Normal values of Quadriceps angle and its correlation with anthropometric measures in a group of Jordanians

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ABSTRACT

Objectives: To establish the normal values of Quadriceps angle(Q angle) in Jordanians according to gender and bilaterality within-subject symmetry in both extremities, and to examine its association with anthropometric measures (body height, weight, body mass index, pelvic width, and waist to hip circumference ratio).

Methods: A double-centered study was conducted at Department of Anatomy of University of Jordan, and Orthopedic Department of Jordanian Royal Medical Services, Amman, Jordan, between September 2014 and December 2014. Q angle was measured using goniometer from 419 individuals (219 males and 200 females). Pearson Correlation coefficient was used to assess the influence of with anthropometric measures on the values of the Q angle in both genders.

Results: The mean values (SD) of the Q angle among males and females were 14.4 (1.9) and 18.4 (1.8), respectively. Those values were relatively higher than normal values recorded in the literature. No significant difference was found between sides in different groups. In both genders, the relationship of mean Q angle was significant when correlated with height and BMI; but with pelvic width, such a relationship was seen only for females. Weight and WHR showed no correlation with Q angle values, but in females showing lower body obesity pattern (BMI > 30 and WHR < 0.85), the WHR had a moderate negative correlation with Q angle measurements.

Conclusion: This study reinforces the need to establish reference values of Q angle in a given population.

Key words: ASIS, iliac tubercle, Jordanian, Q angle.

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Introduction

An understanding of the normal anatomical and biomechanical features of the patellofemoral joint is fundamental for proper assessment of the patellofemoral joint function. The mechanical analysis of the proper alignment and the stability of any joint depend mainly on the study of the effect of structures surrounding that joint. [1] One such method is to study the effect of the muscles working on the joint by applying the principles of vectors on each muscle. The angle that is formed by intersection of the muscles forces vectors gives an insight on the stability of that joint. Quadriceps angle (Q angle) is a meaningful clinical measure to assess the overall lateral line of pull of the quadriceps relative to the patella, and provides useful information about the alignment of the knee joint. [2-5] For example, an increased Q

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angle is a risk factor for many disorders such as patellar subluxation, dislocation, patellofemoral joint pain, and chondromalacia patellae.[6-8]

Q angle was firstly defined as the acute angle formed by the vector for the combined pull of the quadriceps femoris muscle and the patellar tendon.[3,9] The conventional method for measuring the Q angle is by drawing two straight lines one from the ASIS to the center of the patella and the second one is from the center of the patella to the tibial tubercle, and measuring the acute angle formed by the intersection of these two lines.[3] This angle can be measured in supine or standing position with the hip and knee extended and the quadriceps muscle relaxed. [10] Women have higher values of Q angle, this difference was attributed to women's broader pelvis, shorter femur length, and more inwards twist of the femur. [11]

As the biomechanics of patellofemoral joint are affected by patellar tendon length and the Q angle, [12, 13] the aim of the present study was to improve the clinical diagnosis and assessment of malalignment of the patellofemoral joint in Jordanian population. However, for this measurement to be meaningful, clinicians must first have established normal values. The normal range of Q angle values in healthy Jordanians according to gender and bilaterality within-subject symmetry was determined and compared with the other world standard populations. Additionally, the association between Q angle and anthropometric measures (body height, weight, body mass index (BMI), pelvic width, and waist to hip ration (WHR) was also investigated.

Methods

A double-centered study was conducted at Department of Anatomy of University of Jordan, and Orthopedic Department of Jordanian Royal Medical Services, between September 2014 and December 2014. A total number of 419 subjects (219 males, 200 females) were included in this study. Three hundred and twenty nine subjects volunteered from the university population and the surrounding community. In addition, measurements of Q angle were also recorded from 90 patients who visited Orthopedic Clinic for other reasons rather than lower limb problems. Only non-pathological knees were included in this study. Patients with a history of traumatic injuries or surgeries in lower extremities were excluded. Baseline data including age, gender, height, and weight were recorded for all volunteers, and the BMI was calculated by the following formula: BMI = weight ([kg])/height ([m^2]). Interspinous distance (cm) between the ASIS's was also measured as an indicator of pelvic width. Waist circumference (cm) was measured at the level of the umbilicus with the subject in mid-expiratory position. Hip circumference was recorded at the widest point over the greater trochanters, and the waist-to-hip ratio (WHR) was calculated. In obese participants (BMI >30), the waist-hip ratio (>0.9 for men and >0.85 for women) was used as a measure of central obesity, while waist-hip ratio (<0.9 for men and <0.85 for women) was used as a measure of lower body obesity.

To measure the Q angle, both mid patellar point and tibial tubercle were determined, thereafter a line was drawn connecting the ASIS and the mid patellar point, another line passing through the tibial tubercle was also drawn. Finally, the Q angle was measured as the value taken between the intersected lines using the goniometer. It should be noted that in the present study all measurements were taken during the standing position with quadriceps relaxed and the feet together and facing forward, as the normal weight-bearing forces being applied to the knee joint mimic those occur during daily activity. All measurements showed excellent intraobserver and interobserver reliability, with correlation coefficients ranging from 0.74 to 0.83.

Statistical analysis. The data was entered into a spreadsheet and analyzed using the IBM SPSS Statistics for Windows, version 19 (IBM Corp, Armonk, NY, USA). The means (standard deviation), ranges, 5^{th} percentile, 95^{th} percentile, and the 95% confidence intervals for the mean (in order to include the true population mean in 95% of the cases) were all calculated. Differences of continuous variables between two independent groups were assessed with the two tailed *t* test. Relationship between Q angle and each of the five variables- height, weight, BMI, pelvic width, and WHR was assessed with Pearson's correlation coefficient (*r*) to measure the linear correlation (dependence) between two variables X and Y. Pearson's *r* values between 0 and 0.3 (0 and -0.3) indicate a weak positive (negative) relationship, between 0.3 and 0.7 (-0.3 and -0.7) indicate a moderate positive (negative) relationship, and values between 0.7 and 1.0 (-0.7 and -1.0) indicate a strong positive (negative) relationship; where *r* takes on values ranging from -1 to 1. The significance threshold was set at .05. The XY scatter plots were generated by Microsoft Excel 2010 and the figures were processed by Adobe Illustrator CC 2014.

Results

Anthropometric data of participants was shown in Table I. Statistically significant difference between males and females was observed in height**,** weight, BMI, pelvic width and WHR (P<.05). There was no significant difference between the groups in term of age (P>.05).

Table I : Anthropometric data of participants.

	N	Age ([years])	Height ([cm])	Weight (kg)	BMI ([kg/m^2])	PW (cm)	WHR
All	419	32.7 (10.1)	165.7 (8.1)	75.2 (10.2)	27.4 (3.0)	27.0 (2.7)	0.80 (0.1)
Male	219	32.3 (10.1)	171.4 (4.8)	79.4 (8.1)	27.0 (2.6)	26.4 (2.0)	0.84 (0.12)
Female	200	33.2 (10.1)	159.5 (6.1)	70.6 (10.4)	27.7 (3.3)	27.5 (3.2)	0.76 (0.07)
*P value		.3559	<.0001	<.0001	.0258	<.0001	<.0001

* two tailed *t* test, SD- Standard Deviation, BMI- body mass index, PW- pelvic width, WHR- waist to hip ratio

Table II: Q angle values in Males and Females.

	Both knees	Right knee	Left knee	*P value
Male				
Mean (SD)	14.4 (1.9)	14.6 (1.9)	14.3 (1.9)	.06
Range	12-18.5	12-19	12-19	
95% CI of mean	14.19- 14.69	14.36- 14.87	14.01- 14.52	
5th percentile	12.5	12	12	
95th percentile	18	18	18	
Female				
Mean (SD)	18.42 (1.8)	18.6 (1.9)	18.3 (1.7)	.09
Range	15-22	15-22	15-22	
95% CI of mean	18.16- 18.66	18.31- 18.83	18.02- 18.49	
5th percentile	15	15	15	
95th percentile	21	22	20	
*P value	< .0001	< .0001	< .0001	

* two tailed *t* test, SD- Standard Deviation, CI- Confidence Interval

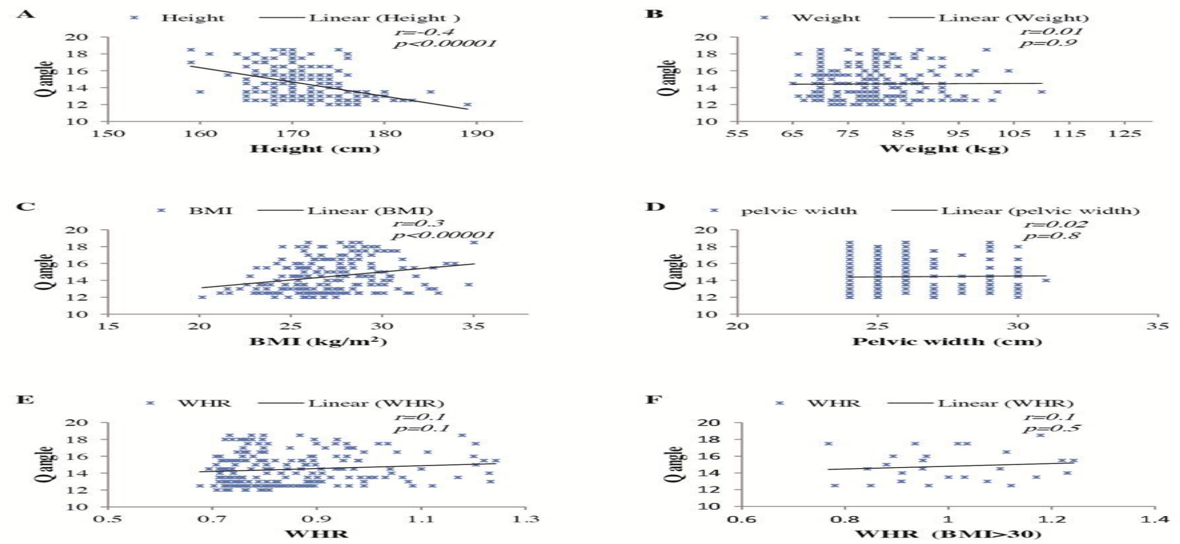

Fig. 1: Scatter plots showing the correlation between Quadriceps angle (Q angle) and: A) height, B) weight, C) body mass index (BMI), D) pelvic width, E) waist-hip ratio (WHR) and F) WHR when BMI> 30 in *males*. Regression lines represent the lines of best fit. r: Pearson correlation coefficient, *P*-values were calculated using the 2-tailed t test, n=219

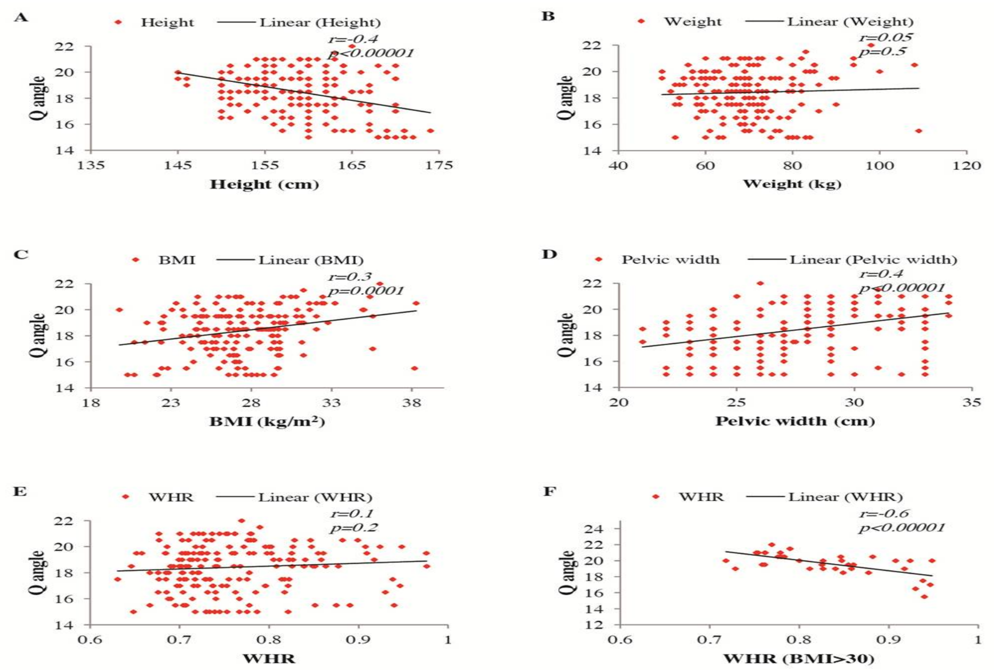

Fig. 2: Scatter plots showing the correlation between Quadriceps angle (Q angle) and: A) height, B) weight, C) body mass index (BMI), D) pelvic width, E) waist-hip ratio (WHR) and F) WHR when BMI> 30 in *females*. Regression lines represent the lines of best fit. r: Pearson correlation coefficient, *P*-values were calculated using the 2-tailed t test, n=200

In standing position, the Q angle value for both right and left knees in females was greater than that of males (*P<.0001*). There was no significant difference between Q angle measurements of right and left sides in both genders, with higher Q angle values on the right side (*P>.05*) (Table II).

In both genders, Pearson's correlation of Q angle with body height had a negative moderate significant correlation (r= -0.4, *P<.00001*) (Figure 1A and 2A). A weak positive linear relationship was seen when BMI was correlated with Q angle measurements (r= 0.3, *P<.0001*) (Figure 1C and 2C). Weight and WHR had no or negligible relationship with Q angle measurements (*P>.05*) (Figure 1B, 1E, 2B, 2E). But with BMI > 30, the WHR showed moderate negative correlation with Q angle in females only (r= -0.4, *P<.00001*) (Figure 2F).

In females, the relation between pelvic width and Q angle measurements showed moderate positive relationship (r= 0.4, *P<.00001*) (Figure 2D). This association was not evident in males (r=0.02, *P>.05*).

Discussion

Several ranges of Q angle values have been cited in the literature. According to Clifford, a normal Q angle in men is 14 degrees and in women is 17 degrees (± 3) .[14] The normal Q angle measurements in the current study were close to the values reported by Clifford, but still our mean values were higher than measurements recorded from other populations.[15-17] Many studies aimed to correlate the variations in the Q angle values to the variations in race.[10,11,17] Therefore, Q angle values for different populations could not be applicable for the Jordanian population.

The present study showed a significant difference between males and females Q angles, which is in line with previous data.[10,15,18,19] this difference was proposed to be as a result of the anatomical differences between male and female pelvic width.[10,16] On the other hand, another study of Grelsamer et al. found that men and women of equal heights demonstrated similar Q angles, concluding that the slight difference in Q angles between men and women can be explained by the fact that men have a tendency to be taller [20]. In addition, the mean Q angle values reported from our population was greater on the right side as compared to the left, but this difference was not statistically significant, this is similar to the bilateral variations documented in other studies.[10,17,18,21] On the other hand, a study on Nigerian adults revealed a significant contra-lateral difference of Q angles in both males and females, recommending the documentation of both right and left angles in the clinics and the research reports. [22]

To further investigate the reason behind the higher Q angle values in our study, the mean values were correlated with anthropometric measures (body height, weight, BMI, pelvic width, and waist to hip ratio). The body height and weight might show variations in different ethnic origins. In addition, variations in the body fat for the same BMI might also be caused by variations of physical activity, diet and ethnicity. So the variations of body parameters could attribute in part to different Q angle measurements in different areas. Our results are in line with previous data suggesting the body height and pelvic width as the main determinants of Q angle.[15,20]

In comparison with females, the relation between the pelvic width (measured as distance between the ASIS's) and Q angle measurements was not observed in males, other factors seem to influence this angle; for example, it was shown that the quadriceps contraction had a significant effect on the Q angle by changing the position of the patella,[23,24] as males in our population are physically more active than females, we expect lower Q angle values based on their stronger quadriceps muscle.

Furthermore, the lower waist to hip ratio in the Mediterranean females compared to other ethnic groups[25] could stand behind the higher Q angle values documented here; BMI and lower body obesity (indicated by lower WHR at BMI > 30) correlated significantly with Q angle values, indicating that the ethnic differences in the amount of body fat distribution at different BMI levels might have an influence on the Q angle measurements, our data suggests a greater Q angle value with the lower body obesity pattern in females.

Conclusion

Jordanian population had mean Q values larger than reference values available in the international literature; this could be attributed to the lower average height of our population. The higher Q angles in females could also be attributed to wider pelvic width measurements and lower body obesity pattern. This study represents a good reference for clinicians to improve the clinical diagnosis and assessment of the malalignment of patellofemoral joint in our population. We strongly recommend that further studies should be carried out on larger sample size to include more subjects at different regions of Jordan.

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