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Evaluation of Torque, Electromyographic Activity and Neuromuscular Efficiency of the Internal Oblique Muscle in Pilates Practitioners

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SUMMARY

Background. The present study aimed to evaluate the neuromuscular efficiency (NME) of the internal oblique (IO) muscle through electromyography (EMG) analysis, torque test in practitioners and non-practitioners (control) of Pilates.

Methods. Participants included 40 health women: Pilates practitioners (n = 20) and non-practitioners (n = 20). They were tested for trunk flexion (torque). Their internal oblique IO muscle (both sides) was submitted to EMG to estimate its NME. Results concerning EMG and NME were compared between practitioners and control.

Results. Statistical analysis (Student t-test; $p < 0.05$) showed significant difference in torque in N.m ($p = 0.00083$), NME ($p = 0.00044$) and EMG in microvolts ($p = 0.0015$) values between practitioners (93.6 ± 17.8, 0.77 ± 0.48, 153.4 ± 65.3, respectively) and control (65.5 ± 19.4, 0.27 ± 0.10, 268.2 ± 81.0, respectively).

Conclusions. Our results suggest Pilates exercises are effective in training the IO muscle to improve the NME in women engaged in Pilates exercises 2 times a week.

KEY WORDS

EMG; torque; trunk; core; biomechanics.

BACKGROUND

Measuring muscle torque aids in assessing muscle force and functions. The torque developed in a joint is strongly dependent on the functional state of the neuromuscular system functions (1, 2). Neuromuscular efficiency (NME) is the relationship between the activity and force of the body muscles and can be measured through EMG (2). Neuromuscular efficiency is calculated by the torque peak value divided by the electromyography (EMG) signal value during the maximal isometric contraction (3-6).

Specific exercise programs aimed at stabilizing joints and preventing damages by excessive loads aid in improving NME (1, 2). Pilates exercise showed that may improve (NME) (6, 7), which varies according to gender, pathology, and training (1). The Pilates method, developed by Joseph H. Pilates, is an alternative to training approaches mostly aimed at body fitness, athletics, and physiotherapy (9-11). It is aimed at a better functioning of the body based on the strengthening of the "powerhouse," or core muscles. The core is composed of 29 pairs of muscles that support the hip-pelvis-lumbar spine complex (11). Exercises are carried out on a mat and on apparatuses, such as the Cadillac, the reformer and the barrel (12).

Pilates provides practitioners with several benefits, such as postural alignment, fitness, muscle flexibility and strength, and body balance and awareness (13). Among its fundamental principles is the "centralization" (14), which is responsible for the isometric contraction of the internal oblique (IO) and transverse muscles of the abdomen (15, 16). The IO is later-

al flexor and rotator of the trunk, also contribute to spinal stability (17), and is recruited during Pilates exercises (18).
Panhan *et al.*'s article (6) evaluated NME and torque of the multifidus in trunk extension of women during Pilates exercise. Generally, the higher the torque value and the lower the EMG value, the better the NME (2). However, the scientific literature lacks investigations on NME in the muscles during trunk flexion in Pilates practitioners. Considering this background, we hypothesize that the torque and NME of Pilates practitioners during the trunk flexion presents higher values in comparison with non-practitioners. Therefore, the aim of this study was to evaluate the NME of the IO muscle through EMG analysis, torque test in practitioners and non-practitioners (control) of Pilates.

METHODS

Participants

Participants included forty women: twenty Pilates practitioners (years of practice: 4.3 ± 1.4; age: 27.6 ± 3.7 years; body mass: 58.7 ± 2.5 kg; height: 1.66 ± 0.03 cm); and twenty (control) non-practitioners (age: 21.4 ± 1.6 years; body mass: 62.5 ± 3.85 kg; height: 1.65 ± 0.08 cm). As inclusion criteria, the Pilates practitioners had to have at least six months of experience, training minimally twice a week (20), with no history of orthopedic and neurologic disorders, cardiovascular diseases, and surgery of the spine or abdomen (21). Individuals practicing physical activities other than Pilates exercises were excluded. The non-practitioners (control) had to be sedentary or free of regular physical activities for at least one year prior to the study. This study was approved by the Ethics Committee of Piracicaba Dental School, University of Campinas (UNICAMP) (protocol: 5418/2017), on February 15, 2017. All participants provided written informed consent.

Data collection and procedures

The electrode placement site was shaved and cleansed with 70% alcohol. To measure the EMG activity of the IO, electrodes were placed bilaterally, 2 cm medially and inferiorly to the anterosuperior iliac spine (15, 21).
After placement of the electrodes, all participants did a warm-up by undergoing the submaximal isometric trunk flexion test. EMG values were expressed as root mean square (RMS). After the warm-up, all participants underwent the isometric torque test (maximum flexion), during which they had to keep their head immobile, and their arms crossed over the chest (1). The torque exerted during flexion was measured with an isokinetic dynamometer (System 4 Pro, Biodex®, Shirley, New York, USA). The test involved three 5-sec repetitions, with an interval of 30 seconds between the repetitions. The angle of the waist and thigh was set at 90° (23). A direct transmission system (Noraxon®, Scottsdale, AZ, USA), consisting of the myoMUSCLE software (TELEmyo DTS, 16 channels, 1500 Hz), was used to capture the EMG biological signals using 1-cm-in-diameter Ag/AgCl electrodes (Miotec®, Porto Alegre, Rio Grande do Sul, Brazil) set 2 cm apart. The software was set at a total gain of 2.000 times (20 times for the sensor and 100 times for the equipment) with an analog-digital converter resolution of 16 bits. EMG signals were filtered (4^{th}-order Butterworth) at frequencies ranging from 20 to 500 Hz and analyzed using the Matlab software (version 2009, Natick, MA, USA). To calculate the NME value, the flexion torque value was divided by the sum of the EMG values obtained for the IO (right side + left side) during its maximal isometric contraction (1-5).

Statistical analysis

The Matlab software was used to analyze the data at a significance level of $p < 0.05$. Data normality was assessed by Lilliefors test. The t-test was used to compare values concerning the EMG, NME, and isometric torque peak, between practitioners and control. The Cohen test was used to verify the power size of the comparisons. Data were expressed as mean values and standard deviation (SD).

RESULTS

Figure 1 shows data concerning the three variables: (a) NME, (b) torque and (c) EMG. When compared with the control, the practitioners showed values that were significantly higher concerning the NME and significantly lower regarding the EMG. The values for Cohen test: NME (D = 0.9) and EMG (D = 1.6), Torque (D = 0.86).
Pilates practitioners revealed higher values for the NME (**figure 1 a**), torque (**figure 1 b**) and lower values for the EMG (**figure 1 c**). Statistical analysis (Student t-test; $p < 0.05$) showed significant difference in torque ($p = 0.00083$), NME ($p = 0.00044$) and EMG ($p = 0.0015$) values between practitioners (93.5 ± 17.5, 0.77 ± 0.48, 153.4 ± 65.3, respectively) and control (65.5 ± 19.3, 0.27 ± 0.11, 268.2 ± 81.0, respectively).

DISCUSSION

To our knowledge, this is the first study that investigates the NME of the IO muscle of Pilates practitioners. Our results confirmed the hypothesis that the group of Pilates practitioners present greater NME and torque with less electromyographic activity compared to the group of non-practitioners. The NME is a rare topic in literature. The evaluation

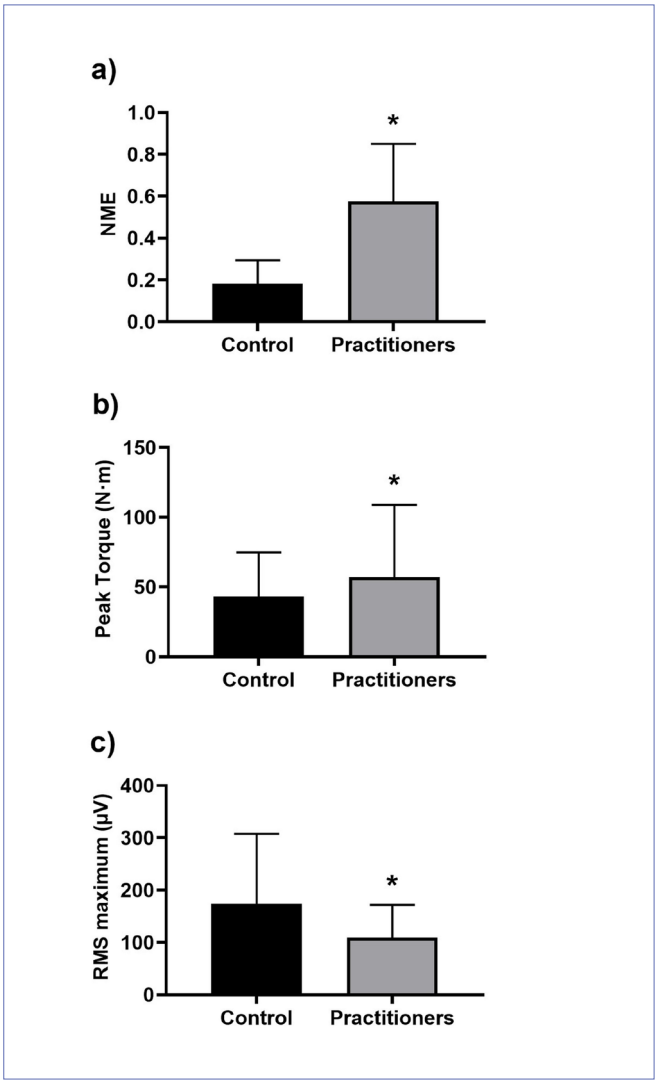

Figure 1. (a) Neuromuscular Efficiency (NME) of the IO muscle, control (non-practitioners) and practitioners. **(b)** Isometric peak of torque (N.m), control (non-practitioners) and practitioners. **(c)** EMG expressed by maximum RMS (root mean square) in microvolts (µV) of the IO muscles.
Control (non-practitioners) and practitioners. *p < 0.05.

of this valence is a strategy for evaluating neuromuscular performance and success of the training process of different modalities (24).

Panhan *et al*.'s article (6) demonstrated that Pilates exercises improve NME and torque of the multifidus (MU) in trunk extension of women. This study showed no difference in the electromyographic activity of the multifidus. Contrary, our findings indicated higher values of EMG of the IO during trunk flexion for the control group. This might be explained by the lack of training which is fundamental for recruiting the muscles and improving their NME. According to Deschenes *et al*. (2) the higher the torque value and the lower the EMG value, the better the NME.

The NME is dependent on training intensity and monitoring, conditions prioritized in the Pilates method, which involves automatic recruitment of the trunk muscles (13), providing them with greater force and lower EMG expenditure (1). Our results confirm the hypothesis that the NME of the IO muscle is better in individuals who undergo regular exercise training programs.

This is especially true for those engaged in Pilates exercises, during which the IO is always recruited, resulting in better spinal stability, condition that is crucial for those seeking to improve their NME. This study reinforces that Pilates can be an alternative method of body fitness, athletics, and physiotherapy.

CONCLUSIONS

The findings of this study can provide pertinent information to instructors of Pilates and exercise training programs since trained individuals need a greater variability of stimuli in training sessions. The NME and the torque parameters were sensitive to the levels of physical fitness of the subjects. Therefore, these parameters can assist in the planning of training sessions because the types and order of exercises must be considered in the training prescription.

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DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

ACP: data collection and analysis. MG, CC; FB: article writing. AC: statistical analysis.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

REFERENCES

1. David P, Mora I, Pérot C. Neuromuscular efficiency of the rectus abdominis differs with gender and sport practice. J Strength Cond Res 2008;22(6):1855-61.
2. Deschenes MR, McCoy RW, Holdren AN, Eason MK. Gender influences neuromuscular adaptations to muscle unloading. Eur J Appl Physiol 2009;105(6):889-97.
3. Racinais S, Périard JD, Li CK, Grantham J. Activity patterns, body composition and muscle function during Ramadan in a Middle-East Muslim country. Int J Sports Med 2012;33(8):641-6.
4. Aragão FA, Schäfer GS, de Albuquerque CE, Vituri RF, de Azevedo FM, Bertolini GR. Neuromuscular efficiency of the vastus lateralis and biceps femoris muscles in individuals with anterior cruciate ligament injuries. Rev Bras Ortop 2015;50(2):180-5.
5. Magalhães I, Bottaro M, Mezzarane RA, et al. Kinesiotaping enhances the rate of force development but not the neuromuscular efficiency of physically active young men. J Electromyogr Kinesiol 2016;28:123-9.
6. Panhan AC, Gonçalves M, Eltz GD, Villalba MM, Cardozo AC, Bérzin F. Neuromuscular efficiency of the multifidus muscle in pilates practitioners and non-practitioners. Complement Ther Med 2018;40:61-63.
7. Marés G, Oliveira KB, Piazza MC, Preis C, Bertassoni LN. The importance of central stabilization in Pilates method: a systematic review. Fisioter Mov 2012;25(2):445-51.
8. Bryan M, Hawson S. The benefits of Pilates exercise in orthopaedic rehabilitation. Tech Orthop 2003;18(1):126-9.
9. Sekendiz B, Altun Ö, Korkusuz F, Akın S. Effects of Pilates exercise on trunk strength, endurance and flexibility in sedentary adult females. J Bodyw Mov Ther 2007;11(4):318-26.
10. Kloubec J. Pilates: how does it work and who needs it? Muscles Ligaments Tendons J 2011;1(2):61-6.
11. Bertolla F, Baroni BM, Leal ECP Jr, Oltramari JD. Effects of a training program using the Pilates method in flexibility of sub-20 indoor soccer athletes. Rev Bras Med Esporte 2007;13(4):198-202.
12. Akuthota V, Ferreiro A, Moore T, Fredericson M. Core stability exercise principles. Curr Sports Med Rep 2008;7(1):39-44.
13. Kolyniak IEGG, Cavalcanti SMDB, Aoki MS. Isokinetic evaluation of the musculature involved in trunk flexion and extension: Pilates© method effect. Rev Bras Med Esporte 2004;10(6):487-90.
14. Latey P. The Pilates Method: history and philosophy. J Bodyw Mov Ther 2001;5(4):275-82.
15. Panelli C, De Marco A. Método Pilates de condicionamento do corpo: um programa para toda a vida. Phorte: São Paulo, 2009.
16. Sitilertpisan P, Joseph L, Paungmali A, Pirunsan U, Chunchai T. Investigation of the Contraction Ratio of Transversus Abdominis and Internal Oblique Muscles during Lumbopelvic Stability Test. Muscles Ligaments Tendons J 2020;10(1):86-91.
17. Marques NR, Morcelli MH, Hallal CZ, Gonçalves M. EMG activity of trunk stabilizer muscles during Centering Principle of Pilates Method. J Bodyw Mov Ther 2013;17(2):185-91.
18. Norwood JT, Anderson GS, Gaetz MB, Twist PW. Electromyographic activity of the trunk stabilizers during stable and unstable bench press. J Strength Cond Res 2007;21(2):343-7.
19. Rossi DM, Morcelli MH, Marques NR, et al. Antagonist coactivation of trunk stabilizer muscles during Pilates exercises. J Bodyw Mov Ther 2014;18(1):34-41.
20. Vieira FT, Faria LM, Wittmann JI, Teixeira W, Nogueira LA. The influence of Pilates method in quality of life of practitioners. J Bodyw Mov Ther 2013;17(4):483-7.
21. Silva GB, Morgan MM, Gomes de Carvalho WR, et al. Electromyographic activity of rectus abdominis muscles during dynamic Pilates abdominal exercises. J Bodyw Mov Ther 2015;19(4):629-35.
22. Hermens HJ, Freriks B, Disselhorst-Klug C, Rau G. Development of recommendations for SEMG sensors and sensor placement procedures. J Electromyogr Kinesiol 2000;10(5):361-74.
23. Kliziene I, Sipaviciene S, Vilkiene J, et al. Effects of a 16-week Pilates exercises training program for isometric trunk extension and flexion strength. J Bodyw Mov Ther 2017;21(1):124-32.
24. Chaves SF, Marques NP, Silva RL, et al. Neuromuscular efficiency of the vastus medialis obliquus and postural balance in professional soccer athletes after anterior cruciate ligament reconstruction. Muscles Ligaments Tendons J 2012;2(2):121-6.