Men and women have similar Q angles

A CLINICAL AND TRIGONOMETRIC EVALUATION

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The Q angle is an important determinant of patellar tracking, though its clinical relevance is debatable. One controversy centres around any possible differences in its value between men and women. The accepted, though unproven explanation, for the greater Q angle in women is that a woman has a wider pelvis. However, because of the long distance between the pelvis and patella, relative to the distance from the patella to the tibial tuberosity, large changes in the position of the anterior superior iliac spine are necessary to effect significant changes in the Q angle. In our study of 69 subjects, we did not find such large differences in the position of the anterior superior iliac spine, and found a mean difference of only 2.3° between the Q angles of men and women.

Furthermore, we found that men and women of equal height demonstrated similar Q angles, with taller people having slightly smaller Q angles. The slight difference in Q angles between men and women can be explained by the fact that men tend to be taller.

The Q angle is the angle subtended by the intersection of a line drawn from the anterior superior iliac spine to the centre of the patella and another line connecting the centre of the patella to the centre of the tibial tuberosity. It is responsible for the bowstring effect, whereby the patella tends to move laterally as the quadriceps contract.

The clinical value of measuring the Q angle, however, is more controversial since there is no specific correlation between patellar symptomatology and an increased Q angle.¹ However, an elevated Q angle itself may influence the choice of surgical procedure in a patient who requires patellar re-alignment. Despite these controversies it is relevant to dispel some lingering misconceptions, one of which being that women have higher Q angles than men, on the basis of a wider pelvis.^{2,3}

If women were to have a wider Q angle this could only be because of a relatively lateralised anterior superior iliac spine. The other two determinants of the Q angle, the position of the patella and of the tibial tuberosity, are accepted as being equal in the two genders as evidenced by the fact that knee replacement jigs are set similarly for men and women.

Our main aim was to determine to what extent a woman's pelvis must be wider than a man's in order to increase the Q angle significantly. We thus measured the Q angle for men and women and assessed their pelvic width. It

was not our goal to establish normal values for the Q angle, nor to compare patients who were healthy with those who were symptomatic, nor to promote or discourage the use of the Q angle.

Patients and Methods

Trigonometric analysis. Through the use of trigonometry and Pythagoras' theorem, it is possible to determine the extent to which a pelvis must be wider or narrower to cause any change in the Q angle. In order to perform these calculations, we placed the Q angle as part of a triangle with the hypotenuse formed by a line connecting the anterior superior iliac spine with the centre of the patella, the leg formed by a vertical line extended from the centre of the patella, and the base formed by a line extending from the anterior superior iliac spine and perpendicular to the vertical line extended from the centre of the patella.

Consequently, the trigonometric relationship between the Q angle and the mediolateral position of the anterior superior iliac spine is that the tangent of the Q angle is equal to the mediolateral position of the anterior superior iliac spine (the base of the triangle, BC) divided by the vertical line AC (Fig. 1).

Using this basic trigonometric approach it is possible to calculate the effect of an arbitrary 2 cm lateralisation of the anterior superior iliac spine on the Q angle as well as the amount of

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Fig. 1

Trigonometric figure analysis of a right triangle (A, centre of patella; B, anterior superior iliac spine; C, extension of line AD; D, tibial tuberosity; Q, Q angle).

lateralisation needed to change the Q angle by an equally arbitrary 5°. In this study we chose a man who was 168 cm tall, and measured the distance AB from his patella to his anterior superior iliac spine to be 50 cm and his Q angle to be 13°.

Clinical analysis. We studied 69 subjects (45 men and 24 women) who attended an orthopaedic clinic and compiled a database documenting the age, gender, height, and weight of each individual. The mean age for men was 30.2 years

(17 to 52) and 28.8 years (17 to 48) for women. The mean height for men was 172.5 cm (155 to 187.5) and 161.0 cm (150 to 170) for women. The mean weight was 75.1 kg (62.7 to 100) for men and 55.9 kg (41.8 to 79.5) for women.

We measured the Q angle by placing the centre of a customised translucent protractor on the centre of the patella, with the long arm of the protractor bisecting the centre of the anterior superior iliac spine and the short arm bisecting the centre of the tibial tuberosity.

The Q angle was measured on the right leg of each subject. The subjects were supine, their quadriceps relaxed and their knees flexed 10°. The hip and leg were maintained in neutral rotation with the patella pointing upwards. No specific screening was undertaken for patellar pain or pathology. A fresh ink mark was placed over the tibial tuberosity, the centre of the patella and the anterior superior iliac spine prior to each measurement. Because the protractor was sufficiently long to span the area encompassed by the Q angle, there was no need to project the proximal limb of the protractor up to the anterior superior iliac spine visually, as would be the case for a standard protractor. The distance from one anterior superior iliac spine to the other (our definition of pelvic width for this study) was measured by a large caliper (Spinal Technology, West Yarmouth, Massachusetts).

Each Q angle and anterior superior iliac spine measurement was performed four times on each person, as two examiners performed and read the measurement twice, with a ten-minute interval between repeat measurements. Both the dial of the Q angle protractor and the anterior superior iliac spine caliper markings were covered, so that the examiner remained unbiased by previous measurements; examiner A placed the device on the patient, and examiner B performed the reading without informing examiner A of his finding. The two examiners then changed places. This approach reduced the possibility that one examiner could be influenced by the other's reading, or by his own previous reading. Measurements were made to the nearest whole degree and to the nearest millimetre. After ten minutes, the exercise was repeated. Both intra- and inter-observer variability were determined.

Statistical methods. After screening for a normal distribution, parametric tests were applied to the continuous data. Comparisons between groups were performed using Student's *t*-test. A stepwise linear regression was performed to determine the interaction of all variables in the database on the prediction of the Q angle. Statistical significance was assumed for an alpha level < 0.05. Non-significant tests were subjected to *post hoc* power analysis where a beta level < 0.20 was assumed to yield a reasonable likelihood that the lack of significance was not created by an insufficient sample size alone. The kappa statistic was computed for both intra- and inter-observer reliability. Significance levels for the kappa value were determined according to the method of Landis and Koch.⁴

Results

Trigonometric analysis. Trigonometric analysis indicated that lateralisation of the anterior superior iliac spine by 2 cm (i.e. a 4 cm wider pelvis) would result in only a 2° change in the Q angle. Conversely a 5° increase in the Q angle would require the anterior superior iliac spine to be lateralised by as much as 4.3 cm (i.e. an 8.6 cm wider pelvis).

Clinical measurements

Q angle. A very slight gender-based difference was noted in the Q angle, with the mean being 13.3° in men and 15.7° in women ($p = 0.005$). The overall standard deviation was 4.5°. The intra-observer variability for Q angle measurement was 0.91 and the inter-observer reliability was 0.63.

Pelvic width. The mean pelvic width was 24.1 cm in men and 24.2 cm in women ($p > 0.05$). However, our sample size of 69 patients was of sufficient size (power = 0.95) to exclude a type II (beta) error. The intra-observer variability for the measurement of pelvic width was 0.93 and the inter-observer reliability was 0.78.

There was no correlation between pelvic width and gender. That is, the width of a woman's pelvis was not statistically different from that of a man's when the two anterior superior iliac spines were used as a measure of width. It might clearly be different if the most lateral aspect of the iliac wings was used instead.

Linear regression of the Q angle on pelvic width, age, gender, height and weight was performed and revealed a significant association between the Q angle and height and the Q angle and mean pelvic width. Adjusting for age, weight, pelvic width, and gender the Q angle decreases by 0.2° for each individual centimetre of height ($p = 0.05$). The combined effects of gender, age and pelvic width are not statistically significant ($p = 0.42$). The women in this study were a mean of 11.5 cm shorter than men, a difference that is comparable to the height difference previously found in a study of the North American population.⁵ This height discrepancy explains the 2.3° gender difference in the Q angle.

There was no correlation between pelvic width and height ($p = 0.112$). However, in multivariate analysis the pelvic width did not independently contribute towards predicting the Q angle after the effect of height had been taken into account.

Discussion

The biomechanical principle of the Q angle has been recognised for more than 100 years and it has gradually come to be an accepted part of the patellar examination. Though the Q angle may be increased in patients with patellar instability, it does not correlate well with patellar pain.¹ Furthermore, measuring the Q angle is cumbersome when using a long protractor and potentially inaccurate when using a short one. The Q angle cannot be measured intra-operatively because the surgical drapes make the anterior superior iliac spine relatively inaccessible and the surgeon therefore cannot quantify intra-operatively the result of any tibial tuberosity transfer he might have performed. Should

surgery be required, the magnitude of the Q angle can affect the choice of realignment procedure, and some of the criticisms leveled at the Q angle appear to be insignificant or incorrect. For example, it has been shown that the Q angle changes when a subject is moved from a supine to a standing position,⁶ but the discrepancy is small when judged against the accuracy of a standard protractor. Woodlands and Francis⁶ reported that the mean difference in Q angle for men in the supine as opposed to the standing position was 0.9° while the mean difference in Q angle for women in the supine as opposed to the standing position was 1.2°.

As for the difference between men and women, Livingston and Mandigo,⁷ as well as Skalley, Terry and Teitge,⁸ noted little difference between the Q angles of men and women. In studies which did find a difference, such as those of Woodlands and Francis,⁶ Aglietti, Insall and Cerulli,⁹ Horton and Hall,¹⁰ and Hsu et al¹¹ the differences ranged from 3° to 4.6°, a difference which appears insignificant when judged against the inaccuracy of a standard protractor. In our study, using a long protractor we found an absolute difference of 2.3° between men and women, a small discrepancy which disappeared altogether when height was taken into account.

When assessed at its widest point, the pelvis of a woman is accepted as being wider than that of a man and it is logical to assume that their anterior superior iliac spine is also more lateralised. However, this is a false assumption. If a woman's anterior superior iliac spine were more lateralised, the pull of the quadriceps would also be more lateral, and women would have a higher incidence of patellar instability after knee replacement surgery than men, which is not the case. Moreover, the surgeon undertaking a knee replacement sets the angle on his femoral intramedullary jig to the same angle in both men and women, further suggesting that men and women exhibit similar femorotibial valgus.

Even if women did have wider pelvises at the level of the anterior superior iliac spine, the effect on the Q angle would be minimal. Because the anterior superior iliac spine is so far from the patella, seemingly important mediolateral translations of the anterior superior iliac spine have little effect on the Q angle. For example, our trigonometric analysis indicates that a 2 cm mediolateral shift of the anterior superior iliac spine only changes the Q angle by 2° in a person who is 168 cm tall. This 2 cm is much greater than the difference in the position of the anterior superior iliac spine between men and women. In contrast, a shift as large as 4.3 cm would be required to effect a 5° change in Q angle in a person who was 168 cm tall. This shift is much greater than the difference we identified between men and women.

Few studies have studied the inter- and intra-observer reliability of the Q angle. We found the intra-observer variability to be 0.91, reflecting excellent agreement for the same observers.⁴ Landis and Koch⁴ reported that an observer variability from 0.61 to 0.80 reflected substantial agreement while an observer variability from 0.81 to 1.00 reflected almost perfect agreement.

Inter-observer reliability, at 0.63, was significantly lower, though still within the range of substantial agreement. It was not the purpose of this paper to pass judgement on the value of the Q angle based on the reliability values we obtained. Our study was performed with an optimal protractor, something which cannot readily be duplicated in other clinics, so that the variability we report might be better than values which might be obtained in the common clinical setting.

Our study shows that large changes in the position of the anterior superior iliac spine are necessary in order to effect significant changes in the Q angle. This is because of the long pelvis-patella distance relative to the patella-tibial tuberosity distance. We found there is no correlation between the Q angle and gender when height is taken into account. Lower Q angles are associated with taller subjects, and, because men are generally taller than women, they tend to have slightly lower Q angles. Although women have a wider pelvis in the traditional sense, the anterior superior iliac spine in women is no more lateralised than in men.

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