Effects in the Q angle measurement with maximal voluntary isometric contraction of the quadriceps muscle

Belchior A.C.G.[1], Arakaki J.C.[1,2], Bevilaqua-Grossi D.[2], Reis F.A.[1] and Carvalho P.T.C.[1]

ABSTRACT

The purpose of this study was to analyze the difference between the angle of the quadriceps in symptomatic and asymptomatic individuals in two different examination situations, having the quadriceps relaxed and in a maximal voluntary isometric contraction (MVIC) through radiographic measurement, aiming to contribute to the assessment and treatment of patients with patelofemoral disorder (PFD). Through the standard radiological method twenty 21 years old mean women (40 knees) were assessed. All individuals were positioned supine using a U-podalic stabilizer, having their lower limbs relaxed, using a plumb film on the anterior tuberosity of the tibia. For the statistical analysis, the averages for the asymptomatic and symptomatic groups in a relaxed and MVIC status, as well as the Student's t-test with $p < 0.05$ significance level were used. The mean values to the Q angle compared to the asymptomatic group were 17.15º on relaxation, and 14.5º on MVIC, while the asymptomatic group presented 21.45º, and 15.8º, respectively. The results in the equality analysis between the symptomatic and asymptomatic groups on the relaxed status attained a $p = 0.004$, and to the maximal voluntary isometric contraction, $p = 0.29$. Considering the data attained in the present study, it can be verified that in a relaxing status, there is a difference between the value of the Q angle among symptomatic and asymptomatic individuals, being found a higher value in the FPD bearers, while in a maximal isometric contraction of the quadriceps muscle no statistical difference was found in the present study, with a reduction in the angle in both groups.

Keywords: Knees. Femoropatellar. Q angle.

INTRODUCTION

The knee joint is involved in about 50% of the musculoskeletal injuries, and the most common of these injuries is the patelofemoral disorder[1-3]. The PFD is an articular disorder manifested by pain in the anterior portion of the knee and a functional deficit that compromises the daily activities[4,5]. It constitutes 25% of the injuries compromising the knee and 5% of every sportive injury, representing a shared complaint in 20% of the population, affecting mainly young 15-25 years old females[1,6,7].

The most frequent symptoms are pain in the anterior knee, peripatellar edema, blockage, and patelofemoral articular crepitation[5,8,9]. Generally, they are bilateral, and presenting exacerbation periods related to long period in the seat position with the knees flexed, when standing up after being seat, while ascending and descending stairs or walking on inclined surfaces, running, training using weights, and kneeling[1,5,6,10].

1. University for the Development of the State and the Lowland Region – UNIDERP – Campo Grande, MS.
2. Department of Locomotive Biomechanics, Medicine and Rehabilitation – Ribeirão Preto Medicine School of the São Paulo University – FMRP-USP.

Received in 1/12/04. Final version received in 22/8/05. Approved in 5/9/05.

Correspondence to: Rua Gravataí, 290, Monte Castelo – 79010-390 – Campo Grande, MS, Brazil. Phone: (67) 351-5400. E-mail: carulms@pop.com.br

There are several etiologic factors that can generate the PFD, such as neuromuscular imbalances of the oblique vastus medialis (OVM) and vastus lateralis (VL); the shortening of the lateral retinaculum, the ischiotiabilis, the iliotibialis tract, and the gastrocnemius; the excessive pronation of the subtalar joint; the loosening, or the ligamentous or capsular shortening; bone abnormalities; the excessive anteversion of the femoral cervix; the external torsion of the tibialis; enlargement of the pelvis and the high patella[6,10-13].

Related to the active strength exerted on the patella, the main structure responsible by such activity is the quadriceps muscle of the thigh that controls the position of the patella related to the trochlea by means of the oblique fibers of its medialis and lateral portions – the vastus medialis (VM) and the vastus lateralis (VL)[1].

The VM muscle is divided in two portions: the vastus medialis longus (VML) a muscle that it is inserted in a 15º related to the longitudinal axle of the femur, and that exerts few or no traction to the adequate positioning of the patella, and the oblique vastus medialis (OVM) that is inserted mainly in a 50-55º on the longitudinal axle of the femur, and it is considered the medial dynamic stabilizer of the patelofemolar joint (PFJ). Likewise, the VL muscle is also divided in two portions: the proximal fibers that are originated in the femur, and that are inserted in the medial third of the quadriceps' tendon of the thigh, constituting the vastus lateralis longus (VLL), and the posterolateral fibers are originated in the iliotibial tract, being more oblique towards its direction, and they are inserted on the base and the lateral edge of the patella, representing the oblique vastus lateralis (OVL) muscle. Taking into account the origins and insertions of these muscles, especially the oblique portions, it is observed its opposite actions, and their importance to the function for the patellar stability[14,15].

Considering the direction of the muscular fibers, the oblique vastus medialis (OVM) is the first muscle that contributes to the medial strength vector, same as the vastus lateralis (VL) is for the lateral strength[6,16].

The insufficiency or hypotrophy of the VMO muscle can generate a patellar malalignment, especially in the last extension grades (0º-15º flexion) of the knee joint, where it occurs a major instability in the joint due to a lower bone congruence, but it does not present an efficiency to restrain the lateral traction of the patella[17].

Another factor that may contribute to the pain development or worsening, with a consequent generation of instability in the knee is the malalignment of the patelofemoral joint, whose measurement can be performed through the quadriceps angle (Q)[4,18].

The Q angle is formed by the crossing of two imaginary lines: the first line is formed by the anterosuperior iliac spine up to the medium patellar spot, and the second line is formed by the anterior tuberosity of the tibia up to the medium patellar spot, and its mean normal value is 13º in men, and 18º in women[1,5,7,11,19].

The increase in the Q angle creates a higher valgus vector and increases the lateral traction of the patella as well, causing a higher pressure in the patellar lateral facet that may lead to a patellar

subluxation, causing a softening of the cartilage and a stress on the retinaculum, besides of contributing to a spread in the PFD[20,21].

The measurement of that angle can be performed using different methods, such as the radiographic method[10,21] or clinically through the goniometer[21], and in different ways, having the patient in supine with his knees in total extension of the knee and relaxed quadriceps[20,21], or contracted[22], in orthostatism[5,7,21], seat with the knees in a 90º flexion, or in a or 20-30º with the maximal medial, lateral rotation or in a neutral position of the tibia[5].

Thus, the aim of this study was to search the difference between the quadriceps angle in symptomatic and asymptomatic individuals in two different examination situations, having the quadriceps relaxed and in maximal voluntary isometric contraction using the radiographic measurement, in order to contribute to the assessment and treatment of patients with PFD.

CASUISTIC AND METHODS

Sampling

It was recruited through oral invitation twenty 15 to 30 years old (mean 21 years) female volunteers (n = 40 knees) during the period from May to July, 2003.

Ten individuals (n = 20 knees) did not present any complaint of pain in the knees; traumatic or surgical records or any pathology involving any of the joints of the lower limbs; vascular, peripheral or central neurological disorder, constituting the group of knees considered normal, that means, asymptomatic.

The remaining persons (n = 20 knees) were diagnosed with PFD, presenting bilateral pain, according to the Cowan *et al.*[22] criteria that have the following inclusion factors: 1) anterior or retropatellar pain when performing at least two of the following activities: ascending stairs, be seat for long periods, upon squatting, kneeling, or jumping; 2) pain on the patellar palpation; 3) symptoms for more than one month whose onset is not related to any trauma.

As exclusion factors it was considered the following: 1) signs or symptoms of another pathology; 2) recent history (less than three months) of surgery in the knees; 3) patellar luxation or subluxation; 4) clinical evidence of meniscal injury; 5) ligamentous instability; 6) patellar tendinitis; 7) osteoarthrosis or pain irradiated from the columna vertebralis; 8) pregnancy or another condition that may interfere in the data collection.

Before performing the assessments, all volunteers were clarified on the procedure used in the research, and they signed a Free Formal and Clarified Consent Term according to the Federal Regulations for Human Subjects Research referred in the Resolution 196/96 of the National Health Council.

Instruments

U-podalic stabilizer: U formatted metallic plate with two mobile arms, upon which the regions of the heels were positioned. The gap of the arms impeded the lateral rotation of the lower limbs, and such gap corresponded to the distance between the feet after the knees were aligned to the hips.

Radiological device: A 500 mmA G3 Model. The distance from the ampoule to the 35 x 91 cm cassette was 1.70 m, a Kodak® film and automatic revelation (Macrotec®).

Procedures

The patient was positioned supine, with their knees in total extension along with the U-podalic stabilizer, and each patient was asked to keep her lower limbs in a relaxing status (figure 1).

Afterwards, the same technician took radiographies in anteroposterior positioning using radiological 35 x 91 cm film, comprising a portion of the hip 15 cm below the previously market TAT using a lead film (4 cm^2) fixed on the skin with adhesive tape, in order to facilitate the visualization of the TAT after revealing the film, when the Q angle was traced by the researcher using a conventional rule, a pen, and protractor (figure 2).

A similar procedure was performed along with the request for a maximal voluntary isometric contraction of the quadriceps muscle.

Fig. 1 *– U-Podalic stabilizer where the lower limbs were kept in the relaxation status*

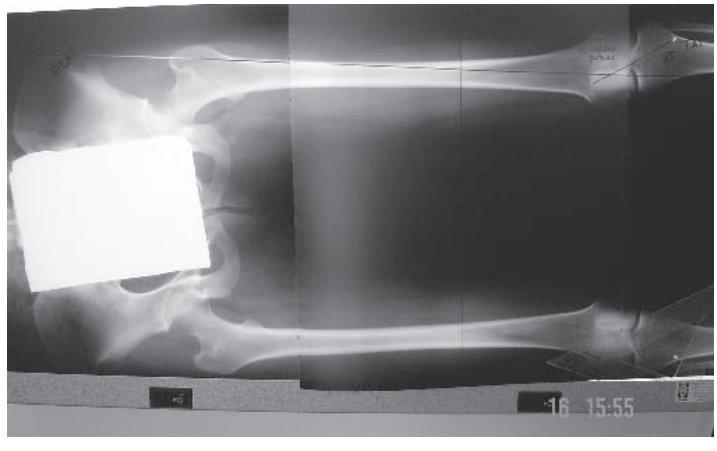

Fig. 2 *– Radiological image with presence of the lead film (4 cm^2) to facilitate the TAT visualization after revealing the film, where the Q angle was traced by the researcher using conventional rule, pen and tractor*

Statistical analysis

It was calculated the averages of the collected values, following the statistical method, the t-Student test with a 0.05 significance level, and the test was applied between the values of the Q angle between asymptomatic and symptomatic patients both in the relaxing status and in maximal voluntary isometric contraction.

RESULTS

First, it was calculated the means of the Q angle presented in the relaxing status and in the maximal voluntary contraction both in the group of asymptomatic and in the symptomatic group of patients (table 1).

TABLE 1
Values of the angle Q means presented in the relaxation and maximal voluntary contraction status

	Asymptomatic		Symptomatic	
	X	D.P.	X	D.P.
Relaxation	17.15°	4.5	21.45°	3.9
Contraction	14.5°	3.0	15.8°	3.5

Next, it was performed the statistical analysis using the t-Student test to analyze the equality between symptomatic and asymptomatic groups (figures 3 and 4). In the relaxation status, it was attained a p = 0.004, while the maximal voluntary contraction presented p = 0.26.

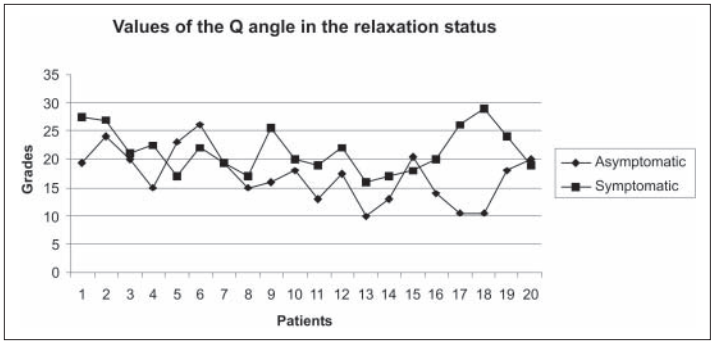

Fig. 3 *– Graphic of the measurement of the Q angle attained in the relaxation status*

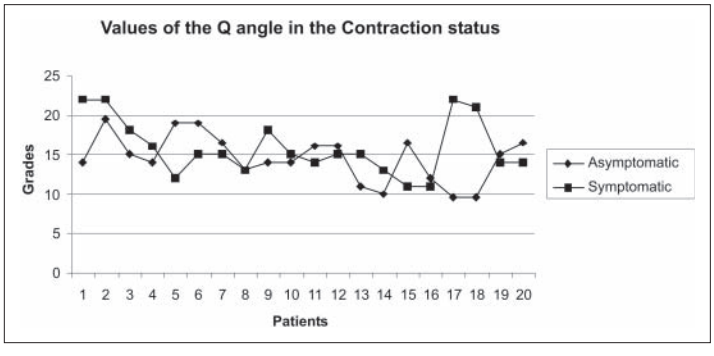

Fig. 4 *– Graphic of the measurement of the Q angle attained in the maximal voluntary isometric Contraction*

DISCUSSION

Following the analysis of the results, it is possible to view the difference in the Q angle magnitude between symptomatic and asymptomatic individuals in the relaxation status (p = 0.004). The mean value found confirms the estimated values found in the literature, which are the following: 15º mean to asymptomatic individuals, and 20º to symptomatic individuals.

The reduction in the Q angle value in the maximal voluntary isometric contraction for asymptomatic individuals were also found in a similar study analyzing the Q angle in mean 22 years old healthy women in the orthostatic position, where the expressed values found were mean 13º[23].

Nevertheless, the value of the Q angle in symptomatic women (p = 0.26) found in this study has also presented a reduction during the maximal voluntary isometric contraction. As they were PFD bearers, it was expected a change in the activation of the OVM muscle, presenting a disturbance in its patellar medial stabilizing function[16], especially having the lower limb in total extension (0º) where it occurs the major articular instability due to the lower bone congruence[17,22], and it did not present any efficiency in restraining the lateral traction of the patella. Thus, with the request on the maximal voluntary isometric contraction of the quadriceps muscle, it was estimated that the patella would be lateralized, thus generating an increase in the Q angle.

But the reduction of the Q angle which was seen can be justified in studies analyzing the activation of the oblique medial and vastus lateralis muscles upon isometric exercises on the quadriceps having the knees in total extension, where none of the muscular portions presented preferential activation[24,25].

Other electromyographic studies has examined variables such as the intensity and the time of the neuromuscular recruitment between the OVM and VL muscles while performing functional activities, such as ascending and descending stairs, and walking in healthy and PFD bearer individuals, but it was found no satisfactory results associated to the PFD[20,24,26].

Analyzing the patellar behavior in PFD bearer women through computerized tomography, no conclusion was attained as to the effect of the quadriceps muscle contraction on the patellar declination angles, but there was a significant increase in the congruence angle, especially in the 0º and 20º flexion knee[27].

Therefore, the behavior in the reduction of the Q angle together with the maximal voluntary isometric contraction of the quadriceps muscle in PFD bearer individuals leads to a justification of the use of treatment ways that use such kind of contraction.

The SLR, an exercise performed having the leg straight raised, is a way of treatment much employed in the PFD rehabilitation[28-31]. Based on this study, we believe that if it is associated to the maximal voluntary contraction during its execution, it can minimize the bad patellar alignment.

Besides, the present treatment proposals emphasize the strengthening of the abductor muscles of the hip[32,33] due to the kinematical imbalance of the lower limbs, and thus, it is wise to initiate a kinesiotherapeutic SLR exercising program associated to the hip abduction.

But regardless the form chosen to perform the SLR, physical exercises promote a sensorial reeducation through the motor activity[34], and this is extremely benefic to PFD bearer individuals, since in general they present proprioceptive abnormalities[3].

Despite this study presents significant data, it had some limitations, such as the cost involved in acquiring radiological images, as well as the positioning adopted to the procedure in supine, which we believe that it does not reproduce the optimum functional measurement.

CONCLUSION

Considering the data attained in the present study, it was verified that in a relaxing status, there is significant difference between the value of the Q angle between symptomatic and asymptomatic individuals, and such difference is not present in a maximal isometric contraction of the quadriceps muscle, and there was a reduction in the value of the angle in both individuals.

All the authors declared there is not any potential conflict of interests regarding this article.

REFERENCES

1. Cabral CM, Monteiro-Pedro V. Recuperação funcional de indivíduos com disfunção femoropatelar por meio de exercícios em cadeia cinética fechada: revisão da literatura. Rev Bras Fisioter 2003;7:1-8.
2. Baker MM, Juhn MS. Patellofemoral pain syndrome in the female athlete. Clin Sports Med 2000;19:315-29.

3. Baker V, Bennell K, Stillman B, Cowan S, Crossley K. Abnormal knee joint position sense in individuals with patellofemoral pain syndrome. J Orthop Res 2002; 20:208-14.
4. Alaca R, Yilmaz B, Goktepe AS, Mohur H, Kalyon TA. Efficacy of isokinetic exercise on functional capacity and pain in patellofemoral pain syndrome. Am J Phys Med Rehabil 2002;81:807-13.
5. Nissen CW, Cullen MC, Hewett TE, Noyes FR. Physical and arthroscopic examination techniques of the patellofemoral joint. J Orthop Sports Phys Ther 1998; 28:277-85.
6. Hung Y, Gross MT. Effect of foot position on electromyographic activity of the vastus medialis oblique and vastus lateralis during lower-extremity weight-bearing activities. J Orthop Sports Phys Ther 1999;29:93-102.
7. Livingston LA. The quadriceps angle: a review of the literature. J Orthop Sports Phys Ther 1998;28: 105-9.
8. Thomeé P, Thomeé R, Karlsson J. Patellofemoral pain syndrome: pain, coping strategies and degree of well-being. Scand J Med Sci Sports 2002;12: 276-81.
9. Andrade PH, Bevilaqua-Grosso D, Bérzin F, Gil I, Monteiro-Pedro V. Comparação da atividade elétrica dos músculos vasto medial oblíquo e vasto lateral oblíquo em indivíduos com disfunção femoropatelar. Rev Fisioter Univ São Paulo 2001; 8:65-71.
10. Sheehy 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.
11. Csintalan RP, Schulz MM, Woo J, McMahon PJ, Lee TQ. Gender differences in patellofemoral joint biomechanics. Clin Orthop Related Res 2002;402:260-9.
12. Fulkerson JP, Arendt EA. Anterior knee pain in females. Clin Orthop Related Res 2000;372:69-73.
13. Stiene HA, Brosky T, Reinking MF, Nyland JM, Beth M. A comparison of closed kinetic chain and isokinetic joint isolation exercises in patients with patellofemoral dysfunction. J Orthop Sports Phys Ther 1996;24:136-41.
14. Hubbard JK, Sampson HW, Elledge JR The vastus medialis oblique muscle and its relationship to patellofemoral joint deterioration in human cadavers. J Orthop Sports Phys Ther 1998;28:384-91.
15. Araujo RC, Amadio AC. Análise biomecânica da ativação das porções superficiais do m. quadríceps femoral durante contrações excêntrica e concêntrica. Rev Bras Fisiot 1996;1:13-20.
16. Sakai N, Luo Z, Rand JA, An K. The influence of weakness in the vastus medialis oblique muscle on the patellofemoral joint: an in vitro biomechanical study. Clin Biomech 2000;15:335-9.
17. Corrêa JCF, Negrão Filho RF, Dócusse Filho AJ, Quialheiro JJA. Tratamento da instabilidade femoropatelar por meio da estimulação elétrica neuromuscular associada a cinesioterapia. Rev Bras Fisiot 1996;1:37-43.
18. Tomsich DA, Nitz AJ, Threlkeld AJ, Shapiro R. Patellofemoral alignment: reliability. J Orthop Sports Phys Ther 1996;23:200-8.
19. Magee DJ. Avaliação músculo-esquelética. 3rd ed. São Paulo: Manole, 2002.
20. Tumia N, Maffulli N. Patellofemoral pain in female athletes. Sports Medicine and Arthrosc Rev 2002;10:69-75.
21. Holmes SW, Clancy WGJr. Clinical classification of patellofemoral pain and dysfunction. J Orthop Sports Phys Ther 1998;28:299-306.
22. Cowan SM, Bennell KL, Crossley KM, Hogdes PW, MacConnell J. Physical therapy alters recruitment of the vasti in patellofemoral pain syndrome. Med Sci Sports Exerc 2002;34:1879-85.
23. Lathinghouse LH, Trimble MH. Effects of isometric quadriceps activation on the Q-angle in women before and after quadriceps exercise. J Orthop Sports Phys Ther 2000;30:211-6.
24. 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.
25. Laprade J, Culham E, Brouwer B. Comparison of five isometric exercises in the recruitment of the vastus medialis oblique in persons with and without patellofemoral pain syndrome. J Orthop Sports Phys Ther 1998;27:197-204.
26. Karen JM, Ronald SK, Marilyn MP, Bradley F, Jacquelin P. Electromyography of the quadriceps in patellofemoral pain with patellar subluxation. Clin Orthop Related Res 2003;415:261-71.
27. Jones S, Kumar A, Bickerstaff DR, Smith TWD. Axial computed tomography of the patello-femoral joint with and without quadriceps contraction. J Bone Joint Surg 2000;82:21.
28. Blazer K. Diagnosis and treatment of patellofemoral pain syndrome in the female adolescent. Physician Assistant 2003;27:23-30.
29. Powers C. Rehabilitation of patellofemoral joint disorders: a critical review. J Orthop Sports Phys Ther 1998;28:345-54.
30. Wilk KE, Reinold MM. Principles of patellofemoral rehabilitation. Sports Med 2001;9:325-36.
31. Henry J. The patellofemoral joint. Southern Med J 2004;97:757-61.
32. Mascal CL, Landel RF, Powers CM. Management of patellofemoral pain targeting hip, pelvis, and trunk muscle function: 2 cases reports. J Orthop Sports Phys Ther 2003;33:642-60.
33. Ireland ML, Willson JD, Ballantyne BT, Davis IM. Hip strength in females with and without patellofemoral pain. J Orthop Sports Phys Ther 2003;33:671-6.
34. Riemann BL, Lephart SM. The sensorimotor system, part I: the physiologic basis of functional joint stability. Athl Train 2002;37:71-9.