

EMG OF THE TRANSVERSE ABDOMINUS AND MULTIFIDUS DURING PILATES EXERCISES

Paulo de Carvalho¹, Ana Pereira¹, Rubim Santos¹ and João Paulo Vilas Boas^{2,3}

School of Allied Health Sciences, Porto Polytechnic Institute, Porto, Portugal¹
Porto Biomechanics Laboratory (LABIOMEP), University of Porto, Portugal²
CIFI2D, Faculty of Sport, University of Porto, Porto, Portugal³

The purpose of this research study was to evaluate the intensity of muscle activation of Transverse Abdominus /Oblique Internal (TrA/OI) and Multifidus (Mu) during the performance of four Pilates exercises (and variations), compared, in order to understand the importance of these exercises in the lumbopelvic stability in healthy subjects. The sample consisted of 8 individuals. Using the surface electromyography (EMG), it was found that there are differences in the intensity of muscle activation in the analyzed exercises and, therefore, "Shoulder bridge" and "ShoulderBridge_extension (right and left legs)" are the more appropriate exercises for co-activation between TrA/OI and Mu muscles for the reeducation of lumbopelvic stability.

KEY WORDS: Core, Electromyography, Lumbopelvic Stability, Pilates Method.

INTRODUCTION: To the group of muscles that control movement and stabilize the lumbar spine and pelvis is given the name of "core". The stabilization of the core represents the complex interaction of passive subsystems (joints and ligaments of the spine) and active (muscle and nerve) (Willardson 2007). Anatomically, the core is the musculature surrounding the lumbar-pelvic region. The core muscles and the thoracolumbar fascia play a role in the stability of the lumbar-pelvic region (Bliss & Teeple 2005). The increased dynamic stabilization of this region is achieved through the training of local and global systems. The local system is based on the muscle consisting of slow twitch fibers, shorter in length and deep, which have direct connection to the spine that control inter-segment movement between adjacent vertebrae or act by increasing intra-abdominal pressure. These muscles are the TrA/OI (inferior fibers) and Mu. These muscles have short lever arms due to the proximity to the spine and must be activated before the global muscles with the purpose of stabilizing the lumbopelvic region (Hodges 1999; Hodges & Richardson 1999; Richardson et al. 2004; Ekstrom et al. 2007; Willardson 2007; Akuthota et al. 2008). The Pilates Method develops muscle strength of the body center, focusing on the contraction of muscles TrA/OI and Mu and thus contributes to lumbopelvic stability (Smith & Smith 2005; Smith & Smith 2005a; Bernardo 2007; Endleman et al. 2008; Queiroz et al. 2010). The purpose of this study was to evaluate the intensity of the TrA/OI and Mu muscle activation during the performance of four Pilates exercises (and variations), in order to realize the importance of these exercises in the lumbopelvic stability in healthy subjects.

METHODS: The research model of this study was quantitative and the study design was observational cross sectional. The sample consisted of 8 healthy women volunteers (with 2 years of minimum experience in Pilates, average age – 24 years old, average height 1.64 m and average mass – 54.7 kg) which performed four exercises included in this method and their respective progressions (Queiroz et al., 2010). Surface active differential electromyography (EMG) was used (wireless bioPLUXresearch system, Plux active electrodes, sampling – 1000 Hz, Filter – 10-450 Hz), in order to measure the muscle activity of muscles TrA/OI and Mu. Synchronized video records (Sony DCR-SR15 camera, 50 Hz) were used to relate EMG signal with motor events. Each subject performed three repetitions of each exercise, which allowed calculating the average intensity of muscle activation of each muscle in each exercise. Subsequently, we calculated the level of muscle EMG normalized to the maximal voluntary contraction (Allison et al. 1998; Marshal & Murphy 2003; Arokoski et al. 2001). The *Shapiro-Wilk* test was used to verify the normality of variables' distributions.

When the sample met the requirements of normal distribution we used the t test for paired samples, while in other cases we used nonparametric Willcoxon test. The confidence interval used was 95% with a significance level of 0,05. All participants were informed about the content of the study and its procedures by signing the informed consent considering the "Helsinki Declaration" of the World Health Organization.

RESULTS AND DISCUSSION: The data analysis showed that between the exercises, compared two by two, there is evidence to support that some exercises are different with regard to the intensity of muscle activation in both muscles TrA/OI and Mu.

For training the local muscles it was observed that, for the TrA/OI muscles, the best exercises are "LegCircle (counter clockwise)", "ShoulderBridge_extension right leg" and "ShoulderBridge_extension left leg". In these exercises were found significant differences between "LegCircle (counter clockwise)" and "Scissors_1" ($p=0.015$); "LegCircle (counter clockwise)" and "RollUp" ($p=0.016$); "ShoulderBridge_extension right leg" and "Scissors_1" ($p=0.005$); "ShoulderBridge_extension right leg" and "RollUp" ($p=0.024$); "ShoulderBridge_extension left leg" and "Scissors_1" ($p=0.022$); "ShoulderBridge_extension left leg" and "RollUp" ($p=0.012$).

For the Mu muscle, there were significant differences in the intensity of activation between "LegCircle (clockwise)" and all the exercises, "LegCircle (counter clockwise)" and all the exercises, "ShoulderBridge" and all the exercises, "ShoulderBridge_extension right leg" and all the exercises and "ShoulderBridge_extension left leg" and all the exercises. The best exercises for the training of the Mu were "ShoulderBridge", "ShoulderBridge_extension right leg" and "ShoulderBridge_extension left leg". These exercises seem to be adequate in reeducation of the lumbopelvic stability (Richardson et al. 2004; Urquhart et al. 2005; Stevens et al. 2007), based on the activation ratio of both muscles (see table 1).

Table 1
Mean and Standard Deviation for the muscle TrA/OI and Mu in the different exercises

Exercises	TrA/OI		Multifidus	
	Mean %	Sta. Deviation	Mean %	Sta. Deviation
LegCircle (clockwise)	17.28	7.34	14.89	4.62
LegCircle (counter clockwise)	20.15	5.75	10.94	5.33
RollUp	14.36	6.18	7.56	2.62
ShoulderBridge	16.98*	5.21	24.46*	9.4
ShoulderBridge_extension right leg	22.4*	7.94	31.37*	13.49
ShoulderBridge_extension left leg	21.03*	13.78	33.71*	8.46
Scissors_Right	18.3	7.64	4.75	1.61
Scissors_Left	17.69	3.52	4.14	1.25
Scissors	17.92	7.55	5.86	1.81
Scissors_1	15.59	6.93	6.65	1.77
Scissors_2	18.13	5.90	6.35	2.08

Legend: Values marked with an asterisk (*) indicate best exercises for co-activation of the TrA/OI and Mu muscles.

CONCLUSION: The Pilates method develops proper muscle activity of the core muscles, contributing to lumbopelvic stability. Based on the relative intensity of muscle activation, it was concluded from this study that, for a co-activation of TrA/OI and Mu muscle for the re-education of lumbopelvic stability, the exercises "ShoulderBridge", "ShoulderBridge_extension right leg" and "ShoulderBridge_extension left leg", are the most effective.

REFERENCES:

- Akuthota, V., Ferreiro, A., Moore, T. & Fredericson, M. (2008). Core stability exercise principles. *Current Sports Medicine Reports* 7, 39-44.
- Allison, G., Godfrey, T. & Robinson, G. (1998). EMG signal amplitude assessment during abdominal bracing and hollowing. *Journal of Electromyography and Kinesiology* 8, 51-57.
- Arokoski, J.P., Valta, T., Airaksinen, O. & Kankaanpaa, M. (2001). Back and abdominal muscle function during stabilization exercises. *Archives of Physical Medicine and Rehabilitation* 82, 1089-1098.
- Bernardo, L.M. (2007). The effectiveness of Pilates training in healthy adults: An appraisal of the research literature. *Journal of Bodywork and Movement Therapies* 11, 106-110.
- Bliss, L.S. & Teeple, P. (2005). Core Stability: The Centerpiece of Any Training Program. *Current Sports Medicine Reports* 4, 179-183.
- Ekstrom, R., Donatelli, R., & Carp, K. (2007). Electromyographic analysis of core trunk, hip, and thigh muscles during 9 rehabilitation exercises. *Journal of Orthopaedic Sports Physical Therapy* 37, 754:762.
- Endleman, I. & Critchley, D. (2008). Transversus Abdominis and Obliquus Internus activity during Pilates exercises: measurement with ultrasound scanning. *Archives of Physical Medicine and Rehabilitation* 89, 2205-2212.
- Hodges, P. (1999). Is there a role for Transversus Abdominis in lumbopelvic stability? *Manual Therapy* 4, 74-86.
- Hodges, P. & Richardson, C. (1999). Transversus Abdominis and the superficial abdominal muscles are controlled independently in a postural task. *Neuroscience Letters* 265, 91-94.
- Marshal, P. & Murphy, B. (2003). The validity and reliability of surface EMG to assess the neuromuscular response of the abdominal muscles to rapid limb movement. *Journal of Electromyography and Kinesiology* 13, 477-489.
- Queiroz, B., Cagliari, M., Amorim, C. & Sacco, I. (2010). Muscle activation during four Pilates core stability exercises in quadruped position. *Archives of Physical Medicine and Rehabilitation* 91, 86-92.
- Richardson, C., Hodges, P. & Hides, J. (2004). *Therapeutic exercise for lumbopelvic stabilization: a motor control approach for the treatment and prevention of low back pain*. 2nd ed. United Kingdom: Churchill Livingstone.
- Smith, E. & Smith, K. (2005). *Pilates for rehab: a guidebook to integrating Pilates in patient care*. Minneapolis: OPTP.
- Smith, E. & Smith, K. (2005a). Integrating Pilates-based core strengthening into older adult fitness programs: implications for practice. *Topics in Geriatric Rehabilitation* 21, 57-67.
- Stevens, V., Vleeming, A., Bouche, K., Mahieu, N., Vanderstraten, G. & Danneels, L. (2007). Electromyographic activity of trunk and hip muscles during stabilization exercises in four-point kneeling in healthy volunteers. *European Spine Journal* 16, 711-718.
- Urquhart, D., Hodges, P., Allen, T. & Story, I. (2005). Abdominal muscle recruitment during a range of voluntary exercises. *Manual Therapy* 10, 144-153.
- Willardson, J. M. (2007). Core stability training for healthy athletes: a different paradigm for fitness professionals. *Strength and Conditioning Journal* 29, 42-49.