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Analysis of the reflex response time of the patellar stabilizer muscles in individuals with patellofemoral pain syndrome

Análise do tempo de resposta reflexa dos músculos estabilizadores patelares em indivíduos com síndrome da dor patelofemural

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Abstract

Objective: To investigate the reflex response time (RRT) of the vastus medialis obliquus (VMO), vastus lateralis obliquus (VLO) and vastus lateralis longus (VLL) muscles in clinically healthy individuals and subjects with patellofemoral pain syndrome (PPS). **Methods:** Twelve clinically health women and twelve women with PPS were evaluated. Electromyography (EMG) records were obtained using active electrodes connected to an electromyograph that was activated by an external sensor attached to the medial portion of the patella ligament, by means of percussion. The RRT was analyzed by measuring the time, in seconds, between zero and peak electrical response of the VMO, VLO and VLL muscles, for both groups. The statistical analysis consisted of analysis of variance (ANOVA, $p< 0.05$) and the Tukey ***post-hoc*** test ($p< 0.05$) to compare the response between muscles, and Student's ***t*** test ($p< 0.05$) to compare the response between groups. **Results:** Both groups presented lower RRT for the VMO muscle than for the VLO and VLL muscles. However, no significant difference was seen between the VLO and VLL muscles. There was no significant difference in RRT between the groups. **Conclusions:** According to these results, it can be suggested that the RRTs in the different portions of the quadriceps muscle do not distinguish between subjects with PPS and clinically healthy individuals. The RRT for the VMO muscle was lower than the RRT for the VLO and VLL muscles, for both groups.

Key words: patellofemoral pain syndrome; response time; electromyography.

Resumo

Objetivo: Avaliar o tempo de resposta reflexa (TRR) dos músculos vasto medial oblíquo (VMO), vasto lateral oblíquo (VLO) e vasto lateral longo (VLL) em indivíduos clinicamente saudáveis e portadores de síndrome da dor patelofemural (SDPF). **Métodos:** Foram avaliadas 12 mulheres clinicamente saudáveis e 12 mulheres com SDPF. Os registros eletromiográficos foram obtidos por eletrodos ativos simples conectados a um eletromiógrafo, acionados por um sensor externo fixado sobre a porção média do ligamento da patela a partir de sua percussão. A análise do TRR foi realizada por meio da medida do tempo zero ao pico da resposta elétrica dos músculos VMO, VLO e VLL, em segundos, para ambos os grupos. A análise estatística empregada foi o teste de análise de variância (ANOVA, $p< 0,05$) e teste ***Tukey post hoc*** ($p< 0,05$) para comparação entre os músculos, e o teste ***t*** de ***Student*** ($p< 0,05$) para a comparação entre os grupos. **Resultados:** Ambos os grupos apresentaram um TRR menor para o músculo VMO, quando comparado aos músculos VLO e VLL; entretanto, não se observou diferença significativa entre os músculos VLO e VLL. Na comparação do TRR entre os grupos, não se observou diferença significativa. **Conclusões:** De acordo com esses resultados, pode-se sugerir que o TRR das porções do músculo quadríceps não diferencia indivíduos com SDFP dos indivíduos clinicamente saudáveis, sendo que o VMO apresenta um TRR menor em relação ao VLO e VLL para ambos os grupos.

Palavras-chave: síndrome da dor patelofemural; tempo de resposta; eletromiografia.

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Introduction

The patellofemoral pain syndrome (PPS) frequently affects female athletes, the female sedentary population, and young women are most affected[1-3]. This syndrome is present in approximately 25% of orthopedic diagnoses[4] and is defined as a pain at the front of the knee and/or rear of the patella[4-6]. It is aggravated during physical activities and when going up and down stairs, walking on slopes, squatting and remaining seated for long periods of time[7].

Although the etiological factors of PPS are not well-defined, some authors have pointed towards biomechanical abnormalities in the lower limbs as the main cause[1-3]. Among the biomechanical factors most frequently correlated with the development of PPS, dynamic disequilibrium stands out[1,2].

Disequilibrium between the medial dynamic stabilizers, vastus medialis obliquus (VMO), vastus lateralis obliquus (VLO) and vastus lateralis longus (VLL) muscles can also cause patellar misalignment, leading to PPS[1,8-10]. Bevilaqua-Grossi et al.[11] reported that the VLO has an important patellar stabilizing function, opposing the VMO. Therefore, studies that also evaluate the electrical activity or reflex response time of this muscle are necessary.

The equilibrium in neuromuscular activity between VMO, VLO and VLL may be considered to be an important factor during patellar kinematics[12]. Some studies have analyzed the beginning of voluntary electrical activity of the median and lateral stabilizing muscles of the patella in clinically healthy and individuals with PPS, and have demonstrated synchronism of these muscles under different functional conditions[13]. However, other authors have not observed this synchronism when comparing the beginning of the electrical activity of the (VMO) and vastus lateralis (VL) muscles between normal individuals and those with PPS[2,7]. The beginning of this activity has been used to evaluate the neuromuscular response time of the patellar stabilizing muscles and also how the effect of carrying out treatment protocols on individuals with PPS influences this parameter[12,14,15].

Voight and Wieder[14] evaluated the beginning of the VMO and VL muscle reflex activity in men and women (both clinically healthy individuals and individuals with PPS) and found that, for the clinically healthy individuals, the VMO muscle was activated before the VL muscle. On the other hand, for the individuals with PPS, the inverse occurred. Likewise, Witvrow et al.[12] suggested that PPS is associated with neuromuscular control disturbances of the patellar stabilizers. However, these authors did not evaluate the VLO muscle and included both genders in their sample.

The reflex response time was also evaluated by Moore et al.[16] before and after inducing fatigue protocols. They reported that men and women demonstrated different reflex response times for the quadriceps muscle. Therefore, when evaluating the reflex response time, the volunteers' gender must be taken into consideration.

Karst and Willett[17] and Powers et al.[13] reported that these time differences in the activation of the VMO and VL muscles are not of great significance and therefore do not influence the patellar kinematics leading to PPS. However, these authors did not evaluate the obliquus portion of the VL muscle. No studies evaluating the neuromuscular control over the VMO, VLO and VLL muscles by means of the reflex response time among clinically healthy and women with PPS were found in the literature consulted. Therefore, the objective of this study was to evaluate the reflex response time of the VMO, VLO and VLL muscles among clinically healthy and individuals with PPS.

Materials and methods

Subjects

Twenty-four sedentary female volunteers who were not doing any physical activities were selected. They underwent functional evaluations and were divided into two groups: a control group of clinically healthy women (n= 12), with a mean age 22.7 years (±2.25) and mean height of 165 cm; and a group with PPS (n= 12), with a mean age 22.0 (±2.04) years and mean height of 158 cm. The inclusion criteria for the PPS group were: previous reports of pain at the front of the knee during functional activities[2]; no pain reported for at least the last two months; and presence of three or more clinical signs and symptoms observed during the functional evaluation[18]. The exclusion criteria for the PPS group were: reports of a history of surgery, trauma and osteomyoarticular system injuries to the hip, ankle and foot; use of medications or previous physical therapy treatment less than six months before the time of the present study; and neurological diseases. The study was conducted in accordance with National Health Council Resolution 196/96 and was approved by the Research Ethics Committee of the Centro Universitário do Triângulo (UNITRI) on April 11, 2002. All volunteers signed a free and informed consent statement.

Equipment

For collecting electromyographic records from the VMO, VLO and VLL muscles, simple differential active Ag/AgCl electrodes were used (10 x 1 mm) made by Lynx Electronic Technology Ltda. (São Paulo, SP), with a gain of 20 times. These was connected to the Myosystem® (São Paulo, SP), electromyograph with a 12-bit A/D converter and 100 time amplification, thus giving a total gain of 2000 times. The common-mode rejection ratio (CMRR) was 93 dB and the acquisition frequency was 2 kHz. A reference electrode of 3 cm^2 was connected to the equipment and attached to the lateral malleolus of the lower limb that was analyzed. A flexible sensor was also attached to the median portion of the patellar ligament, which allowed immediate detection after percussion using the reflex hammer.

Procedures

Before placing the electrodes, the area was shaved and antiseptic treatment with 70% alcohol was applied. The electrodes were positioned on the VMO, VLO and VLL muscles with the patient in dorsal decubitus.

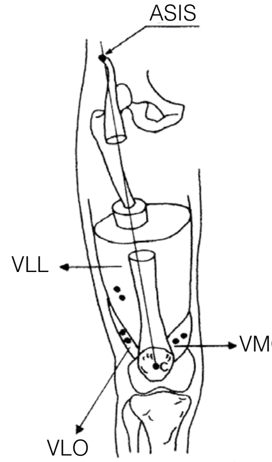

Figure 1. Positioning of the electrodes on the vastus medialis obliquus (VMO), vastus lateralis longus (VLL) and vastus lateralis obliquus (VLO) muscles, in accordance with the inclination of each portion in relation to the anterosuperior iliac spine (ASIS) and the center of the patella (C)[11].

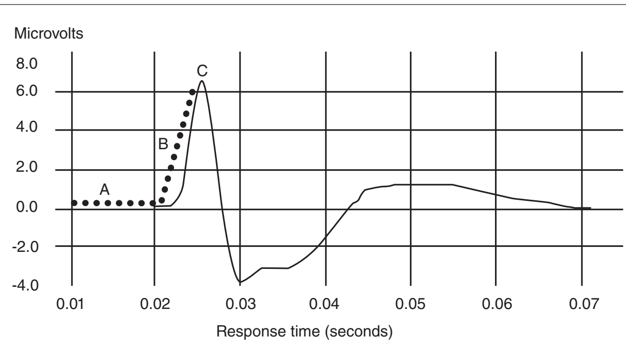

Figure 2. Electromyographic activity during percussion of the patellar tendon. Onset of response and latency period (A), rise time (B) and reflex response peak (C).

On the vastus medialis obliquus (VMO) muscle, the electrode was positioned four cm above the superomedial edge of the patella, with an inclination of 55° in relation to the center of the patella and the anterosuperior iliac spine. In relation to the vastus lateralis longus (VLL), the electrode was positioned 15 cm from the superolateral edge of the patella, with an inclination of 13.6º. To position the electrode on the vastus lateralis obliquus (VLO), the lateral epicondyle of the femur needed to be located and the beginning and middle of the muscle belly needed to be followed, with an inclination of 50.4º[11]. The reference electrode was positioned over the anterior tibial tuberosity of the limb to be tested (Figure 1).

The volunteers were put in a seated position with the hips at 90° of flexion and the knees supported on the bed with the feet hanging, in accordance with the recommendations from the SENIAM project[19]. In the seated position, a function test on the quadriceps muscle was performed to verify the positioning of the electrodes. Three percussions were performed on the patellar ligament, at intervals of 30 seconds between percussive actions. As the reflex hammer touched the sensor, the discharge system instantly picked up the electrical activity of the VMO, VLL and VLO muscles through the electrodes.

The reflex response time analysis was done by measuring from time zero to the peak electrical response of the VMO, VLO and VLL muscles, in seconds, through the *Myosystem-Br1* software version 2.9 b (Uberlândia, Minas Gerais) (Figure 2). Because the analysis was performed in relation to the reflex response time, no bandpass filter was applied, because this, especially the high pass filter, could alter the initial reflex response time.

Statistical analyses

For the statistical analysis, the means of the three percussive actions performed on each volunteer were calculated. To compare the reflex response time between the VMO, VLL and VLO muscles in the PPS and control groups, ANOVA and the Tukey post-hoc test were used. To compare the PPS and control groups, Student's *t* test for unpaired measurements was used. Both of these tests used a significance level of less than 5%.

Results

The results revealed that for both the control group and the PPS group there were lower reflex response times for the VMO muscle than for the VLL and VLO muscles. However, no significant differences were observed between the VLO and VLL muscles. Comparing the control and PPS groups, there were no significant differences in the VMO, VLL and VLO muscles (Table 1).

Table 1. Means and standard deviations (in seconds) for the reflex response times of the vastus medialis obliquus (VMO), vastus lateralis obliquus (VLO) and vastus lateralis longus (VLL) muscles, for the control and PPS groups.

Muscle	Control group	PPS group	p
VMO	0.027 (± 0.002)*	0.026 (± 0.003)*	NS
VLL	0.031 (± 0.005)	0.030 (± 0.006)	NS
VLO	0.032 (± 0.002)	0.031 (± 0.003)	NS
p	0.003	0.004	

* Significant difference between VMO muscle and the VLL and VLO muscles: statistical analysis using ANOVA and post-hoc Tukey tests.

Discussion

The data revealed that, for both the control and the PPS groups, the medial stabilizer (VMO) reached its reflex peak activation earlier than did the lateral stabilizers (VLO and VLL). According to Cowan et al.[7], the VMO presents a biomechanical advantage over the VL due to the oblique orientation of its muscle fibers. However, the neuromuscular response of the VMO may relate to the attempt by this stabilizer to resist the lateral patellar forces, given that the patella tends to lateralize.

Despite the methodological differences, these data concur with what was found by Crossley et al.[20]. Those authors found that the VMO muscle had a shorter activation time than did the VL muscle, among individuals with PPS, although they were investigating the activation time when going up and down a step.

It could be seen when comparing between groups that the reflex response time patterns of the patella stabilizer muscles were similar. However, it must be emphasized that the multifactorial nature of PPS, the lack of validated diagnostic research instruments for improving the nature of the sample, and the number of volunteers may have affected the characterization of the individuals with PPS.

This study is in agreement with the data presented by Voight and Wieder[14] and Witvrow et al.[12], who reported differences in reflex response time between the VMO and VL muscles that was less than six milliseconds for the control group. However, these authors demonstrated that, among the individuals with PPS, the VL muscle showed a lower reflex response time than did the VMO. Thus, these authors suggested that this inversion could have been caused by neuromuscular disequilibrium in the VMO and VL muscles, thereby altering the patellar kinematics. However, these authors did not evaluate the obliquus portion of the VL muscle. The data from the present study do not confirm this affirmation, because the present study did not demonstrate lower reflex response times for the VLO and VLL muscles, in comparison with the VMO muscle for the PPS and control groups, thus suggesting that reflex response time was not a parameter that was able to distinguish between individuals with and without PPS.

Although Karst and Willett[17] did not find any differences in the activation times for the VMO and VLL muscles, either under reflex conditions or during voluntary contraction, these authors also suggested that alterations in the reflex response times of these muscles are not capable of predisposition towards PPS. The results from the present study are in agreement with this, thereby reinforcing the idea that disequilibrium between the medial and lateral portions was not an etiological factor for this syndrome.

However, it must be taken into consideration that the sample evaluated in the present study was asymptomatic, since the pain in individuals with PPS is usually insidious and intermittent at first[21]. Thus, studies evaluating neuromuscular disequilibrium of the patellar stabilizers among symptomatic individuals need to be conducted. Therefore, under these experimental conditions, alterations in the reflex response time cannot be considered to be indicative of PPS, because no differences between the groups were observed. Therefore, reflex response time must not be used in physiotherapeutic evaluations to characterize individuals with PPS.

Therefore, it can be concluded that the reflex response time cannot be used as a differential factor between people with PPS and clinically healthy individuals. For both groups, the reflex response times in the VMO muscle were lower than what was observed in the VLO and VLL muscles.

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