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Relationship between Quadriceps Angle, Body Parameters, and Occurrence of Lower Extremity Injuries of Sri Lankan National Level Athletes

L.W. Rashmika[1], L.R.N.D.Weerarathna[2]
[1]*(Department of Sports Sciences and Physical Education, Sabaragamuwa University, Sri Lanka)*
[2]*(Department of Sports Sciences and Physical Education, Sabaragamuwa University, Sri Lanka)*

Abstract:
Background*: This study aimed to identify the relationship between Quadriceps (Q) angles with body parameters (Gender, height, weight), the occurrence of lower extremity injuries, and contributing factors to the Q angle (femoral anteversion, tibial torsion, and genu valgum) among National level athletes in Sri Lanka.*
Materials and Methods*: This case study was conducted at the Institute of Sports Medicine, Colombo, Sri Lanka. The study sample consisted of two groups, national-level male and female athletes with injuries (N=17) and without injuries (N=16) to lower limbs. Athletes who had recent acute lower limb injuries within a period were excluded from the study. Body height, Bodyweight, and Q angle of both limbs were measured using a stadiometer, electrical weighing scale, and goniometer respectively. Three clinical tests were done to identify the femoral anteversion, tibial torsion, and genu valgum of both limbs of injured and non-injured athletes. Data were collected from January to February in the year 2022.*
Results*: According to the results, there was no significant difference between the Q angle of injured (Injured limb P= 0.776, Non-injured limb P= 0.739) and non-injured (Right P= 0.974, Left P = 0.786) athletes' reference to the gender. There is a significant negative correlation between the Q angle and body height of both genders in spite of having injuries. Though there is no significant mean difference in Q angles between injured and non-injured limbs of males (P= 0.171), there is a significant mean difference in Q angle between injured and non-injured limbs of females (P = 0.013). There is a positive significant correlation between Q angle and femoral anteversion, tibial torsion, and genu valgum in both injured and non-injured athletes. Knee injuries were the most common and highest injuries (35%) and females had the highest risk of knee injuries.*
Conclusion*: It may be concluded that height, femoral anteversion, tibial torsion, and genu valgum had an impact on the magnitude of the Q-angle. Females are more prone to have lower limb injury occurrence than males because of their higher Q angles than males.*
Key Words*: Quadricep angle, Femoral anteversion, Tibial torsion, Genu valgum*

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I. Introduction

In the dynamic motions of the human body, the lower extremity arrangement is a crucial factor. Due to altering joint biomechanics, and inequity between ligamentous and muscle forces, slight deviations in typical alignments may be one of the important factors for lower extremity injuries.Previous studies have suggested that poor knee and body control during landings and cutting actions, as well as a lack of muscle strength, decreased balance, and increased ligament laxity, are all intrinsic risk factors for lower extremity injuries. When considering intrinsic risk factors, Q angle is one of the uncommon factors that can be seen in Sri Lankan studies. The Q-angle affects the quadriceps muscle on the knee, which is a clinically significant characteristic. In addition, maintaining good posture and movement of the knee patella is a critical component when examining knee-related disorders. Knee disorders are proven to be caused by misalignment. As a result, calculating athletes' Q-angles is crucial.The purpose of this study was to see how gender, weight, and height, as well as injured and non-injured lower limbs affected to the Q-angle using a goniometer with the participant standing in a weight-bearing position. In addition, the relationship between Q angle and the contributing factors to the Q angle (femoral anteversion, tibial torsion, tibial tubercle, genu valgum) was investigated.

II. Material and Methods

Thisstudy was carried out on athletes of theInstitute of Sports Medicine Torrington Place, Colombo from January 2022 - February 2022. A total of 30subjects (both male and female) participatedin this study.

Study Design: Descriptive Cross-sectionalStudy Design
Study Location: Institute of Sports Medicine33, Torrington Place, Colombo, Sri Lanka
Study Duration: January 2022 - February 2022
Sample size: 30 athletes
Sample size calculation: 30 Sri Lankan national-level athletes
Subjects & selection method:Sri Lankan national-level athletes who registered under the Institute of Sports Medicine
Inclusion criteria:

1. Athletes who don't have lower limb injuries (Non-injured)
2. Athletes who have lower limb injuries (More than a week)

Exclusion criteria:

1. Athletes who have acute lower limb injuries (Within a week)

Procedure methodology

Measuring Quadricep Angle
Q- angle measured with the participant standing in the erect weight-bearing position with a full circle universal manual goniometer made of clear plastic. The anterior superior iliac spine (ASIS), the patella's midpoint, and the tibial tuberosity were replaced and measured. The goniometer's hinge was placed at the midpoint of the patella, the goniometer armsadjusted to align with the line connecting the ASIS and the tibia tuberosity, and the tiny angle on the goniometer was read as the Q angle. For each person, both sides were measured. All measurements were done by the same expert investigator.

Craig's Test
Craig's test was done to identify the femoral anteversion. On an examination table, the patient lay prone, with the hip in neutral, and the knee flexion should test the side at 90 degrees. The examiner was positioned on the opposite side of the subject's hip. The greater trochanter was palpated using the hand that would be more cranial while the forearm will be stabilizing the sacrum. Next, palpated the greater trochanter of the tested side while passively internally rotating the hip until the most prominent component of the greater trochanter reached its most lateral position with his caudal hand. One examiner placed the leg in the most conspicuous position of the greater trochanter. Using a goniometer or an inclinometer, another examiner measured the angle formed by the tibia's shaft (a line bisecting the medial and lateral malleoli) and a line perpendicular to the table (an imaginary vertical line extending from the table)
Transmalleolar Axis test
A Transmalleolar Axis test was done to identify the tibial torsion. The patient was asked to lie prone with their knees flexed to 90 degrees and their ankles in a neutral posture. The angle between a line connecting the centers of the medial and lateral malleoli (Transmalleolar axis, TMA) and a line perpendicular to the long axis of the thigh (tibial torsion) was measured.

Genu valgum
Genu valgum was identified from the quadricep angles. If the quadriceps angle was above 17 degrees, consider it as genu valgum for females,and an angle of 12 degrees, is considered as for males.

Statistical analysis
Descriptive statistics were used to find mean and standard deviation differences for analysis. Furthermore, the statistical procedure was carried out using the Statistical Package for the Social Sciences (SPSS) version 22 assistance software. The independent sample t-test was used to determine the variation of Q angle and specific gender. A correlation test was done to identify the variation between Q angle, height, and weight as well as Q angle with femoral anteversion, tibial torsion, and genu valgum abnormalities. A correlation

test and paired t-test were used to identify the relationship between injured and non-injured legs. The level $P < 0.05$ was considered as the cutoff value or significance.

III. Result

Comparing the male and female Q angle mean values in injured athletes

Mean Q angles of males and females were analyzed by using the independent sample t-test. According to the below table, the mean right-side Q angle in injured females is 14.800 (N= 7) and 12.820 in injured males (N= 10). The mean Q angle of the left side is shown as 13.620 in injured females (N= 7) and 13.620 in injured males (N= 10). There are mean differences in both right and left Q angles but not significant. Females have a 2-degree higher mean Q angle value than males when considering the right side. When considering the left side females have 1degree higher mean Q angle than males.

Table 1 Comparing the male and female Q angle mean values in injured athletes

	Gender	N	Mean	Std. Deviation	Sig.
Q – angle (Injured limb)	M	10	12.820	2.6717	0.776
	F	7	14.800	1.7330	
Q - angle (Non-injured limb)	M	10	13.620	2.2419	0.739
	F	7	14.600	1.4029	

Comparing the male and female Q angle mean values in non-injured athletes

According to table 2, the mean right-side Q angle in non-injured females is 17.71(N= 7) and 12.67 in non-injured males (N= 9). The mean Q angle of the left side is shown as 17.28 in non-injured females (N= 7) and 13.20 in non-injured males (N= 9). There are mean differences in both right and left Q angles but not significant. Females have a 5.04 degree higher mean Q angle value than males on the right side. When considering the left side females have 4.08 degrees than males.

Table 2Comparing the male and female mean values in non-injured athletes

	Gender	N	Mean	Std. Deviation	Sig.
Q - angle Right	M	9	12.67	2.828	0.974
	F	7	17.71	3.352	
Q - angle _Left	M	9	13.20	3.1353	0.786
	F	7	17.28	3.1997	

Relationship between Q angle values with height and weight in injured male athletes

Pearson correlation test was done to identify the relationship between Q angle, height, and weight. Pearson's correlation is used when identifying a linear relationship between two quantitative variables. The hypothesis is used to find a linear relationship between those variables.

H0: There is no relationship between the two variables.

H1: There is a relationship between the two variables.

As illustrated in table 3 the relationship between right Q angle with height in injured (cc =-.712, 0.021< 0.05) and non-injured (cc =- .639, 0.054 < 0.05) male athletes had a negative correlation with a significant relationship. Therefore, the investigator can reject the null hypothesis. The relationship between left Q angle with height in injured (cc =-.639, 0.047< 0.05) and non-injured (cc =- .623, 0.043 < 0.05) male athletes had a negative correlation with a significant relationship. Therefore, the investigator can reject the null hypothesis.

The relationship between right Q angle with weight in injured (cc =-.0217, 0.354> 0.05) and non-injured (cc =- .020, 0.060 >0.05) male athletes had a negative correlation without a significant relationship. Therefore, the investigator cannot reject the null hypothesis. The relationship between left Q angle with weight in injured (cc =-.0217, 0.548 > 0.05) and non-injured (cc =- .015, 0.070 >0.05) male athletes had a negative correlation without a significant relationship. Therefore, the investigator cannot reject the null hypothesis.

Table ***Error! No text of specified style in document.*** *Relationship between Q angle values with height and weight in injured male athletes*

		Height		**Weight**	
		CC	**Sig**	**CC**	**Sig**
Q angle_ Right	**Injured**	-0.712	0.021	-0.217	0.354
	Non-injured	-0.639	0.054	-0.200	0.600
Q angle_ Left	**Injured**	-0.639	0.047	-0.217	0.548
	Non-injured	-0.623	0.043	-0.15	0.70

According to table 03, the relationship between right and left Q angle with height in injured and non-injured female athletes negatively correlated with a significant relationship. Therefore, the investigator can reject the null hypothesis.

The relationship between both right and left Q angle with weight in injured and non-injured female athletes had a negative correlation without a significant relationship. Therefore, the investigator cannot reject the null hypothesis.

Table 4Relationship between Q angle values with height and weight in injured female athletes

		Height		Weight	
		CC	**Sig**	**CC**	**Sig**
Q angle_ Right	**Injured**	-0.869	0.011	-0.432	0.333
	Non-injured	-0.214	0.045	-0.789	0.085
Q angle_ Left	**Injured**	-0.897	0.006	-0.226	0.626
	Non-injured	-0.050	0.042	-0.557	0.194

Figure 11 Injured males_weight with left Q angle

Comparing the injured and non-injured limbs Q angle mean values

To identify the relationship and mean Q angle difference of the injured and non-injured legs, the Pearson correlation was done and there was a significant positive correlation between them. To compare the mean differences paired sample t-test was done and it was identified that there was a significant mean difference in both male and female athletes. The injured leg had a higher Q angle than the non-injured leg in both males and females.

Table 5 Comparing the injured and non-injured limbs Q angle mean values in females

		Mean	N	Std. Deviation	Std. Error Mean	Mean difference	Significance
Pair 1	Injured leg	15.31	7	3.4658	1.3099	1.23	.013
	Non-injured	14.08	7	3.1809	1.2023		

The above table consists of Paired sample t-test results between injured and non-injured legs of injured female athletes. According to the results, the mean value of the injured leg and non-injured leg is 15.31 and 14.02. There was a significant mean difference between the injured leg and the non-injured leg (0.013 < 0.05). The injured leg values were 1.23 points higher than the non-injured leg values.

Table 6Comparing the injured and non-injured limbs Q angle mean values in males

		Mean	N	Std. Deviation	Std. Error Mean	Mean difference	Significance
Pair 1	Injured leg	13.58	10	3.6593	1.1572	0.3296	.171
	Non-injured	12.86	10	3.3297	1.0530		

The above table consists of Paired sample t-test results between injured and non-injured legs of injured male athletes. According to the results, the mean value of the injured leg and non-injured leg is 13.58 and 12.86. There was no significant mean difference between the injured leg and the non-injured leg (0.171 >0.05). But on the mean, injured leg values were 0.72 points higher than the non-injured leg values.

Relationship between Q angle, femoral anteversion, tibial torsion, and genu valgum

Pearson correlation test was done to identify the relationship between Q angle, femoral anteversion, tibial torsion, and genu valgum.

H0: There is no relationship between the Q angle and the femoral anteversion.
H1: There is no relationship between the Q angle and the femoral anteversion.
As illustrated in table 7, the relationship between Q angle and femoral anteversion, Q angle and tibial torsion, and Q angle and genu valgum of the right and the left side of both injured and non-injured male athletes. Right, Q angle and right femoral anteversion had a significant positive correlation in both injured (r = .666, 0.036< 0.05) and non-injured (r = .894, 0.001< 0.05) male athletes. Left Q angle and left femoral anteversion had a

significant positive correlation in both injured (r = .755, 0.012< 0.05) and non-injured (r = .717, 0.030< 0.05) male athletes. Therefore, the investigator can reject the null hypothesis.
Right, Q angle and right tibial torsion had a significant positive correlation in both injured (r = .871, 0.001<0.05) and non-injured (r = .894, 0.001<0.05) male athletes. Left Q angle and left tibial torsion had a significant positive correlation in both injured (r = .847, 0.02< 0.05) and non-injured (r = .933, p < 0.001) male athletes. Therefore, the investigator can reject the null hypothesis.
Both right Q angle with right genu valgum and left Q angle with left genu valgum had a significant, strong and positive correlation in both injured and non-injured male athletes (r = 1.000, .000< 0.05). Therefore, the investigator can reject the null hypothesis.

Table 7: Relationship between Q angle, femoral anteversion, tibial torsion, and genu valgum in males

	Femoral anteversion		Tibial torsion		Genu valgum	
	CC	**Sig**	**CC**	**Sig**	**CC**	**Sig**
Injured (Non-injured limb)	.666	.036	.871	<.001	1.000	.000
Injured (Injured limb)	.755	.012	.847	.002	1.000	.000
Non-injured (right)	.894	.001	.549	<.001	1.000	.000
Non-injured (left)	.717	.030	.933	<.001	1.000	.000

As illustrated in table 11, the relationship between Q angle and femoral anteversion, Q angle and tibial torsion, Q angle and genu valgum of the right and the left side of both injured and non-injured female athletes. Right Q angle and right femoral anteversion had a significant positive correlation in both injured (r = .927, 0.03< 0.05) and non-injured (r = .807, 0.028< 0.05) male athletes. Left Q angle and left femoral anteversion had a significant positive correlation in both injured (r = .938, 0.002< 0.05) and non-injured (r = .835, 0.019 < 0.05) male athletes. Therefore, the investigator can reject the null hypothesis.

Right Q angle and right tibial torsion had a significant positive correlation in both injured (r = .806, 0.028<0.05) and non-injured (r = .782, 0.038 <0.05) male athletes. Left Q angle and left tibial torsion had a significant positive correlation in both injured (r = .849, 0.016< 0.05) and non-injured (r = .753, 0.050 < 0.050) male athletes. Therefore, the investigator can reject the null hypothesis.

Both right Q angle with right genu valgum and left Q angle with left genu valgum had a significant, strong, and positive correlation in both injured and non-injured male athletes (r = 1.000, .000< 0.05). Therefore, the investigator can reject the null hypothesis.

Table 8 Relationship between Q angle, femoral anteversion, tibial torsion, and genu valgum in females

	Femoral anteversion		Tibial torsion		Genu valgum	
	CC	**Sig**	**CC**	**Sig**	**CC**	**Sig**
Injured (Non-injured limb)	.927	.003	.806	.028	1.000	.000
Injured (Injured limb)	.938	.002	.849	.016	1.000	.000
Non-injured (Right)	.807	.028	.782	.038	1.000	.000
Non-injured (Left)	.835	.019	.753	.050	1.000	.000

IV. Discussion

Our study investigated the mean Q angle and its relationship with gender, height, weight, and Q angle with femoral anteversion, tibial torsion, and genu valgum in Sri Lankan National level injured and non-injured male and female athletes registered under the Institute of Sports Medicine. There are several studies found on the Q angle aiming at the relationship between the Q angle and various body parameters. This study shows the findings of the Q angle and its relation to body parameters in the Sri Lankan population. According to the outcomes Q angle was greater in females when compared to the males similar to the previous studies regarding the Q angle and gender (Raveendranath et al., 2009). According to CARREIRO, 2009, the mean Q angle for male range from 8 to 14 degrees, while girls' Q angles range from 11 to 20 degrees. And Murat Sen et al studied Turkey wrestlers and footballers' mean Q angles of males as 15.08° ± 1.79° and females as 14.49° ± 1.82°and Our study also showed similar values of Q angles. The possible clarification for females having higher mean Q angle values may be females having wider pelvis than males. So, they have a long distance between the pelvis and patella when comparing the distance of the patella to the tibial tuberosity. It can conclude that the anterior superior iliac spine has a considerable impact on the q angle. (Grelsamer RP et al, 2005). Having higher Q angle values in females, increase their compression of articulating surfaces and is at higher risk of patellofemoral pain.

As well as it leads to an increase in the thickness of cartilage of the medial femoral condyle and cartilage grading in females according to recent studies. Jaiyesimi, A.O et al, 2009 suggested that males seem to be taller than females, and small Q angle values can be seen in tall persons. Our study suggests a significant negative correlation between Q angle values and height in both genders and in both injured and non-injured athletes. Under the findings of this study, there is no significant relation between Q angle and body weight. Sra A.et al 2008 also conclude that there is no significant variation with weight and Q angle. When comparing the injured and non-injured limbs, there was a significant mean difference in Q angle values in female athletes and there was no significant difference in male athletes. Nguyen, A. D et al. 2009 reported that femoral anteversion has a strong relationship with high Q angle values and it impacts the Q angle values similarly in both genders. According to this study, there is a significant relationship between the Q- angle and femoral anteversion, Q angle, and tibial torsion. According to the. T.R. Malone et al 2017 patients with greater Q angles can have increased genu varum, and genu recurvatum. Our study also proved that there is a significant, strong relationship between the Q- angle with genu valgum.

V. Conclusion

This study was applied to the Sri Lankan national-level athletes who registered under the Institute of Sports Medicine to determine the relationship between the Q angle, body parameters, and contributing factors to the Q angle. According to the findings, females have a higher risk of injuries than males because of having higher Q angles. Q angle had a significant correlation with Height. Femoral anteversion and tibial torsion, and genu valgum had a significant positive correlation with the Q angle. Femoral anteversion, external tibial torsion, and genu valgum may be the reasons for excessive Q angles. An excessive Q angle can lead to knee injuries, non-specific anterior knee pain, develop patella-femoral syndrome pain, and muscle imbalance. As well as when doing repetitive activities using the knee, excessive Q angles lead to biomechanical stress, because Q angles interfere with smooth movements in the patella. Preventing excessive pronation and lowering the stress on the knee are the solutions for higher Q angles. Understanding the lower limb alignments leads to prevent from future injury risks for athletes.

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