



## Research Article

# Bilateral Variability of the Quadriceps Angle (Q angle) in an Adult Kashmiri population

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### Abstract

**Objective(s):** *The objective of this study was to document and explain bilateral differences in the Q angle in adult Kashmiri population.*

**Materials and Methods:** *Four hundred limbs of healthy adult Kashmiri volunteers were studied. The Q angle was measured with a goniometer with the subjects supine, quadriceps relaxed and lower limbs in neutral rotation. The position of the tibial tuberosity with respect to the centre of the patella was measured. Appropriate statistical tests have been used in this study to determine the bilateral variability in the Q angle and lateral placement of tibial tuberosity in the adult population. Inter-observer variation parameters mentioned above were studied in fifty limbs.*

**Results:** *The average value of Q angle of all the 200 limbs was 12.73 °C; the mean value on the right being 12.86 °C and 12.60 °C on the left. A significant difference was noted in males when the Q angle and the lateral placement of the tibial tuberosity were considered in pairs. The Q angle value on the right side was quite often greater than the left. The relative position of the tibial tuberosity showed a significant positive correlation with the Q angle. The correlation coefficient was 0.66 for the Q angle and 0.8 for the lateral placement of the tibial tuberosity.*

**Conclusion:** *The present study shows that bilateral variability in the Q angle could be attributed to an alteration of the relative lateral placement of the tibial tuberosity with respect to the centre of the patella.*

**Keywords:** *Bilateral variability, Q angle, Tibial tuberosity.*

### Introduction

Brattstrom was the first to define Q angle which was described as the angle formed between the ligamentum patellae and the extension of the line formed by the quadriceps femoris muscle resultant force, apex being at the patella<sup>(1)</sup>. Later on, Q angle was measured using the anterior superior iliac spine (ASIS) as the proximal landmark<sup>(2)</sup>.

This angle provides an estimate of the vector force between quadriceps femoris muscle and the patellar tendon<sup>(3)</sup>. This angle is formed by two imaginary lines, first line extending from the ASIS to the centre of the patella (CP) and the second line from the tibial tuberosity (TT) to the centre of patella. This Q angle has been accepted as an important factor in assessing knee joint

function<sup>(4)</sup>. Any increase in Q angle beyond the normal range is considered as indicative of extensor mechanism malalignment, and has been associated with patellofemoral pain syndrome, knee joint hypermobility and patellar instability<sup>(5-7)</sup>. Its role in assessing other lower extremity injuries in sports and military populations has also been documented<sup>(8)</sup>. Though bilateral differences in the Q angle have been documented, most studies so far done have concentrated on between-group rather than within-subject differences<sup>(9-12)</sup>. Substantial amounts of bilateral asymmetry in the Q angle values has been demonstrated when analyzed on an individual basis<sup>(9, 13)</sup>, which has been attributed to bilateral asymmetry in the quadriceps muscle strength<sup>(13)</sup>. The aims of this study were, to observe bilateral differences in the mean Q angle, to study whether there was any difference of the above findings between the two sexes and the possible explanation for the findings in an adult Kashmiri population.

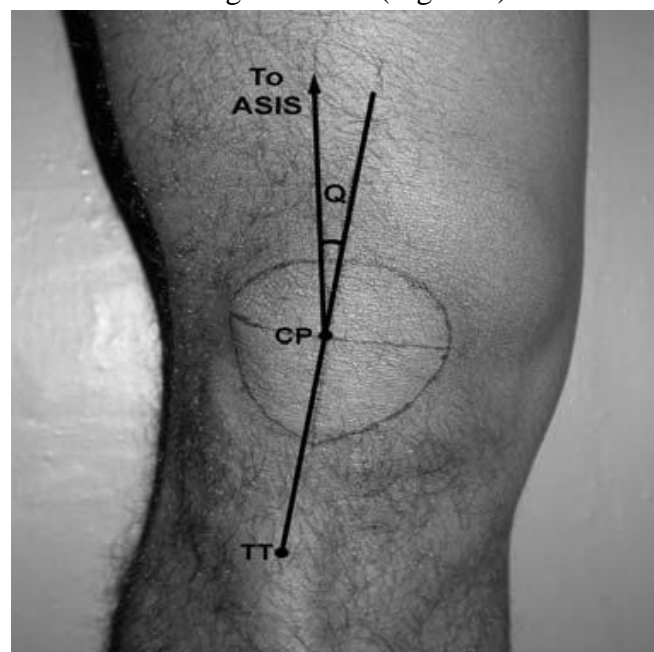
### Materials and Methods

The healthy adult volunteers who came in opd for complaints unrelated to lower limbs were taken as subjects. An informed written consent was taken from volunteers after explaining the procedure to them. A total of 400 lower limbs (200 subjects consisting of 100 males and 100 females) were studied. Males and females of the age of 18 years and above were included in the study, mean age of the subjects was 23 years (range 18-45 years). Criteria for the study were same as described by Belchior *et al*<sup>(14)</sup>, subjects with a history of the following conditions were excluded from the study: 1) Any previous or recent history of fracture of the lower limb, patellar dislocation and spinal cord pathology with lower limb involvement. 2) Anterior or retropatellar pain upon squatting, kneeling or jumping. 3) Any history of surgical procedure on the knee. All measurements were taken once by a single investigator. Fifty measurements (bilaterally in twenty subjects) were performed independently by another

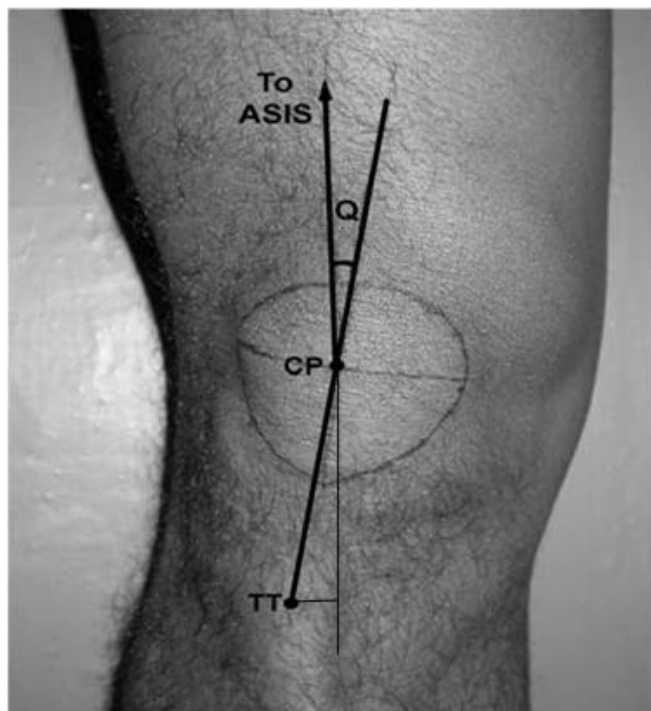
observer after one week to assess inter-observer variability.

### Measurement of the Q angle

A goniometric method was adopted while measuring the Q angle (15). The Q angle was measured with the subject supine, pelvis squared, lower limbs extended at the knee joint and the quadriceps muscle relaxed. The feet were placed in the neutral rotation, such that the toes were pointing directly upwards and the feet perpendicular to the resting surface. The bony landmarks which were marked with a marker pen are: ASIS, CP and centre of the TT. The outline of patella was drawn, after palpating its borders and making sure that the skin was not stretched in doing so. The Centre of Patella (CP) is defined as the point of intersection of the maximum vertical and transverse diameters of the patella. The point of maximum prominence is defined as the centre of the tibial tuberosity (TT). Line drawn from the ASIS towards the CP using the straight edge of a measuring tape represented the longitudinal axis of the femur. Another line was formed by joining the centre of the CP and the TT and then extended upwards. This angle formed between the above two lines is defined as the Q angle and was measured with a goniometer (Figure 1).



**Figure 1** Measurement of the Q angle. ASIS – anterior superior iliac spine; CP-centre of patella; TT-tibial tuberosity; Q- quadriceps angle.



**Figure 2.** Determination of the relative lateral placement of the tibial tuberosity with respect to the centre of patella. CP -centre of patella; TT-tibial tuberosity; A-point of intersection of vertical line drawn from CP and horizontal line drawn from TT; d-lateral placement of TT

#### Measurement of relative position of CP and TT

A digital photograph of the knee joint with the markings mentioned as above was taken with a scale and then lateral placement of TT was calculated as follows using Adobe Photoshop software. A vertical line was drawn inferiorly from the CP at first and then horizontal line was drawn from the TT to meet the above line at A (Figure 2). The distance between TT and A (d in Figure 2) was measured which represented the lateral placement of the TT with respect to the CP.

#### Statistical Analysis

The mean and standard deviation for the Q angle values and the lateral placement of the TT on the right and left side were separately calculated and bilateral differences between these two values were tabulated. P value was calculated between groups using the Mann-Whitney U test for the Q angle values and the lateral placement of the TT. p value < 0.05 was taken as significant. The Wilcoxon sign rank test was used to calculate

significant bilateral differences in the above parameters in an individual. The Spearman's rank order correlation coefficient between the Q-angle and the lateral placement of the tibial tuberosity was calculated. All the statistical analysis was performed using SPSS version 10.0 for Windows.

#### Results

The average Q angle value of all the 400 limbs was 12.73 °C. The mean Q angle value on the right side was 12.86 °C as compared to 12.60 °C on the left. The mean values of the Q angle and the lateral placement of the TT did not show any significant bilateral differences. However, on comparing the values of the Q angle between the right and left Side in pairs, significant bilateral variability was noted (Table 1). The significant positive correlation ( $r= 0.49, P< 0.001$ ) was found between Q angle and the lateral placement of the TT. The interobserver correlation coefficients for the Q angle and lateral placement of the TT were 0.66 and 0.80 respectively. In males, the average Q angle value of the 200 limbs was 10.98 °C. The value on the right side being 11.24 °C as compared to 10.24 °C on the left. The mean values of the Q angle did not show any significant bilateral differences. However, the mean lateral placement of the TT was significantly greater on the right side as compared to left. Paired comparison of the Q angle and the lateral placement of the TT between the right and left side revealed significant differences (Table 1). A mean Q angle value of 14.48 °C was noted in the 200 female limbs. The mean Q angle value on both right and left sides was 14.48 °C and no bilateral differences in the mean values of the Q angle and the lateral placement of the TT were observed. When the values of the Q angle and the lateral placement of the TT were compared in pairs between the right and left side no such significant bilateral variability was noted (Table 1). When the difference between the right and left Q angles was calculated it was found that in 36% of the subjects there was no bilateral difference. The Q angle was oftenly found greater on the right

side as compared to the left, both in males and females. However bilateral asymmetry in both the

values was more commonly seen in males (Table 2).

**Table 1** Bilateral comparison between Q angle values and placement of the tibial tuberosity d- lateral placement of tibial tuberosity; n - number of limbs studied; SD – standard deviation;

	Parameter subjects(n)	Right (Mean±SD)	Left (Mean±SD)	Significance (P value) Between groups	Significance (P value) Within Subject
	All(400)	12.86 ± 2.36	12.6 ± 2.78	0.20	0.02
Q angle	Male(200)	11.24 ± 1.67	10.24 ± 2.29	0.10	0.01
	Female(200)	14.48 ± 1.76	14.48 ± 3.03	0.44	0.28
	All(400)	1.40 ± 0.74	1.31 ± 0.80	0.13	0.08
D	Males(200)	1.1 ± 0.46	0.82 ± 0.44	0.004	0/003
	Females(200)	1.78 ± 0.64	1.86 ± 0.66	0.33	0.18

**Table 2** Individual differences between Q angle values on the right and left sides.

Difference between right and left Q angle in degrees	Right= Left		Right >Left		Left > Right	
	Males (n = 100)	Females (n = 100)	Males (n = 100)	Females (n = 100)	Males (n = 100)	Females (n = 100)
0	12 (24%)	24 (48%)	-	-	-	-
1	-	-	19 (38%)	11 (22%)	10 (20%)	4 (8%)
2	-	-	5 (10%)	3(6%)	2 (4%)	1(2%)
3	-	-	1 (2%)	3 (6%)	0	1 (2%)
>3	-	-	1 (2%)	0	0	3 (6%)

**Table 3** Comparison between different studies on the bilateral variability in the mean Q angle

Author	Year	Number of normal subjects studied	Bilateral variability in mean Q angle values	Method of measurement	Details
Hahn and Foldspang	1997	339	R>L	Universal goniometer	Supine position with quadriceps relaxed, and legs strapped together
Livingston and Mandigo	1997	50	L>R	Universal goniometer	Standing position with quadriceps relaxed
Byl and Livingston	2000	34	R>L	Universal goniometer	Standing position with the medial borders of the feet in contact
Livingston and Spaulding	2002	20	R>L*	OPTOTRAK	Standing position with quadriceps relaxed and the feet in Romberg stance
Sra <i>et al</i>	2008	70	L>R*	Universal goniometer	Standing position with quadriceps relaxed and the feet in Romberg stance Present study
Present study	2009	100	R>L	Universal goniometer	Subjects supine with quadriceps relaxed and feet in neutral rotation

values R and L – right and left sides respectively

**Discussion**

Though numerous studies on Q angle have been conducted worldwide, only few of them have focused on its bilateral variability. Hahn and

Foldspang were among the first investigators who made a detailed study of the bilateral variability in the Q angle<sup>(10)</sup>. Following this, other studies have documented similar bilateral variations<sup>(9,11-13)</sup>,



some studies found that the mean Q angle on the right side was greater than that on the left<sup>(10, 11, 13)</sup> while in few studies the mean Q angle was more on the left as compared to the right<sup>(9,12)</sup> but in only two of the studies these differences were found significant<sup>(11,12)</sup>. In the current study the mean Q angle was greater on the right side as compared to the left but this difference was not statistically significant (Table 3).

The minor bilateral differences in the mean Q angle could be explained as a result of normal variation or minor errors in measurement, significant differences need further explanation. One of the explanations put forth for this variability is the bilateral difference in the quadriceps strength. It was found that the Q angle varied quite inversely with the peak torque angle during active knee extension<sup>(13)</sup>. However, in the studies which had shown significant bilateral differences in the Q angle, the quadriceps muscle was relaxed<sup>(11, 12)</sup>. In one of the studies, the sample size taken was relatively small (20 individuals), which could be the possible explanation for the significant bilateral difference in the mean Q angle<sup>(11)</sup>. Though many of the studies referred to above did not show significant bilateral differences in the mean Q angle, within-subject only few studies had shown significantly differences in the Q angle<sup>(9,13)</sup>. In previous studies, difference of less than 4 °C was noted in 32% of subjects by Livingston and Mandigo (9) and in 35% of subjects by Byl *et al*<sup>(13)</sup>. In the above studies the Q angle was measured while subjects being in the standing position. In the present study a difference of less than 3 °C was noted in about 96% of subjects, with bilateral variability greater in males as compared to females (Table 2). The increased variation noted in the other studies could be due to accentuation of bilateral Q angle differences due to weight bearing. The previous study done in India by Jha and Raza position of subject was supine<sup>(15)</sup>. For accurate comparison with the previous study we used a similar method, keeping in mind the effect of limb position on the magnitude of the Q angle.

The difference in males and females could be explained on the basis of greater asymmetric limb usage in males, leading to more bilateral variability in the quadriceps muscle tone in them. In the present study, there was no significant bilateral difference in the mean Q angle value but when considered as pairs there was a significant difference noted between the right and left sides. The ASIS being relatively fixed in position, it is less likely to be a cause for bilateral variability. Thus this variability can then be attributed to a relative alteration in the positions of the CP and the TT. The bilateral variability in this parameter was significantly greater in males as compared to females with a higher mean value on the right side (Table 1). The Q angle showed a significant positive correlation with the relative lateral placement of the TT. This indicates that any alteration in the relative placement of the distal two bony landmarks could be a cause for bilateral variability in the Q angle. In the present study, calculation of inter-observer correlation of 0.8 for the lateral placement of the TT with respect to the CP indicates that the method described in our study is a reliable one. The accurate determination of the Q angle needs the three bony landmarks to be precisely identified and measured. France and Nester found in their study that even small differences in the placement of the CP and TT could alter the Q angle greatly<sup>(16)</sup>. There is a subjective bias in determining the CP as it depends on marking of the point of intersection of the greatest transverse and vertical diameters. Also, in some subjects the centre of the TT cannot be determined precisely. In these subjects the TT is marked as plateau atop an elevation. Thus, the more accurate methods need to be used for validating these findings, such as those described by Roush *et al*<sup>(17)</sup>. Some authors have questioned the reliability and validity of the Q angle in evaluating and treating patello-femoral joint pathology (18-20). Smith *et al* in a systematic review of the literature found that in the measurement procedure of the Q angle there is a lack of standardization<sup>(21)</sup>. The inter-observer

variability in the Q angle has varied widely from 0.17 to 0.97 in different studies<sup>(18,22)</sup>. In the present study it was found to be 0.66. The inter-tester reliability of the Q angle could be improved by properly standardizing the method, and adequately trained testers<sup>(22)</sup>. In spite of the above limitations in our present study, we feel that it could have some value in explaining the side differences that exist in the values of the Q angle.

### Conclusion

The present study documents the bilateral variations in the Q angle in young healthy adults. All measurements in the study were made with the subjects supine, the quadriceps fully relaxed and the feet in neutral rotation. The relative lateral placement of the TT with respect to the CP was also noted. Mean Q angle measurements were marginally greater on the right side as compared to left when males and females were considered together. This difference was more in males, though insignificant. Even though bilateral mean Q angle values were not so significantly different, but when taken in pairs a significant difference was noted in males. On tabulating the differences between the Q angle values on the right and left, it was noted that the value was less than 3 °C in 96% of the subjects. The bilateral variability was noted greater in males as compared to females. The present study shows that this bilateral variability in the Q angle could be attributed to an alteration of the relative placement of the TT with respect to the CP on each side. Though the present study may not have any direct clinical applications but it is likely to be useful in explaining the side differences in the Q angle.

Prior publication- nil

Support- nil

Conflicts of interest- nil

Permissions- nil

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