Effect of various parameters on Quadriceps angle in adult Indian population

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ABSTRACT

Background: The purpose of this study was to compare the values of quadriceps angle (Q angle) in relation to age, weight, height, gender, bilateral and postural variations, and strenuous activities on the weight bearing limbs in order to observe its variability.

Materials and methods: A total of 450 adult healthy volunteers (150 male students, 150 female students and 150 male labourers) were enrolled in this cross sectional study. Each volunteer had its height, weight and Q angles measured. Q angle was measured in all subjects bilaterally in both supine and standing position with the same goniometer. Comparison of Q angles and various parameters and groups were studied and tabulated. Correlation between age, weight, height and Q angles was determined by Karl Pearson's correlation coefficient.

Results: Females had statistically significant higher Q angles in both knees than males of either group, and difference between males of two groups was insignificant. It was more often greater on left side (42.36%) as compared to right, both in males and females. Majority of subjects showed an increase in angle from supine to standing position. There was negative correlation between height and Q angle with both standing and supine position all three groups. Weight and age did not show significant correlation with Q angle. Physical activity did not show any significant effect on the angle.

Conclusion: Q angle is an important parameter to assess quadriceps muscle's function and its effect on knee. An increase in the angle is clearly associated with patellofemoral problems. Higher Q angle among females may predispose them to sports related injuries. It is important to take into consideration of such factors like sex, height, posture, side, foot rotation and muscle's relaxation while measuring and comparing the angle.

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1. Introduction

The quadriceps angle (Q angle) is formed when the line connecting anterior superior iliac spine (ASIS) and midpoint of patella intersects with the line connecting tibial tubercle to midpoint of patella.^{1,2} Q angle is an important parameter to assess patellofemoral mechanics and is thus of great interest to

clinicians.^{3–6} An increase in angle is considered as indicative of extensor mechanism misalignment, can be a precursor of overuse injuries and has been associated with patellofemoral pain syndrome, knee joint hypermobility, chondromalacia patellae, recurrent subluxation of patella and anterior cruciate ligament tears.^{6–10} Studies have reported a greater Q angles in individuals who are suffering with pathological conditions of patellofemoral joint.^{9,11–16} The reasons for high angle among females are increased pelvic width, shorter femur length, or due to a more laterally placed tibial tuberosity.^{11,17,18} The position of subject while measurement is being taken is a critical factor as Q angle magnitude changes with knee movement and muscle activation.^{14,19–22}

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Because of its great clinical and biomechanical importance, the aim of this study was to compare values of Q angle in relation to age, weight, height, gender, bilateral and postural variations, and strenuous activities on the weight bearing limbs. Our hypothesis is that parameters like age, height, weight, gender, posture and side have effect on Q angle values. The observations shall be helpful for sports therapist in understanding evaluation of Q angle in athletes as prognostic value for probable knee pathologies that may appear in future. The observations shall also be useful to physiotherapist and orthopedic surgeon in understanding and dealing with replacement arthroplasty and patellofemoral disorders.

2. Materials and methods

This is a descriptive cross-sectional study which was approved by the ethical committee and institutional review board before its commencement, and was performed in accordance with the ethical standards of the 1964 declaration of Helsinki. We randomly selected 450 adult healthy volunteers (150 male students, 150 female students and 150 male labourers). We included individuals of 18–35 years old which must had a palpable anterior superior iliac spine, patella and tibial tuberosity to be used as landmarks in the investigation. Each volunteer had its height, weight and Q angles measured. Excluded individuals were with any injury to lower limb that leads to ligamentous, muscular or bony defect, and any spinal or neurological injury. Subjects with any diagnosed knee disorder, like fracture, acute or chronic knee pain, dislocation of patella were also excluded from the study.

2.1. Measurement of Q angle

The right and left sided Q angles were measured with subjects barefooted and in both standing and supine position.²¹ All angles were measured using the same goniometer (stainless steel, half circle goniometer, with two arms-one stationary and lengthened and the other movable arm (Fig. 1).

The following steps were performed in measurement: 1. Anterior superior iliac spine (ASIS) was palpated and marked. 2. The outline of patella was drawn and the centre of patella (CP) was defined as point of intersection of maximum vertical and transverse diameters of patella. 3. Tibial tuberosity (TT) was palpated and point of maximum prominence was defined as the center of TT.¹⁸ 4. The center of goniometer was placed on the center of patella. The stationary arm of goniometer was aligned with ASIS

Fig. 1. Hand held goniometer used to measure the Q angle.

and the movable arm was aligned with TT. The angle formed between above two lines was defined as the Q angle and was measured in degrees.^{23,24}

For measurement of Q angle in supine position, the subject was positioned flat and keeping pelvis square. The legs were extended at knee joint with quadriceps muscle relaxed. The feet were placed in a position of neutral rotation, such that toes were pointing directly upwards and feet were perpendicular to the resting surface.¹⁸ For measurement in standing, subject stood with feet in the Romberg position (i.e., medial borders of feet touching) with the knees extended without voluntary quadriceps contraction.¹⁴

2.2. Data and statistical analysis

The mean and standard deviation were determined for age, weight, length, and Q angle values. Comparisons of parameters were performed with one-way analysis of variance (ANOVA) test. Bilateral differences in the Q angle values were tabulated. Change in Q angle values from supine to standing position was also tabulated. Karl Pearson's correlation coefficient (*r*) was determined between parameters (age, weight, height and Q angles) in all three groups. Linear regression graph was plotted between height and Q angle values in all groups.

3. Results

The male labourers ranged in age from 18 to 29 years (mean 22.86 ± 2.66 years), in weight from 41.0 to 68.0 kg (mean 55.83 ± 6.35 kg), and in height from 154 to 185 cm (mean 168 ± 7.49 cm). The male students ranged in age from 18 to 23 years (mean 19.61 ± 1.46 years), in weight 49.0–92.0 kg (mean 65.79 ± 9.55 kg), and in height 155.0–185.0 cm (mean 171.57 ± 8.23 cm). The female students ranged in age from 18 to 22 years (mean 19.26 ± 1.13 years), in weight 39.0–75.0 kg (mean 54.31 ± 14.42 kg), and in height from 144 to 173 cm (mean 158.71 ± 5.35 cm).

Table 1 depicts analysis of data for all the three groups bilaterally. The change in Q angle from supine to standing and from one knee to other is also clearly shown. On statistical comparison of Q angle between different groups by one way ANOVA test, the change was found to be significant between male students vs. female students and male labourers vs. female students, and insignificant between male students vs. male labourers (Table 2). Table 3 shows comparison of Q angles by the same statistical test between different positions and limbs in the same individual.

When the differences between right and left Q angles were calculated in standing position it was noted that in 27% of subjects there was no bilateral difference. In male students 38% and 41% of subjects had greater Q angle values on right and left respectively. In male labourers 27.3% and 44.2% of subjects had greater Q angle values on right and left respectively. Whereas in female students 36.4% and 40.9% of subjects had greater Q angle values on right and left respectively. The Q angle was more often greater on left side (42.36%) as compared to the right, both in males and females.

When change in Q angle from supine to standing position was tabulated it was observed that majority of the subjects showed increase in Q angle. In male students, 48% of right knees and 42.67% of left knees showed an increase in angle from supine to prone position. In female students, 54% and 44% of right and left knees respectively showed an increase in angle. While as in male labourers, 52.67% and 49.33% of right and left knees had an increase in angle. The results are summarized in Table 4.

Karl Pearson's correlation coefficient (*r*) between Q angles, age, weight, and height was determined in all three groups. Corresponding *p*-value was derived statistically from *r* value. The results are summarized in Tables 5–7. In male students (Table 5) negative correlation was observed between height and Q angles, bilaterally,

Table 1

Mean & standard deviation, maximum & minimum values and change in Q angle (°) from supine to standing position.

Parameter	Male labourers (N = 150)		Male students (N = 150)		Female students (N = 150)	
	Supine	Standing	Supine	Standing	Supine	Standing
Right Knee	12.26 ± 2.62	12.70 ± 2.51	12.53 ± 2.54	13.13 ± 2.46	14.15 ± 1.92	14.79 ± 2.13
Left Knee	12.56 ± 2.24	13.03 ± 2.16	13.01 ± 2.70	13.38 ± 2.65	14.66 ± 1.91	15.01 ± 1.87
Change in Q-angle (Right Knee)	0.44 ± 1.68		0.59 ± 1.38		0.64 ± 1.01	
Change in Q-angle (Left Knee)	0.47 ± 1.18		0.37 ± 1.54		0.35 ± 1.18	
Average Q-angle	12.41 ± 2.27	12.87 ± 2.17	12.77 ± 2.48	13.25 ± 2.38	14.40 ± 1.75	14.90 ± 1.77
Maximum right Q- angle	20	20	18	19	18	20
Minimum right Q-angle	9	10	9	9	10	10
Maximum left Q-angle	20	18	19	20	20	20
Minimum left Q-angle	9	9	9	9	10	11

Table 2

Results of statistical (one way ANOVA test) comparison of Q angle between various groups.

	Subject	Side	Position	Subject	Side	Position	p-value	Result
1	FS	Right	Standing	MS	Right	Standing	<0.001	Significant
2	FS	Left	Standing	MS	Left	Standing	<0.001	Significant
3	FS	Right	Supine	MS	Right	Supine	<0.001	Significant
4	FS	Left	Supine	MS	Left	Supine	<0.001	Significant
5	MS	Right	Standing	ML	Right	Standing	0.138	Not significant
6	MS	Left	Standing	ML	Left	Standing	0.216	Not significant
7	MS	Right	Supine	ML	Right	Supine	0.360	Not significant
8	MS	Left	Supine	ML	Left	Supine	0.120	Not significant
9	FS	Right	Standing	ML	Right	Standing	<0.001	Significant
10	FS	Left	Standing	ML	Left	Standing	<0.001	Significant
11	FS	Right	Supine	ML	Right	Supine	<0.001	Significant
12	FS	Left	Supine	ML	Left	Supine	<0.001	Significant

MS–male student, ML–male labourer and FS–female student.

Table 3

Results of statistical (one way ANOVA test) comparison of Q-angle in subjects in different position and limb of same group.

	Group	Side	Position	Group	Side	Position	p-value	Result
1	MS	Right	Standing	MS	Left	Standing	0.392	Not significant
2	MS	Right	Supine	MS	Left	Supine	0.119	Not significant
3	MS	Right	Standing	MS	Right	Supine	0.041	Not significant
4	MS	Left	Standing	MS	Left	Supine	0.228	Not significant
5	FS	Right	Standing	FS	Left	Standing	0.344	Not significant
6	FS	Right	Supine	FS	Left	Supine	0.021	Not significant
7	FS	Right	Standing	FS	Right	Supine	0.007	Not significant
8	FS	Left	Standing	FS	Left	Supine	0.113	Not significant
9	ML	Right	Standing	ML	Left	Standing	0.218	Not significant
10	ML	Right	Supine	ML	Left	Supine	0.287	Not significant
11	ML	Right	Standing	ML	Right	Supine	0.138	Not significant
12	ML	Left	Standing	ML	Left	Supine	0.063	Not significant

MS–male student, ML–male labourer and FS–female student.

in both standing and supine position i.e. with increase in height there is decrease in Q angle ($p < 0.05$). Age and weight did not show statistical significance with Q angle values ($p > 0.05$). In female students (Table 6) negative correlation was observed between height and Q angles, bilaterally, in both standing and supine position ($p < 0.05$). Age and weight did not show statistical significance with Q-angle values ($p > 0.05$). In male labourers (Table 7) negative correlation was observed between height and right Q angles, bilaterally, in both standing and supine position

($p < 0.05$). The left Q angles did show negative correlation with height but it was not statistically significant ($p > 0.05$). Weight showed negative correlation with the Q angle but it was statistically significant only in supine position on both sides ($p < 0.05$). Age did not show statistical significance with Q angle values ($p > 0.05$).

4. Discussion

The evaluation of Q angle of three different groups was performed in this study aiming to assess possible variations in different situations. It has been found that a larger Q angle predisposes the knee to anterior knee pain and patellofemoral malalignment. Moreover a negative correlation of Q angle with height is noted. Indian population have an average height lesser as compared to European/American subjects, thus have a larger Q angle. So this theoretically predispose short statured Indian to anterior knee pain. A study of anterior knee pain prevalence in young Indian population is needed. This also can be a factor favouring patellar resurfacing in Indian knee replacements. The sample in this study comprised of both genders in the age group 18–35 years because anterior knee pain symptoms and pathologies such as patellofemoral dysfunction present mostly in this group. Also at this age, knee do not present bone growth, and there are no degenerative pathologies that could change the Q angle.

In most orthopedic clinics, Q angle is measured using the standard pocket goniometer which is a reliable and cost effective method.²⁵ Many workers measured Q angle using goniometer^{16,17,21,23,25–31}; or modified goniometer.^{20,32,33} Biedert et al. measured Q angle in radiographs.³⁴ Braz et al. determined Q angle by digital photogrammetry.³⁵ Q angle can be measured reliably and it provides a reasonable estimate of the angle of quadriceps muscles' pull on patella in the frontal plane.³⁹ The Q angle creates a lateral force vector on patella and predisposes the

Table 4

Change in Q angle from supine to standing position.

Group	Increase				Decrease				No Change			
	Right Knee		Left Knee		Right Knee		Left Knee		Right Knee		Left Knee	
	N	%	N	%	N	%	N	%	N	%	N	%
MS (N = 150)	71	48.00	64	42.67	27	18.00	33	22.00	50	34.00	53	35.33
FS (N = 150)	81	54.00	66	44.00	21	14.00	33	22.00	48	32	51	34.00
ML (N = 150)	79	52.67	74	49.33	8	5.33	24	16	63	42.00	52	34.67

N=number, %-percentage, MS=males student, ML=males labourer and FS=females student.

Table 5

Correlation between parameters in the male student (MS) Values expressed in Karl Pearson's Correlation Coefficient.

	Age	weight	height	MS Right Q angle (Standing)	MS left Q angle (Standing)	MS Right Q angle (Supine)	MS left Q angle (Supine)
Age	1						
weight	0.045	1					
Height	-0.032	-0.15	1				
MS Right Q angle (Standing)	0.013	-0.03	-0.31 [*]	1			
MS left Q angle (Standing)	-0.005	0.044	-0.29 [*]	0.734 [*]	1		
MS Right Q angle (Supine)	-0.023	-0.023	-0.29 [*]	0.849 [*]	0.705 [*]	1	
MS left Q angle (Supine)	-0.040	0.015	-0.28 [*]	0.613 [*]	0.834	0.794 [*]	1

^{*} Significant (*P* value <0.05).**Table 6**

Correlation between parameters in the Female student (FS) Value expressed in Karl Pearson's Correlation Coefficient.

	age	weight	height	FS Right Q angle (Standing)	FS left Q angle (Standing)	FS Right Q angle (Supine)	FS left Q angle (Supine)
Age	1						
weight	-0.07	1					
Height	0.126	0.149	1				
FS Right Q angle (Standing)	-0.004	0.165 [*]	0.148 [*]	1			
FS left Q angle (Standing)	0.052	-0.024	0.002	0.565 [*]	1		
FS Right Q angle (Supine)	-0.014	0.097	0.180 [*]	0.872 [*]	0.617 [*]	1	
FS left Q angle (Supine)	-0.042	0.062	-0.059	0.565 [*]	0.806 [*]	0.675 [*]	1

^{*} Significant (*P* value <0.05).**Table 7**

Correlation between parameters in the Male labourer (ML) Value expressed in Karl Pearson's Correlation Coefficient.

	age	weight	height	ML Right Q angle (Standing)	ML left Q angle (Standing)	ML Right Q angle (Supine)	ML left Q angle (Supine)
Age	1						
Weight	0.396 [*]	1					
Height	-0.002	0.009	1				
ML Right Q angle (Standing)	-0.027	0.006	-0.34 [*]	1			
ML left Q angle (Standing)	-0.006	0.057	-0.20 [*]	0.719 [*]	1		
ML Right Q angle (Supine)	-0.017	-0.015	-0.33 [*]	0.787 [*]	0.626 [*]	1	
ML left Q angle (Supine)	-0.001	0.070	-0.30 [*]	0.777 [*]	0.856 [*]	0.748 [*]	1

^{*} Significant (*P* value <0.05).

patella to lateral displacement during activation of quadriceps.^{36,37} The magnitude of this lateral force vector and tendency for lateral displacement of patella are believed to increase as the Q angle increases.³⁹ The mean Q angle has varied from 8° to 27.5° in different populations.^{21,37,38}

The RQA and LQA, in standing position, in our study are higher than those reported by Livingston et al.²⁷ They reported in male subjects (N=50) RQA and LQA of 9.5 ± 4.6° and 10.4 ± 5.7°, respectively; and in female subjects (N=50), RQA and LQA of 10.5 ± 4.2° and 12.2 ± 5.2°. The values obtained are also higher than those observed by Byl and Livingston.²⁶ They observed in male subjects (N = 16), RQA and LQA of 6.3° and 5.9°, respectively; and in female subjects (N = 18), RQA and LQA of 10.1° and 9.7°. However, higher values were reported in Nigerian studies.³⁹ Jaiyesimi and

Jegade reported in male subjects (N=200) RQA and LQA of 12.20 ± 3.96° and 10.38 ± 3.49°, respectively.²⁴ The differences between these values and that of the present study may therefore be racial.

However, in the supine position, the average Q angle (AQA) in the subjects was comparable to the results from a studies conducted in India. Jha and Raza in their study reported AQA as 12.364° and 13.968° in males (N=140) and females (N=110) respectively.³⁸ Another study on Indian population, Veeramani et al. reported in their study on 50 male and 50 female subjects AQA as 10.98 ± 1.75° and 14.48° ± 2.02, respectively.³⁰

Several studies have reported higher Q-angle values when a shift is made from a supine to a standing posture.²⁰ Increased Q-angle upon standing is attributed to a shift in lower limb alignment

due to weight bearing. In the present study also majority i.e. 48% of the subjects showed increase in Q angle from supine to standing position.

Hahn and Foldspang were among first to study bilateral variability in the Q angle. Following this, other workers reported bilateral variations. Some of these studies reported greater mean Q angle on right side than that on left. While some reported greater mean Q angle on left as compared to right. In only two of the studies were these differences significant.^{17,22} To Livingston and Spaulding, however, the reason for this difference is unclear and these authors do not suggest any explanation for the fact.¹⁴ For Livingston and Mandingo, the difference of values between both sides is explained by the higher tropism and muscle tone in the dominant limb, which would cause a force on the patella displacing it and decreasing the value of the angle.²⁷ For Raveendranath et al., however, the difference in values between the lower limbs can be attributed to a change in the relative position of the tuberosity of the tibia regarding the center of the patella.³⁰

In the present study significantly higher mean Q angles were recorded in females as compared to males on both right and left sides. This is in concurrence with other studies conducted previously.^{21,38} Various explanations have been given for this. In the past, it was hypothesized that the reason for a higher Q angle in females was their wider pelvis, which resulted in a more lateral proximal reference point than in men.¹⁷ This may no longer be a valid explanation considering the report of Grelsamer et al.³⁶ They did not find such large differences in position of the anterior superior iliac spine in their trigonometric study and opined that large changes in the position of 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. Furthermore, they reported taller people having slightly smaller Q angles and concluded that slight difference in Q angles between men and women can be explained by the fact that men tend to be taller. Observations by other studies suggest that sex differences in Q angle are due to differences in the placement of tibial tuberosity (TT). TT was reported to be significantly more laterally placed in females as compared to males.^{30,38} A more laterally placed TT in females could be due to an increase in the valgus angle or tibial torsion.

It was also observed in this study that Q angle had negative correlation with height. Jha and Raza in their study reported that Q angle had negative correlation with height, length of lower limb and length of femur.³⁶ Grelsamer et al. found significant association between the Q angle and height.³⁸ Furthermore, they found that adjusting for age, weight, pelvic width, and gender the Q angle decreases by 0.2° for each individual centimetre of height.

The effect of lifestyle on Q angle was done by comparing between male students and labourers. The mean Q angle in male labourers was less than those in students. This could be due to difference in quadriceps muscle tone and strength. Bayraktar et al. compared Q angle in sedentary and soccer players and reported that activity, causes a change in quadriceps strength and tone, has a remarkable effect on Q angle and results in decrease in Q angle.²² Byl et al. reported that Q angle magnitude is inversely related to quadriceps tone.²⁶

The only limitation of the study is that there may be high chances of intraobserver variation in the measurement of Q angle due to the fact it was done by one author only and the method chosen by hand held goniometer is subjective.

5. Conclusion

The present study documents variations in the Q angle in young healthy adults. From the foregoing, we conclude that Q angles are

higher in females than males and right and left Q angles are not equal in the same individual. Female students had statistically significant higher mean Q angles than male students and male labourers in both the limbs and in both standing and supine position. It was noted that Q-angle changes from supine to standing position, with majority (48%) of limbs showed increase in Q-angle from supine to standing position. The height showed negative correlation with Q angle, and age did not influence the Q angle.

It is important to take into consideration of such factors like posture, side, foot rotation and muscle's relaxation while measuring and comparing the Q angle.

Conflict of interest

All the authors declare that they have no conflicts of interest.

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