AMERICAN JOURNAL OF SPORTS TRAINING

Electromyographic Analysis of the Tibialis Anterior and Peroneus Longus Muscles in Pilates Proprioceptive Exercises

ajst.science/article/electromyographic-analysis-of-the-tibialis-anterior-and-peroneus-longus-muscles-in-pilates-proprioceptive-exerc

Ingrid Quartarolo, Luiz Yassunaga Jr. João António Alves Santinha, Ronaldo ECD Gabriel, Eric Shamus

2016-04-30 16:45:19

Ingrid Quartarolo

Physiotherapist, Acupuncturist, Master in Sports Sciences UTAD-Portugal, founder and Instructor of Contemporary Pilates

Luiz Yassunaga Jr.

Physiotherapist, Acupuncturist, Professor of Contemporary Advanced Pilates, Professor of Acupuncture, Auriculotherapy and Shiatsutherapy.

João António Alves Santinha

Physics Department, FCT-UNL, Lisbon, Portugal.

Ronaldo ECD Gabriel

Department of Sports Sciences, Exercise and Health, Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB), University of Trás-os-Montes and Alto Douro, Vila Real, Portugal.

Eric Shamus

PhD, DPT, Chair and Associate Professor, Department of Rehabilitation Sciences, Florida Gulf Coast University, Florida, USA.

Abstract: *Background:* Dynamic ankle stability depends on the rapid response capability of the tibialis anterior and peroneus longus for protection and joint stability. In ankle rehabilitation, a delay in the activation time of these muscles may cause functional ankle instability. *Hypothesis/Purpose*: The purpose of this study was to examine the effect of closed chain Pilates exercises on electromyography activity of the tibialis anterior and peroneus longus muscle activations. *Study Design*: Randomized study *Methods*: Ten healthy individuals were examined during dynamic exercises on the Reformer and the proprioception exercises on the Step chair of the Pilates. *Results:* The tibialis anterior muscle had significantly higher electromyography activity on the Step Chair exercises. The peroneus longus presented significantly higher electromyography activity on the Reformer exercises. *Conclusion*: The results demonstrated an increase of recruitment of the tibialis anterior and the peroneus longus in closed chain exercises that maybe useful in ankle stability rehabilitation.

Introduction

Dynamic ankle stability depends on the rapid response capability of the tibialis anterior and peroneus longus for protection and joint stability.[3] Chronic and functional ankle instability, repetitive sprains, and ligament injuries can cause a sensorimotor and proprioceptive deficit, which results in a motor control changes of the tibialis anterior and peroneus longus.[5] A delay in the activation time of the tibialis anterior and peroneus longus muscles may cause functional ankle instability.[3] Sensorimotor deficit, proprioception deficit, decreased peroneus longus muscle control and balance are related to the instability of the ankle joint.[3,4] The proprioceptive deficit produces a decrease in the reflex of the tibialis anterior and peroneus longus, causing a decrease in balance, change in posture control and decreased functional ankle instability.[3]

Proprioceptive deficit, muscle fatigue and muscle imbalance compromise the muscle spindle which is the most compromised receptor in the ankle stability.[3] The fatigue of the lower limb muscles including the hip, knee, and ankle may affect stability and postural control.[1,6]

Conceição conducted an electromyographic analysis in patients with chronic ankle sprains and found that electrical activation of the peroneus longus muscle was decreased in a state of chronic ankle instability.[19] Weakness of the peroneus longus muscle was suspected as a cause of chronic ankle instability and high incidence of ankle sprains by inversion.[19] The high incidence of recurrent inversion ankle sprains is likely the combination of the decreasing ankle proprioception with evertor muscle weakness. [19] In a review of the literature on the EMG activation of the leg muscles in proprioceptive exercises in the ankle rehabilitation, there was a higher activation of the lateral muscles, specially the peroneus longus muscle.[20]

Cunha and Regina[21] studied the EMG activation of the tibialis anterior muscle and peroneus longus during posture maintenance on the balance board with single-leg and bipedal supports. The results showed that the anterior tibialis muscle presented higher activation in exercises with balance board and bipedal support, while the peroneus longus muscle presented higher activation in single- leg support exercises.[21] Ferreira et al. found the activation of the tibialis anterior and peroneus muscles was observed on stable and unstable surfaces, and it was also found that both muscles have muscle activation on both types of surfaces.[22]

The Pilates Method has been an option for the treatment of various pathologies, as it is provides core body control and proprioceptive feedback.[11] Cruz-Ferreira et al. reported that Pilates exercises are a good resource for improving dynamic balance and healthy adults.[12]

Proprioceptive training is essential to improve balance, proprioception and ankle stability, which is used in the treatment of ankle injuries and injury prevention. Exercises that promote better postural control, proprioception and balance training are being used in treatment programs for ankle instability.[6-8] Repetition and control are crucial for the development of motor coordination exercises that develop body and mind.[8-10]

The Pilates method has been used in several rehabilitation programs by developing improvement in balance, proprioception, flexibility and motor coordination.[14,15] The most used equipment in the Pilates method is the Reformer by incorporating various adjustments and resistors as well as enabling the plyometric exercises.[16]

The objective of this study was to perform electromyographic analysis of the tibialis anterior and peroneus longus in proprioceptive exercises on the Step chair and Reformer of the method Pilates to determine if there is an increase in muscle recruitment with these closed chain exercises.

Methods

A convenience sample was used according to the sample size calculation. Ten subjects were required for the

analysis of tibialis anterior and peroneus longus activations on the Reformer and Step Chair exercises of the Pilates method.

The inclusion criteria were individuals, between 20 and 45 years old. The exclusion criteria were individuals with lower limb injuries, visual impairment or had any vestibular disorders.

To collect the electromyographic activity, an electromyograph BiosignalsPlux with eight channels,12 bits and 1000Hz frequency made by Plux (http://www.plux.info/, Lisbon, Portugal) was utilized for data collection.

For the tibialis anterior baseline calibration (TA), the subject performed five resisted dorsiflexion contractions. Three moments of this contraction were recorded. For the peroneus longus baseline calibration, the subject performed five resisted dorsiflexion with eversion contractions. Three moments of this test were also recorded.

Electromyographic analysis was performed during the six jumping exercises on the Reformer: two-legged hops, one-legged hops, two-legged hops with support on the proprioceptive disc and with eyes open and closed, and one-legged hops with eyes open and closed with proprioceptive disc.

Figure 1- Exercise in Step Chair

Figure 2- Jumping on the Reformer

For the analysis of exercises on the Step Chair, the exercises were performed from the standing position with a lower limb on the long box and another lower limb on the pedal of the Step Chair, performing the following

movements:

1. flexion and extension of the knee on the pedal

2. flexion and extension of the knee on the long box

3. alternating flexion and extension of the limb on the pedal and on the Step Chair as well as the limb on the box.

These exercises were performed with eyes open and closed.

The results of the data were analyzed by descriptive and inferential statistical test. A mixed model ANOVA was used for the inferential analysis. All statistical analysis were performed with the statistical package SPSS version 16.0.

Results

The results were calculated from percentage of average muscle activation with and without the disc. No significant differences were found when performing the same exercise with and without the disc. The following results were obtained: 4.30 for the left anterior tibial with disc and 4.25 without disc ($p = 0.942$); 4.04 for the right tibialis anterior with disc and 4.26 without disc ($p = 0.563$); 5.09 for the left peroneus longus with disc and 4.72 without disc ($p = 0.577$); 5.88 for the right peroneus longus with disc and 5.26 without disc ($p = 0.443$) (Figure 1).

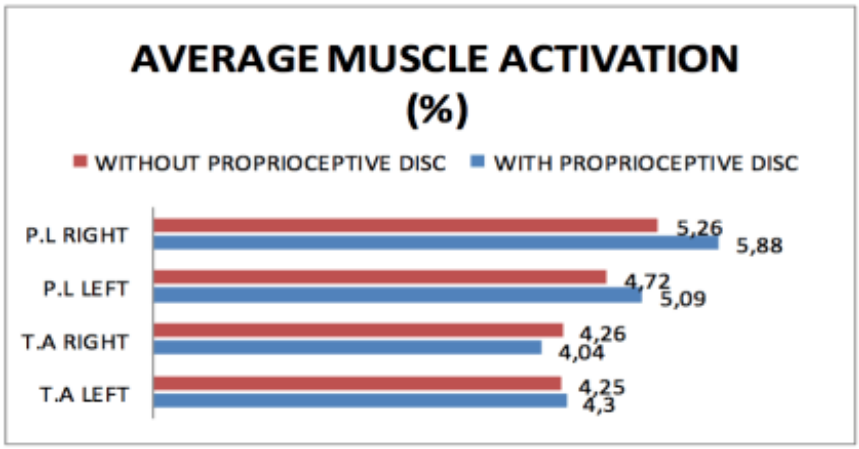

Figure 1: Average muscle activation of the tibialis anterior and peroneus longus with and without proprioceptive disc

As for the exercises performed with eyes open or closed on the Reformer no significant difference was found when performing the same exercise, $p = 0.986$ for the left tibialis anterior, $p = 0.147$ for the right tibialis anterior, $p = 0.230$ for the left peroneus longus and $p = 0.548$ for the right peroneus longus (Figure 2).

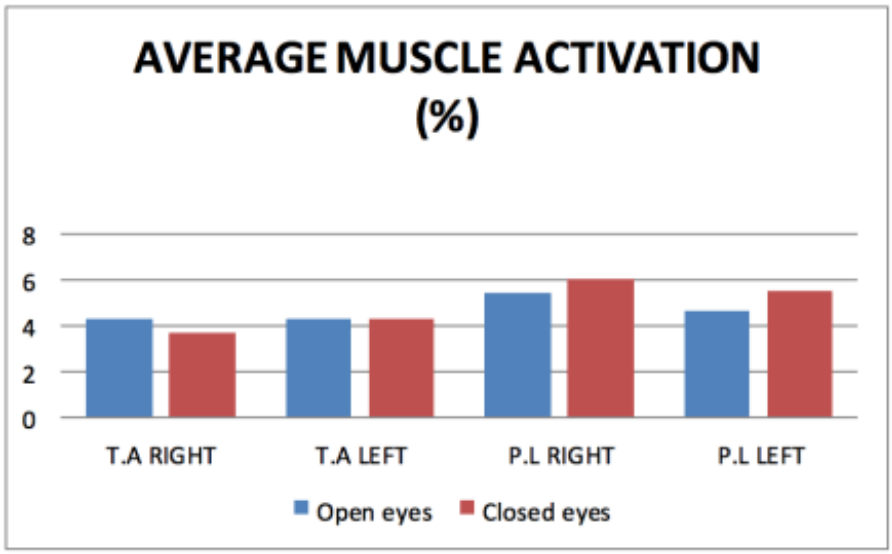

Figure 2: Average muscle activation of the tibialis anterior and peroneus longus in exercises with eyes open and closed

Considering that the individuals in the sample were all right-handed, the left tibialis anterior was more activated in the left knee flexion exercise on the box with disc and eyes closed on the chair (6.47), and right single-leg hop on the Reformer (5.70) with p = 0.826; the right tibialis anterior was more activated in the right knee flexion on the box with disc, eyes open on the chair (6.61) and two- legged hop with eyes open on the Reformer (5.02) with p = 0.094. Yet, as for the left peroneus longus, there was a higher activation in the exercise on the chair of knee flexion on the box and right leg resting on the pedal (3.78), and single-leg hop with the left leg, with eyes closed and disc (10.09) with p = 0.03.

Finally, the right peroneus longus had increased activation in the knee flexion exercise on the box with disc and eyes open (5.34), and the two- legged hop (13.04) on the Reformer with p = 0.029 (Figure 3).

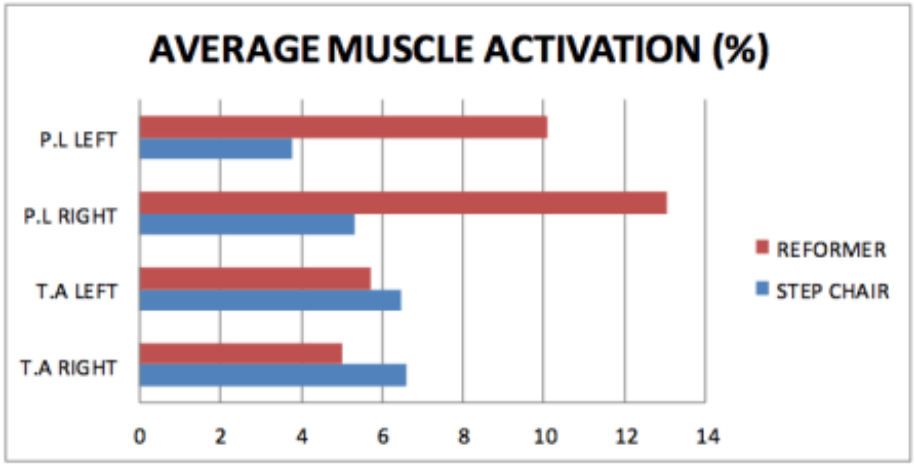

Figure 3: Average muscle activation of the tibialis anterior and peroneus longus in the average of the step chair and reformer exercises.

Discussion

Similar studies suggest a statistically significant electrical activity of the tibialis anterior and peroneus longus which is higher with eyes closed than with eyes open and on unstable surface, and the activation of muscles on both

stable and unstable soil.[17] In this study, there was higher electrical activity of the peroneus longus muscle during the movement performed with eyes closed and proprioceptive disc on the single-leg hop on the Reformer. The afferent information provided to the balance and posture controls comes from three types of systems: the visual, vestibular and somatosensory. Thus, the exercises were chosen with the lack of vision in order to increase the afferent information from somatosensory receptors and optimize the efferent responses.

The jump exercises performed on the Reformer such as two-legged and single-leg hops, with or without proprioceptive disc, and with eyes open and closed are important for proprioceptive training as they are plyometric exercises. Plyometric exercises increase eccentric-concentric cycle of skeletal muscle, causing its mechanical, elastic and reflex potentiation, being able to promote stimulation of body proprioceptors, influencing the myotatic reflex, Golgi tendon organ reflex and neuromuscular spindle. Plyometrics improve neural efficiency, increase control and neuromuscular coordination as well as joint proprioception. Therefore, plyometric training not only increases joint proprioception and kinesthesia but also restores the functional stability; so, it is a suitable training for athletes' performance, treatment, injury prevention and strength gains.[18]

The current study showed that tibialis anterior muscle presented higher EMG activity in exercises on the chair without the proprioceptive disc and with eyes open; and in exercises on the Reformer performed in single- leg hop of the right lower limb, the left contralateral tibialis anterior was the most active. It is believed that the largest number of mechanoreceptors (the Paccini corpuscles, Ruffini and Golgi tendon organ) lie in the ankle ligaments and are responsible for proprioception and joint stability. The exercises performed on unstable surface and on multiple planes of motion bring rapid changes in the ligaments of the ankle, which causes afferent reflex and motor responses and encourages agonist and antagonist co-contraction to produce a rapid joint stability and proprioception increase. Muscle fatigue and chronic ankle instability affect balance and dynamic postural control of the body, creating a proprioceptive deficit and joint damage, respectively.[23]

Conclusion

It is concluded that the peroneus longus muscle showed higher electromyographic activity and higher statistical significance in the exercises with the balance disc and eyes closed on the Reformer. The tibialis anterior muscle showed higher electromyographic activity and higher statistical significance in exercises performed without disc and with eyes open in the Step Chair. Muscle activation of the tibialis anterior and peroneus longus are important for the stability and proprioception of the ankle. The two exercises maybe useful in exercise protocols for motor control training and rehabilitation for ankle rehabilitation.

Reference

Aquino CF, Viana SO, Fonseca ST, Bricio RS, Vaz DV. Mecanismos neuromusculares de controleda estabilidade articular. *Revista Brasileira de Ciência e Movimento*. 2004;12(2):35-42.

Hogervorst T, Brand RA. Mechanoreceptors in joint function*. J Bone Joint Surg Am*. 1998 Sep;80(9):1365-78. [PMID 9759824]

Munn J. Sullivan SJ, Schneiders AG. Evidence of sensoriomotor defictis in functional ankle instability: A systematic review with meta-analysis. *Journal of Science and Medicine in Sport*. 2010 Jan;13(1):2-12. [PMID 19442581]

Twist C, Gleeson N, Eston R. The effects of plyometric exercise on unilateral balance performance. *J Sports Sci*. 2008 Aug;26(10):1073-80. [PMID 18608837]

Hertel J. Sensorimotor deficits with ankle sprains and chronic ankle instability. *Clinical Sports Med*. 2008;27(3):353-70. [PMID 18503872]

Gribble PA, Hertel J, Denegar CR, Buckley WE. The effects of fatigue and chronic ankle instability on dynamic

postural control. *J Athl Train*. 2004 Dec;39(4):321-9. [PMID 15592604]

Delahunt E. Neuromuscular contributions to functional instability of the ankle joint. *J Bodyw Mov Ther*. 2007;11:203-13.

Latey P. *The Pilates method: history and philosophy.* Harcourt Publishers Ltd, 2001.

Quartarolo ILA, Barcelos J, Yasunaga Jr L, Serafini G. The usage of the pilates procedures in the post operatory of bariatic surgeries. *Fisioterapia Ser*. 2011;6(3):177-81.

Quartarolo I, Magalhaes F, Maciel D, Cupertino A, Sampaio B. Eficacia do metodo Pilates na funcao motora e ampltitude de movimento em portadores de paralisa cerebral em fase escolar. *Fisioterapia Ser*. 2011;6(4):234-43.

Wells C, Kolt GS, Bialocerkowski A. Defining Pilates exercise: a systematic review. *Complementary Therapies in Medicine*. 2012;20(4):253-62.

Cruz-Ferreira A,Fernandes J, Laranjo L, Bernardo LM, Silva A. A systematic review of the effects of pilates method of exercise in healthy people. *Arch Phys Med Rehabil*. 2011 Dec;92(12):2071-81.

Bernardo LM. The effectiveness of Pilates training in healthy adults: An appraisal of the research literature. *Journal of Bodywork and Movement Therapies*. 2007;11:106-10.

Quartarolo I, Lima MO, Sampaio BM, Yassunaga Jr L, Lamarão FRM. Analise da flexibilidade durante um periodo de nove dias de pratica no metodo pilates. *Fisioterapia Ser*. 2012;7(3):158-61.

La Touche R, Escalante K, Linares MT. Treating non-specific chronic low back pain through the Pilates Method. *J Bodyw Mov Ther*. 2008 Oct;12(4)364-70. [PMID 19083695]

Johnson EG, Larsen A, Ozawa H, Wilson CA, Kennedy KL. The effects of Pilates-based exercise on dynamic balance in healthy adults. *J Bodyw Mov Ther*. 2007;11(3):238-42.

Ferreira LAB, Pereira WM, Oliveira DC, Figueiredo RR. Comparação eletromiográfica dos estabilizadores dinâmicos do tornozelo com os olhos abertos e fechados. 21o Congresso Brasileiro de Engenharia Biomédica, 2008;1715-18. (ISBN: 978-85-60064-13-7)

Rossi LP, Brandalize M. Pliometria aplicada a reabilitacao de atletas. *Revista Salus-Guarapuava-PR*. 2007 Jan/Jun;1(1):77-85.

Conceição SS. Analise eletromiografica em portadores de entorse cronica de tornozelo. Institutos Superiores de Ensino do Centro Educacional Nossa Senhora Auxiliadora (ISECENA), 2009.

Ferreira LAB, Pereira WM, Vieira FF, Rossi LP. Ativacao eletromiograficia dos musculos da perna em exercicios proprioceptivos na reabilitacao de tornozelo: uma revisao bibliografica. XI Encontro Latino Americano de Iniciação Científica- Universidade Vale do Paraíba, 2009.

Cunha PLB, Regina T. Ativação eletromiográfica em exercícios sobrea prancha de equilíbrio. *Revista Fisiterapia Brasil*. 2007;8(3):192-7.

Ferreira LAB, Rossi LP, Pereira WM, Vieira FF, Rodrigues de Paula Jr A, Analise da atividade eletromiografica dos musculos do tornozelo em solo estavel e instavel. *Fisioter Mov Curitiba*. 2009;22(2):177-87.

Abdalla RJ, Cohen M. *Lesões no Esporte- Diagnóstico, Prevenção e Tratamento.* Ed Revinter, 2003. ISBN 857309608X