ORIGINAL ARTICLE

Analysis of neuromuscular activation of the vastus medialis obliquus and vastus lateralis with the use of functional taping

Análise da ativação neuromuscular do vasto medial oblíquo e vasto lateral com o uso da bandagem funcional

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ABSTRACT

Muscular and anatomical changes are mostly responsible for patella femoral syndrome (PFPS). Knowing that the quadriceps muscles are very important in stabilizing the patella, studies have questioned the influence of the Vastus Medialis Obliquus (VMO) in the patellar stabilization avoiding the PFPS. Many researchers have investigated the use of taping as a means of muscle activation. **Objective:** The present study aimed to analyze the use of functional taping to activate the VMO during the squat exercise. **Method:** The activity of the VMO and Vastus Lateralis (VL) was assessed by electromyography during squats and squats with adduction using functional taping. The sample, composed of 39 individuals, was divided into four groups: males and females, both separated into sedentary and athletic types. **Results:** Although greater activation of the VMO has been found in comparison with the VL, with the applied methodology and variables, we could not demonstrate a statistical difference between groups in squats with and without the use of functional taping. However, it is important to emphasize that the lack of difference in the activation of VMO during squats with adduction and taping suggests a positive effect of the taping in muscle activation. This result is very important in the treatment of acute injuries where active movement is limited. **Conclusion:** Future studies should be done with other electromyography parameters and reflex activation in order to investigate the actual role of functional taping in muscle activation.

Keywords: Athletes, Patellofemoral Pain Syndrome, Quadriceps Muscle, Electromyography, Rehabilitation

RESUMO

Alterações musculares e anatômicas são em sua maioria responsáveis pela síndrome patelofemoral (SDPF). Sabendo que a musculatura do quadríceps é de grande importância na estabilização da patela, questiona-se como o músculo Vasto Medial Oblíquo (VMO) influencia na estabilização patelar evitando a SDPF. Muitos pesquisadores tem investigado o uso da bandagem funcional como meio de ativação muscular. **Objetivo:** O presente estudo teve como objetivo analisar o uso da bandagem como meio de ativação do VMO no exercício de agachamento. **Método:** A atividade dos músculos VMO e Vasto lateral (VL) foi avaliada através de eletromiografia durante o agachamento com adução e o agachamento com o uso de bandagem. A amostra composta por 39 indivíduos foi dividida em quatro grupos: indivíduos do sexo masculino sedentários e atletas, e indivíduos do sexo feminino sedentárias e atletas. **Resultados:** Embora tenha sido encontrada uma maior ativação do VMO em relação ao VL, com a presente metodologia e variáveis estudadas, não foi possível demonstrar diferença estatística entre os grupos nos agachamentos com e sem o uso da bandagem. No entanto, é importante ressaltar que a ausência de diferença na ativação do VMO durante o agachamento com adução e com bandagem sugerem um efeito positivo e facilitador da bandagem na ativação muscular. Este resultado é muito importante no tratamento de lesões agudas onde o movimento ativo está limitado. **Conclusão:** Sugere-se a execução de novos estudos aonde outros parâmetros da eletromiografia e estimulação reflexa sejam abordados, a fim de investigar o real papel da bandagem funcional na ativação muscular.

Palavras-chave: Atletas, Síndrome da Dor Patelofemoral, Músculo Quadríceps, Eletromiografia, Reabilitação

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INTRODUCTION

Among the most common dysfunctions in the musculoskeletal system of the knee is the Patellofemoral Pain Syndrome (PFPS). PFPS is described as an anterior and/or retro-patellar pain of the knee stemming from structural and biomechanical alterations in the joint itself.[1-3] Generally it afflicts athletes and the sedentary population of the female gender, representing approximately 25% of the orthopedic diagnoses.

The etiological factors of PFPS are not well defined, however some authors point to biomechanical alterations of the lower limbs as the principal cause, in addition to static and dynamic imbalances.[1-3] Among the dynamic stabilizers, an imbalance in the response time between the Vastus Lateralis (VL) and the Vastus Medialis Obliquus (VMO), and alterations in the activation reflex time of the VMO may be the triggering factors for PFPS.[4-6]

Anatomically, the Adductor Longus (AL) and the Adductor Magnus (AM) muscles maintain relationships with the Vastus Medialis (VM) via some insertions in the medial margin of the linea aspera of the femur. Based on these anatomical relationships, researchers believe that adduction of the hip can increase the electrical activity of the VM. This increase in activity is of great importance for its oblique portion (VMO) having a large medial patellar stabilizing activity.[7,8]

The protocols for rehabilitation and prevention of PFPS prefer selective strengthening of the VMO to re-establish normal function of the femoropatellar articulation.[3,9,10] Among the rehabilitation protocol authors, McConnell[11] was one of the first to describe functional taping as an integral part of the treatment for PFPS, for it can alter the position of the patella, increase the activation of the VMO, and consequently diminish the level of pain.

OBJECTIVE

The present study sought to evaluate the difference in muscle activation of the VMO and VL among athletic and sedentary individuals of both genders and their possible anatomical alterations doing squat exercises with adduction and with a functional taping applied.

METHOD

The research was done in the Human Movement Analysis Laboratory at the School of Physiotherapy Clinics of UNICENTRO. In agreeing to take part in this study, all the participants signed the Terms of Free and Informed Consent, based on the proposals of the Ministry of Health according to Resolution 196/96 by the National Health Council. The project was approved by the Committee on Ethics and Research of the State University of the Midwest - UNICENTRO (nº 550/2011).

The sample was composed of 39 individuals (20 men and 19 women, aged between 18 and 25 years) divided into four groups: the first group was made up of male athletes from the Lobo Bravo rugby team, the second by female athletes from the futsal team from Guarapava, a city in Paraná. The third team was made up of sedentary female students, and the fourth by sedentary male students.

The inclusion criteria of activity and sedentarism used in the sampling included players registered in the sports teams mentioned above, who attended all the trainings stipulated by their coaches, and students who were sedentary. Excluded were individuals from any group with acute lesions, who had undergone surgery, or who were recovering from some type of knee or thigh muscle injury within the previous 12 months, and athletes who did not participate in their teams' weekly trainings.

An evaluation sheet was filled in before collecting any personal or anthropometric data, the time practicing sports, the weekly time spent in training, their usual position on the team, and prior history of injuries over the last two years of training.

For collecting electromyographic activity, an 8-channel electromyography was used (EMG System Brasil Ltda), however only 4 channels were used; the signal went through a bandpass filter of 20-500 Hz and was amplified x1,000. All the data was processed using software specific to acquiring and analyzing the signal (WinDaqXL), converted by a 12-bit A/D board with a sampling frequency of 2 KHz for each channel; the electrical activity was measured using the Root Mean Square (RMS) values during a time window of one minute.

Disposable inactive bipolar adhesive electrodes by Kobme were used spaced 40 mm apart on the ventral VMO muscles, placed 4.0 cm above the superomedial border, and 15.0 cm above the superolateral border of the patella on the VL muscle by the second used protocol.[12,13] The reference electrode was placed on the right fist. Electromyographic readings were taken at two moments, the first of which was while the subject was doing a squat (simultaneous knee and hip flexion, both at 90º) with no taping and with adduction. The feet were hip-width apart and verbal encouragement was given to maintain adduction. At the second moment, a functional elastic bandage was applied (Therapy Taping) on the above-mentioned thigh muscles and a squat was again requested, now free of adduction, to analyze the paired data of the surface electromyography.

The bandage was applied to the lower limbs in order to activate the VMO musculature and inhibit the VL, where two strips of tape were used (Figure 1). The first one (VMO) with its base applied at the muscle origin situated on the intertrochanteric line and the medial lip of the linea aspera of the femur and inserting its anchor in the insertion located at the base of the patella by the patellar ligament on the tibial tuberosity. The second one (VL) had its base fixed on the base of the patella and by the patellar ligament that inserts into the anterior tibial tuberosity passing the bandage over the ventral muscle anchoring on the origin of the muscle that is on the proximal half of the lateral surface of the femur.

The SPSS program version 19.0 for Windows was used for statistical analysis. A multivariate ANOVA test was used to compare the effect of functional bandaging between the four groups and the VMO and VL muscles. In order to verify any difference between the groups, the ANOVA test was followed by the post hoc Tukey test. The normality and homogeneity of the sample was confirmed through the Shapiro-Wilk and Levene tests, respectively. The level of significance was established as $p < 0.05$, with a confidence interval of 95%.

RESULTS

The demographic and anthropometric data of the 39 subjects were divided into four groups: male (MA) and female athletes (FA), and the sedentary males (SM) and females (SF)-as shown in Table 1.

First a simple ANOVA test was used, which showed differences between the groups for age, weight, and height. The post hoc Tukey test showed a significant difference in the age item between the FA and the MA ($p = 0.048$) and between the FA and the SF ($p = 0.018$). In relation to weight, a significant difference was found between the MA and the FA ($p = 0.003$) and between the FA and the SF ($p = 0.008$). In the height item, a difference was found between the MA and the FA ($p = 0.003$), the MA and the SF ($p = 0.005$), and the FA and the SM ($p = 0.048$).

Figure 1. Taping for activation of the VMO and inhibition of the VL

Table 1. Average values and standard deviations of the sample characterization

	N	Age (years)	Weight (Kg)	Height (m)	BMI (kg/m^2)
MA	13	21.23 (± 2.35)	80.92 (± 17.4)	1.79 (± 0.09)	24.9 (± 3.78)
FA	10	19.10 (± 0.88)	61.10 (± 5.36)	1.67 (± 0.53)	21.9 (± 1.85)
SM	7	20.9 (± 1.57)	71.29 (± 8.66)	1.77 (± 0.65)	22.7 (± 1.81)
SF	9	21.78 (± 2.06)	62.56 (± 10.9)	1.67 (± 0.08)	22.4 (± 3.45)
F (*p* value)		3.82 (0.018)	6.29 (0.002)	7.25 (0.001)	2.19 (0.106)

The results from the multivariate ANOVA test evaluating the effect of taping on the VMO and VL muscles between the groups did not show any significant statistical difference. However, there was greater activation of the VMO when compared to the VL (F = 20.66; p = 0.000) (Figure 2). The statistical power was less than 0.80 for each test made.

DISCUSSION

The main objective of this study was to evaluate the effect of functional taping on the muscle activity (RMS) of the VMO and VL muscles during the squat exercise, comparing males and females, athletes and sedentary. All the participants were young adults (aged between 18 and 25 years). Although this study showed a statistically significant difference between the FA and MA groups, and between the FA and SF, this difference of ± 2 years had no influence on the results of the present research, for no physiological and structural alteration (e.g. loss of muscle strength) occurs between the age of 18 and 25 years, which can be observed especially in the older phase of life, when most of the muscle loss occurs.[14]

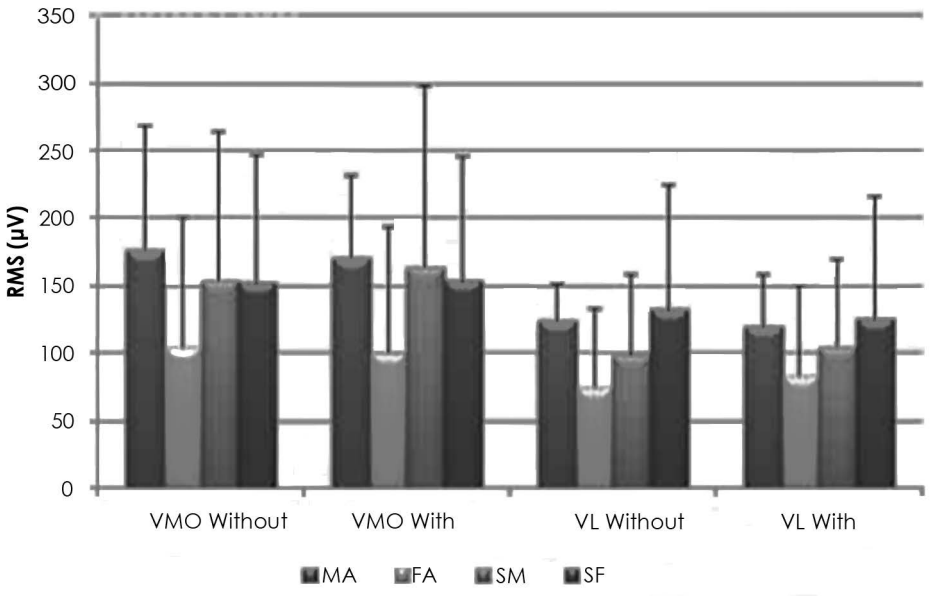
According to Teixeira,[15] the angle of the quadriceps - or Q angle - is greater in females than in males, therefore in the present study the RMS was compared between the genders. This disparity between the female and male Q angles is explained by the female pelvis being larger than the male pelvis[16] and due to the EIAS being more lateralized in females, leading to an increase in the Q angle.[17] This angle has been studied in the patellofemoral dysfunctions for its importance in generating stress in the knee joint.

This angle is formed by the non-collinear interaction resulting from two primary forces acting on the patella in the frontal plane - the force vector of the quadriceps (QF) and the force vector of the patellar tendon. Its resulting force moves laterally, and may be influenced directly by any change that occurs in the obliquity of these two vectors. Thus, a greater obliquity of the QF caused, for example, by the adduction and medial rotation of the hip would increase the resulting lateral force on the patella and the valgus of the knee.[18] At certain moments in the present study, the participants were asked to perform a squat with adduction, which could create greater obliquity of the QF. As already mentioned in the introduction, due to its anatomical insertion together with the adductors of the linea aspera of the femur, it is believed that the VMO has greater activity when producing a hip adduction; this increase in the activity may have great value in the study, knowing that the oblique portion of the muscle medializes the patella.[6]

Still emphasizing the difference between genders analyzed in the present study, many studies in the literature that evaluate different sports movements such as running, walking, and changing direction also report greater dynamic valgus among women.[19] Therefore it is suggested that the difference between genders in the angles in valgus of the knee during sports maneuvers, as well as in the postures adopted by women before landing on the ground, is the consequence of an altered muscle control of the lower limb and probably reflects differences in the contraction pattern of the periarticular muscles of the knee, as well as of the hip muscles, contributing to the disparity of injuries between genders, which may justify any difference that may have occurred in the results.[19-21] Although the present study did not evaluate postural changes, in case alterations in the RMS values were found between genders, these could be explained by the studies mentioned above.

Borin et al.[22] analyzed the electromyographic activity of leg extensor muscles in volleyball athletes and concluded that the VMO muscle was more active than the VLL (vastus lateralis longus), VLO (vastus lateralis obliquus), and RF (rectus femoris) at all the angles analyzed in athletes as well as in sedentary subjects. The EMG activity of the VMO, VLL, and RF muscles in CCA was greater in the athletes' group than in the sedentary group.

Santos et al.[23] using the EMG in his study, demonstrated that the analysis of the muscle recovery index of the athletes group tended to



Average values (± SD) of the RMS of the VMO and VL muscles. No significant effect was found between the sedentary and athletes' groups, with and without taping. (VMO: Vastus medialis obliquus; VL: Vastus lateralis; MA: Male athletes; FA: Female athletes; SM: Sedentary males; SF: Sedentary females).

Figure 2. The effect of taping on the VMO and VL muscles

show more capacity for muscle recuperation after the exercise performed in the fatigue limit, as compared to sedentary individuals. It is suggested that this behavior may be related to the greater capacity of athletes muscular system to remove the catabolic effect responsible for the alteration of the EMG signal, which are produced during the muscular work in fatigue limit. This would explain the difference between the athletes and sedentary groups in the present study, which did not occur even if the individuals performed two exercises of isometric contraction with a relatively small resting period.

The present study showed a greater activation of the VMO as compared to the activation of the VL, as much in performing the squat with adduction as in the application of functional taping, showing no statistical difference between the genders, nor between the athletes and sedentary groups. Felício et al.[24] also demonstrated in their study that the squat exercise associated with the adduction of the thigh promoted a greater muscular activation of the VMO, in addition to increasing the activity of the gluteus medius.

For Coqueiro et al.[25] the association of the squat with the adductive isometric contraction of the thigh was able to promote similar electromyographic amplitude values between the medial and lateral portions of the quadriceps when compared to the conventional squat, thus offering a better dynamic balance of the patellofemoral joint.

In their study, Earl et al.[26] concluded that combining the hip adduction with a mini-squat isometric exercise significantly increases the activity of the quadriceps as a whole. However, based on their data, it cannot be concluded that this exercise preferably recruits the VMO.

As for the application of functional taping, in the present study there were no statistical differences in the values with and without the use of functional taping on the muscles observed. This result suggests that the voluntary isometric contraction in the movement of adduction has the same effect as the application of taping, since in the second isometric squat, the individuals did not perform adduction.

In their study, Chen et al.[27] observed that the activation of the VMO occurred before the other muscles of hip, when compared to the group not using functional taping, but there was no difference between the placebo (that is, application of common adhesive strips in the same position of the functional taping) and the group that used the taping. This is interesting within the theory that the sooner the activation of the VMO, the better will be the positioning of the patella, thus helping the patellar medialization, in addition to better distributing the pressure exerted on a particular portion of the joint cartilage.

The results of the study by Vithoulket et al.[28] suggest that the application of functional taping on the anterior surface of the thigh, in the direction of the vastus medialis and of the rectus femoris, can increase the eccentric muscle strength (peak of eccentric isokinetic torque) in healthy adults. According to the study by Murray,[29] the functional taping applied to the anterior surface of the thigh could significantly improve the active group of amplitude of movement, and this increase would be related to an increase of the surface EMG of the muscles in the anterior compartment of the thigh - the femoral quadriceps.

CONCLUSION

Although a greater activation of the VMO had been found in the squat exercise with adduction as much as in the squat exercise with functional taping, as initially hypothesized, with the methodology used in the present study it was not possible to find any significant difference between the activation of the VMO and of the VL with the use of the functional taping. In the same way, it was not possible to find any difference in the level of activation between the genders and between sedentary and athletic groups. However, the absence of difference between the activation of the VMO with and without the use of taping during the squat exercise suggests the efficiency of the taping on muscular activation, since taping was not used with voluntary adduction.

New studies are necessary where other electromyography parameters and reflex stimulation can be analyzed to investigate the real role of functional taping in muscular activation.

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