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Isometric Contractions in the Patellofemoral Pain Syndrome

An Electromyographic Study

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Summary. The role played by the vastus lateralis and vastus medialis obliquus in their alignment of the patella during maximal isometric quadriceps contractions was studied by electromyography in 28 patients with unilateral symptoms of the patellofemoral pain syndrome. Eleven knees were classified as subluxation of the patella and 17 as idiopathic chondromalacia patellae. The muscular activity pattern was the same in the two groups but decreased as compared with the contralateral nonsymptomatic knees. However, none of the groups revealed differences in the activity of vastus lateralis and vastus medialis obliquus suggesting muscular imbalance.

The main muscular stabilizers of the patella are the vastus lateralis (VL) and the vastus medialis (VM). the distal part of VM in particular, referred to as vastus medialis obliquus (VMO), is generally accepted as having the function of preventing lateral luxation of the patella [3, 6, 11, 16, 21].

Clinical assessment of minor patellar instability is difficult [8, 16, 19], and radiological procedures and arthroscopy are often of limited value [8, 19]. Electromyography during dynamic conditions has recently been added to the diagnostic methods [23]. Though patellar instability most frequently occurs during knee extension on the weight-bearing limb, there are situations, particularly in sports, where a sudden maximal isometric contraction of VL and VMO is present and thus influences the alignment of the patella. To elucidate the role played by VL and VMO in the alignment of the patella during maximal isometric contractions, and electromyographic study was carried out on patients suffering from the "patellar pain syndrome."

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Patients and Methods

Twenty-eight patients, 7 men and 21 women, with unilateral anterior knee pain were included. Their ages ranged from 18 to 35 years. Patients with obvious signs of meniscal tears or recurrent luxation of the patella were excluded, as were patients who had undergone former surgery of the knee, those with radiological osteoarthritis, and those with fracture sequelae.

All the symptomatic knees were examined by arthroscopy, which revealed a normal tibiofemoral joint in all patients. On the basis of history and clinical examination the patients were classified into three groups:

Group A: Twenty-eight knees on the unaffected side served as controls

Group B: This group included 11 knees, in two men and nine women with a history and findings of patellar instability [10, 16, 17, 24].

Group C: Seventeen knees, in five men and 12 women, were classified as idiopathic chondromalacia patellae [4, 5, 9, 13, 18, 25, 30, 31].

The circumference of the quadriceps muscle was measured 8 cm above the patella, and none of the patients had atrophy of the quadriceps exceeding 1 cm. All knees had a normal range of motion and all were without effusion.

Electromyographic recordings were obtained from both knees prior to arthroscopy and were recorded in knee flexions of 90°, 60°, 45°, 30°, 15°, and 0°. Silver-silver chloride surface electrodes were placed over VL and the most prominent part of VMO. The patients were positioned on a modified quadriceps table with their leg supported by an adjustable platform connected to the table. The platform was locked in the above-mentioned positions. Velcro straps were placed firmly across the ankle. The back was kept against the back of the table to attempt a hip angle of 90°. The foot was kept in a neutral position in order to keep the Q-angle unchanged.

The patients were instructed to extend the knee, attempting to break the resistance offered by the distal velcro straps. These maximal isometric contractions were held for 5 s and

followed by intervals of 15 s between each degree of flexion. These exercises were repeated twice, and the mean values were used for the calculations.

Simultaneous electromyography (EMG) registration was performed on a DISA 1500 electromyograph equipped with a DISA high-frequency writer (15F11), papers speed 5 cm/s and gain 0.5 mV/cm. For on-line quantitation a KDC quantitator was used [20]. The quantitator is an analog device that counts the number of times the slope of the electrical waveform of the EMG equals zero within a preselected period of time (2 s). The resulting count is an expression of the total electrical activity in the superficial part of the muscle underlying the surface electrode.

For statistical analysis a paired t-test or the Mann-Whitney test was used.

Results

The results of the unaffected side (group A) are shown in Fig. 1. The activity of VL and VMO increased through the entire range, from 90° of flexion to full extension. The activity of VMO was slightly lower than that of VL, especially during the last 30° ($P > 0.05$, t-test).

In patients with subluxation of the patella (group B) the activity of both VL and VMO was generally decreased as compared with the contralateral side (Fig. 2), but only significantly decreased in VMO at 45° of extension ($P < 0.05$, Mann-Whitney test). However, the relationship between VL and VMO revealed no significant differences at any of the investigated degrees of extension ($P > 0.05$, t-test).

The activity of VL and VMO among patients with idiopathic chondromalacia showed the same pattern as in groups A and B (Fig. 3), with increasing muscular activity toward full extension. As in group B, a marked decline of the activity of both VL and VMO was registered at 45°, particularly in VL ($P < 0.05$, Mann-Whitney test) when compared with the control side. No significant difference between VL and VMO was found at any degree ($P > 0.05$, t-test). There were no significant differences between group B and group C at any degree of extension ($P > 0.05$, Mann-Whitney test). The difference in the activity levels of men and women was nonsignificant in all three groups ($P > 0.05$, Mann-Whitney test).

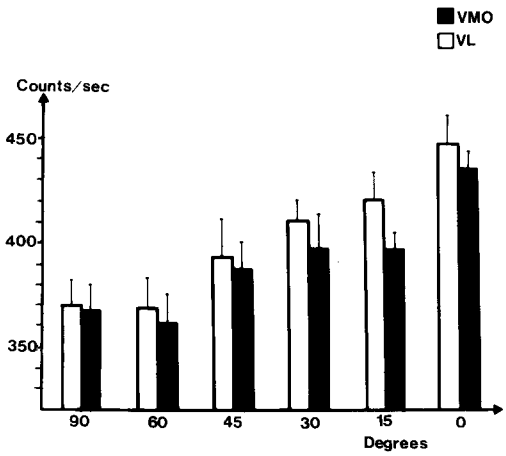

Fig. 1. Activity pattern of the vastus lateralis (VL) and the vastus medialis obliquus (VMO) of the nonsymptomatic knees. *Vertical bars* indicate SEM

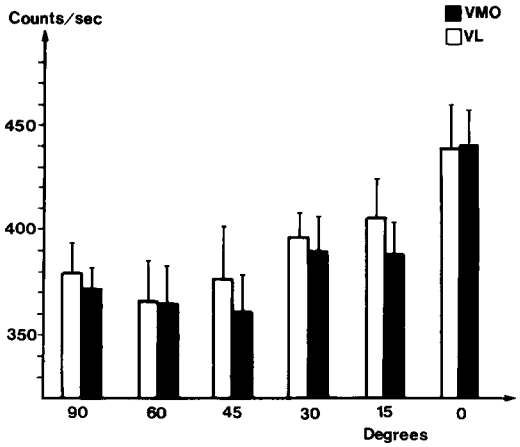

Fig. 2. Activity of vastus lateralis (VL) compared with that of vastus medialis obliquus (VMO) in patients with patellar subluxation. *Vertical bars* indicate SEM

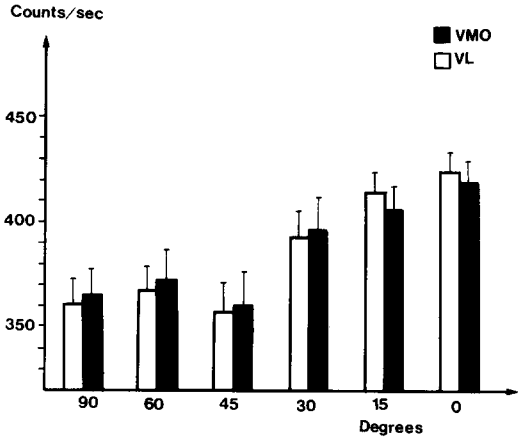

Fig. 3. Activity of vastus lateralis (VL) and vastus medials obliquus (VMO) in patients with idiopathic chondromalacia patellae. *Vertical bars* inciate SEM

Discussion

The theory of selective action of the vastus medialis during extension of the knee is still controversial [2, 7, 12, 14, 15, 21, 22, 27]. However, most authors agree in regarding the vastus medialis as two anatomically and functionally separated muscles [6, 21, 26,

28]: the vastus medialis longus and the vastus medialis obliquus. The function of VMO is to prevent the VL from laterally dislocating the patella, especially during the last 45° of extension, where the bony support of the patella offered by the femoral sulcus is diminished.

Most studies concerning isometric contractions of the quadriceps muscle have focused on the activity of VL and VM, but only a few studies have specifically addressed the activity of VMO compared with that of VL [22, 26]. Reynolds et al. [26] examined the integrated EMG activity of VMO and VL as a percentage of maximum isometric contractions during the last 30° of knee extension during weight bearing. These authors reported a nonsignificant difference between the two muscles in normal women. This correlates with our data from the contralateral unaffected knees and is in agreement with Stratford [29], confirming the observations by Lieb and Perry [21, 22], who stressed the importance of VMO and VL in opposing each other and preventing lateral subluxation of the patella.

Patellar subluxation commonly occurs during the last 30° of extension. In a dynamic EMG investigation, Mariani and Caruso [23] reported a decreased activity of VM, particularly during the last 30° of extension, in eight patients suffering from subluxation of the patella. However, the changes were similar in the opposite knee, where no abnormalities were observed. In our isometric study, the activities of both VL and VMO were slightly lowered compared with the nonsymptomatic side, probably due to pain, but, in contrast to Mariani and Caruso [23], the activity in patients with subluxation of the patella revealed no significant differences that suggested muscular imbalance between VL and VMO. This indicates that VMO, in most situations during maximal isometric contractions, is able to oppose the pull performed by VL and thus to align the patella properly, and that subluxation must consequently be regarded as a dynamic rather than a static event in patients with predisposing factors such as increased Q-angle, shallow femoral sulcus, and high-riding patella. The exact mechanism of decreased activity of VMO in patients with patellar subluxation as shown by Mariani and Caruso [23] remains obscure. A reflex inhibition of VMO similar to that proposed by Stratford [29] in knees with effusion or pain inhibition due to large compressive forces of the patellofemoral joint [10] might be a possibility, but further investigations in that field are required.

The activity pattern of the idiopathic group was comparable to that of group B, with a general, probably pain-induced decrease of activity, especially at 45° as compared with the nonsymptomatic side. This similarity of the activity patterns in the two groups might support the statement by Insall et al. [18] that the difference between subluxation of the patella and idiopathic anterior knee pain is one of degree rather than kind.

In all three groups the greatest activity was registered when the leg was in full extension. Several studies have shown that the activity of the quadriceps muscle increases as the leg is extended [1, 23, 28], because the quadriceps in full extension works at its maximal physiological and mechanical disadvantage. However, others have observed that the activity is unchanged [29] or even greatest at 90°, but with great variations among individuals [22]. These conflicting findings may be explained by variations in technique, in patients, and in the methods of assessing the electrical activity of VL and VMO.

In conclusion, no significant signs of muscular imbalance between VL and VMO were found when the muscles were contracted with maximal isometric force. Thus, the EMG examination in the present design cannot be used for differential diagnosis between patellar subluxation and idiopathic chondromalacia patellae, but the method does provide a possibility of assessing the efficiency of isometric quadriceps exercises recommended for patients with patellofemoral disorders.

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