning this article.

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