Original research

Does the change in Q angle magnitude in unilateral stance differ when comparing asymptomatic individuals to those with patellofemoral pain?

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**A R T I C L E   I N F O**

Article history:
Received 25 August 2011
Received in revised form 29 November 2011
Accepted 21 February 2012

Keywords:
Q angle
Knee
Patella
Pain

**A B S T R A C T**

Objective: To determine if Q angle changes in magnitude from bilateral stance when compared to unilateral stance and then if they are significantly different changes related to the presence of patellofemoral joint pain.

Design: Observational correlation.

Setting: University biomechanics laboratory.

Participants: 60 Asymptomatic females and 12 females with patellofemoral joint pain.

Main outcome measure: Bilateral and unilateral stance Q angle.

Results: Sixty females had their Q angles measured in bilateral and unilateral stance. Linear regressions showed predictive equations and positive correlations for unilateral and bilateral stance Q angles (r = 0.81–0.89, p < 0.001). The equations generated were used to predict unilateral Q angle from bilateral Q angle measurements in 12 patients with patellofemoral joint pain. The actual unilateral Q angle measurement of the symptomatic knee was significantly greater than that predicted for each individual (p = 0.01), whilst the asymptomatic knee showed no significant difference (p = 0.16).

Conclusion: This study showed a strong positive relationship between bilateral and unilateral stance Q angles which could be represented in a positive linear regression equation. The linear regression equation was then used to predict the effect on the Q angle of moving from a bilateral to a unilateral stance. It has been found previously that patients with patellofemoral joint pain on loading the limb in unilateral stance in activities such as walking and stair descent have increased knee valgus angle. The current study supports these findings indicating that when taking up unilateral stance patients with patellofemoral joint pain demonstrate greater than expected increase in Q angle which could increase loading on the patellofemoral joint.

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1. Introduction

When viewed in the frontal plane, the quadriceps does not function in a true vertical plane and so functions at an angle (Grelsamer & Klein, 1998). The resultant angle is commonly referred to as the quadriceps (Q) angle. The Q angle is the force vector formed between the pull of the quadriceps femoris muscle group on the patella relative to the alignment of the patella tendon. Clinical estimates of this force vector can be formed by drawing a line connecting the anterior superior iliac spine (ASIS) to the midpoint of the patella, this vector is then related to the alignment of the patella tendon connecting the midpoint of the patella to the tibial tubercle (Lathinghouse & Trimble, 2000).

Q angle is frequently cited as a possible predictor of knee pathology and lower limb injury (Rauh, Koepsell, Rivara, Rice, & Margherita, 2007). Abnormally high Q angles in excess of 15° for males and 20° for females are regarded as an anatomical risk factor in the aetiology of overuse injuries of the knee (Ilahi & Kohl, 1998; Rauh et al., 2007). In spite of this, there is currently an inability among health professionals to conclude what should be considered as a ‘normal’ angle (Wilson & Kitsell, 2002). Subsequent to this questions have arisen as to the validity of linking excessive Q angles with the occurrence of knee pathologies and other lower limb injuries, resulting in doubts concerning the diagnostic value of the Q angle (Livingston & Mandigo, 1998). These findings could be somewhat explained by the methods used for the measurement of Q angle (Wilson & Kitsell, 2002).

The reliability of measurement for the Q angle remains a contentious topic with studies by Caylor, Fites, and Worrel (1993) and Lathinghouse and Trimble (2000) reporting different levels of...
reliability ranging from fair to very good (correlations from \( r = 0.22 \) to \( r = 1.0 \)). In addition conventionally Q angle is a static bilateral measurement used for the prediction of dynamic often unilateral movement dysfunction, with the majority of patients describing symptoms occurring during unilateral activities such as walking, running and stair ascent and descent (Herrington & Al-Shehri, 2007). Investigations by Cornwall and McPoil (1996) and Pantano, White, Gilchrist, and Leddy (2005) demonstrated bilateral static measures to be poor predictors of problems in these patients who appear to have dynamic unilateral dysfunction. Measuring Q angle in bilateral stance would appear somewhat functionally unrelated to the incidence of injury occurring in relation to activities in a unilateral stance and may mask the underlying unilateral movement dysfunction.

It would therefore appear logical to assess the affect of unilateral stance on Q angle, which may give more functional validity to this measure, though no previous research appears to have undertaken this. Therefore, the first aim of this study was to determine what changes in Q angle might be occurring when moving from bilateral stance to a unilateral stance, in an asymptomatic population. Once this was established, then use this information to define if there is a predictable relationship between the positions. Then finally compare if patients with patellofemoral pain syndrome have a different relationship between bilateral and unilateral stance Q angles than that which has been predicted from the “normative” data, which may relate to different loading patterns at the patellofemoral joint.

2. Method

2.1. Subjects

Sixty female subjects, ranging from 18 to 38 years of age (mean 21.9 ± 4.1 years), with no history of lower limb, pelvic or spinal pathology recruited from the host university sports courses, participated in the first element of the study to develop the linear regression equations and establish normative values. Twelve female patients with unilateral patellofemoral pain, age ranging from 20 to 38 years (mean 24 ± 3.2 years) recruited from the host university sports injury clinic, formed the symptomatic comparison group. These subjects were examined by an experienced musculoskeletal clinician to establish that they met the required inclusion and exclusion criteria shown in Table 1 along with only having unilateral pain, which were based on those used by the authors of previous studies (Herrington & Al-Shehri, 2007). All subjects gave written informed consent to participate and the research was approved by a University Research and Ethics Committee.

2.2. Procedure

All subjects had their anterior superior iliac spines (ASIS), tibial tubercles and midpoint of their patella marked bilaterally by the same examiner. All subjects stood barefoot on lines marked on the floor corresponding to the width of their pelvis with their feet aligned parallel along these lines. Q angles were then measured in bilateral and unilateral stance positions from images taken using digital photography. The Q angles for each position were measured by obtaining a digital photograph of the subject using a Fuji Finepix S304 digital camera (with a picture resolution of 3 megapixels). The camera was positioned on a tripod 3 m away from the subject, with camera height set to the individual’s patella height, the subject was framed within the picture to maximise the limb within the frame, and the settings of the camera remained constant for all pictures taken. The photograph was then loaded onto a PC and the angles were calculated using ImageJ computer software (http://rsb.info.nih.gov/ij/download.html). The Q angle was measured by using the software to calculate the intersection of the lines between the ASIS and patella and tibial tubercle and the patella. Three images were taken for each position with the average values for each subject being used for further analysis.

2.3. Analysis

Statistical analysis of all data was carried out using SPSS version 13.0 for Windows. Paired samples T-tests were conducted to compare stance positions and linear regressions used to formulate predictive equations for Q angles.

3. Results

Fig. 1 shows the average Q angles for each position for asymptomatic subjects. Statistical analysis (paired t-tests) revealed significant differences between both bilateral positions and unilateral stance positions (\( p < 0.005 \)) for asymptomatic subjects. Linear regression showed predictive equations and positive correlations for unilateral and bilateral Q angles. The equation therefore then allowed for the prediction of unilateral Q angle from the bilateral Q angle measurements. An example of a linear regression

![Figure 1: Average (± standard deviation) Q angles for normal asymptomatic subjects.](image-url)
interactive graph for bilateral against unilateral conditions is presented in Fig. 2.

The equations generated were then used to predict unilateral Q angle from bilateral Q angle measurements in 12 patients with PFP. The actual unilateral Q angle measurement of the symptomatic knee was significantly greater than that predicted for each individual ($p = 0.01$), with the mean difference being $2.3^\circ$ greater, whilst the asymptomatic knee showed no significant difference between the predicted and actual measured unilateral Q angle ($p = 0.16$) (Fig. 3).

4. Discussion

The Q angles found in this study for female subjects during bilateral stance were in line with those previously reported (Guerra, Arnold, & Gajdosik, 1994; Livingston & Mandigo, 1998). This study has presented new findings showing significant differences between the Q angle measured during bilateral and unilateral conditions for asymptomatic female subjects. The study undertaken has also been the first to present data showing a strong positive relationship between bilateral and unilateral stance Q angles which could be represented in a positive linear regression equation. The linear regression equations generated by this study made it possible to predict the effect on the Q angle of moving from a bilateral to a unilateral stance in asymptomatic individuals, which from the numbers in the study could be regarded as a normal response for the population studied.

The patients with patellofemoral joint pain when moving from a bilateral to a unilateral stance, did not show this typical predictable response on their symptomatic leg, with the Q angle found being significantly greater than the value predicted using the predictive linear regression equations reported in this study. This pattern did not occur in their asymptomatic leg of the patellofemoral pain patients, the Q angle followed the predictable decrease expected.

Wilson and Kitsell (2002) commented on the lack of a clear relationship between Q angle and the presence of knee pathology suggesting this was due to the variety of methods adopted to measure Q angle. The methodological issues of previous studies might be one issue why only an inconsistent relationship has been found between Q angle and the presence of pathology, but in their systematic review Smith, Hunt, and Donell (2008) found the majority of studies to have adequate ($r > 0.4$) or better reliability and the range of measurements were generally consistent across the method of measurement, that is lying or standing goniometric or photographic. Another reason for the poor relationship might be that the Q angle is a static anatomical measure which does not reflect what is happening to the limb under unilateral load. The aim of this study was to provide data which more accurately reflects the quadriceps force vector or Q angle by describing the Q angle in unilateral stance to address this issue.

The data presented within this paper would indicate that when Q angle is measured during unilateral stance there is a consistent and predictable decrease in the angle in normal asymptomatic individuals and in the asymptomatic limb of patellofemoral pain patients. But, in the symptomatic limb, when weight bearing it fails to show the predicted decrease in Q angle, actually demonstrating a significant increase in Q angle during the unilateral stance. Elias, Cech, Weinstein, and Cosgrove (2004) showed that changing Q angle had a significant effect on patella loading, indicating that the PFP patients in the study maybe increasing patellofemoral joint stresses because of their increased Q angle which in turn increases the lateralisation of the patella, which might then be related to their symptoms.

The reasons why this change is occurring were not addressed in the current study, but could possibly be related to poor control of pelvo-femoral and/or foot and tibial motion. Barton, Bonanno, Levinger, and Menz (2010) found patellofemoral patients to have significantly greater foot mobility and pronated foot posture which if they were unable to control dynamically could increase Q angle on unilateral stance. Similarly, decreased strength in the hip abductors has been associated with increased knee joint displacement medially during which could also relate to increased Q angle in unilateral stance (Jacobs, Uhl, Mattacola, Shapiro, & Rayens, 2007).

The study undertaken showed patellofemoral pain patients to have significantly greater than predicted than normally would be expected Q angles. These findings to a degree reflect those of Willson and Davis (2008) which showed that despite increasingly demanding tasks, patellofemoral pain patients demonstrated similar lower extremity mechanics in relation to controls involving with relatively increased frontal plane projection angle.

Fig. 2. Plot of relationship between bilateral and unilateral Q angle for normal asymptomatic subjects.

Fig. 3. Average (± standard deviation) bilateral, unilateral and predicted Q angles for patellofemoral pain group.
5. Conclusion

The study found that in asymptomatic individuals Q angle decreased in a consistent and predictable manner when moving from bilateral to unilateral stance. Patients with patellofemoral pain failed to follow the predicted change in Q angle demonstrating significantly greater Q angles than those predicted, which could increase loading on the patellofemoral joint.

Conflict of interest
None declared.

Ethical approval
The project was approved by the University of Salford Research ethics committee. All subjects signed consent documents to participate.

Funding
None declared.

References


