Isokinetic evaluation, pain and functionality of subjects with patellofemoral pain syndrome

Avaliação isocinética, dor e funcionalidade de sujeitos com síndrome da dor patelofemoral

Evaluación isocinética, dolor y funcionalidad de sujetos con síndrome de dolor patelofemoral

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ABSTRACT | This study aimed at determining the influence of patellofemoral pain syndrome (PFPS) on torque peak and the work of knee flexor and extensor muscles, in addition to evaluating the pain and functionality of individuals that have this dysfunction. Fifty-two female subjects, 23 with diagnosis of PFPS, and 29 control subjects, clinically healthy and similar in age, height, and body mass participated in this study. The isokinetic evaluation was performed on concentric mode for knee flexors and extensors at speeds of 60° and 180°/s. The Visual Numerical Scale and the Kujala questionnaire were also applied before and after each speed of isokinetic testing. The data were analyzed through descriptive and inferential statistics (U Mann–Whitney, Wilcoxon, and independent *t*-tests) with a significance level of α=0.05. The patellofemoral pain syndrome group had lower scores (p=0.01) on the Kujala questionnaire (75.7±12.3 points) in relation to the control group (100±0.0 points), and lower peak torque of knee flexors (0.82±0.24 Nm/kg; 0.51±0.22 Nm/kg) and extensors (1.85±0.48 Nm/kg; 1.13±0.44 Nm/kg) at 60° and 180°/s as well as lower total work of knee extensors at 180°/s (6.46±2.54 Joules/kg) and 60°/s (9.42±3.27 Joules/kg). In addition, there was exacerbation of pain in the patellofemoral pain syndrome group after the isokinetic evaluation at 180°/s (0.9 cm) and 60°/s (2.3 cm). The results evidenced that individuals with PFPS have lower functional capacity, lower torque peak, and decreased function of knee flexors and extensors, which suggests that strengthening these muscles must be considered in the rehabilitation of these subjects.

Keywords | patellofemoral pain syndrome; knee; torque.

RESUMO | Este estudo visou determinar a influência da Síndrome da Dor Patelofemoral (SDPF) sobre o pico de torque e trabalho da musculatura flexora e extensora do joelho, além de avaliar a dor e funcionalidade de sujeitos com a disfunção. Participaram 52 sujeitos do gênero feminino, 23 com SDPF e 29 clinicamente saudáveis similares em idade, estatura e massa corporal. A avaliação isocinética foi realizada no modo concêntrico para os flexores e extensores do joelho nas velocidades de 60 e 180°/s. Também foi aplicada a Escala Visual Numérica antes e após cada velocidade do teste isocinético e o questionário de Kujala. Os dados foram analisados pela estatística descritiva e inferencial (testes U de Mann-Whitney, Wilcoxon e *t* independente) com nível de significância de α=0,05. O Grupo com Síndrome da Dor Patelofemoral (GSDPF) apresentou menor pontuação (p=0,01) no questionário de Kujala (75,7±12,3 pontos) em relação ao Grupo Controle (GC) (100±0,0 pontos), além de menor pico de torque, tanto em 60 como 180°/s, dos flexores (0,82±0,24 Nm/kg; 0,51±0,22 Nm/kg) e extensores (1,85±0,48 Nm/kg; 1,13±0,44 Nm/kg) do joelho, bem como menor trabalho total dos extensores do joelho a 180°/s (6,46±2,54 J/kg) e 60°/s (9,42±3,27 J/kg). Além disso, foi observado aumento da dor do GSDPF após a avaliação isocinética a 180°/s (0,9 cm) e 60°/s (2,3 cm). Os resultados evidenciaram que sujeitos com SDPF possuem menor capacidade funcional e menor pico de torque e trabalho dos flexores e extensores do joelho, sugerindo que o fortalecimento desta musculatura deve ser considerado na reabilitação destes sujeitos.

Descritores | síndrome da dor patelofemoral; joelho; torque.

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RESUMEN | Este estudio tiene como objetivo determinar la influencia del Síndrome de Dolor Patelofemoral (SDPF) sobre el peak de torque y el trabajo de la musculatura flexora y extensora de la rodilla, además de evaluar el dolor y la funcionalidad de sujetos con esta disfunción. Participaron 52 sujetos de género femenino, 23 con SDPF (GSDPF) y 29 clínicamente saludables (GC) similares en edad, estatura y masa corporal. La evaluación isocinética fue realizada en el modo concéntrico para los flexores y extensores de rodilla en las velocidades de 60 y 180°/s. También fue aplicada la Escala Visual Numérica antes y después de cada velocidad del test isocinético y el Cuestionario de Kujala. Los datos fueron analizados por estadística descriptiva e inferencial (Tests U de Mann-Whitney, Wilcoxon y T independiente) con un nivel de significancia de α=0,05. El GSDPF presentó menor puntuación (p=0,01) en el Cuestionario de Kujala (75,7±12,3 puntos) en relación al GC (100±0,0 puntos), además presentó un menor peak de torque, tanto en 180°/s y 60°/s. Los resultados evidencian que sujetos con SDPF poseen menor capacidad funcional y peak de torque de trabajo de los flexores y extensores de rodilla, sugiriendo que el fortalecimiento de esta musculatura debe ser considerada en la rehabilitación de estos sujetos.

Palabras clave | síndrome de dolor patelofemoral; rodilla, torque.

INTRODUCTION

Patellofemoral pain syndrome (PFPS) is characterized as a diffuse pain in the knee anterior region[1] with a generally insidious onset and slow progression[2,3]; it is responsible for 25% of all lesions that afflict this joint[4,5]. Its incidence is higher in physically active populations, such as teenagers and young adults[2,3], especially female[6], and it generates functional incapacities that compromise daily life activities[3].

Its etiology is multifactorial, and the most accepted hypothesis for its development is poor patellar alignment[2,3,6]. However, other factors may also contribute to the onset or worsening of PFPS, such as quadriceps weakness[2], alterations in the postural alignment of lower limbs, especially related to hind foot and Q angles[7], and abnormalities in the biomechanics of lower extremities, such as subtalar excessive eversion[8], smaller angle of knee flexion[11,12], weak hip muscles[13], in addition to excessive hip adduction and internal rotation[14].

The signs and symptoms of this syndrome are exacerbated especially during the performance of functional activities, among which we highlight the movements of going up and down the stairs and inclined surfaces[15,16], which could result in the modification of locomotive patterns. Even so, this is a strategy adopted by these individuals in order to reduce muscle strain and, consequently, the pain[17-19].

These modifications in locomotive patterns may lead to alterations in the muscle strength of lower limbs, especially the quadriceps, given that this muscle is considered the knee's primary stabilizer during walking, especially during response to the load applied to it. Additionally, the strength or torque of this muscle group can be an important factor in determining gait characteristics and the functional ability of individuals with PFPS, considering that a higher torque of the quadriceps muscle may be associated with higher gait speed and the length of the steps.

Some studies have been performed in order to evaluate the torque of knee flexors and extensors using isokinetic dynamometry on individuals with patellofemoral pain, but they differ in relation to test speed and contraction type[15,18-23]. Some of these studies have associated the higher torque of knee flexors and extensors to a higher functional capacity in individuals with PFPS[15,19,24]. In addition, only the study by Duffey et al., which evaluated the work of knee flexor and extensor muscles in individuals with PFPS, has been found to the present day. However, this study was conducted with runners, and it did not connect the individuals' work and functionality to the syndrome.

Therefore, this study aimed at determining the influence of PFPS on torque peak, and the work of knee flexor and extensor muscles, in addition to evaluating the pain and functionality of individuals afflicted by it.

METHODOLOGY

Individuals

Fifty-two female individuals participated in this study, 23 with PFPS – group with patellofemoral syndrome (PFPSG) – and 29 clinically healthy – control group (CG). The PFPSG was composed of women between 16 and 38 years of age, with a clinical diagnosis of PFPS. For the CG, women of the same age, height, and body mass were selected. The characteristics of the individuals in the PFPSG and in the CG are presented in Table 1. This study was approved by the Ethics and Research Committee of the Universidade do Estado de Santa Catarina (Santa Catarina State University), protocol number 33/2010.

Data collection

Data collection began with the application of Kujala's questionnaire in order to evaluate the symptoms and functional limitations of the individuals with PFPS. Next, the quadriceps, ischiotibial, and triceps leg muscles were stretched and warmed up on a stationary bicycle for 5 minutes.

The evaluation of torque peak and work of the knee flexor and extensor muscles at speeds of 180° and 60°/s was performed through the isokinetic dynamometer Biodex Multi Joint System 3®. For this evaluation, the individual was placed on the seat of the isokinetic equipment in the sitting position with the hip at an angle of 85°. A cushion for limb support was installed and fixed onto the seat with a T bar, and the support angle was adjusted. The individual remained attached to the seat by means of straps on the thigh, torso, and pelvis. The dynamometer rotation axis was aligned with the knee movement axis (lateral femoral epicondyle). The test was conducted on the concentric/concentric for knee extensors and flexors at speeds of 180° and 60°/s, with five repetitions of each speed, and 30-second intervals between each speed. At the time of the evaluation, maximum strength for each movement was requested from the individuals through visual stimulation and verbal encouragement. The Visual Numerical Scale was applied before and after each speed of the isokinetic evaluation.

Data handling

The data obtained from the isokinetic evaluation were normalized by the individual's body mass. We analyzed the data of the limb with pain in the patellofemoral joint in the PFPSG; in cases of bilateral dysfunction, the limb with higher pain intensity was considered. In the CG, we analyzed the data of the dominant limb, which was determined by the body part that the individuals used to kick a ball[27].

Statistical analysis

The data were analyzed through the *Statistical Package for the Social Sciences* (v. 17.0), with the use of descriptive statistics for the individuals' characterization, Shapiro–Wilk's test to verify data normality, Mann–Whitney U test to compare the score obtained on the Kujala questionnaire between the two groups, independent *t*-test to compare torque peak and the work of knee flexors and extensors at the speeds of 180° and 60°/s in the PFPSG and the CG, and Wilcoxon test to compare the pain of PFPSG members before and after the isokinetic evaluation at the speeds of 180° and 60°/s. We adopted a significance level of α=0.05.

RESULTS

The questionnaire evidenced a lower score (75.7±12.3 points) in the PFPSG in comparison to the CG (100±0.0 points) (p=0.01).

The comparison of the torque peak (Nm/kg) of knee flexors and extensors at the speeds of 180° and 60°/s between the PFPSG and the CG can be observed in Table 2.

Table 1. Characteristics of the individuals

Characteristics	PFPSG (n=23)	CG (n=29)	p-value*
Age (years)	22.7±6.1	21.4±3.7	0.308
Mass (kg)	59.1±8.3	59.2±8.4	0.724
Height (m)	1.64±0.07	1.64±0.05	0.519
Dominance			
Right lower limb	22 (96%)	27 (93%)	
Left lower limb	1 (4%)	2 (7%)	
Workout			
Yes	9 (39%)	9 (31%)	
No	14 (61%)	20 (69%)	
Limb affected by pain			
Unilateral (right knee)	5 (22%)	-	
Unilateral (left knee)	5 (22%)	-	
Bilateral (+ right knee)	11 (48%)	-	
Bilateral (+ left knee)	2 (8%)	-	
Onset of symptoms			
Less than 2 years	11 (50%)	-	
2 to 4 years	8 (34%)	-	
Over 4 years	4 (16%)	-	

*Independent *t*-test; PFPSG: patellofemoral pain syndrome group; CG: control group

The results of the work (Joules/kg) performed by the knee flexor and extensor muscles at the speeds of 180° and 60°/s in both groups evaluated are presented in Table 3.

The pain intensity (cm) before and after each speed of isokinetic evaluation in the PFPSG and the CG is shown in Figure 1.

DISCUSSION

The isokinetic evaluation of knee flexors and extensors evidenced lower torque peak for both muscles at the speeds of 60° and 180°/s in individuals with PFPS in comparison to control individuals. Considering that the torque peak represents the maximum torque value reached during movement, calculated from the result of maximum strength in relation to the distance of the application of this strength from the rotation center of the axis of the movement, we can infer that, upon presenting lower torque peak, the individuals with PFPS also presented less strength in the muscles evaluated.

Other authors have also observed lower torque values in individuals with PFPS[15,18,22], although they point several reasons for torque diminution in this population. Ott et al.[18], attributed the lower torque of knee extensors in individuals with PFPS to the inhibition of this muscle because of the pain presented by the individuals, in the same manner that Powers et al.[15], consider this muscle's deficiency a result of strategies adopted to avoid the pain. Callaghan and Oldham[22] affirm that lower torque in individuals with PFPS cannot be explained by muscle atrophy, given that they did not find correlation between torque peak and the quadriceps transversal section area in these individuals, which points to the existence of more subtle mechanisms, such as modifications in the strategies of neuromuscular control that end up limiting quadriceps functioning.

Nevertheless, Witvrouw et al.[20], while evaluating athletes, a different population than the one in our study, did not observe differences in the concentric torque peak of knee flexors and extensors at 60°, 180°, and 240°/s. Souza[21] did not observe differences in the torque of knee extensors among individuals with and without PFPS either. However, the author evaluated isometric torque, which differs from our study in the sense that we assessed concentric torque. Moreover, it is important to register that isometry requires other strategies of motor control that do not distinguish individuals with and without PFPS[21].

Besides reduction in torque peak, there was exacerbation of pain after both speeds used in the isokinetic test, with more acute pain after the speed of 60°/s (2.3 cm) in comparison to 180°/s (0.9 cm). According to Herrington[29], the higher pain intensity at the speed of 60°/s would be related to the fact that the duration of the load inflicted upon the patellofemoral joint is three times longer at 60°/s than at 180°/s. In addition, Dvir[30] affirms that the speeds of the isokinetic test may be related to the pain intensity presented by the individuals, since there is a tendency of occurrence of lower pain intensity at medium or high speeds, because at these numbers the joint is exposed to external resistance for a shorter period, therefore receiving the lightest load on the patellofemoral joint, and reducing inhibition potential.

Table 2. Averages and standard deviations in the torque peak (Nm/kg) of knee flexors and extensors at the speeds of 180° and 60°/s in the patellofemoral pain syndrome group and control group

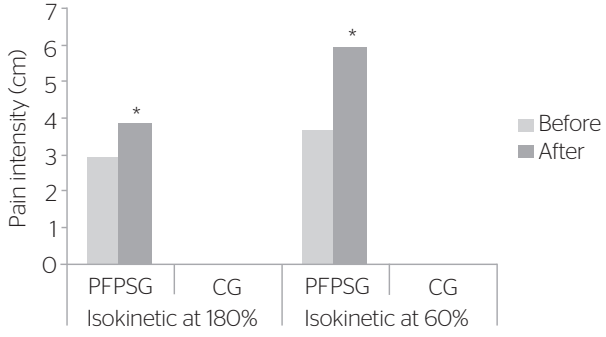
		Torque peak (Nm/kg)		
		PFPSG (n=23)	CG (n=29)	p-value
180°/s	Flexors	0.51±0.22	0.68±0.18	0.005*
	Extensors	1.13±0.44	1.44±0.32	0.006*
60°/s	Flexors	0.82±0.24	0.97±0.25	0.03*
	Extensors	1.85±0.48	2.21±0.36	0.004*

*Statistically significant difference; PPSG: patellofemoral pain syndrome group; CG: control group

Table 3. Averages and standard deviations in the function (Joules/kg) of knee flexors and extensors at the speeds of 180° and 60°/s in the patellofemoral pain syndrome group and control group

		Total function (Joules/kg)		
		PFPSG (n=23)	CG (n=29)	p-value
180°/s	Flexors	2.66±1.66	3.54±1.78	0.17
	Extensors	6.46±2.54	8.13±2.72	0.05*
60°/s	Flexors	4.13±1.91	5.07±1.43	0.14
	Extensors	9.42±3.27	11.55±2.09	0.01*

*Statistically significant difference; PFPSG: patellofemoral pain syndrome group; CG: control group



*Statistically higher after activity performance. PFPSG: patellofemoral pain syndrome group; CG: control group

Figure 1. Comparison of the pain intensity (cm) of each group before and after the isokinetic evaluation at 180° and 60°/s

Therefore, we believe that the lower torque of flexor and extensor muscles might have been influenced not only by PFPS, but also by the pain generated during the isokinetic test, considering that the pain could lead to a strategy of adaptation by these individuals with the purpose of decreasing muscle activation[31]. According to Herrington[31], muscle inhibition is a potential cause in reducing torque peak. If the individuals' pain level is reduced, the quadriceps torque peak could theoretically increase.

According to Terreri et al.[28], muscle work represents the energy used for muscle effort during movement. Duffey et al.[25], observed less work from knee extensors in long-distance runners who had experienced previous knee pain. In this study, we also verified less work required from knee extensors in the PFPSG at both speeds used in the isokinetic test. We believe that this difference was observed only in the extensors due to the fact that the quadriceps acts as the knee's main stabilizer[15]. In addition, this muscle is required for the balance of medium-lateral strength, contact strength, and pressure distribution in the patellofemoral joint[32].

It is possible that the reduction in the torque peak of flexors and extensors and in the function of the knee extensor muscle found in our study in individuals with PFPS can be related to a lower functionality of the patellofemoral joint, and to the higher difficulty presented by these individuals to perform functional activities, as indicated by the Kujala questionnaire, given that these muscles, especially the quadriceps, are fully used during functional activities such as walking, going up and down the stairs and ramps, among others. A lower torque and work in this muscle could lead to the difficulty in performing these activities, since these variables, especially work, are related to muscle performance during movement with the potential of directly affecting these individuals' functionality.

Likewise, some studies have associated alterations in the torque of knee muscles with the functionality of individuals with PFPS. Powers et al.[15], suggest that the functional ability in people with PFPS is related to a higher quadriceps torque, given that the extensor torque was the only predictor of gait functioning, with a higher torque related to an improvement in the characteristics of the steps. In addition, Nakagawa et al.[19], found that the higher the knee eccentric extensor torque, the higher the functional capacity and the lower the pain intensity reported by the individuals with PFPS during the study's last week. Therefore, both the restoration of the strength of the muscle involved with knee functioning, especially the quadriceps, and the affected limb's regained capacity are important for the individual's recovery[24].

However, not only a decrease in the strength of knee flexors and extensors may lead to alterations in functionality[33]; the adoption of coping strategies during the performance of functional activities with the purpose of reducing or avoiding pain might also lead to long-term reduced strength in individuals with PFPS[15,19]. Among these strategies, we highlight the reduction of the knee's flex angle, an alteration observed in several studies[11,27,34] which has the purpose of reducing stress and patellofemoral pain, but might incur harmful effects in the future, causing quadriceps atrophy and weakness[19]. However, caution is necessary, considering that we did not conduct cinematic evaluation during the performance of functional activities, which would verify the occurrence or non occurrence of these findings in the individuals involved in this study.

Considering that eccentric contraction is more related to the functional than to the concentric or isometric[19] capacity of individuals with PFPS, we consider it a limitation that we did not conduct an evaluation of eccentric torque in the individuals that participated in this study.

CONCLUSION

The results of this study suggest that PFPS leads to alteration in the functionality of its carriers, lower torque peak of knee flexors and extensors, and decreased function of knee extensor muscles both at the speed of 180°/s and 60°/s, thus inferring that these individuals present weaker muscles when compared to individuals without the syndrome, probably due to the influence of the pain generated by the isokinetic test or by the syndrome itself.

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