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Study of Variation in Quadriceps Angle in Healthy Individuals

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Abstract: Quadriceps angle is defined as the angle formed by the vector for the combined pull of the quadriceps f muscle and the patellar tendon. The aim of the study was to analyse the effect of age and gender on quadriceps angle. A cross-sectional study was conducted in 600 healthy individuals. Subjects with any present or past history of trauma, degenerative disorders, structural deformity, inflammatory condition of bilateral lower extremities and spine were excluded. Quadriceps angle was measured using goniometric method in supine lying position bilaterally. Of the 600 participants, 300 were males and 300 females. There was a statistically significant negative correlation ($r = -0.232$, $p = 0.000$) between age and right limb quadriceps angle. Also, it was observed that women have greater value quadriceps angle than men in both right ($p = 0.000$) and left limb ($p = 0.000$). The present study showed that there was an inverse relationship between age and quadriceps angle. The gender difference in quadriceps angle was statistically significant with greater quadriceps angle in women than men. Evaluation of quadriceps angle is an essential component to assess the knee function and alignment.

Keywords: Quadriceps angle, Knee joint, Age, Alignment, Lower limb.

INTRODUCTION

The quadriceps angle or the Q angle was first described by Brattstrom as an angle with its apex at the patella and formed by the vector for the combined pull of the quadriceps femoris muscle and the patellar tendon [1]. Q-angle is formed at the point of intersection of two imaginary lines.

The first line is drawn from anterior superior iliac spine to the center of patella and the second line is drawn from tibial tuberosity to the center of the patella. The angle formed between these two lines represents the quadriceps angle [2]. This angle can be measured in supine or standing position with the hip and knee extended and the quadriceps muscle relaxed [3].

Quadriceps angle is an important indicator of biomechanical function of the knee joint and describes the lateral force applied to the patellofemoral joint by the contraction of the quadriceps muscle [4]. It is a quantitative measurement of patellar position with respect to the lower extremity alignment [5]. An increase in quadriceps angle is considered as indicative of extensor mechanism misalignment and has been associated with patellofemoral pain syndrome, knee joint hypermobility and patellar instability [5-7]. Aging affects the structure and function of different systems of the body including the musculoskeletal system. It affects the musculoskeletal system by bringing about changes in the muscle mass, muscle power, muscle endurance, flexibility and range of motion of joints. This may alter the alignment of the knee joint and in turn may affect the amplitude of the quadriceps angle. Hence the study aimed to evaluate the effect of age on quadriceps angle.

MATERIAL AND METHODS

A cross-sectional study was conducted after the approval of institutional research review committee. 600 healthy individuals in the age group of 11 to 60 years were recruited. Subjects with any history of any knee surgery, traumatic injury, infectious conditions, degenerative condition in the lower extremity or on steroidal injection were excluded from the study. Subjects were explained about the nature of the study in the language best understood by them. A duly signed written informed consent was taken from the subjects who were willing to participate in the study. The demographic information of participants such as age and gender were recorded.

Measurement of Quadriceps angle

The starting position of the subject was in supine lying. Three landmarks were identified namely;

anterior superior iliac spine (ASIS), center of the patella and tibial tuberosity. For marking center of patella, borders of patella were palpated and outline of patella was drawn using a body marker without stretching the skin over the patella. The intersecting point of maximum vertical and transverse diameter of patella was taken as the point for center of patella. The point of maximum prominence at anterior upper end of tibia is marked as the tibial tuberosity. Then the squaring of pelvis was done. Subjects were instructed to relax the quadriceps muscle with lower extremity in neutral rotation and the foot pointing upwards as well as perpendicular to the resting surface. The axis of goniometer was placed on center of the patella, fixed arm aligned with the anterior superior iliac spine and the movable arm with the tibial tuberosity. The first line was drawn from the ASIS to the center of the patella using the straight edge of measuring tape. The second line was drawn from the tibial tuberosity to the center of patella & then extending the second line upwards, the angle formed between these two upper lines was Quadriceps angle [8]. The quadriceps angle was measured bilaterally and was documented in degrees.

The data collected was analyzed using a SPSS Software (Version 20). Kolmogorov Smirnov test was used for normality analysis of the data which indicated that the data is normally distributed. Parametric test for correlation i.e. pearson's correlation was used for the data analysis to evaluate correlation between the variables. Comparison of mean values was done using unpaired t test for two independent variables. Comparison of mean values was done using one-way ANOVA test for more than two independent variables. A 5% level of probability was used to indicate statistical significance.

RESULTS

The present study included 600 healthy subjects (300 men and 300 women) in the age group of 11 to 60 years. Table 1 & 2 shows the mean values of quadriceps angle based on gender and different age groups. Comparison of mean values of quadriceps angle among the different age groups on right limb (p = 0.024) was statistically significant and on left limb (p = 0.589) was not statistically significant in men using one-way ANOVA test (Table 1). Comparison of mean values of quadriceps angle among the different age groups on right limb (p = 0.000) and left limb (p = 0.017) was statistically significant in women using one-way ANOVA test (Table 2). There was a statistically significant (r = -0.232, p = 0.000) negative correlation between age and quadriceps angle of right limb using Pearson correlation test (Table 3). Comparison of mean values of quadriceps angle between men and women was statistically significant using unpaired test on right limb (p = 0.000) and left limb (p = 0.000) with values greater in women than men (Table 4).

Table-1: Comparison of mean values of quadriceps angle in right and left side in males

Age groups (years)	Age		Quadriceps angle in Right side					Quadriceps angle in left side				
	Mean	SD	Mean	SD	95% Confidence Interval		One-way ANOVA test	Mean	SD	95% Confidence Interval		One-way ANOVA test
					Lower Bound	Upper Bound	p value			Lower Bound	Upper Bound	p value
11-20	16.45	3.01	17.5	4.13	16.43	18.57	0.024*	15.68	3.99	14.65	16.72	0.589
21-30	24.4	2.84	15.58	4.61	14.39	16.77		14.95	4.16	13.87	16.03	
31-40	35.75	2.84	15.77	3.77	14.79	16.74		15.42	3.93	14.4	16.43	
41-50	46.1	3.02	15.77	4.22	14.68	16.86		15.43	4.08	14.38	16.49	
51-60	55.3	2.92	15	4.67	13.79	16.21		16.17	4.27	15.06	17.27	

*p value less than 0.05 is considered statistically significant

Table-2: Comparison of mean values of quadriceps angle in right and left side in females

Age groups (years)	Age		Quadriceps angle in Right side					Quadriceps angle in left side				
	Mean	SD	Mean	SD	95% Confidence Interval		One-way ANOVA test	Mean	SD	95% Confidence Interval		One-way ANOVA test
					Lower Bound	Upper Bound	p value			Lower Bound	Upper Bound	p value
11-20	18.55	1.94	18.98	3.87	18.32	20.12	0.000*	18.98	3.87	17.98	19.98	0.017*
21-30	23.9	2.53	17.22	3.64	19.39	21.27		17.21	3.64	16.28	18.16	
31-40	35.78	3.13	17.65	3.88	15.47	17.67		17.65	3.88	16.65	18.65	
41-50	45.25	2.4	17.7	3.74	14.99	17.25		17.7	3.74	16.73	18.67	
51-60	55.15	2.97	16.58	4.29	15.55	17.72		16.58	4.29	15.48	17.69	

*p value less than 0.05 is considered statistically significant

Table-3: Correlation between quadriceps angle & age

Variable	Quadriceps angle	
	Right Limb	Left Limb
Age	r = -0.232*	r = -0.043
	p = 0.000	p = 0.289

*Correlation is significant at the 0.05 level (2-tailed).

Table-4: Comparison of quadriceps angle between males and females

Quadriceps angle	Male (N = 300)		Female (N = 300)		Significance
	Mean	Std.Deviation	Mean	Std.Deviation	p value
Right Limb	15.92	4.34	17.77	4.32	0.000*
Left Limb	15.53	4.08	17.63	3.94	0.000*

*p value less than 0.05 is considered statistically significant

DISCUSSION

Quadriceps angle is considered as an index of knee alignment that has an influence on the function and patellofemoral kinetics. It was observed that there was statistically significant difference in quadriceps angle among different age groups. Also, there was negative correlation between age and quadriceps angle. Q angle has been defined as the acute angle formed by the vector for the combined pull of the quadriceps muscle and the patellar tendon. The patella is embedded in the quadriceps femoris muscle or complex and the magnitude of the quadriceps angle will vary with changes in strength of the quadriceps musculature [9]. Quadriceps femoris muscle has a combination of muscle fiber type. Being a postural muscle, quadriceps have a higher content of slow twitch fibers (type 1 muscle fibers). The process of aging is associated with reduction in muscle cross - sectional area, that has been observed to begin in early adulthood and accelerates beyond 50 years of age [10]. A study by Bulent Bayraktar *et al*. showed that a change in quadriceps strength and tone caused by activity leads to decrease in quadriceps angle [11].

It was observed in our study that the quadriceps angle was greater in females as compared to males. The larger quadriceps angle in women is attributed to the presence of wider gynecoid pelvis in comparison with the narrower android pelvis of men. A wider pelvis creates more lateral proximal reference points for the quadriceps angle measure and necessitate a more valgus orientation of the knee to re-establish mechanical axis through the hip, knee and ankle [12]. There is increased lateral shift of the patella in women during quadriceps femoris muscle contraction secondary to wide spaced hips. The combination of wider hip and shorter femurs could increase the valgus of the lower limbs and thus increase the quadriceps angle [13]. Grelsamer et al. opined that due to the long distance between the pelvis and patella relative to the distance from the patella to the tibia tuberosity and changes in the position of the ASIS has an effect on quadriceps angle. The study reported that men and women who have equal heights demonstrated similar quadriceps angles. Men have the tendency to be taller whereas women are shorter. Women have shorter femur as compared to men. The shorter femur in women increase the valgus angulation of lower limb thereby increasing the quadriceps angle [14]. Quadriceps angle is a clinical measure to assess the lateral line of pull of the quadriceps relative to the patella and provides information about the alignment of the knee joint.

CONCLUSION

The present study showed that there was an inverse relationship between age and quadriceps angle. The gender difference in quadriceps angle was statistically significant with greater quadriceps angle in women than men. Evaluation of quadriceps angle is an essential component to assess the knee function and alignment.

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