



A Comparative Analysis of Quadriceps Angle (Q Angle) and Its Correlation to Anterior Knee Pain in Young Active Population (Amongst The Students of Santosh Medical College)

Nisha V Kaul¹, Yogesh Yadav², Amit Dwidi³, Manu Gupta⁴

^{1,4}Department of Anatomy, Santosh Medical College and Hospital

²Department of Anatomy, NIMS, Greater Noida

³Department of Orthopaedics, Santosh Medical College and Hospital, Ghaziabad, Uttar Pradesh, India.

ABSTRACT

The Q angle is an important reflection of biomechanical effect of quadriceps femoris on the movements of knee articulation & maintenance of proper posture. So, its evaluation is an important diagnostic method for evaluation of alignment of knee with that of hip, femur and tibia. Study included healthy students of the Santosh University Ghaziabad, aged 17-30 years who gave their consent to participate in the study after due explanations. The total no of subject's chosen was 300 students. This study was performed upon approval of the Ethics Committee on Human Research of Santosh University Ghaziabad. The clinical importance of conducting this study was explained to all participants. The mean of Right Q angle in Orthostatic parallel feet position is (13.12±1.76 degree) greater than the rest of the positions. A statistically significant difference was appreciated in the Q angle among males and females and in mean Q angle among patients of group 1 (patient having knee pain) and group 2 (patients having no knee pain). A significant negative correlation was found in the Q angles (right & left) with different knee positions (OPF, OAF, LFP, LAF) with height (cm) and age of the subjects. A highly significant correlation of each Q angle in different knee position (OPF, OAF, LFP, LAF) with the rest of the other angles in different knee position was found. Assessment of Q angle is very important and mandatory for picking early patellofemoral problems particularly in young adult athletically and physically active sports person.

Keywords: Quadriceps angle (Q angle), Orthostatic and Supine position, patello femoral articulation, gender, anterior knee pain.

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INTRODUCTION

The Quadriceps femoris angle or Q angle is defined as the angle formed between the quadriceps muscles and the patella tendon. The Q angle is considered an important reflection of biomechanical effect of quadriceps femoris on the movements of knee articulation & maintenance of proper posture [1]. The Q angle not only signifies quadriceps muscle force on patella, but also function and dysfunction of patello-femoral articulation [2]. It is considered as an important diagnostic method for evaluation of alignment of knee with that of hip, femur and tibia [3-5].

Q-angle representation

The angle is demarcated by drawing two imaginary lines. One line connects anterior superior iliac spine (ASIS) to the center of the patella. Another line connects center of the patella to the middle of the tibial tuberosity, thereby forming an acute angle i.e Q angle [6-8]. In general, the normal range of the value of Q angle is between 12 and 20 degrees. The values are higher in females as compared to males [9-10]. According to Davies and Larson (normal values considered for men are between 8° and 10° and for females up to 15°, a higher value (>20°) this indicate an abnormality [11]. An excessive lateral pull of the quadriceps femoris muscle on the patella increases Q angle value, leading to patello-femoral disorders. Hence a knowledge of Q angle value helps us in prognosis & the management of knee diseases [12-13]. Different normal values of Q angle for male & female have been given by different researches [14].

According to Kishali et al (2004), the Q angle value varied from 8 to 17 degrees irrespective of gender, being 15- 13.5 degrees in males & higher in females [15]. Esmaeili et al (2015), found Q angle value up to 15 degree irrespective of gender [16]. Horton and Hall (1989) observed Q angle value of 13.5° in general, with 15.8° in females & 11.2° in males. Livingston and Mandingo (1997) gave Q angle value of 15-20° in

general [17]. Variations in Q angle values obtained can be attributed to using different methods, different positions of subjects, subjects having bilateral symmetry or not and state of quadriceps femoris muscle (whether relaxed or in contractile state). It is claimed that Q angle value is an excellent indicator of effectiveness quadriceps mechanism on knee articulation and its functioning [18].

A correlation has been found between Q angle and various body parameters like gender, height, weight, condylar distance of the femur and the dominant side. Greater the angle, smaller is the quadriceps force. This justifies the occurrence of patello-femoral joint diseases in subjects with low quadriceps power and hence higher Q angle [19]. In addition Q angle value is also affected by position of patient (standing or lying down position) & internal/external rotation of lower limb [20]. Factors which maintain knee alignment along with good quadriceps force are considered essential for a good sports performance [21]. A non aligned knee complex articulation may predispose for anterior cruciate ligament injury [22]. A subject with misaligned extensor mechanism of knee with subsequent anterior knee pain, patellar subluxation or dislocation, will show an excessive Q angle value [23-25]. Patients who are athletically and physically active, but have latent misalignment features of the pelvis, leg, foot and the knee function, determination of Q angle is of immense importance for them to prevent further deterioration [25-27]. Hence it becomes more imperative to know the value of Q angle of those female subjects who indulge in vigorous walking, climbing stairs, participate in sports for their health purpose as long period participation in sports activities may lead to muscular imbalance [28-29]. Excessive wear & tear of patellar cartilage with damage to the articular surface of tibio femoral articulation in subjects who are athletes, can cause serious damage to the above articulations and can affect normal movements at knee joints [30].

For this purpose Q angle assessment is an important parameter for early diagnosis of many tibio femoral pathologies like degenerative knee disorders, anterior knee pain & osteoarthritis. Since Q angle is also related to movements of foot, hence unrestricted internal rotation of leg as a result of unrestrained pronation of foot, causes damage to the quadriceps mechanism and movements of patella. Hence such damage can be restricted by reducing excessive pronation movements. A person can land up pathological conditions like chondromalacia patella, lateral dislocation of the patella etc [31-33].

Effects of physical activity and sports on Q angle:

Though normal physical & sports activities are essential for normal Q angle value, yet athletic and overuse sports injuries of knee articulation are responsible for anterior knee pain, anterior cruciate ligament (ACL) injuries, subluxation of the patella having a high Q angle of 20°-22° [34].

MATERIAL AND METHOD:

The subjects for our study were healthy students of the Santosh University Ghaziabad, aged 17-30 years who were sought to participate in the study after due explanations. The subjects were selected randomly from the students of Santosh University Ghaziabad. The total no of subject's chosen was 300 (as per statistical calculation).

1. All ethical guidelines were duly followed. This study was performed upon approval of the Ethics Committee on Human Research of Santosh University Ghaziabad. The clinical importance of conducting this study was explained to all participants. A consent form was duly signed by every participant.
2. All the subjects showed their willingness to undertake their participation in this project without any force.

Inclusion criteria:

1. The participating subjects should not have history of any gross knee disease either due to injury or any disease.
2. For measuring Q angle, all landmarks should be easily palpable.

Exclusion criterion:

1. Subjects with neurological disorders
2. Obese subjects
3. History of bone bone injury
4. Pregnant ladies

Materials: Electronic universal Goniometer, electronic scale, weighing machine, marker pen

Procedure: The dress advised to be worn by subjects was a t shirt & half pant. A documentation of their age, gender, weight and height, history of their involvement in athletics and any history of anterior knee pain was prepared in a format. The anatomical bony points were marked with marker pen. Measurement of the Q angle in different positions was done following the principals laid by Hugo Machado Sanchez et al as follows [35].

Different four positions were:

1. Orthostatic with parallel feet - OPF

2. Orthostatic with abductees feet) – OAF
3. Lying with parallel feet - LPF
4. Lying with abducted feet - LAF.

Method of recording Q angle in any position:

The axis of the goniometer was placed on the midpoint of the patella, its stationary arm on the ASIS while the movable arm was aligned to the tibial tubercle. The angle thus obtained was recorded as the Q-angle in both lower limbs.

STAGE-I: Orthostatic with parallel feet – OPF: Subjects standing upright with the feet placed together touching medially (orthostatic with parallel feet), arms along the body & eyes facing forwards trying to keep the quadriceps relaxed.

STAGE-II: Orthostatic with abducted feet – OAF: standing position with heels apart by 7.5 cm, and an external rotation of forefoot by 10 degrees from the medium line (orthostatic with abducted feet).

STAGE-III: Lying with parallel feet – LPF: Subject was placed in the supine position with the hip in a neutral position with feet parallel and close to each other, (lying feet parallel) and relaxed quadriceps muscles.

STAGE-IV: Lying with abducted feet – LAF: Subject in the supine position with the feet (lying with abducted feet). Given in figures 1 -6.

Statistical Analysis

The whole data were analyzed using SPSS software. To compare the mean of the parameters for the two independent groups male and female, a t-test was performed and for the difference to be significant the p value has to be <0.05. Also, the same procedure was followed for the group with pain and without pain. To identify the association between the study parameters Pearson Correlation was calculated among the parameters of the study.



Fig- 1 showing markings of bony landmarks on the lower limb for measuring Q angle



Fig 2. measurement of Q angle with goniometer Fig 3. Q angle in orthostatic and parallel feet.



Fig 4. Q angle in orthostatic and abducted feet FIG 5 Q angle in lying with parallel feet.

Fig 6. Q angle in lying and abducted feet.



RESULT AND DISCUSSION

A total of 320 subjects were assessed in which 154 were males and 166 were females. The mean Q angle (right and left) side in different positions (OPF, OAF, LFP and LAF) including both males and females was assessed which is depicted individually in table -1. The mean of Right Q angle in Orthostatic parallel feet position is greater (13.12 ± 1.76 degree) than the rest given in the table-1. The mean Q angle (right and left) side in different positions (OPF, OAF, LFP, LAF) was greater in females as compare to males (including subjects of both groups). A statistically significant difference was appreciated among males and females. The mean of Right Q angle in Orthostatic parallel feet position is greater (14.23 ± 1.614 degree) than the rest Q angles in females. Similarly, in males the mean of Right Q angle in Orthostatic parallel feet position is greater (11.97 ± 0.999 degree) than the rest Q angles. The mean Q angle (right and left) side in different positions (OPF, OAF, LFP, LAF) among males and females was depicted individually in table-2. Significant difference in mean at $P=0.05$.

Out of total assessed subjects, 35 patients were actively involved in sports activity and complained of recurrent mild to moderate knee pain on both sides. We arranged study participants into two groups. In Group 1 patient having knee pain (right and left) including both males and females (35 patients). Group 2 consisting of 285 subjects having no (right and left) knee pain including both males and females. Mean Q angle (right and left) in different positions of leg (OPF, OAF, LFP, LAF) was increased in group 1 those having knee pain. A statistically significant difference was found in mean Q angle among patients of group1 and group 2. The mean of Right Q angle in Orthostatic parallel feet position is greater (14.23 ± 1.614 degree) in patients with anterior knee pain than the rest Q angles of different positions with anterior knee pain. Similarly, in patients with absence of knee pain the mean of Right Q angle in Orthostatic parallel feet position is greater (13.01 ± 1.73) degree than the rest Q angles. The mean Q angle (right and left) side in different positions (OPF, OAF, LFP, LAF) among group 1 and group 2 patients was depicted individually in table-3. Significant difference in mean at $P=0.05$.

A highly significant negative correlation was found between Q angles (right & left) with different knee positions (OPF, OAF, LFP, LAF) and height (cm) of the subjects. A negative correlation was also analyzed in the present study between Q angles (right & left) with different knee positions (OPF, OAF, LFP, LAF) and age of the subjects. As the age advances the Q angle will decrease. Correlation value (r) is given in the table-3.

We found a highly significant correlation of each Q angle of both side legs in different knee position (OPF, OAF, LFP, LAF) with the rest of the other angles of both side legs in different knee position (OPF, OAF, LFP, LAF). If Q angle will increase on one side in one position than other Q angle in different position on same and opposite side will also increase. Correlation value of each Q angle with other Q angles of same and opposite side is given in table-4 (4.1-4.8). Table-4.1-4.8 Correlation of age and height of subjects with Q angles measured in different leg positions and their correlations with each other. Since the limbs are thought to be symmetrical, hence quadriceps angle assessment is commonly performed unilaterally. However a difference between Q angles of the right and left side in athletes was also found by Hahn and Foldspang.

Regarding variations in Q angle value

While comparing values of bilateral Q angle in orthostatic and supine position with internal & external rotation, a difference of Q angle value in orthostatic position but no difference in supine position. Hence it was concluded that supine position could be the most neutral position for measuring Q angle [35]. The reason for the difference in Q values between the lower limbs is a change in the relative position of the tuberosity of the tibia with regard to the center of the patella [36]. Evaluating the Q angle in different

posture with external and internal rotations of lower limbs gives comparative correct value as the patella rises when this muscle is contracted [37-38]. In our study, the mean Q angle in different positions (OPF, OAF, LFP and LAF) including both males and females are greater on the right side. An increase (5°-15°) of Q angle in internal rotation and decrease by same range in external rotation, was observed by Olerud and Berg [39]. A difference in Q angle values with the limb in different supine position was noticed in both genders by Livingston and Spaulding. While assessing the bilateral variability of the TF-angle, El Fouhil *et al.* and Ekwedigwe *et al.* found no significant difference of Q angle between both the sides [40-41]. In our study the mean Q angle in different positions is greater on the right-side leg. The mean of Right Q angle in Orthostatic parallel feet position is greater (13.12±1.76 degree) than the rest Q angle (right and left) side in different positions (OPF, OAF, LFP, LAF). (Table-1)

Gender Effect:

A study on Q angle and relation to gender by Jaiyesimi *et al.* (2009) showed a significantly higher Q-angles value in both the RQA and LQA of the females. A wider pelvis in females was attributed to greater Q-angle. Byl & Livingston reported RQA and LQA of 6.3° and 5.9° respectively for their male & female population [42]. Woodland, Livingston suggested long distance between the pelvis and patella to, relative to the distance from the patella to the tibial tuberosity, a significant factor changing the Q-angle value. These factors induce an alternation in the position of the anterior superior iliac spine that has a huge impact on the Q angle values. One more factor responsible for greater Q angle in female than in males is lateralized position of anterior superior iliac spine in females [43].

Ebeye OA *et al.* (2014) in a study on "influence of gender on quadriceps (Q) angle among adult Urhobos in Nigeria population" found that Q angle was higher in females as compared to males, the right Q-angle is higher than the left ($P < 0.05$) for both gender [44]. In our study a statistically significant difference was appreciated among males and females. The mean Q angle (right and left) side in different positions (OPF, OAF, LFP, LAF) was greater in females as compared to males (including subjects of both groups) [Table -2].

Leg dominance

Gharib *et al.* (2020) it was shown that there was a significant difference in terms of the Q-angle in both the dominant and non-dominant legs of all athletic and non athletic subjects [45]. Jaiyesimi *et al.* (2009) did not find any significant relationships between Q-angle and leg dominance. No such observation was noticed in our study.

With physical activity

Regarding the relation of Q angle with physical activity, in supine position the Q angle measured was found in the range of 12-20 degrees in maximum females & in the range of 9-17 degrees in the males; while in standing position the range was 12-23 degrees in females & 9-20 degrees in males.

In a study on Analysis of q angle values of female athletes from different branches, it was noticed that higher degrees of Q angle was seen in female volleyball and futsal players when compared with other branches ($p < 0.05$). Amr Almaz Abdel-aziem *et al.* (2014) revealed no alteration in the value of Q angle with regard to the body position (standing and supine) in healthy group. Whereas the group with anterior knee pain recorded higher Q angle from standing than supine lying [46]. Şen *et al.* found that football players showed lower values of Q angle among female football players; and male wrestlers showing lower values of Q angle than male football players [47].

Biedert and Warnke consider high and low Q-angles as abnormal and an aetiological factor of patellofemoral disorders, where high values indicate Patellofemoral pain syndrome and low values suggest patellar instability. Chandan Kumar *et al.* (2018) observed that Abnormal patellar alignment is considered to be one of the factors for Anterior Knee Pain (AKP) - a common problem felt by patients & can be assessed by measurement of Q-angle, which were 15.2°, 20.4° and 17.9° among men, women and all participants in patient with Anterior Knee Pain (AKP). The values in the control group 12.2°, 16.3° and 14.3° respectively; the incidence of AKP being slightly more in female as compared to males [48-49].

Similarly in our present study the mean Q angle (right and left) in different positions of leg (OPF, OAF, LFP, LAF) was increased in group 1 i.e. those were actively involved in sports activity and complained up recurrent mild knee pain in both sides. A statistically significant difference was found in mean Q angle among patients of group 1 and group 2 (patients having no knee pain). The mean of Right Q angle in Orthostatic parallel feet position is greater (14.23±1.614 degree) in patients with anterior knee pain than the rest Q angles of different positions with anterior knee pain. Similarly, in patients with absence of knee pain the mean of Right Q angle in Orthostatic parallel feet position is greater (13.01±1.73) degree than the rest Q angles. [Table-3]

Correlation of Q angle with age & height

According to Ramada R. Khasawneh *et al.* a significant correlation ($P < 0.05$) was noticed between Q angle and height on both sides in both males and females. With weight no important variation in Q angle was

found in both sexes on sides. A similar observation regarding Q angle with weight was recorded by Sra *et al* [50].

However Rajeev Choudhary *et al* (2019) reported a negative correlation between height and Q angle with both standing and supine position. No significant correlation of Weight and age with Q angle was seen [51].

A highly significant negative correlation was observed in the present study between the height (cm), age of subjects and their Q angle of both sided legs in different positions (OPF, OAF, LFP, LAF). With increase in height & age, the Q angle was of lesser value. We found a highly significant positive correlation of each Q angle of both sided legs in different knee position (OPF, OAF, LFP, LAF) with each other. If Q angle will increase on one side in one position than other Q angle in Different position on same and opposite side will also increase [Table -4.1 to 4.8]

Table 1. Mean of Right and Left Q angle in different positions (OPF, OAF, LFP, LAF)

Variables	N	Mean (Degrees)	Std. Deviation (Degrees)	Std. Error Mean
Right Q Orthostatic & Parallel	320	13.1275	1.76041	.09841
Left Q Orthostatic & Parallel	320	12.7119	1.82528	.10204
Right Q Orthostatic & Abducted	320	12.9216	1.73290	.09687
Left Q Orthostatic & Abducted	320	12.6731	1.81999	.10174
Right Q Lying & Parallel	320	12.9425	1.77006	.09895
Left Q Lying & Parallel	320	12.7466	1.74781	.09771
Right Q Lying & Abducted	320	13.0456	1.75599	.09816
Left Q Lying & Abducted	320	12.4969	1.76520	.09868

Table 2. Mean of Right and Left Q angle in different positions (OPF, OAF, LFP, LAF) among male and females.

Variables	Gender	Number of Subjects	Mean Q angle in degree	Std. Deviation	P value (2-tailed)
Right Q Orthostatic & Parallel	M	154	11.97	.999	<0.001*
	F	166	14.23	1.614	
Left Q Orthostatic & Parallel	M	154	11.49	1.024	<0.001*
	F	166	13.83	1.686	
Right Q Orthostatic & Abducted	M	154	11.75	.974	<0.001*
	F	166	14.01	1.635	
Left Q Orthostatic & Abducted	M	154	11.50	.992	<0.001*
	F	166	13.80	1.711	
Right Q Lying & Parallel	M	154	11.71	1.003	<0.001*
	F	166	14.10	1.522	
+Left Q Lying & Parallel	M	154	11.61	.992	<0.001*
	F	166	13.84	1.689	
Right Q Lying & Abducted	M	154	11.86	1.025	<0.001*
	F	166	14.13	1.635	
Left Q Lying & Abducted	M	154	11.30	.998	<0.001*
	F	166	13.62	1.668	

Table 3. Mean of Right and Left Q angle in different positions (OPF, OAF, LFP, LAF) among patients having knee pain or absent.

Variables	Patients having ant. knee pain	Number of Subjects	Mean Q-angle in degree.	Std. Deviation	P value (2-tailed)
Right Q Orthostatic & Parallel	YES	35	14.23	1.664	<0.001*
	NO	285	13.01	1.733	
Left Q Orthostatic & Parallel	YES	35	14.14	1.717	<0.001*
	NO	285	12.53	1.767	
Right Q Orthostatic & Abducted	YES	35	13.57	1.803	0.028*
	NO	285	12.84	1.747	
Left Q Orthostatic & Abducted	YES	35	14.14	1.751	<0.001*
	NO	285	12.51	1.747	
Right Q Lying & Parallel	YES	35	14.11	1.745	<0.001*
	NO	285	12.80	1.715	
Left Q Lying & Parallel	YES	35	13.66	1.846	0.004*
	NO	285	12.66	1.751	
Right Q Lying & Abducted	YES	35	14.17	1.723	<0.001*
	NO	285	12.90	1.744	
Left Q Lying & Abducted	YES	35	12.71	1.856	0.478
	NO	285	12.48	1.803	

Table-4.1 Correlation of the right q orthostatic parallel of the subjects with q angle in different positions of both sides and between q angles:

Variables	Pearson correlation
age	-.060
height in cm	-.420**
right q orthostatic parallel	1
left q orthostatic parallel	.961**
right q orthostatic abducted	.972**
left q orthostatic abducted	.960**
right q lying parallel	.968**
left q lying parallel	.962**
right q lying abducted	.981**
left q lying abducted	.945**

Table-4.2 Correlation of the left q orthostatic parallel of the subjects with q angle in different positions of both sides and between q angles:

Variables	Pearson correlation
Age	-.054
height in cm	-.418**
right q orthostatic parallel	.961**
left q orthostatic parallel	1
right q orthostatic abducted	.952**
left q orthostatic abducted	.990**
right q lying parallel	.965**
left q lying parallel	.971**
right q lying abducted	.962**
left q lying abducted	.957**

Table-4.3 Correlation of the right q orthostatic abducted of the subjects with q angle in different positions of both sides and between q angles:

Variables	age	height in cm	right q orthostatic parallel	left q orthostatic parallel	right q orthostatic abducted	left q orthostatic abducted	right q lying parallel	left q lying parallel	right q lying abducted	left q lying abducted
Pearson correlation	-.096	-.419**	.972**	.952**	1	.950**	.964**	.968**	.974**	.957**

Table-4.4 Correlation of the left q orthostatic abducted of the subjects with q angle in different positions of both sides and between q angles:

Variables	age	height in cm	right q orthostatic parallel	left q orthostatic parallel	Right q orthostatic abducted	left q orthostatic abducted	right q lying parallel	left q lying parallel	right q lying abducted	left q lying abducted
Pearson correlation	-.053	-.428**	.960**	.990**	.950**	1	.963**	.970**	.960**	.950**

Table-4.5 Correlation of the right q lying parallel of the subjects with q angle in different positions of both sides and between q angles

Variables	age	height in cm	right q orthostatic parallel	left q orthostatic parallel	right q orthostatic abducted	left q orthostatic abducted	right q lying parallel	left q lying parallel	right q lying abducted	left q lying abducted
Pearson correlation	-.085	-.435*	.968**	.965**	.964**	.963**	1	.962**	.977**	.944**

Table-4.6 Correlation of the left q lying parallel of the subjects with q angle in different positions of both sides and between q angles

Variables	age	height in cm	right q orthostatic parallel	left q orthostatic parallel	right q orthostatic abducted	left q orthostatic abducted	right q lying parallel	left q lying parallel	right q lying abducted	left q lying abducted
Pearson correlation	-.076	-.401**	.962**	.971**	.968**	.970**	.962**	1	.964**	.966**

Table-4.7 Correlation of the right q lying abducted of the subjects with q angle in different positions of both sides and between q angles:

Variables	age	height in cm	right q orthostatic parallel	left q orthostatic parallel	right q orthostatic abducted	left q orthostatic abducted	right q lying parallel	left q lying parallel	right q lying abducted	left q lying abducted
Pearson correlation	-.088	-.406*	.981**	.962**	.974**	.960**	.977**	.964**	1	.944**

Table-4.8 Correlation of the left q lying abducted of the subjects with q angle in different positions of both sides and between q angles

Variables	age	height in cm	right q orthostatic parallel	left q orthostatic parallel	right q orthostatic abducted	left q orthostatic abducted	right q lying parallel	left q lying parallel	right q lying abducted	left q lying abducted
Pearson correlation	-.123*	-.410**	.945**	.957**	.957**	.950**	.944**	.966**	.944**	1

*. Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

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