Quadriceps angle and its relation with hip rotation measured in two starting positions

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Abstract. *Introduction.* The knowledge and measurement of *Q*-angle is highly important in clinical evaluation of knee function. The study was designed to investigate the relationship between quadriceps angle and hip rotation and to determine the influence of age on *Q*-angle values of a selected healthy Nigerian population. *Material and Method.* Four hundred, apparently healthy volunteers (200 males, 200 females) within the age range 9-50 years, were divided into pre-puberty, adolescent, young adult and adult age groups. Subjects' *Q*-angle (measured in supine lying), hip rotation (measured in prone lying and sitting positions) were measured using standardized procedures. Data obtained were analyzed using descriptive statistics of mean, range, standard deviation and inferential statistics of correlation matrix. *Results. No* significant correlations (r<0.04, P< 0.05) were obtained between *Q*-angle and values of internal and external hip rotation measured in prone lying and sitting positions in case of the analysis of entire population and when each age group was considered separately. *Conclusion.* Hip rotation and age may not be true predictors of *Q*-angle.
Key Words: *Q-angle, hip rotation, age, prone lying, sitting.*

Introduction

Abnormally high quadriceps angle has been reported as one of the main purported causes of patella-femoral pain, instability and dislocation, the measurement of this angle is thus a relevant clinical line of assessment (1-3).

According to Lathinghouse and Timble (4), *Q*-angle represents an estimate of the resultant force of the quadriceps on patella as well as a predictor of lateral movement of the patella under dynamic condition.

The angle is measure by drawing an imaginary line from the anterior superior iliac spine (ASIS) to the centre of patella and from the centre of the patella to the middle of the tibial tuberosity (5, 6).

Several attempts have been made by previous studies to identify factors that would increase *Q*-angle and such factors include increased knee valgus position, a laterally situated tibial tuberosity, a tibial tuberosity that stands outwardly rotated, an internal femoral torsion or femoral neck anteversion, increased strength of the lateral components of the muscle quadriceps compared to the medial components, the flexion and extension positions of the knee (7).

Previous studies that tested the correlation of *Q*-angle with anatomical measurements like hip width, femur length and patella height found no significant correlation (8-10) but concluded that gender is the only viable predictor of *Q*-angle. Hvid and Andersen (10) reported a fairly significant correlation between Q-angle and internal hip rotation which was measured as an estimate of femoral torsion (r = 0.428, n = 58, (P = 0.01).

Nguyen et al (11) carried out a study to determine the extent to which lower extremity alignment characteristics of the pelvis, hip, knee, and foot are related to the Q-angle and found tibio-femoral angle and femoral anteversion as the most predictors of *Q*-angle; a change of 1^0 in femoral anteversion and tibiofemoral angle was reported to have predicted 0.18^0 and 0.6^0 changes in Q-angle of 102 male and 106 female subjects.

The knowledge of anatomical factors and measurements that have the potential to impact the magnitude of Q-angle may allow clinicians and researchers to better determine its role in dynamic motion and risk of knee injury. It is also important to ascertain if variation exists as the individual grows from pre-puberty to adulthood stages of life. The present study was specifically designed to determine if any significant relationship exists between Q-angle and hip rotation measured in prone lying and sitting positions among the age groups considered.

Materials and Methods

Four hundred subjects aged 9-50 years (200 males, 200 females) participated in this study. They were categorized into pre-puberty (9-12years), adolescent (13-15 years), young adult (20-30years) and adult (35-50 years) groups (10). The participants were volunteers from Obafemi Awolowo University community in Ile-Ife, South -Western, Nigeria.

The purposive non-probability sampling technique was used to recruit subjects who were assessed as they became available. Participants satisfied the selection criterion of the study which is based on the observation of their lower extremities. They had no history or evidence of musculoskeletal or neurological disorders in their lower extremities.

Procedure and Measurements. Ex-post-facto design was used for the study. Measurements were taken once and there was no intervention. Instruments for Data Collection were: 1**.** Flexiometer (J.A. Preston Cooperation, Canada). It was used to measure Q-angle in degrees. It has the range of 0^0 to 180^0. 2. Meter rule (Universe, China). It was used to draw and trace the surface markings of Q-angle. 3. Gravity Reference Goniometer (OB Rehab, Sweden). This was used to measure the range of hip rotation (both internal and external) in degrees. 4. Stadiometer (Gulfex, England). It was used to measure subjects' height in meters. Its scale ranges from 0 to 2.0 meters.

Approval of the Ethical Review Committee of the Obafemi Awolowo University, was sought and obtained before the commencement of the study. Written informed consent was sought and obtained directly from all participants in young adult and adult groups while the parents of the children in pre-puberty and adolescent groups signed the consent form on their behalf. Participants' ages were recorded in years and their heights were measured and recorded in meters using standardized procedure.

For the purpose of uniformity, participants' dominant lower limbs were determined using the procedure described by Jaiyesimi and Jegede (12), and was chosen for the measurement of *Q*-angle and hip rotation.

For *Q*-angle measurement, subject lay fully supine in light shorts on the plinth with feet together, thigh muscles relaxed and ankles in neutral position.

The centre of patella, tibial tuberosity and anterior superior iliac spine (ASIS) were carefully located by palpation. The meter rule was used to draw a straight line from the centre of the patella to ASIS, and another line from the tibial tuberosity to the centre of patella.

The acute angle formed between the two lines was measured with the flexiometer and recorded as Q-angle in degrees.

For hip rotation measurement, the subject were in prone lying, the knee in 90 degrees flexion and the hip in neutral position, the gravity reference goniometer was attached to the posterior lower leg via a velcro at a point which is 15 cm superior to the area of insertion of the Achilles tendon.

The attachment was done in such a way that the zero axis of the goniometer tallies with the vertical line from Achilles tendon.

Participants actively internally rotated their hips to its end point by turning it away from the midline. The range of motion was taken and recorded in degrees as internal hip rotation in prone lying (IHRP) (13). With the hip back in neutral position and knee in 90 degrees flexion, external hip rotation in prone lying (EHRP) was similarly measured by active turning of the leg towards the midline and recorded in degrees.

A research assistant who is a physiotherapist stabilized participants's buttocks while goniometry was being taken.

Internal and external hip rotations in sitting were measured with subject assuming upright sitting position and both legs hanging off the side of the sitting platform (the plinth).

Subject folded his arms around his chest and the goniometer was attached to the anterior leg at a point which is 5cm below the tibial tuberosity, and the zero axis of the goniometer was in line with tibial anterior crest.

The lower leg was moved toward and away from the midline until subject felt a pain of restriction at the hip; the range of motion was taken in both directions and recorded as internal hip rotation in sitting (IHRS) and external hip rotation in sitting (EHRS) respectively.

Statistical Analysis. The data collected were analyzed using SPSS version 15 for both descriptive and inferential statistical techniques. Descriptive statistics of mean and standard deviation was used to summarize all data. Inferential statistics of correlation matrix was

Results
The results are presented in tables I-III. Table I shows the distribution of subjects' physical characteristics, *Q*-angle and values of hip rotation measured in prone lying and sitting positions, summarized with range, mean and standard deviation.

Table I. Physical Characteristics, Q-angle and Hip Rotation of Entire Subjects (N=400)

Variables	Min	Max	X ± SD
Age (years)	9.00	50.00	22.31± 12.84
Height (m)	1.20	1.90	1.54± 0.18
IHRP(Degrees)	40.00	86.00	59.81±8.18
EHRP(Degrees)	40.00	90.00	70.59±8.21
IHRS(Degrees)	42.00	88.00	63.44±8.04
EHRS(Degrees)	40.00	90.00	72.64± 8.10
Q-angle(Degrees)	8.00	20.00	14.33± 3.19

Table II. Correlation matrix showing the relationship of *Q*-angle with other variables of the entire population (male and female separately)

Male (N=200)

	Age	Height	IHRP	EHRP	IHRS	EHRS	*Q*-angle
Age	-						
Height	0.63*	-					
IHRP	-0.07	-0.09	-				
EHRP	-0.04	0.09	-0.21	-			
IHRS	-0.07	-0.23	0.63*	-0.03	-		
EHRS	-0.51*	-0.33	-0.03	0.59*	0.16	-	
Q-angle	-0.26	-0.04	-0.04	0.10	-0.21	-0.23	-

Female (N=200)

	Age	Height	IHRP	EHRP	IHRS	EHRS	*Q*-angle
Age	-						
Height	0.63*	-					
IHRP	-0.07	-0.09	-				
EHRP	-0.04	0.09	-0.21	-			
IHRS	-0.07	-0.23	0.63*	-0.03	-		
EHRS	-0.51*	-0.33	-0.03	0.59*	0.16	-	
Q-angle	-0.26	-0.04	-0.04	0.10	-0.21	-0.23	-

*Indicates significance ($p < 0.05$)

Table III. Correlation matrix showing relationship of *Q*-angle with other variables among the four age groups

	Height	IHRP	EHRP	IHRS	EHRS	Q-angle
Height	-					
IHRP	-0.07	-				Pre-puberty
EHRP	0.01	-0.05	-			Group
IHRS	0.12	0.43*	-0.07	-		N= 100
EHRS	-0.39	0.01	0.30	0.27	-	
Q-angle	0.19	0.06	-0.05	0.10	0.13	
Height	-					
IHRP	0.07	-				Adolescent
EHRP	0.18	-0.09	-			Group
IHRS	-0.18	0.32	0.21	-		N= 100
EHRS	0.14	-0.05	0.65*	0.24	-	
Q-angle	0.05	-0.05	-0.31	-0.36	-0.01	
Height	-					
IHRP	-0.15	-				Young Adult
EHRP	0.33	-0.43*	-			Group
IHRS	-0.18	0.41*	-0.11	-		N=100
EHRS	0.15	-0.01	0.19	-0.01	-	
Q-angle	-0.50	0.03	-0.29	-0.09	0.27	
Height	-					
IHRP	-0.07	-				Adult Group
EHRP	0.38	-0.17	-			
IHRS	-0.08	0.32	0.21	-		N=100
EHRS	0.14	-0.05	0.65*	0.24	-	
Q-angle	0.06	-0.05	-0.32	-0.31	-0.36	

*indicates significance

Table II presents a correlation matrix used to test the relationship of *Q*-angle with hip rotation and other variables with entire male and female population considered.
No significant correlation was observed between *Q*-angle, age, IHRP, EHRP, IHRS and EHRS of both male and female population. A negative insignificant correlation was however obtained for *Q*-angle, age, IHRS and EHRS (r= -0.26, -0.21 and -0.23 respectively; $p<0.05$).
A correlation matrix showing the relationship of *Q*-angle with hip rotation among the four age groups tested is presented in table III. No significant correlation was found between *Q*-angle and hip rotation among the four age groups considered.
A negative insignificant correlation was however observed between *Q*-angle, EHRP and IHRS (r=-0.31 and -0.36 respectively) of the adolescent group. A positive insignificant correlation was obtained between *Q*-angle and EHRS (r= 0.27) of the young adult group; while a
negative insignificant correlation was recorded between *Q*-angle, EHRP, IHRS and EHRS of the adult group.

Discussion
The results of this study show that there is no significant correlation ($r<0.4$, $p>0.05$) between *Q*-angle and values of hip rotation measured in two different starting positions of prone lying and sitting. Our findings here were not consistent with the results of the work of Hvid and Andersen (8) who tested the correlation between internal hip rotation (as an estimate of femoral torsion) and *Q*-angle (Spearman rank correlation co-efficient $r=0.428$, n=58, $p<0.01$) and found a significant correlation.
The correlation matrix used in this study did not show any correlation between *Q*-angle, IHRP and IHRS when analysis was done with entire male and female population (n=200 in each case), although there was a negative insignificant correlation between *Q*-angle and internal hip rotation measured in sitting position ($r=-0.21$, $p<0.05$).

A negative insignificant correlation was also observed between *Q*-angle and IHRS of the adolescent and adult age groups (r=-0.36and -0.31 respectively<0.05). Hvid and Andersen (8) measured the internal hip rotation of their internal hip rotation of their participants in prone lying position and goniometer was used for measurement. The variation of *Q*-angle and internal rotation in the findings of both studies could be attributed to the difference in instruments employed in both studies. Flexiometer and gravity reference goniometer was used to assess *Q*-angle and hip rotation in the present study. The sample size could also account for the difference in the results, Hvid and Andersen assessed 29 subjects (11 male, 18 female) while a total of 400 participants (200 male and 200 female) were assessed in present study. Racial variation may also be another source of difference as the former study was conducted on Scandinavians (Caucasians) while present study was carried out on Nigerians (Black Africans). Staheli et al (14) had earlier reported that internal hip rotation is not the best estimate for internal torsion and that a more accurate estimate would be the difference between internal and external hip rotations.

Some authors have suggested that the *Q*-angle is a composite measure of pelvic position, hip rotation, tibial rotation, patellar position and foot position (15,16). However, there is a dearth of literature on the relationship of *Q*-angle with direct measurement of hip rotation as in the case of present study; some other studies which investigated the relationship of *Q*-angle with lower extremity alignment have identified some factors that have the potentials to influence the magnitude of *Q*-angle. Nguyen et al (11) investigated the relationship of *Q*-angle with pelvic angle, hip anteversion, tibio-femoral angle, *genu recurvatum* , tibial torsion, navicular drop, femur and tibial length and found tibio-femoral angle and femoral anteversion as most predictors of *Q*-angle. They observed that greater tibiofemoral angle and femoral anteversion were significant predictors of greater *Q*-angle in both male and female subjects, with changes in tibio-femoral angle having a substantially greater impact on the magnitude of *Q*-angle compared with femoral anteversion. Pelvic angle, *genu recurvatum*, tibial torsion, navicular drop, and femur to tibial length ratio were not significantly independent predictors of *Q*-angles in male or females. These results may not be comparable to the findings of present study as hip rotation is different from femoral anteversion and tibio-femoral angle in procedure and landmarks of measurement.

Daneshmandi et al (3) observed a significant association of increased *Q*-angle with tibiofemoral angle, femoral anteversion and hip internal rotation, although they measured hip rotation in prone lying as in the case of present study. Their subjects were young female athletes which did not cut across four different age groups as we have in our study. The position of Q-angle measurement can also introduce some degrees of variation in findings as *Q*-angle in present study was measured in supine position in contrast to the standing position employed by Daneshmandi and his colleagues. Athletic population was not classified in present study, a larger sample size was studied and different tools were used for measurement of *Q*-angle and hip rotations, racial differences in population studied may account for reasons why the findings of both studies are not similar.

Mizuno et al (1) performed an in vitro knee simulation to relate the Q-angle to tibiofemoral and patello-femoral kinematics in their study of six cadaver knee. The knees were assessed with a normal alignment, after increasing the *Q*-angle and after decreasing the *Q*-angle. They observed that an increase in *Q*-angle significantly shifted the patella laterally from 20^0 to 60^0 of the knee flexion, tilted the patella medially from 20^0 to 50^0 of flexion. Decreasing *Q*-angle was also reported to have significantly tilted the patella laterally at 20^0 and from 50^0 to 80^0 of flexion, rotated the tibial externally from 30^0 to 60^0 of flexion, and increased the tibio-femoral *varus* orientation from 40^0 to 90^0 of flexion. They concluded that an increase in *Q*-angle could lead to lateral patellar dislocation or increased lateral patello-femoral contact pressure while a *Q*-angle decrease may not shift the patella medially but could increase the medial tibio-femoral contact pressure by increasing the *varus* orientation. The present study cannot really be compared with the work of Mizuno and his colleagues as there was no intervention and measurements were taken on healthy living humans.

Conclusion

The results of this study have shown that age and hip rotation measured in prone lying and sitting positions using gravity reference goniometer may not be a reliable predictor of *Q*-angle. Future researchers could involve a larger sample size to improve on the internal validity of the study.

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The relationship of *Q*-angle with other anatomical measurements like tibial torsion, femoral anteversion, tibiofemoral angle, and femoral angle of inclination measured in Africans could also be investigated to further contribute to the existing body of knowledge on the probable predictions of *Q*-angle.

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Received: 15 October 2012
Accepted: 30 November 2012