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Relationship between bilateral quadriceps angle and anterior knee pain and its association with knee injury in long distance runners.

Authors: Mehul Padasala,[1]   Jaymin H Bhatt ,[2]   Rosario D'Onofrio. [3]

[1] Senior Lecturer, N.R. Institute of Physiotherapy, Ahmedabad, Gujarat – India.

[2] Musculoskeletal Physiotherapist, Aash Arthroscopy Center, Ahmedabad, Gujarat – India.

[3] Rehab Conditioning Specialist and Athletic Trainers in Rehabilitation – Sapienza University of Rome - Italy.

ABSTRACT

Background: Quadriceps angle (Q-angle) is an important indicator of biomechanical function in the lower extremity and describes the lateral force applied to the patellofemoral joint by the contraction of the quadriceps muscle. It is a quantitative measurement of patellar position with respect to the lower extremity alignment. Nowadays, not only in sports world but also in general population, patellofemoral pain syndrome, and dislocations of knee joint have become very common problem.

Objective: To evaluate the relationship between quadriceps angle (Q-angle) and risk of knee injury among long distance runners.

Methods: A total of 100 subjects (50 symptomatic and 50 Asymptomatic) as cases and controls of the age group 25-35 were studied. *They were assigned to two groups. Group A consisted of 50 subjects with anterior knee pain* either the right or left limb*, and group B consisted of 50 subjects with no history of knee pain.* The measurement of Q-angle was carried out on both right and left lower limbs with the help of goniometer in a standing position with quadriceps relaxed in both cases and controls and data were statistically analyzed. The differences in Q-angles within and between the groups were analyzed using the independent t-test at a significance level of 0.05. SPSS version 16.0 was used for statistical analysis.

Results: According to the findings of the present study, there was a highly significant difference in the value of bilateral Q angle with the right limb exhibiting higher values compared with the left. (p=0.005). The study also showed a statistically highly significant difference when Q-angle were compared between the asymptomatic and symptomatic groups with greater Q-angle values observed in the groups (p=0.001). The findings of this study suggest that there is bilateral asymmetry in Q-angle. Conclusion: The study shows that Q-angle is bilaterally asymmetric with right limb having higher value. Findings from this study also show that anterior knee pain increased the values of Q-angle. Long distance runners with large or asymmetric Q-angles may be at greater risk for running injury. Our study suggests that Q-angle measurement be included in preseason screening exams. So, This anatomical expression of Q-angle can be used as a tool for early prediction of anterior knee pain *(Mehul Padasala, Jaymin H Bhatt, Rosario D'Onofrio - Relationship between bilateral quadriceps angle and anterior knee pain and its association with knee injury in long distance runners. Ita. J. Sports Reh. Po.; 2019 ; 6 ; 2 ; 1240 -1252; ISSN 2385-1988 [online] IBSN 007-111-19 - 55 ; CGI J OAJI :0,101).*

KEYWORDS: *Q angle, anterior knee pain, running injury.*

INTRODUCTION

Although running has been popular since the 1970s,[1] the number of runners and running events has increased steadily since 2000.[1,2] This increase is largely due to girls and women who started running. [2,3] Running in the adult population is one of the most popular physical activities around the world. And in the Western society many cities have their own recreational running event. Furthermore, running is one of the most efficient ways to achieve physical fitness, which is linked with longevity.[1] A drawback of the sport is the relatively high risk of injury, with an incidence varying between 19% and 79%.[4] this large variation is due to differences in the definition of injury, study populations, and follow-up periods. [5]

Acute running injuries are rare, consisting mainly of muscle injuries, sprain, or skin lesions (Blisters and abrasions). [7] Eighty percent of running disorders are overuse injuries, resulting.
From a mismatch between the resilience of the connective and supporting tissue and running.[7] Running is one of the most common sports that give rise to overuse injuries of lower back and the leg.[8] The predominant site of leg injuries is the knee, for which the location specific incidence ranged from 7.2% to 50.0%.[4] Risk factors for running injuries can be clustered into three domains 1) personal factors (e.g. age, sex, height, genetic imprinting), 2)running/training factors (e.g. weekly running days, distance, running shoes), and 3) health and lifestyle related factors (e.g. smoking, a history of co morbidity and previous injuries).[4]

Long-distance running (greater than 3000 m) is frequently recommended to maintain a healthy lifestyle.[9] between 37% to 56% of recreational runners who steadily train and participate in a long-distance run periodically will sustain a running-related injury each year.[10] A retrospective study of adolescent runners (13-18 years) demonstrated a lifetime.

Prevalence of previous running injury (68% in girls and 59% in boys) with strong associations with higher mileage and faster performance.[11] Known predictors of lower extremity injury include running greater than 40 miles per week and previous lower extremity injury.[12,13,14] While training errors lead to the majority of running injuries, biomechanical factors, such as foot insufficiency, muscle weakness, genu varum, and high Q-angle, contribute to 40% of running injuries.[15] A recent systematic review of the incidence of leg injuries among long-distance runners found that most injuries involve the knee (7.2%-50%), lower leg (9%-32.2%), foot (5.7%-39.3%), or thigh (3.4%-38.1%).[4]

Runners with an abnormal Q angle may be predisposed to developing patellofemoral pain syndrome, chondromalacia patella and increased femoral anteversion.[16] In running the most common site of injuries occur at the knee and associated structure and tissue around it. Previous running injuries are a strong risk factor for re-injury again. The dominant site of injury in runners occurs at the knee joint, with up to 42% of all running injuries.[17] The most common overuse running injuries was patellofemoral pain syndrome. Alteration in training method such as increasing intensity, frequency and distance have been shown to influence the rate of injury. Changes in training method such as rapid increase in intensity or frequency have been linked to injury like patellofemoral pain syndrome.[18] over the period of one year; nearly two thirds of runners will experience at least one running injury that will disrupt their training program. Injuries range over different experience levels but long distance runners that are more frequently injured.[19]

Overuse injuries are more due to chronic repetitive micro trauma that exceeds the tissues ability to repair itself throught the whole gait cycle, large forces are placed over the structures of lower limb

especially on knee joint. The chance of experiencing a running injury in runners with abnormal biomechanics will be increased with these repetitive large forces.[20]

Patella femoral angel is a frequently used method in knee-joint and lower-extremity's evaluation in kinesiology sense, firstly verbalized by Brattström, and nowadays Q angle is m. quadriceps femoris's angle. [21]

The quadriceps angle, or Q angle, is the angle formed by the encounter of two lines, one that starts at the anterior iliac spine (AIS) and goes to the center of the patella, and another that goes from the tibial tuberosity to the center of the patella.[22] It is a clinical measurement used to measure knee alignment with respect to the hip, femur and tibia, and to evaluate the patella alignment.[24, 27, 26] The importance of assessing the Q angle is cited by several studies involving biomechanics, clinics and knee surgery. This angle helps indicating the force vector acting on the patella and patellofemoral joint[22-26] furthermore, it is also used as a criterion to identify candidates for surgery or as predictor of risk of injury.[24-26]

Overwhelming evidence exists to show that females (range =15°-20°) have a higher Q-angle (of wider pelvis) than male (range = 12°-15°).A Q-angle in excess of 20° may lead to knee joint instability and lateral patella tracking.[28] Lateral patella tracking over a long period of time may cause breakdown of the patello-femoral joint surface resulting in patello-femoral pain also called anterior knee pain (AKP), and it is often cited as a risk factor for the occurrence of chondromalacia patellae and patello-femoral subluxation or dislocation.[28, 29]

Some studies have associated the risk of knee injury with the quadriceps (Q)-angle.[30,31,10] Van Mechelen[10] has suggested that during running there is excessive use of the extensor mechanism of the knee resulting in an imbalance of the components of the quadriceps muscle. A stronger vastus lateralis pulls the patella laterally resulting in a larger Q-angle, while a stronger vastus medialis pulls the patella medially resulting in a smaller Q-angle.[32, 33, 34] Therefore the Q-angle is an indicator of the imbalance between components of the quadriceps muscle.

Few Studies have evaluated bilateral Q-angle asymmetry in bilateral anterior knee pain.[35] Limited literatures are available for assessment of Q angle in individuals with unilateral anterior knee pain. Furthermore few literature supports that anterior knee pain increases Q angle as lateral maltracking commonly occurs in patient with unilateral anterior knee pain.[36] Some studies show no significant difference in Q angle in patient with Unilateral anterior knee pain.[35, 37] Hence the purpose of this study was to compare bilateral quadriceps angle in subjects with unilateral anterior knee pain in long distance runners and in healthy individual.

MATERIALS and METHOD
Study Design

This research is conducted as an cross sectional study where participants will be in standing position to measure their Quadriceps angle bilaterally.

Study Setting

The study was conducted at the N.R. institute of physiotherapy, Ahmedabad.

Subjects

One hundred (100) subjects, encompassing both asymptomatic (no anterior knee pain) and symptomatic (unilateral Anterior knee pain, from running sports injury) participated in the study. The subjects comprised of 50 Asymptomatic and 50 symptomatic participants. All subjects were males and were between the ages of 25 and 35 years. The subjects were recruited from the different sports club.

The subjects were divided into 2 groups;

Group A: This group consisted of long distance runners with either right or left sided anterior knee pain.

Group B: This is the control group of asymptomatic male Subjects who are free from any pain in knee joint.

INSTRUMENTATION

- Universal goniometer
- Water soluble marker & meter ruler
- Spirit & cotton wool
- A weighing machine: to measure the weight of the subject.
- A recording sheet: to record the data.
- Measuring tape

Outcome Measure

Q-angle value

Criteria for Selection

Inclusion Criteria
The inclusion criteria for asymptomatic subjects were;
Age between from 25 to 35 year, individuals with no history of anterior knee pain, and individuals with normal gait and posture.
And the inclusion Criteria for symptomatic subjects were;
Individuals with unilateral anterior knee pain of either of the limbs.

Exclusion Criteria
The exclusion criteria for both groups.
With bilateral anterior knee pain and knee deformities such as genu varum, valgum, and recur vatum were excluded. And limb length discrepancy, any surgical history of knee, Ligament and meniscal injuries of knee, Neurological conditions that affect the lower extremity like cerebral palsy, stroke, GBS, polio, leprosy.

Procedures:
A brief description of the procedure was given to the subjects after recording their age, gender, weight and height and body mass index (BMI). Each subject, dressed in shorts and T-shirt, was decently exposed to show the landmarks. With the subject standing in the erect, weight-bearing position, the anatomical landmarks including the border of the patella, tibia tubercle and anterior superior iliac spine (ASIS) were palpated and the centre of the patella marked by an indelible marker. Then the subjects were divided in groups according to their presence of anterior knee pain. Subject was first given detailed information about the procedure. Subjects had been decently exposed to show the landmarks. The anatomical landmarks were located through palpation and then marked with a water soluble marker. Subject was in standing position & quadriceps was relaxed and feet were in neutral position. Q angle was taken by universal goniometer. The anatomical landmarks which is already marked joined by the use of a meter ruler and a marker. With the pivot of the goniometer placed on the mid-point of the patella, the stationary arm on the line adjoining the ASIS to the mid-point of the patella, and the moveable arm placed over the line adjoining the tibial tubercle to the mid-point of the patella. The angle thus formed between the two arms of the goniometer measured and recorded as the Q-angle. Bilateral measurements of the Q-angle have been taken and recorded for each subjects. (Photo 1,2)

All measurements were taken by the same investigator. An excellent intertester reliability (ICC, r = 0.80) has been reported for Q-angle measurement (Shrout et al, 1979; Fleiss, 1986).[44]

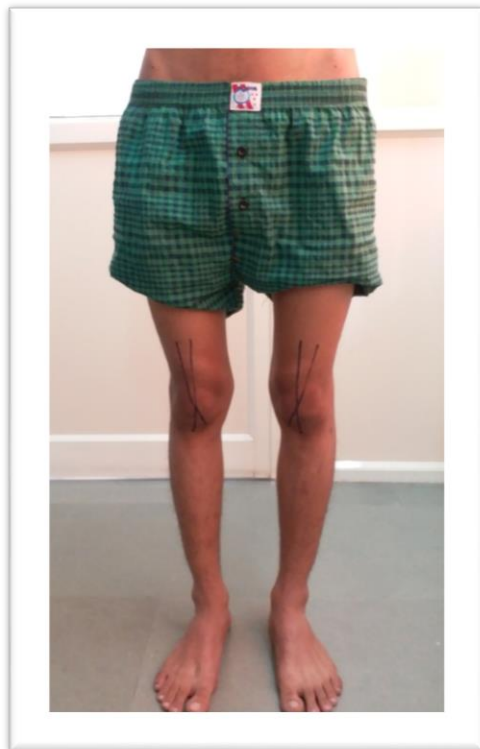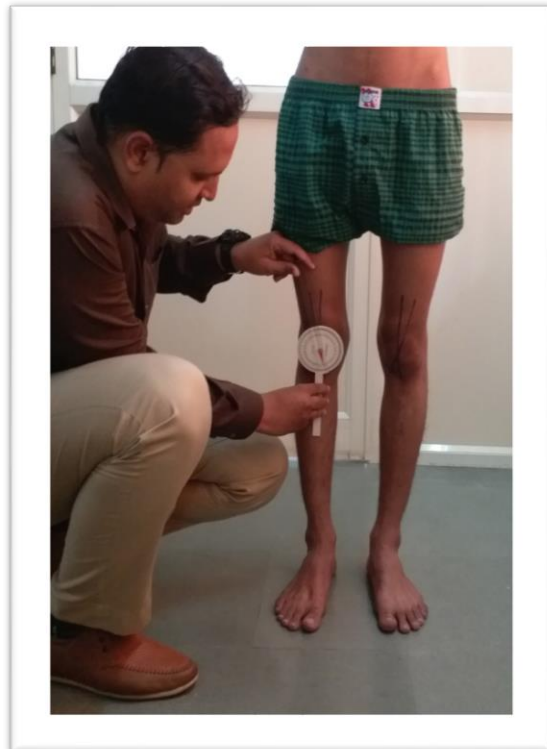**Photo 1:** Q angle. (Bilateral)

Photo 2. Measurement of Q angle.

STATISTICAL ANALYSIS

Data was analyzed using the descriptive statistics of mean and standard deviation (X ± SD). Inferential statistics of independent t-test was used to compare for bilateral Q-angle symmetry as well as the Q-angle values between the corresponding limbs of the symptomatic and Asymptomatic subjects with unilateral unilateral anterior knee pain. Level of significance was set at the $p<0.05$.

RESULTS

variables	GROUP A symptomatic	GROUP B Asymptomatic	T value	P value
Age(year)	29.82 ±3.1278	28.90 ± 3.0254	1.043	0.307
Height(cm)	168.84± 8.6102	162.42 ± 5.0430	4.592	0.032
Weight(kg)	60.40 ± 8.6920	57.90 ±7.3073	3.000	0.083
BMI	21.52 ±2.4773	21.80 ±2.2067	0.320	0.572

Table 1. Demographic data and anthropometric data of the subjects.

Interpretation: The above table shows the mean and standard deviation of age, height, weight and BMI of symptomatic subjects in symptomatic subjects in group A respectively 29.82 ± 3.1278, 168.84

± 8.6102 , 60.40 ± 8.6920, 21.52 ± 2.4773 and in Asymptomatic subjects in group B respectively 28.90 ± 3.0254, 162.42± 5.0430, 57.90 ±7.3073, 21.80 ±2.2067

Q angle dominance	Mean±standard deviation	min	max	T value	P value
Right Q angle	15.48 ± 2.7496	10	20	8.000	0.005 **
Left Q angle	12.74 ± 2.7241	8	19		

Table 2. Comparasion of bilateral Q angles for symmetry in the symptomatic subjects.
Level of significance p≤0.05
** - highly significant

Interpretation: The above table shows the mean and standard deviation of right and left Q angle of symptomatic subjects respectively on right side 15.48 ± 2.7496 and on left side 12.74 ± 2.7241 for the present study. The result shows highly significant difference for symptomatic subjects. (t =8.000, p = 0.005).

Q angle dominance	Mean ± standard deviation	mini	max	T value	P value
Right Q angle	11.56 ± 1.4020	9	14	5.397	0.005 **
Left Q angle	11.64 ± 1.4535	9	14		

Table 3. Comparison of bilateral Q angles for symmetry in the Asymptomatic subjects.
Level of significance p≤0.05
** - highly significant

Interpretation: The above table shows the mean and standard deviation of right and left Q angle of Asymptomatic subjects respectively on right side 11.56 ± 1.4020 and on left side 11.64 ± 1.4535 for the present study. The result shows highly significant difference for symptomatic subjects. (t =5.397, p = 0.005).

variables	Symptomatic $\overline{X}$ ± S.D	Asymptomatic $\overline{X}$ ± S.D	T value	P value
Right Q angle	15.48 ± 2.7496	11.56 ±1.4020	33.80	0.001 **
Left Q angle	12.74 ± 2.7241	11.64± 1.4535	25.19	0.001**

Table 4. Comparison of the corresponding limbs of symptomatic and Asymptomatic subjects with unilateral anterior knee pain.
Level of significance p≤0.05
** - highly significant

Interpretation: The result shows highly significant difference for symptomatic and Asymptomatic subjects on right side (t = 33.80, p =0.001). And on left side (t = 25.19, p =0.001).

DISCUSSION

Quadriceps femoris angle ("Q-angle") can be considered as an index of knee function and patellofemoral kinetics. The findings of this study suggest that larger Q-angle is significantly associated with anterior knee pain in long distance runners. The results showed that there was no significant difference between the ages, weights, heights and BMI of the symptomatic and Asymptomatic groups. The differences thus observed between the groups were not likely to be due to differences in the physical characteristics. This study results showed 15.48 ± 2.7496(SD) as mean of right Q angle for male with right anterior knee pain and 11.56 ±1.4020 (SD) for healthy male, 12.74 ±2.7241 (SD) as mean of left Q angle of male with left Anterior knee pain and 11.64 ± 1.4535(SD) for healthy male. So, highly significant difference in right Q angle for male having right Anterior knee pain and healthy male (t =33.80, p = 0.001), left Q angle for male having left AKP and healthy male (t=25.19, p=0.001).The results accord with those of Akinbro sra et al[36] and Mohammad-Jafar Emami et al.[39] Akinbo Sra et al. studied comparison of bilateral quadriceps angle in asymptomatic and Symptomatic males with unilateral anterior knee pain. He found 15.70 ± 1.72 (SD) as a mean of left Q angle for asymptomatic and 21.15±1.96 for symptomatic male, 12.28±1.30 mean of right Q angle for asymptomatic and 21.22±2.09 for symptomatic male. He concluded that anterior knee pain increased the values of Q angle.[36]

Mohammad-Jafar Emami et al (2007) studied Q-angle as an invaluable parameter for evaluation of bilateral Anterior Knee Pain. He found mean Q-angle for men, women, and all participants in the case group was 15.2, 20.1, and 18.0 degrees, respectively and In the normal control group the angles were 12.1, 16.7, and 14.9 degrees, respectively. He concluded that patients with bilateral anterior knee pain have larger Q-angles than healthy individuals.[38]

While some studies [28, 39, 40] reported bilateral symmetry of Q angle, others [41, 24] claimed bilateral asymmetry. This study corroborated the bilateral asymmetry of Q-angle with the right side exhibiting higher values compared with the left limb. In this study, mean of Q-angle of long distance runners with anterior knee pain was significantly higher than those without knee pain (controls). This suggests that high Q-angle is significantly associated with anterior knee pain. The findings of this study suggest that there is bilateral asymmetry in Q-angle. It was observed in this study that the mean Q-angles of the symptomatic subjects in the right limb was higher (15.48 ± 2.7496) than that observed in the left symptomatic subjects (12.74 ±2.72). This is quite opposed to what was obtained in the asymptomatic subjects. There is however little evidence in literature regarding this observation. It may be postulated that the probability is high that the right limb of symptomatic subjects may have suffered greater trauma in addition to other intrinsic factors compared with the left since the right limb is dominant in all the subjects.

Another important finding reported the mean Q-angles of the Asymptomatic subjects in the left limb was higher (11.64 ± 1.4535) than that observed in the right Asymptomatic subjects (11.56 ±1.4020). The reason behind for this finding is that quadriceps training tends to lower the magnitude of Q-angle, since the right limb is often the dominant limb in most people and its frequently more in use. [41,39] This observation was also reported by Livingston and Mandigo[28], who reported that Q-angle is not bilaterally symmetric, with the magnitude and direction of the observed asymmetry varying according to whether an individual is asymptomatic, unilaterally symptomatic or bilaterally symptomatic with anterior knee pain. Another reason for this may be the bilateral difference in the quadriceps strength. It was found that Q-angle varied inversely with the quadriceps strength.[42] as in most of the controls right limb is the dominant limb, their right Q angle is smaller than Left Q angle.

Livingston and Mandigo[28] conducted a study to find out whether Q-angle was bilaterally symmetric in individuals; asymptomatic and symptomatic for knee pain. They found out that there were significant right versus left lower limb differences in Q-angles, both in symptomatic and asymptomatic group (*P*

< 0.001) and between males and females ($P < 0.05$). They found Q-angles are not bilaterally symmetric, with the magnitude and direction of observed asymmetry varying according to whether an individual is asymptomatic, unilaterally symptomatic or bilaterally symptomatic for anterior knee pain which is in accordance with the present study.

An important point should be considered here in this present study is how increased Q angle is associated with anterior knee pain. This is explained by the study done by Mitchell j. rauh et al (2007)[43]. Mitchell j. rauh et al (2007) examined Quadriceps Angle and Risk of Injury among High School Cross-Country Runners through prospective cohort study and concluded High school cross-country runners with large or asymmetric Q-angles may be at greater risk for running injury. He explained the reason for that is larger Q-angle increases the lateral pull on the patella against the lateral femoral condyle, thus contributing patellar subluxation and other patellofemoral pain disorders.[43]

1248 **CONCLUSION**

From the foregoing, we conclude that larger Q-angle is significantly associated with anterior knee pain in long distance runners. And with a higher Q-angle being the most important risk factor for knee injury. The result of this study shows that Q-angle is bilaterally asymmetric with right limb having higher value compared with the left. Findings from this study also show that anterior knee pain increased the values of Q-angle. It is recommended that Q-angle assessment should be an essential component in the knee injury evaluation in long distance runners. And therefore, this anatomical expression of Q-angle can be used as a tool for early prediction of Anterior Knee Pain.

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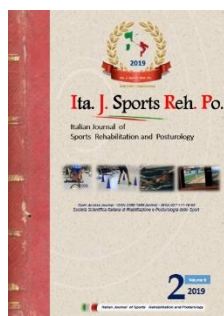
Corresponding Author

Dr. Mehul Padasala, MPT.

Senior Lecturer, N.R .Institute of Physiotherapy, Ahmedabad, India.

E mail: padasalamehulkumar@gmail.com

Declaration of interest

The authors declare that they have no financial, consulting, and personal relationships with other people or organizations that could influence the author's work.

Author's Contributions

All authors played a significant role in this project; All authors were involved in drafting the manuscript critically for important content, and all authors approved the final version.

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