ONSET OF ELECTRICAL ACTIVITY OF PATELLAR STABILIZER MUSCLES IN SUBJECTS WITH PATELLOFEMORAL PAIN

DÉBORA BEVILAQUA-GROSSI[1], LILIAN RAMIRO FELÍCIO[1], GERALDO WENDEL PEREIRA SILVÉRIO[2]

ABSTRACT

Objective: To asses the onset (%) of patella stabilizer muscles during maximal isometric contraction exercises (MIC) in individuals with and without signs of patellofemoral pain syndrome (PFPS) in open (OKC) and closed (CKC) kinetic chain exercises. Method: Assessments were carried out on 22 women; ten with no complains of anterior knee pain, and 12 with PFPS signs during MIC in OKC and CKC with the knee flexed at 90º. The onset of the electromyographic activity of the vastus medialis obliquus (VMO), vastus lateralis obliquus (VLO) and vastus lateralis longus (VLL) was identified by means of an algorithm in the *Myosystem Br 1* software. The statistical analysis used was Chi-Square test and *student's t test*, which are both tests with a level of significance at 5%. Results: The VMO and VLO muscles presented a greater onset compared to the VLL during OKC exercises for both groups and for the PFPS group without CCF. No differences were observed between the groups. Conclusion: CKC and OKC exercises seem to benefit the synchronism of the musculature that supposedly benefits the patella stabilizer musculature, and can be recommended in physiotherapeutic treatment programs.

Keywords: *Exercise. Patellofemoral pain syndrome. Electromyography.*

Citation: *Bevilaqua-Grossi D, Felício LR, Silvério GW. Onset of electrical activity of patellar stabilizer muscles in subjects with patellofemoral pain. Acta Ortop Bras. [online]. 2009;17(5):297-9. Available from URL: http://www.scielo.br/aob.*

INTRODUCTION

Petellofemoral pain syndrome (PFPS) is one of the most common conditions of osteomyoarticular injuries, particularly affecting young sedentary women. PFPS is defined as an anterior knee pain, worsened during functional activities such as climbing up and down stairs, squatting, and remaining in sedestation for long periods.[1,2] While its etiological factors are not well defined, some authors report that changes on dynamic patellar stabilizers may be associated to this condition.[1,3] Some authors suggest that the unbalance of the response time between vastus medialis obliquus (VMO) and vastus lateralis (VL) muscles and that changes on VMO reflex response time could trigger PFPS.[1,4,5] However, many authors found no difference between the onset of electric activity of these muscles among individuals with and without PFPS.[1,4,6] Witvrouw et al.[4] found that, during activities in open kinetic chain (OKC), the VMO muscle starts its activity later than VL muscle, and, according to those authors, this could lead to patellar misalignment during the activity, a finding consistent with Cowan et al.[1], who also found a difference of the onset of electric activity of patellar stabilizers. However, some studies evidence a simultaneous onset of electric activity between VMO and VL muscles when the leg is extended in OKC exercises, ruling out the hypothesis that the lack of synchronicity could be an etiological factor for PFPS.[5,7-9] Anyway, these studies assessed the onset of electric activity of the VMO muscle compared to VLL, and, according to Bevilaqua-Grossi et al.[10], vastus lateralis obliquus (VLO) muscle is an important stabilizer, with antagonistic and synchronic action to VMO. Only Morrish and Woledge[7] assessed the onset of electriomyographic activity of the vastus lateralis obliquus (VLO); however, they assessed it only during isometric contraction with the knee flexed at 20°. Thus, the present study targeted the assessment of the onset of electric activity of the VMO, VLL and VLO muscles through surface electromyography during OKC and CKC exercises in individuals with and without PFPS signs or symptoms.

MATERIALS AND METHODS

Subjects

Ten women with no anterior knee pain complaints (healthy group) and mean age of 22.2 ± 2.25 years were assessed, as well as 12 individuals with PFPS (PFPS group) with mean age of 22 ± 2.04 years, screened from a conveniently selected sample. Inclusion and exclusion criteria for groups with and without PFPS signs followed the recommendations by Coqueiro et al.[11] and Bevilaqua-Grossi et al.[6] The study was conducted according to the Resolution 196/96 of the National Health Council, being approved by the Committee of Ethics of the Institution.

All the authors state no potential conflict of interest concerning this article.

1 – Ribeirão Preto Medical School, FMRP-USP
2 – University of Rio Verde (in memorian)

Study conducted at the Department of Biomechanics, Medicine and Locomotive Apparatus Rehabilitation, Ribeirão Preto Medical School, FMRP-USP.
Correspondences to: Av. Bandeirantes 3900, casa 2 Fisioterapia CEP 14049-900. Ribeirão Preto, SP. Brazil. E-mail: deborabg@fmrp.usp.br

Received in: 04/29/08; approved in: 11/12/08

Instrumentation

In order to assess the onset of electromyographic activity time for VMO, VLL and VLO muscles, single differential active electrodes (10X1mm) Ag/AgCl by Lynx Tecnologia Eletrônica Ltda. (São Paulo, SP) with 20x gain, connected to an electromyographer brand *Myosystem*® (Uberlândia, MG) 12-bit A/D converser plate with 100x magnification have been used, totaling a 2000x gain. The common-mode rejection ratio (CMRR) was 93dB and the acquisition frequency, 2KHz. The 3-cm^2 reference electrode was fixated to tibial tuberosity[1] of the assessed limb. Electromyographic signs were processed by means of the *Myosystem–Br1* software, release 2.9 b (Uberlândia, MG), following an algorithm identifying and quantifying into seconds the onset of electromyographic activity of patellar stabilizer muscles.

During OKC exercises, an extensor equipment was employed, where the volunteer remained in sedestation position with the hip and knee at 90° of flexion (Figure 1), while the CKC exercises were made on the *Leg Press* device bended at 45° from the floor, with knees flexed at 90º (Figure 2), for both exercises, with volunteers' trunk and head stabilized with a belt.

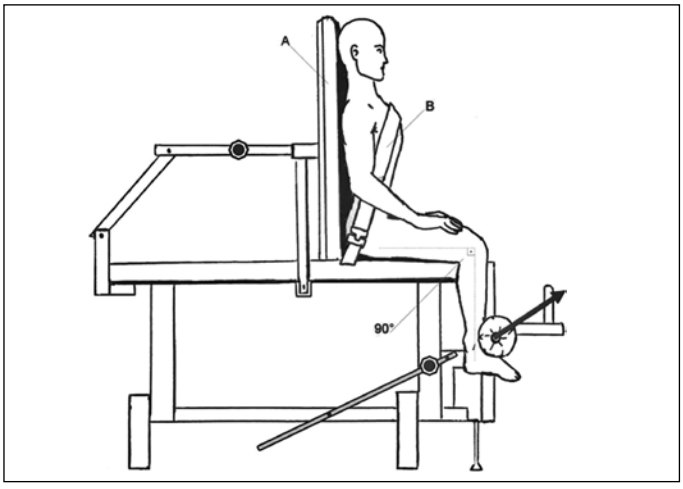

Figure 1 – *Extensor device employed for OKC exercises. (A) Support for spine and head, (B) belt for trunk stabilization. The arrow represents the orientation of the strength applied by volunteers*

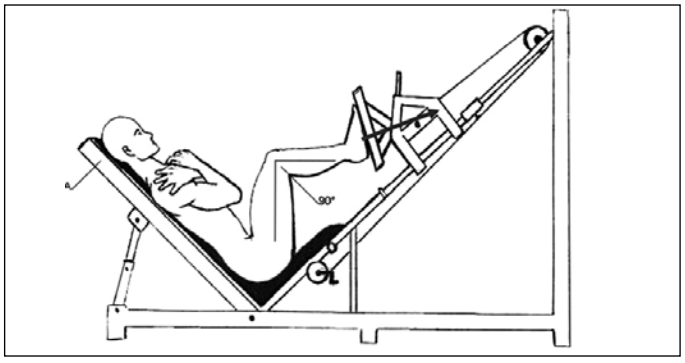

Figure 2 – *Leg Press device employed for CKC exercises. (A) Support for head and spine. The arrow represents the orientation of the strength applied by volunteers*

Procedures

The exercises were randomly made on the dominant lower limb for the group without PFPS signs and on the affected limb for the individuals with PFPS. Prior to electrode application, the skin was trichotomized and cleaned with 70% alcohol. The electrodes were placed on VMO muscle at a 55° bending from femoral axis and 4 cm above the superomedial patellar edge[12,13], while, for VLL, the electrode was placed at 2 cm above the femoral lateral epicondyle with 50.4° bending.[14] The reference electrode was placed at the anterior tibial tuberosity of the lower limb to be assessed. Once all electrodes were in place, the subjects were asked to repeat three maximum voluntary isometric contraction (MVIC) with the knee flexed at 90° in OKC and CKC, being verbally encouraged during the tests. Between contractions, the subjects were allowed to rest for 30 seconds.

Statistical Analysis

For the statistical analysis, the onset percentage of the electromyographic activity determined by the proportion of the number of times in which VM, VLL and VLO muscles shot first in seconds on each group. The onset percentage between patellar stabilizers was compared by means of Chi-squared test, with $p<0.05$.

For comparing the onset of electric activity of the VMO, VLL and VLO muscles between OKC and CKC exercises and between groups, the independent Student's t-test was used, with $p\leq0.05$.

RESULTS

During MVIC in OKC, the results evidenced that VMO and VLO muscles have a higher onset percentage than the VLL muscle, for both groups. During MVIC in CKC, the onset percentage is higher on VMO and VLO muscles than on VLL muscle for PFPS group. No significant differences were found for onset percentage between patellar stabilizers during MVIC in CKC for the groups without PFPS signs. (Table 1)

Regarding comparisons between both groups (healthy and PFPS), no significant differences were found during activities in both OKC and CKC. (Table 2)

Table 1 – *Onset percentage (%) of VMO, VLO and VLL muscles on exercises in open kinetic chain (OKC) and closed kinetic chain (CKC) during maximum volunteer isometric contraction (MVIC). p≤ 0.05*

	OKC		CKC	
	Healthy	PFPS	Healthy	PFPS
VMO	40*	54*	50	69*
VLO	60**	46**	40	31**
VLL	0	0	10	0

* Significant difference between VMO and VLL muscles ** Significant difference between VLO and VLL muscles NS between VMO and VLO muscles

Table 2 – *Onset of electric activity of Vastus Medialis Obliquus (VMO), Vastus Lateralis Obliquus (VLO) and Vastus Lateralis Longus (VLL), as milliseconds, on exercises in OKC and CKC for individuals with and without PFPS*

OPEN KINETIC CHAIN			
	VMO	VLO	VLL
Healthy	83.3 ± 214.49	12.8 ± 14.32	128.6 ± 217.89
PFPS	57.1 ± 102.43	44.9 ± 89.63	90.4 ± 68.61
p	0.64	0.27	0.55
CLOSED KINETIC CHAIN			
	VMO	VLO	VLL
Healthy	45.9 ± 82.85	49.3 ± 81.27	116.7 ± 183.67
PFPS	55.8 ± 103.07	49.5 ± 92.11	95.4 ± 71.53
p	0.80	0.99	0.70

NS comparison between groups

DISCUSSION

According to the results, the onset percentage for healthy and PFPS groups during exercises in OKC was higher on VMO and VLO muscles compared to VLL. Voight and Wieder[15] corroborate these findings. Those authors suggest that the neurophysiologic motor control on the extensor apparatus contributes for preventing anterior knee pain; on the other hand, they did not assess VLO, which is functionally important for controlling VMO action, contributing to patellar stabilization and to the maintenance of femoropatellar balance.[7,10]

This higher onset percentage of VMO is associated, according to Grabiner et al.[16], to its mechanical advantage over VL due to the oblique orientation of its muscular fibers as a way to collaborate on maintaining patellar positioning at femoral trochlea.

According to Cowan et al.[1] and Cowan et al.[5], patellofemoral pain is associated to the unbalance between VMO and VL muscles, and exercises providing an improvement of patellar stabilizers balance should be included in physiotherapeutic rehabilitation programs. However, as discussed by Bevilaqua-Grossi et al.[10], VLL and VLO muscles show different actions, with VLO being responsible for balancing VMO action forces, thus, exercises leading to balance between VMO and VLO should be performed.

The results of the present study evidenced no significant difference between VMO and VLO muscles for both groups and exercises. Thus, we can find synchronicity between VMO and VLO muscles in both groups during activities in OKC and CKC, confirming the results reported by Bevilaqua-Grossi et al.[10] who, by conducting an analysis of the electromyographic activity, suggested that these muscles act synchronically. No studies evaluating the onset percentage of VLO muscle were found.

According to our findings, no significant difference was noticed between healthy and PFPS groups for the activities studied; however, we can see that exercises in OKC and CKC for the groups show synchronicity between major patellar stabilizers - VMO and VLO. Another aspect studied here is that the hypothesis of VLL's onset coming first to VMO muscles on individuals with PFPS has not been confirmed; therefore, we believe that other factors are involved in the onset of PFPS.

These data are inconsistent to those reported by Stensdotter et al.[17], who found that VMO's onset comes first for control group than for PFPS group. However, while this statistical difference was not noticed, a lower VMO muscle onset can be found PFPS group compared to control group during exercises in OKC and a better synchronicity in CKC. According to Neptune et al.[18], a delayed onset of electric activity of the VMO of at least 5 milliseconds compared to VL would increase patellar peak and response strength over trochlea, which could lead to anterior knee pain.

Our data suggest that MVIC in both OKC and CKC performed at 90 degrees of flexion do not show any difference of electromyographic response, suggesting that these exercises can be used in the rehabilitation of patellar stabilizers, and may be indicated in physiotherapeutic treatments in individuals with PFPS.

CONCLUSION

According to the results of the present study, we can state that the onset percentage for VLL muscle isn't higher when compared to VMO muscle in individuals with PFPS, and that the onset percentage of VMO and VLO muscles do not differ from each other, suggesting a synchronic action on patellar stabilization during exercises in OKC and CKC for both groups, and that there is no difference in terms of time response between individuals with and without PFPS. Therefore, exercises in both OKC and CKC may be performed during physiotherapeutic interventions.

REFERENCES

1. Cowan SM, Bennell KL, Hodges PW, Crossley KA, McConnell J. Delayed onset of electromyographic activity of vastus medialis obliquus relative to vastus lateralis in subjects with patllofemoral pain syndrome. Arch Phys Med Rehabil. 2001;82:183-9.
2. Pulzatto F, Gramani-Say K, Siqueira ACB, Santos GM, Bevilaqua-Grossi D, Oliveira AS et al. A influência da altura do step no exercício de subida posterior. Estudo eletromiográfico em indivíduos sadios e portadores da síndrome da dor femoropatelar. Acta Ortop Bras. 2005;13:168-70.
3. Cowan SM, Bennell KL, Hodges PW. The test-retest reliability of the onset of concentric and eccentric vastus medialis obliquus and vastus lateralis electromyographic activity in stair stepping task. Phys Ther Sport. 2000;1:129-36.
4. Witvrouw E, Sneyers C, Lysens R, Victor J, Bellemans J. Reflex response times of vastus medialis oblique and vastus lateralis in normal subjects and in subjects with patellofemoral pain syndrome. J Orthop Sports Phys Ther. 1996;24:160-5.
5. Cowan SM, Hodges PW, Bennell KL, Crossley KM. Altered vastii recruitment when people with patellofemoral pain syndrome complete a postural task. Arch Phys Med Rehabil. 2002;83:989-95.
6. Bevilaqua-Grossi D, Felicio LR, Leocádio LP. Análise do tempo de resposta reflexa dos músculos estabilizadores patelares em indivíduos com síndrome da dor patelofemural. Rev Bras Fisioter. 2008;12:26-30.
7. Morrish GM, Woledge RC. A comparasion of the activation of muscles moving the patella in normal subjects and in patients with chronic patellofemoral problems. Scand J Rehab Med. 1997;29:43-8.
8. Powers CM, Landel R, Perry J. Timing and intensity of vastus muscle activity during functional activities in subjects with and without patellofemoral pain. Phys Ther. 1996;76:946-55.
9. Sheery P, Burdett RG, Irrgang JJ, VanSwearingen J. An electromyographic study of vastus medialis oblique and vastus lateralis activity while ascending and descending steps. J Orthop Sports Phys Ther. 1998;27:423-9.
10. Bevilaqua-Grossi D, Monteiro-Pedro V, Bérzin F. Análise funcional dos estabilizadores patelares. Acta Ortop Bras. 2004;12:99-104.
11. Coqueiro KRR, Bevilaqua-Grossi D, Bérzin F, Soares AB, Candolo C, Monteiro-Pedro V. Analysis on the activation of the VMO and VL muscle during semisquat exercises with and without hip adduction in individuals with patellofemoral pain syndrome. J Electromyogr Kinesiol. 2005;15:596-603.
12. Lieb FJ, Perry J. Quadriceps function. An anatomical and mechanical study using amputed limbs. J Bone Joint Surg Am. 1968;50:1535-48.
13. Hanten WP, Schulthies SS. Exercise effect on electromyographic activity of the vastus medialis oblique and vastus lateralis muscles. Phys Ther. 1990;70:561-5.
14. Bevilaqua-Grossi D, Monteiro-Pedro V, Sousa GC, Bérzin F. Contribution to the anatomical estudy of the obliqúe portion of the Vastus lateralis muscle. Braz J Morphol Sci. 2004;21:47-52.
15. Voight ML, Wieder DL. Comparative reflex response times of vastus medialis obliquus and vastus lateralis in normal subjects and subjects with extensor mechanism dysfunction. An electromyographic study. Am J Sports Med. 1991;19:131-7.
16. Grabiner MD, Koh TJ, Draganich LF. Neuromechanics of the patellofemoral joint. Med Sci Sports Exerc. 1994;26:10-21.
17. Stensdotter AK, Grip H, Hodges PW, Häger-Ross C. Quadriceps activity and movement reactions in response to unpredictable sagittal support-surface translations in women with patellofemoral pain. J Electromyogr Kinesiol. 2008;18:298-307.
18. Neptune RR, Herzog W. Adaptation of muscle coordination to altered task mechanics during steady-state cycling. J Biomech. 2000;33:165-72.