■ *Original Article*

Quadriceps angle in eastern Nepalese population

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Abstract

Introduction: Controversy still exists about within-subject and between-group variation of quadriceps angle (Q angle). Moreover, the reference value for our population has not been studied. Still many more determinants of Q angle are to be explored. **Objectives:** To determine a reference value for normal Q-angles among eastern Nepalese population and determine its correlation with other anthropometric determinants. **Methods:** 1200 subjects were included form representative districts of eastern Nepal and their Q angle from both sides in various position of limb was measured. Correlation between them as well as their correlation with age, height, weight and arm span of every individual was analyzed. **Results:** Quadriceps angle in the study population was symmetrically distributed. Between-group (male versus female), within-subject (right versus left lower limb), within-position (supine versus standing) difference in Q angle was not significant. Weight in males, in contrast to females, has strong correlation with Q angle. **Conclusion:** We conclude that there is within subject, within position and between gender asymmetry in Q angle. Thus in recording Q angle measurements, both sides should be measured with limb position specified.

Keywords: quadriceps angle, extensor mal-alignment, q angle variation, anthropometry

Introduction

Quadriceps angle (Q angle) of the knee is an acute angle formed between two lines, one line drawn from the anterior superior iliac spine (ASIS) to the center of the patella, and another line drawn from the center of the patella to the tibial tuberosity.[1]

An excessive Q angle is considered indicative of extensor mechanism malalignment and has been associated with anterior knee pain syndrome (AKPS), patellar subluxation or dislocation, patello-femoral degenerative joint diseases and lower limb overuse injuries. It is useful during planning and identifying candidates for surgery and assessing probable outcome that require patellar re-alignment surgery. Most recently, an excessive Q angle has been identified as a potential risk factor for non-contact anterior cruciate ligament injuries in female athletes.[2] But there may be other factors that lead to increased risk of injury in women athletes (strength, skill, hormones etc).[3]

The accepted, though unproven explanation for the greater Q angle in women is that a woman has a wider pelvis but large changes in the position of ASIS are necessary to significantly change the Q angle.[4] Some researchers regard Q angles in excess of 20° to be pathologic, while others have suggested that value as low as 10° to 14° are problematic. Less understood is the effect of foot position on Q-angle magnitude, even though it is viewed as a factor that must be controlled during measurement.[2] However, it has been reported that the Q angle increased or decreased by 5º with 15º internal or external rotation of the foot respectively.[5] This lack of consensus may be due in part to the absence of a standardized measurement position or methodological differences.

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The standing position has the advantage of measuring the Q angle in the patient's usual upright posture, so that the normal weight-bearing stresses are included. Since we are most concerned with assessing how the knee functions during daily activities and sports participation, it certainly makes sense to obtain this important measurement while in a weight-bearing position.[6]

Previous attempts to link excessive Q angles to the occurrence of knee pain and attempts to determine whether Q angles were bilaterally symmetric in individuals asymptomatic versus symptomatic for anterior knee pain have yielded equivocal results.[7] Numerous authors have described lateral patellar displacement in patello-femoral pain patients leading to the intriguing possibility that the Q-angle might be undervalued in them with laterally displaced patella.[8] Literature review revealed studies describing either only the relation of Q angle with supine and standing position or its variation with gender. Few authors have studied on Q angle asymmetry within and between individual. To our knowledge till date, no such studies estimating normal Q-angle among Nepalese population are available in the literature neither it's relation with direct or indirect determinants like gender, right and left sides, position of limb, height, weight, arm span etc. has been studied and with large sample size of 1200.This is the only study to fill the gap.

Methods

Ethical and methodology approval

Ethical clearance was obtained from BPKIHS ethical committee and methodology approved by the academic committee.

Design and setting

This is a community based descriptive study of Q angle among normal eastern Nepalese population. A preliminary investigation was done to determine inter-tester and intra-tester reliability of the measurement. A mixed between-within, repeated-measure design was used for measurement.

Sample size calculation

Alpha (α) was set at 0.05 and power of study (1-β) was taken as 0.9. Assuming the variability of Q angle (S) in the community as 2° and tolerance (δ) as 0.2°, the estimated sample size after adjusting for non-responders (as 10%), the minimum sample size was 1159.

Patient selection and random sampling

A total of 1200 randomly selected individuals, 200 observations from each teaching district attached to BPKIHS community (Dhankuta, Ilam, Bhadrapur, Rajbiraj, Inaruwa and Rangeli) and consenting to participate were included in this study. Any individual with history of trauma, gross deformity of the lower limbs, previous hip or knee joint disease, symptomatic for knee pain or when landmarks necessary for measurement cannot be located were excluded.

For random sampling, a spherical toy with an arrow mark on it (marked by the investigator himself) was rotated manually and data was collected from the locality along the direction pointed by the arrow, which was repeated for every teaching district.

The anatomical landmarks were located by visual estimation and palpation by same investigator. A fresh ink mark was placed over the tibial tuberosity, centre of the patella and anterior superior iliac spine prior to each measurement. The limbs were projected proximally and distally as per need. A universal goniometer was used to measure the Q angle by placing its centre on the mid-point of the patella.[4]

For standing position, both the knees were fully extended, quadriceps relaxed with patella facing forward in the sagittal plane, foot in the stance position and heels along with the medial border of the soles touching each other. For supine position, both the quadriceps relaxed with knees flexed 10^0, and the lower limb in neutral rotation with patella pointing upwards.[4]

Q angle was measured on both the sides each in standing as well as in supine position with quadriceps relaxed and other data were collected as per pre-fixed pro forma.

Statistical analysis

All the statistical analysis was done using the software SPSS (Statistical Package for Social Science).Level of significance was fixed at $P < 0.05$. Demographic characteristics of the study were worked out and screening was done to verify the normal distribution of the samples. Comparison between groups (male and female) was done for each of the variables under study and significance of the difference between two means (p value) was tested using Wilcoxon sum rank test.

Q angle was compared between the two sides (right and left); two postures (supine and standing) in the same individual and between different gender as well as its correlation with various determinants (age, height, weight, arm span) were also studied. Comparison of Q-angles in various limb positions and sides with gender as the grouping variable required unpaired t-test whereas for different limb positions and between two sides of the same subject required paired t-test.

Results

Out of total 1200 participants, 614 (51.2%) were males and 586 (48.8%) were females. Maximum participants were students (49.2%), followed by farmers (16.8%), servicemen (15.75%), housewives (12.85%) and teachers (0.6%) while 4.9% were children. They were mostly Hindus (91.5%), followed by Muslims (5.8%), Buddhists (1.6%), Kirats (0.8%) and Christians (0.3%).

Except age, all the variables under study were symmetrically distributed including Q angle. The ranges for age, height, weight and arm span were 2 to 69 years, 71 to 178 centimeters, 8 to 78 kilograms and 69 to 179 centimeters respectively. Similarly, the Q angle ranged from 10 to 18 degrees irrespective of the gender, side and position of the limb. Considering total observations, mean Q angle for right side in supine and standing position were 13.81 ± 1.62 degrees and 13.91 ± 1.74 degrees respectively. The corresponding values for left side were 14.08 ± 1.53 degrees and 13.83 ± 1.64 degrees respectively. Comparing between male and female, mean age was slightly higher for females but mean weight was higher for males (P>0.05). The mean height and arm span of males were higher than that of female (P<0.05). It seems that male tend to be taller and heavier than female (Table 1).

Table 1: Anthropometric variables considering total observations, males and females

Mean ± SD	Total Obs. (n=1200)	Male (n=614)	Female (n=586)	P-value
Age (Yr)	23.31 ± 15.67	22.96 ± 16.35	23.67 ± 14.92	0.670
Height (cm)	143.38 ± 22.23	143.99 ± 24.53	142.75 ± 19.54	0.001
Weight (kg)	41.68 ± 16.02	41.81 ± 17.21	41.55 ± 14.67	0.496
Arm Span (cm)	142.56 ± 22.87	143.25 ± 25.04	141.84 ± 20.34	0.001

Analysis of between-within Q angles in both the supine and standing position of the limb for right and left limb shows their mean values lying very close to each other irrespective of gender. Highest mean value for Q angle was found to be 14.08 degrees in supine left side in females with lowest value being 13.76 degrees on left side standing position in males. There was no statistically significant difference between Q angle on right side and left side when measured in supine or standing position for both males and for females (Table 2) (P>0.05).

Table 2: Mean Q angle between Right and Left side

	Q angle in male		Q angle in female	
	Supine	Standing	Supine	Standing
Right limb	13.81 ± 1.69	13.89 ± 1.74	13.80 ± 1.55	13.94 ± 1.74
Left limb	14.07 ± 1.55	13.76 ± 1.66	14.08 ± 1.52	13.90 ± 1.61
P value	>0.05	>0.05	>0.05	>0.05

Considering for both the supine and standing position of limb, when Q angle was measured on right limb and on left limb for male as well as for female there was no statistically significant difference between them (Table 3) (P>0.05).

Table 3: Mean Q angle in supine and standing position

	Q angle Right limb		Q angle Left limb	
	Male	**Female**	**Male**	**Female**
Supine	13.81 ± 1.69	13.80 ± 1.55	14.07 ± 1.55	14.08 ± 1.52
Standing	13.89 ± 1.74	13.94 ± 1.74	13.76 ± 1.66	13.90 ± 1.61
P value	>0.05	>0.05	>0.05	>0.05

Similarly, there was no statistically significant difference between Q angle in male and female when measured in supine or standing position on right and on left side (Table 4) (P>0.05).

Table 4: Mean Q angle between male and female

	Q angle in standing		Q angle in supine	
	Right limb	**Left limb**	**Right limb**	**Left limb**
Male	13.89 ± 1.74	13.76 ± 1.66	13.81 ± 1.69	14.07 ± 1.55
Female	13.94 ± 1.74	13.90 ± 1.61	13.80 ± 1.55	14.08 ± 1.52
P value	>0.05	>0.05	>0.05	>0.05

A univariate, one to one Pearson correlation analysis was done considering all the subjects (n=1200), males only (n=614) and females only (n=586) which showed the strong correlation among their age, height, weight and arm span (P<0.001). Strength of association was found to be greatest between height and arm span for total observations (Pearson coefficient = 0.986), males (Pearson coefficient = 0.988) as well as for females (Pearson coefficient = 0.982).

Correlation analysis was done between Q angle in supine and standing position for both right and left sides considering all the subjects (n=1200), males only (n=614) and females only (n=586). The Pearson coefficient was ranging from 0.604 to 0.673, from 0.626 to 0.677 and from 0.581 to 0.689 respectively which invariably showed the strong correlation between the angles for each subject. The highest Pearson correlation coefficient for male (0.677) as well as for female (0.689) was between right and left side Q angle in standing position.

So, it was seen that Q angle measured in one limb either in supine or in standing position, correlates positively with the Q angle measured from other limb either in supine or standing position for the same individual with variable strength of correlation depending upon the side or position of the limb compared.

Similarly, correlation analysis was done between Q angle with each of these variables - age, height, weight and arm span which showed statistically significant correlation between weight and Q angle in supine and standing position as well as for the right and left side when either total observation (Table 5) or males (Table 6) are considered (P<0.05). In contrast, we found no such significant correlation between weight and Q angle for females (Table 7) (P>0.05).

Table 5: Test for correlation between the variables (total subjects)

	Q angle supine (Right side)	Q angle supine (Left side)	Q angle standing (Right side)	Q angle standing (Left side)
AGEP				
earson correlation:	0.004	0.012	0.016	0.001
p-value :	0.902	0.668	0.572	0.962
HEIGHT				
Pearson correlation:	0.033	0.040	0.042	0.030
p-value :	0.256	0.169	0.143	0.294
WEIGHT				
Pearson correlation:	0.073*	0.071*	0.069*	0.072*
p-value :	0.011	0.013	0.017	0.013
ARM SPAN				
Pearson correlation:	0.046	0.046	0.043	0.031
P-value :	0.113	0.112	0.136	0.286

Table 6: Test for correlation between the variables (male)

	Q angle supine (Right side)	Q angle supine (Left side)	Q angle standing (Right side)	Q angle standing (Left side)
AGE				
Pearson correlation:	0.001	0.009	0.014	0.016
p-value :	0.987	0.818	0.736	0.685
HEIGHT				
Pearson correlation:	0.039	0.049	0.063	0.067
p-value :	0.339	0.224	0.116	0.096
WEIGHT				
Pearson correlation:	0.095*	0.086*	0.088*	0.103*
p-value :	0.019	0.033	0.029	0.011
ARM SPAN				
Pearson correlation:	0.057	0.059	0.069	0.073
p-value :	0.156	0.144	0.087	0.071

Table 7: Test for correlation between the variables (female)

	Q angle supine (Right side)	Q angle supine (Left side)	Q angle standing (Right side)	Q angle standing (Left side)
AGE				
Pearson correlation:	0.007	0.016	0.019	0.018
p-value :	0.859	0.696	0.650	0.655
HEIGHT				
Pearson correlation:	0.024	0.028	0.016	0.017
p-value :	0.555	0.502	0.703	0.688
WEIGHT				
Pearson correlation:	0.070	0.053	0.046	0.033
p-value :	0.092	0.198	0.266	0.423
ARM SPAN				
Pearson correlation:	0.030	0.029	0.011	0.022
p-value :	0.474	0.479	0.793	0.598

Discussion

Previous study had shown that Q angle decreases by 0.2º for each centimeter of height adjusting for age, weight, pelvic width and gender ($p=0.05$), however the analysis was done only for supine position on right side. Though the mean age, height and weight for both male and female subjects included in that study were higher, we found no correlation between Q angle and gender which was consistent with the study.[4]

On the basis of generalized ligament laxity, more lateralized ASIS (wider pelvis) and relatively shorter femur length (shorter lever arm), the Q angle was accepted to be higher in females, but not proven yet. However, this study showed that the difference in Q angle between male and female was statistically not significant ($p < 0.05$). ASIS being so far from patella relative to tibial tuberosity, seemingly important medio-lateral translations have only little effect. Two centimeters of medio-lateral shift of the ASIS only changes 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 ASIS between men and women. Although women have a wider pelvis in the traditional sense, their ASIS is no more lateralized than in men. It might clearly be different if the most lateral aspect of the iliac wings was used instead.[4]

If a woman's ASIS were more lateralized, they would have a higher incidence of patellar instability after knee replacement surgery than men because of more lateral quadriceps pull, which is not the case. Moreover, the surgeon sets the same angle on his femoral intramedullary jig for both men and women during knee replacement, further suggesting that men and women exhibit similar femoro-tibial valgus. An elevated Q angle equally influence the choice of surgical procedure in a male or female both who requires patellar re-alignment.[4]

Analysis of between-group (male versus female) and within-subject (right versus left lower limb) variation in Q angle with subjects standing erect revealed no significant gender ($p < 0.05$) or right to left differences ($p < 0.05$).[9] Our study also verified this fact, moreover we found no significant difference even for the subjects in supine position.

Study of Q angles in standing position with quadriceps relaxed in male and female individuals asymptomatic versus symptomatic for anterior knee pain found a weak significant correlation only between right and left Q angles in symptomatic group ($r = 0.53$, $p < 0.001$)[7] or between men and women.[10] However, some study failed to reproduce this fact ($p = 0.07$).[11] We did not study Q angle in symptomatic knees and thus the relationship between anterior knee pain syndrome (APKS) and Q angle could not be established but we found no significant difference in Q angle between right and left knees in asymptomatic knees in standing and supine position, irrespective of gender.

Our study revealed no significant difference ($p>0.05$) in the mean Q angle in upright and supine position which was in consistence with other study.[12] The study further found same result on paired sample t-test in their three subgroups having variable joint hypermobility.[12] However, we have not studied the effect of joint hypermobility on Q angles. Study on effect of position of limb and Q angle revealed no significant relation between them, however, isometric quadriceps contraction showed significant effects on Q angle for both men and women ($p < 0.001$).[13] We had measured Q angle with quadriceps relaxed and thus we were unable to draw any conclusion on the effect of quadriceps contraction on Q angle from this study.
Comparison of Q angles in supine and standing positions of college-aged men and women showed statistically significant difference between them. ($P < 0.05$)[14,15] This was in contrast to our study.
Study of Q angle using OPTOTRAK motion-measurement sensors by placing infra-red light emitting diodes (LED) on bony landmarks revealed statistically significant difference between right and left Q angles in standing position ($p < 0.05$)[2] in contrast to our study.

We found no significant correlation between Q angle and age irrespective of gender in consistent to previous study however, they showed a significant correlation between quadriceps strength and a decrease in Q angle.[16]

The mean difference of Q-angle between male and female ranged from 3.0^0 to 4.6^0 in various studies.[17, 18, 19]

Results of this study were derived from a healthy, normal eastern Nepalese population. Whether similar results would be observed for other population with / without any patellar pathology is unknown. Positioning the subject in an upright, weight-bearing posture was purposely chosen to include the biomechanical stress on the knee joint during standing. During weight transmission in a standing individual, an alteration of the load bearing axis might be possible.

In contrast to males, weight of females had not shown significant correlation with their Q angle in this study. We could find no explanation, but there might be a cut-off value for weight for females below which the correlation with Q angle becomes statistically insignificant. Detail study for females including pelvis width, femur length, femoral neck shaft angle, genu varum/valgum is to be considered to explain this observerd discrepancy. In general, there might be other factors determining Q angle of an individual apart from those considered in this study. Functional overloading of the knee, muscle and ligament insufficiency, bone and chondral morphological changes, malalignment or asymmetric leg length of the lower limbs and foot alterations could be responsible to varying extent.

Poor reproducibility and reliability (Inter-observer and Intra-observer) and absence of standardized methodologies could be responsible for observed discrepancies between our results and that reported in previous investigations. The accuracy of measurement can be also affected by an error in identifying the anatomical landmarks. An error in setting the anatomical landmarks by 2 mm may alter Q angle measurement up to 5° [20].

Conclusion

We conclude that there is within subject and between gender asymmetry in Q angle. It also varies with the change in limb position. However, the mean value of Q angle for eastern Nepalese is consistent with previously accepted Q angle values in western literature. There is significant positive correlation between Q angle and weight of individual. We recommend that in recording Q angle measurements, both sides should be measured with limb position specified.

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