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Q angle and subtalar pronation are not good predictors of pain and function in individuals with patellofemoral pain syndrome

Ângulo Q e pronação subtalar não são bons preditores de dor e função em indivíduos com Síndrome da Dor Femoropatelar

Ángulo Q y pronación subtalar no son buenos predictores del dolor y función en individuos con Síndrome de Dolor Femoropatelar

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ABSTRACT | This study aimed to evaluate the clinical trials' ability in Q angle measurement and subtalar pronation to predict the pain and functional limitations alluded by individuals with Patellofemoral Pain Syndrome (PFPS). Thirty-one individuals with PFPS were recruited for this study. The Anterior Knee Pain Scale questionnaire was used to identify the functional limitations and the Visual Analogue Scale of pain was used to identify the pain experienced by these individuals in the last month. Two clinical trials were performed, measurement of Q angle and posture measurement of the subtalar pronation. The values of the tests were inserted into linear and multiple regression models to obtain the R^2 and the coefficients of regression for non-continuous measures standardized with the significance level established at $\alpha = 0.05$. Both tests when placed separately in linear regression models obtained low results for predicting pain and function. On the other hand, when inserted together in multiple regression models the tests explained 9% and 4% of the pain and of the functional limitations of individuals with PFPS, respectively. Although the prediction of pain and functional limitations has improved when the tests were evaluated together, our findings show that both measures, Q angle and subtalar pronation, are not good predictors of pain and functional limitations of individuals with PFPS.

Keywords | Linear Models; Knee; Patella; Patellofemoral Pain Syndrome.

RESUMO | Este estudo teve como objetivo avaliar a capacidade dos testes clínicos de mensuração do ângulo Q e pronação subtalar em predizer a dor e as limitações funcionais referidas por indivíduos com Síndrome da Dor Femoropatelar (SDFP). Trinta e um indivíduos com SDFP foram recrutados para este estudo. O questionário *Anterior Knee Pain Scale* foi utilizado para identificar as limitações funcionais, e a Escala Visual Analógica de dor para a dor vivenciada por esses indivíduos referente ao último mês. Foram realizados dois testes clínicos estáticos, mensuração do ângulo Q e mensuração da postura da pronação

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subtalar. Os valores dos testes foram inseridos em modelos de regressão linear e múltipla para a obtenção do R^2 e dos coeficientes de regressão para medidas não contínuas padronizadas com o nível de significância estabelecido em α=0,05. Ambos os testes, quando inseridos isoladamente em modelos de regressão lineares, obtiveram resultados baixos de predição de dor e função. Por outro lado, quando inseridos conjuntamente em modelos de regressão múltipla, os testes explicaram 9% e 4% da dor e das limitações funcionais de indivíduos com SDFP, respectivamente. Embora tenha sido observada melhora da predição da dor e limitação funcional quando os testes foram avaliados em conjunto, os achados deste estudo mostram que ambas as medidas – ângulo Q e pronação subtalar – não são bons preditores de dor e limitações funcionais de indivíduos com SDFP.

Descritores | Modelos Lineares; Joelho; Patela; Síndrome da Dor Femoropatelar.

RESUMEN | El objetivo de este estudio fue evaluar la capacidad de de las pruebas clínicas de medición del ángulo Q y pronación subtalar en predecir el dolor y las limitaciones funcionales mencionados por individuos con Síndrome de Dolor Femoropatelar (SDFP). Treinta y un individuos con SDFP fueron reclutados para este estudio. El cuestionario *Anterior Knee Pain Scale* fue utilizado para identificar las limitaciones funcionales; mientras la Escala Visual Analógica del dolor para identificar el dolor experimentado por los individuos en el último mes. Se realizaron dos ensayos clínicos estadísticos, medición del ángulo Q y medición de la postura de la pronación subtalar. Los valores de las pruebas fueron insertados en modelos de regresión linear y múltiple para obtener el R^2 y los coeficientes de regresión para medidas no continuas estandarizadas con el nivel de significancia establecido en α=0,05. Ambas pruebas cuando insertadas aisladamente en modelos de regresión lineares obtuvieron resultados bajos de predicción de dolor y función. Por otro lado, cuando insertados en modelos de regresión múltiple, los ensayos explicaron el 9% y 4% del dolor y de las limitaciones funcionales de individuos con SDFP, respectivamente. Aunque hubo mejora de la predicción del dolor y de la limitación funcional cuando las pruebas se evaluaron juntas, los resultados de este estudio muestran que ambas las medidas, el ángulo Q y la pronación subtalar, no son buenos predictores del dolor y de las limitaciones funcionales de individuos con SDFP.

Palabras clave | Modelos Lineales; Rodilla; Rótula; Síndrome de Dolor Patelofemoral.

INTRODUCTION

Patellofemoral pain syndrome (PFPS) has as a characteristic insidious pain in previous regions, peri or retropatellar. It is one of the main disorders that affect the knee, has a higher incidence in the female population and reaches approximately 13% of women aged between 18 and 35 years[1]. This painful condition is exacerbated by functional gestures as climbing up and down a ladder, squatting and racing, which limits the participation of those individuals in sports and daily life activities (DLAs)[2].

Despite the high rates of incidence, the set of procedures to diagnose this dysfunction is not yet defined, because the literature about its etiological factors has not reached a consensus[3]. Because of this, investigations about biomechanical variables to identify specific musculoskeletal habits in individuals with PFPS are often found, to assist in the characterization of this disorder[4–6]participants performed a fatiguing protocol in which they performed submaximal knee-extension contractions at 20% and 70% MVIC held to exhaustion. The MDF and RMS values from the EMG signals were recorded from the vastus medialis (VM. A systematic review that investigated biomechanical factors associated with PFPS outlined 47 studies with good methodological quality and that evaluated a total of 523 different biomechanical parameters[6]. However, even with this arsenal of parameters investigating PFPS in a multifactorial form, there is great controversy about which parameters are changed in individuals with PFPS[2,7].

In this context, the concern in the area consists in finding kinesiological static and/or dynamic changes that are related or can explain the pain and functional limitations of individuals with PFPS[8–10]. For example, Nakagawa et al. (2013) investigated through a kinemetry system how much three kinematic variables of hip and knee were able to predict the referred pain and functional limitations of those individuals. They found 63% of prediction for variation of pain and 44% for functional limitations[8]. However, the biomechanical tools used to verify those results are neither common nor usual instruments in daily clinical practice. 3D kinematic systems have high financial cost and require skilled labor for its use. In the same way,

kinetic analysis systems as force platforms and isokinetic dynamometers are common in scientific research, but rare in rehabilitation and diagnostic clinics. This fact reinforces the idea that clinical trials may be the most viable option and should be better exploited due to the ease of implementation and low cost. Due to the absence of a gold standard diagnostic tool, studies have used sets of clinical trials to compose their inclusion criteria and classify individuals as PFPS or not[11,3].

Clinical tests of static changes such as the measurement of the Q angle and the attitude of the subtalar pronation have been composing sets of tests that classify individuals as PFPS[2,12]. However, there are gaps in the literature about how these tests are able to explain the pain and functional limitations found in these individuals. Despite performing good interobserver reproducibility and being widely reported[13–15], these clinical trials must show their ability to predict pain and function in PFPS. This type of approach can be directly related and transferred to the clinical practice, because the viability to continue using these tests depends on analysis as the one proposed by this study.

This study aimed to evaluate the clinical trials' ability in Q angle measurement and subtalar pronation to predict the pain and functional limitations alluded by individuals with PFPS.

METHODOLOGY

Characterization of the sample

Sixty-four volunteers with knee pain were selected to participate in the study, however, 31 volunteers, identified with PFPS, fitted in the inclusion criteria. To be included in the study, the volunteers were subjected to a screening process recommended by high-quality studies in the area of PFPS[7,16].

Inclusion criteria were: (1) anterior knee pain during at least two of the following activities: remain seated for long periods, during sustained squatting or in repetitions, kneeling, during race and climbing up and down the stairs; (2) pain during palpation of the patella; (3) the symptoms with at least one month of insidious onset; (4) the average pain level of at least 3cm in the Visual Analogue Scale (VAS) in which 0cm means no pain and 10cm the maximum level of pain in the previous month[17]; and (5) three or more positive clinical signs in the following exams: Clarke's sign, McConnell test, Noble's compression test, Waldron's test and patella in medial or lateral position. Participants had to necessarily meet all five requirements to be identified with PFPS. As a non-inclusion criterion, any condition beyond the PFPS was considered, such as: events of patellar subluxation or dislocation, inflammatory process in any lower limb, osteoarthritis, patellar tendon injury or meniscus or the presence of neurological diseases. All the participants were assessed according to the inclusion and non-inclusion criteria by two physiotherapists, with five years of experience in the evaluation of individuals with PFPS, who were only included in the study if these two physical therapists were in agreement with the criteria. The anthropometric data of the individuals are described in Table 1.

Design and Experimental Procedure

All participants were informed about the procedures to be performed, they signed a free and informed consent form according to the rules of the research ethics committee at the Universidade Estadual do Oeste do Paraná, approved under number 096/2013.

The Anterior Knee Pain Scale questionnaire (AKPS) validated for the Brazilian population[18] was applied to evaluate the participants' functional limitations. The AKPS is a quiz of 13 items that assess subjective symptoms and functional limitations associated with anterior knee pain. The questionnaire score ranges from 0 to 100 points, with a maximum total score of 100 indicating no functional limitation and below 82 indicating a tendency to patellofemoral disorders[19]. After answering the questionnaire, the participants underwent two clinical trials, Q angle and subtalar pronation measurements.

The Q angle measurement was performed as follows: the individual was placed in supine position on a stretcher, with the feet perpendicular to the ground, then, with a dermographic pencil, the anatomical points were demarcated in the anterior superior iliac spine (ASIS), in the anterior tibial tuberosity (ATT) and also the superior, inferior, lateral and medial patellar and thus the patellar center edges were located. From this demarcation, two lines were drawn, the first between the ASIS and the center of the patella and the second between the ATT and the patellar center. Then, using a universal goniometer (CARCI®) the assessor noted the angle formed between these two lines[13]. The test is considered positive when the Q angle exceeds 20°[13].

The subtalar pronation measurement (Figure 1) was carried out as follows: with the subtalar joint in neutral position, the individuals were placed in ventral position on a stretcher with the ankle and the calcaneus parallel to the ground. The subtalar joint neutral position was determined by palpation of the talus head on the medial and lateral edges of the talonavicular joint, and when the talus was not palpable or when it was felt to be equally prominent on both sides, the neutral position was considered. Next, the bisection of the leg was determined by palpation of its medial and lateral region, regardless of the direction of the calcaneal tendon. The middle longitudinal line of the posterior calcaneus was also estimated by palpation of its medial and lateral edges. Vertical lines were drawn with a ruler to assist the alignment of the goniometer. After this step, the participant was instructed to stand on a stool and the angle formed by these two lines represented the angle of the subtalar joint[14]. The test is considered positive when the angle is greater or equal to 8°[20]. The limb analyzed for both tests was the one affected by PFPS, and in the case of bilateral pain the most symptomatic limb was assessed.

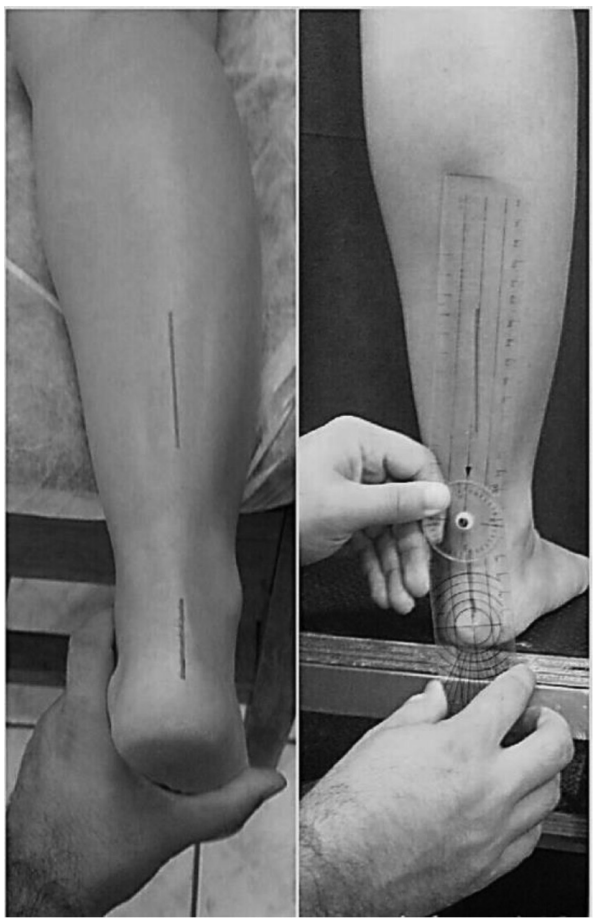

Figure 1. Clinical Test of static posture measurement of subtalar pronation

Statistical Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS v. 18.0, Inc. Chicago, Illinois, USA). Descriptive statistics was used to characterize the individuals and the Shapiro-Wilk test confirmed the normal distribution of the data. To check how the clinical trials are able to predict the referred pain and functional limitations of individuals with PSPF multiple linear regression-type, models of forced entry were executed. The associations within each multivariate model were considered significant if $p \leq 0.05$. The strength of the predictive capacity of clinical trials in each multivariate model was determined by regression coefficients for non-continuous standardized measures (B), with confidence intervals established in 95%. The overall performance of the final models was assessed using the R^2 of Nagelskerke, which estimates the measure variation explained by the model[21]. In addition, to make sure the data were correctly adjusted to the model, regression diagnostics were made to assess the presence of outliers, collinearity and waste. For all the analyses it was considered a significance level of $\alpha=0.05$.

RESULTS

The average score in the AKPS and the average pain of the participants are reported in Table 1 with their respective standard deviations.

Table 1. Anthropometric data and characterization of participants

Characteristics	Average	Standard Deviation
Age (years)	21.90	3.67
Mass (kg)	65.76	10.77
Height (m)	1.66	0.05
Pain *	5.32	1.37
AKPS (Final score)	72.64	9.22
Clinical trials Q Angle (°)	22.61	2.23
Clinical trial Subtalar Pronation (°)	8.42	2.24

The data of pain were obtained through the Visual Analogue Scale applied at the time of the inclusion criteria. The pain to which the data refer is the pain the participant lived through in the last month before data collection

Regarding the regression models, first a linear regression for each clinical trial was performed, and, then, a multiple regression with two tests inserted to

identify the change in pain explained by the models. The best combination was obtained in the multiple regression model, which was able to explain 9% of the referred pain by individuals with PFPS. No value of B was significant and the confidence intervals established at 95% were extensive ranging from negative to positive (Table 2).

Table 2. Multiple and linear regression model with the values found in the clinical trials of subtalar pronation and Q angle as predictors, and the values of pain as the dependent variable

Model	Variables	R^2	F-ANOVA	B – (95%CI)	P-value (B)
1	Q Angle	0.067	2.089	0.16 (-0.066; 0.38)	0.159
2	Subtalar Pronation	0.01	0.027	0.01 (-0.21; 0.25)	0.872
3	Q Angle	0.09	1.406	0.20 (-0.47; 0.45)	0.678
	Subtalar Pronation			0.10 (-0.14; 0.35)	0.396

Models 1 and 2 refer to linear regression, and model 3 to multiple regression. In model 3, three cases of collinearity were identified and the individuals were discarded by the multiple regression test forced entry type. The p values for the three models were p>0.05

The same method of regression analysis was used to quantify how much the clinical trials were able to explain the functional limitations detected via the AKPS questionnaire. Similarly, the best prediction value was found in the multiple regression model, which was able to explain 4% of the functional limitations mentioned by the participants. As well as pain, no value of B was significant (Table 3).

Tabela 3. Modelo de regressão linear e múltipla com os valores encontrados nos testes clínicos de pronação subtalar e ângulo Q como variáveis preditoras e os valores do AKPS como variável dependente

Model	Variables	R^2	F-ANOVA	B – (95%CI)	P-value (B)
1	Q Angle	0.006	0.178	-0.32 (-1.88; 1.24)	0.676
2	Subtalar Pronation	0.001	0.007	0.06 (-1.49; 1.62)	0.934
3	Q Angle	0.04	1.093	-0.36 (-2.12; 1.40)	0.678
	Subtalar Pronation			-0.08 (-1.83; 1.66)	0.918

Models 1 and 2 refer to linear regression, and model 3 to multiple regression. The p values for the three models were p>0.05

The values of F-ANOVA found in tables 2 and 3, when the tests were inserted separately in the regression model, were lower than 1, except for the Q angle as a predictor of pain. The results of F-ANOVA in the multiple regression models were all greater than 1.

DISCUSSION

Clinical tests have been used to characterize individuals with PFPS, however, there is a lack of studies that report how the results of these tests can explain the pain experienced and the functional limitations in these individuals. It is already well established in the literature that the subtalar hyperpronation and excessive Q angle are PFPS' aspects[22,23], due to this, this study investigated the ability of two clinical tests, Q angle measurement and posture of the subtalar pronation, in predicting the referred pain by VAS and the functional limitations by AKPS.

Regarding the regression models, the authors were cautious not to commit the type II error, since it is suggested that for each variable inserted in a model, a "n" sample of 15 individuals must also be inserted. Because two predictor variables were used, the sample of 31 individuals was enough not to compromise the quality of the regression[24]. When inserted separately in linear regression models, the tests showed weakness in explaining the pain mentioned by the individuals. For example, the clinical trial of subtalar pronation explained only 0.1% of the variation of the pain, which indicates that this change may exist on PFPS, as reported by recent studies[2,25], however, it shows little connection with the source of these individuals' pain. As reported by Aliberti et al. (2012)[26], who used a photogrammetry system to identify the angulation of the subtalar pronation and Q angle in individuals with PFPS, a significant association between these measures and the pain found in PFPS does not exist. However, the results have improved when the multiple regression model was performed; together the tests explained 9% of the pain. These results indicate that, when it comes to clinical trials, the association between tests can generate better results.

When the regression was made based on functional limitations, the tests' ability of prediction were lower than the values obtained with pain. Separately, the test of subtalar pronation explained 0.1% and the Q angle test 0.6% of the functional limitations of these individuals, which shows that these measures separately are even more fragile when related to function. The multiple regression was able, again, to improve the predictive capacity. Together, the variables explained 4% of the functional limitations. Freedman and Sheehan (2013)[9] indicated that static measuring instruments may not be good predictors of dynamic functions, as the questions that appear in the AKPS refer to the dynamic conditions, our results reinforce the assertion of this study.

As the literature in the area of PFPS offers several clinical tests used as inclusion criteria, the results of this study suggest not to use the subtalar pronation tests and Q angle because they are not good predictors of pain and functional limitations of individuals with PFPS.

The relationship between Q angle and PFPS is based on the theoretical model that the increased Q angle represents a source of excessive stress in the patellofemoral joint[27]. This causes pain, providing the PFPS symptoms[27]. In addition, there is evidence suggesting that high Q angle values can lead to the degeneration of the articular cartilage[28]. It should be emphasized that this assumption is based on the presumption that the Q angle represents the angle formed by the application of quadriceps strength and the direction of the patellar tendon[29]$p<0.001$. To confront this concept, the findings of Freedman et al. (2014)[30] can support the findings of the present study, since the authors compared three different ways of measuring the Q angle, during activities with no weight discharge by means of MRI, to determine whether the clinical test of Q angle truly represents the application's line of quadriceps strength and analyze its relationship with patellofemoral kinematics. According to the authors' hypothesis, the Q angle did not represent the line of action of the quadriceps and greater values of Q angle did not correlate with lateral patellar displacement. Therefore, the authors suggested that the static clinical measurements of Q angle are not related to the PFPS.

However, these results question the classical assumption that increased patellofemoral stress is the result of the patella moving towards the femoral condyle. Although it seems to be a reasonable explanation, during activities that reduce weight, the contact between the patella and the femoral condyle may result of an excessive rotation of the femur under the patella[31]. Thus, to analyze the Q angle during activities that do not reduce weight (clinical test of the Q angle) can be a potential source of bias because the femur remains fixed throughout the measurement and as it is well established in the literature, the femoral rotation seems to be an important factor in the occurrence of an abnormal Q angle[31].

Regarding the findings of the foot posture, a possible explanation is that the theoretical model that underlies the relation between the subtalar hyperpronation and individuals with PFPS[32] is based on a dynamic condition. It was proposed that the excessive range of motion of the subtalar pronation during the stance phase of the gait would result in excessive internal rotation of the tibia, that would delay or reduce the range of external rotation of the tibia towards the femur. This movement is essential to allow the extension of the knee during the stance phase, with this, as compensatory mechanism the femur would perform excessive internal rotation which would decrease the patellofemoral joint contact area and, therefore, increase the lateral compression and the stress in the joint and cause the development of the PFPS[32]. Recently, in the study by De Oliveira Silva et al. (2015)[2], the authors evaluated individuals with PFPS in dynamic and static conditions and found out that in the dynamic condition the majority of individuals presented excessive subtalar pronation, however, the same individuals showed no change in the clinical trial for the posture of the subtalar pronation.

Future studies that address the use of dynamic and functional tests for the characterization of these individuals are necessary, static test results have not been effective, contrary to the ones showed by the biomechanical parameters under functional conditions. Another issue that must be taken into consideration is the popularization of biomechanical tools in the clinical context, since they have shown better results. For example, a study of diagnostic accuracy was able to diagnose PFPS by means of electromyographic measurements[16]. The validation of low-cost electromyography can be an excellent alternative and would contribute to the characterization of PFPS in clinical reality.

The lack of studies that address prediction analysis of clinical trials in PFPS limited the discussion of this study with the literature. Another limitation that can be pointed out was the non-inclusion of dynamic clinical trials to prove the raised hypothesis that dynamic tests

can better predict PFPS. However, the authors have chosen to use the two classic tests often included in the characterization of individuals with PFPS.

CONCLUSION

The presented results show that the clinical tests of measurement of the Q angle and posture of subtalar pronation are not good predictors of pain and functional limitations mentioned by individuals with PFPS.

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