ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Bicondylar Angle of Femur: An Anthropometric Study in South Indian Population.

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ABSTRACT

The femoral bicondylar angle is a characteristic feature of bipedal gait in humans. The bicondylar angle of the femur is the angle between the axis of the shaft of femur and the perpendicular to the transcondylar axis of femur. This article aims to study and document the gender differences in the bicondylar angle of femur in South Indian population. This study also attempts to find the correlation between bicondylar angle, epicondylar breadth and femoral length. The study is done on 110 dry adult bones obtained from the Department of Anatomy, Sri Siddharta Medical college, Tumkur. The bicondylar angle on the right side is $7.26^0\pm1.67$ in males and $8.71^0\pm1.58$ in females. The bicondylar angle on left side range from $7.39^0\pm1.40$ in males and $8.96^0\pm1.49$ in females. The difference in the bicondylar angle between males and females is found to be statistically significant on both sides. On the right side, the bicondylar angle shows a moderately negative correlation with the epicondylar breadth and a strong negative correlation with the femoral length. So, larger the bicondylar angle, lesser the epicondylar breadth and femoral length which further supports our inference that females have higher bicondylar angle than men.

Keywords: Bicondylar angle, femoral obliquity, sexual dimorphism, Epicondylar breadth, femoral length.

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INTRODUCTION

The skeletal morphology is determined by its mechanical environment during development. Many skeletal features reflect the habitual functions to which they are adapted for [1]. The femoral bicondylar angle is one such feature which is characteristic of bipedal gait in humans. The bicondylar angle of the femur is the angle between the axis of the shaft of femur and the perpendicular to the transcondylar axis of femur. The bicondylar angle places the knee close to body's centre of gravity during bipedal locomotion. [2]. The development of femoral bicondylar angle parallels the development of normal bipedal walking in children [1]. Several dimensions of femur are studied extensively for stature and sex determination[3,4,5] but bicondylar angle of the femur is not much explored as a parameter for the identification of sex. The bicondylar angle of femur is known to exhibit inter and intrapopulation variations[6]. The bicondylar angle of femur in the South Indian population has been studied by few researchers.The aim of this article is to determine the sex discrepancy in bicondylar angle of femur and to find out the correlation between bicondylar angle of femur, epicondylar breadth and length of femur in South Indian population.

MATERIALS AND METHODS

This study is done on 110 dry adult bones (51 female and 59 male femora) obtained from the Department of Anatomy, Sri Siddharta Medical college, Tumkur . Bones with deformities (bowing , arthritic deformities) , incompletely ossified bones , fractured bones are excluded from the study.

Bicondylar angle

The femur is placed with the posterior surface of femoral condyles touching the smooth horizontal surface of an osteometric board, over which a graph sheet is fixed. The condyles of the femur are placed against a vertical plate on the osteometric board. Transverse axis of the knee is taken as the plane of the vertical plate touching the lower ends of condyles and was drawn as a horizontal line on the paper. Maximum diameter of the shaft are noted on the graph sheet with the help of a vernier caliper at two levels, just below the lesser trochanter (Fig. 1) and another level at about 25% of the standard maximum length from the distal end (Fig. 2). Midpoints at the two levels A and B are noted. The axis of the shaft of the femur was then drawn by joining the midpoints of diameters at A and B, and prolonged downwards to meet the transverse axis of the knee joint(7). The angle between the axis of the shaft of the femur(AB) and the vertical axis (BC) meeting the horizontal line (XY) of the knee joint at B denotes the bicondylar angle(Fig. 3).

Epicondylar breadth

Greatest breadth of the most projecting points of the epicondyles, parallel to the infracondylar plane. Length of femur: Distance from the most superior point on the head of the femur to the most inferior point on the distal condyles. Place the medial condyle against the fixed vertical end board.

The data is collected by two observers and the average values were tabulated and statistically analysed.

RESULTS

The mean value of bicondylar angle in males is 7.26^0 on the right side and 7.39^0 on the left side(Table 1) . The mean value of bicondylar angle in females is 8.71^0 on the right side and 8.96^0 on the left side (Table 2).

The difference in the bicondylar angle between males and females is found to be statistically significant on both sides (Table 3) .

Overall, the bicondylar angle shows a moderately negative correlation with the epicondylar breadth and a strong negative correlation with the femoral length on the right side and the correlation is significant at 0.01 level (Table 4). The bicondylar angle shows a moderately negative correlation with the femoral length on the left side and the correlation is significant at 0.05 level (Table 5).

ISSN: 0975-8585

Table 1: Descriptive statistics in males

	N	Minimum	Maximum	Mean	Std. Deviation	Std. Error
Bicondylar Angle Right	31	5^{o}	12^{o}	7.26^{o}	1.67^{o}	0.30
Bicondylar Angle Left	28	5^{o}	10^{o}	7.39^{o}	1.39^{o}	0.264
Epicondylar Breadth Right (Cm)	31	7	8	7.74	0.404	0.73
Epicondylar Breadth Left (Cm)	28	6.5	8.4	7.51	0.51	0.097
Length Of Femur Right (Cm)	31	39	48	42.87	2.012	0.361
Length Of Femur Left (Cm)	28	38	48	42.39	2.36	0.446

Table 2: Descriptive statistics in females

	N	Minimum	Maximum	Mean	Std. Deviation	Std. Error
Bicondylar Angle Right	28	5^{0}	12^{0}	8.71^{0}	1.58^{0}	0.299
Bicondylar Angle Left	23	7^{0}	13^{0}	8.96^{0}	1.492^{0}	0.311
Epicondylar Breadth Right (Cm)	28	6.1	7.8	6.975	0.469	0.0887
Epicondylar Breadth Left (Cm)	23	6.3	7.8	7.052	0.4823	0.1006
Length Of Femur Right (Cm)	28	38	43	40.86	1.353	0.256
Length Of Femur Left (Cm)	23	38	43	40.74	1.573	0.328

Table 3: Comparison of values between males and females

	Males	Females	T-Test Value	p-Value
Bicondylar Angle Right	$7.26^{0} \pm 1.67^{0}$ (n=31)	$8.71^{0} \pm 1.58^{0}$ (n=28)	-3.424	<0.001
Bicondylar Angle Left	$7.39^{0} \pm 1.40^{0}$ (n=28)	$8.96^{0} \pm 1.49^{0}$ (n=23)	-3.858	<0.001
Epicondylar Breadth Right (Cm)	7.74 $\pm$ 0.40 (n=31)	6.98 $\pm$ 0.47 (n=28)	6.743	<0.001
Epicondylar Breadth Left (Cm)	7.51 $\pm$ 0.52 (n=28)	7.05 $\pm$ 0.48 (n=23)	3.257	0.002
Length Of Femur Right (Cm)	42.87 $\pm$ 2.01 (n=31)	40.86 $\pm$ 1.35 (n=28)	4.461	<0.001
Length Of Femur Left (Cm)	42.39 $\pm$ 2.36 (n=28)	40.74 $\pm$ 1.57 (n=23)	2.872	0.006

Table 4: Correlation between Bicondylar angle, Epicondylar breadth and Length of femur on the right side .

		Bicondylar Angle	Epicondylar Breadth	Femoral Length
Bicondylar Angle	Pearson Correlation	1	-.344(**)	-.488(**)
	Sig. (2-tailed)		.008	.000
	N	59	59	59
Epicondylar breadth	Pearson Correlation	-.344(**)	1	.340(**)
	Sig. (2-tailed)	.008		.008
	N	59	59	59
Femoral length	Pearson Correlation	-.488(**)	.340(**)	1
	Sig. (2-tailed)	.000	.008	
	N	59	59	59

** Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

ISSN: 0975-8585

Table 5: Correlation between Bicondylar angle, Epicondylar breadth and Length of femur on the left side

		Bicondylar Angle	Epicondylar Breadth	Femoral Length
Bicondylar Angle	Pearson Correlation	1	-.147	-.355(*)
	Sig. (2-tailed)		.305	.011
	N	51	51	51
Epicondylar breadth	Pearson Correlation	-.147	1	.262
	Sig. (2-tailed)	.305		.063
	N	51	51	51
Femoral length				
	Pearson Correlation	-.355(*)	.262	1
	Sig. (2-tailed)	.011	.063	
	N	51	51	51

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 6: Bicondylar angle of femur (right side)in various studies

		Bicondylar Angle Right	
		Male	Female
1.Sharma et al.[6]	Mean	6.371	8.206
(Madhya Pradesh)	S.D	1.821	2.119
	Range	3.6° -11°	4° -12°
	S.E.	0.3078	0.3806
	P value	0.0003	
	t value	3.784	
2.Pandya et al.[11]	Mean	8.88	10.50
(Gujarat)	S.D	2.05	2.42
	Range	3^0-13^0	5^0-13^0
	P value	<0.05	
	t value	2.37	
3.Mahajan et al.[7]	Mean	8.17	8.82
(Punjab)	S.D	2.311	2.173
	Range	2^0-14^0	5^0-16^0
	S.E	0.220	0.362
	P value	>0.05	
4.Present study	Mean	7.26	8.71
	S.D	1.67	1.58
	Range	5^0-12^0	5^0-12^0
	S.E	0.30	0.29
	t value	-3.424	
	p value	<0.001	

Table 7: Bicondylar Angle of femur (left side) in various studies.

		Bicondylar Angle Left	
		Male	Female
1.Sharma et al.[6]	Mean	7.348	8.729
(Madhya Pradesh)	S.D	2.366	2.302
	Range	3° -11°	5° -12.5°
	S.E.	0.4118	0.4134
	P value	0.212	
	t value	2.364	
2.Pandya et al.[11]	Mean	8.76	10.83
(Gujarat)	S.D	2.24	1.94
	Range	4^0-13^0	6^0-13^0
	P value	<.001	
	t value	4.38	
3.Mahajan et al.[7]	Mean	7.89	8.57
(Punjab)	S.D	2.230	2.193
	Range	3^0-14^0	4^0-15^0
	S.E	0.200	0.367
	P value	>0.05	
4.Present study	Mean	5^0-10^0	7^0-13^0
	S.D	7.39	8.96
	Range	1.40	1.49
	S.E	0.26	0.31
	t value	-3.858	
	p value	<0.001	

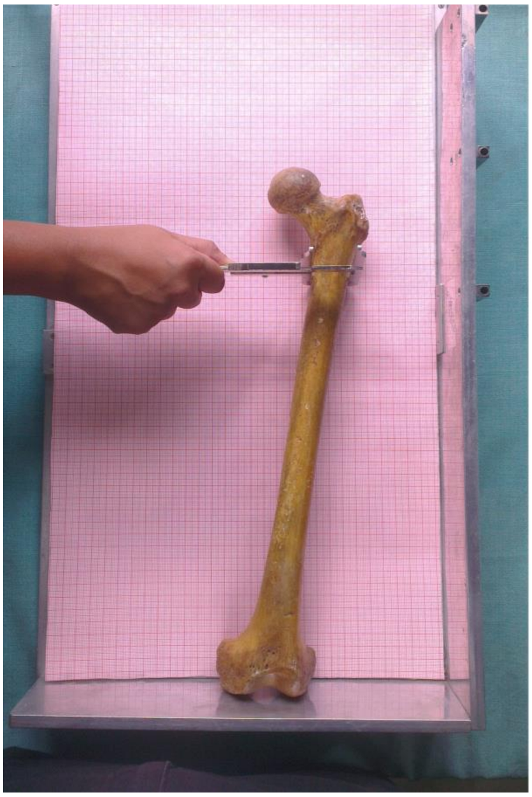

Figure 1: Measuring the maximum diameter of the shaft just below the lesser trochanter .

Figure 2. Measuring the maximum diameter of the shaft at about 25% of the standard maximum length from the distal end.

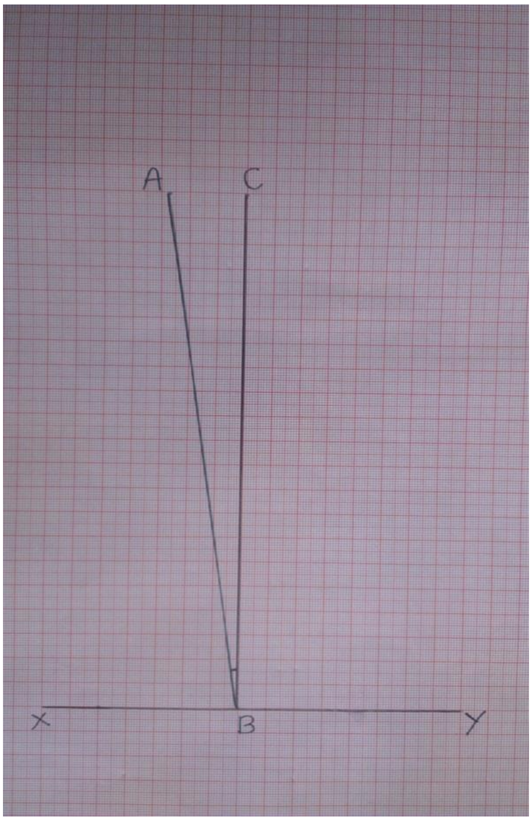

Figure 3: Measuring the Bicondylar angle of femur.

DISCUSSION

The bicondylar angle of femur is the angle between the axis of shaft of femur and the perpendicular to the transcondylar axis of femur . The long axis of shaft of femur makes an angle of approximately 10^0 with the vertical [8]. According to Tardieu , the mean femoral bicondylar angle varies between 8^0-11^0 [9].

Newborn femora don't exhibit femoral bicondylar angle It is gradually formed during the initial years after birth when the child learns walking [2] . The load axis that passes medial to the axis of shaft of the femur during the first three years of life, crosses the axis of shaft of femur later in life due to change in the angle of neck of femur . This increase in the bicondylar angle brings the knee closer to midline . Also, this corresponds to the time the child is capable of walking independently [10].

Presence of genu valgum and associated femoral obliquity are the characteristic features of bipedal gait in humans. The bicondylar angle places the knee close to the body's centre of gravity during bipedal locomotion [9].

The increase in bicondylar angle has been attributed to several factors. According to Tardieu the increased apposition on the medial surface of the distal end of the metaphysis causes the increase in bicondylar angle. The gradual increase in the angulation of the neck of femur during infancy is also considered a contributing factor [10]. Femoral bicondylar angle can be considered as a marker of infancy as it is formed due to the angular remodelling during the early years of life in response to weight bearing [9].

Increase in bicondylar angle defines the shape of distal femoral epiphysis in adults. Protuberance of lateral trochlear lip and elliptical profile of lateral condyle of femur is attributed to the increase in bicondylar angle [9].

In the present study, the bicondylar angle is higher in females than males on both sides [Table 3]. The difference between males and females is statistically significant on both sides in our study[Table 3]. The significant difference between sexes is in accordance with the findings of Pandya et al [11] . The sex discrepancies observed may be attributed to environmental factors such as mechanical stress and nutrition. Genetic factors may also have a role in determining the bicondylar angle.

The significant differences in the bicondylar angle between males and females have been noted by various authors[3,9]. According to Tardieu , the bicondylar angle is generally higher in women due to wider pelvis and greater interacetabular distance[9]. Higher bicondylar angle in females is not only attributed to greater pelvic breadth but also to shorter femoral length [3,12].

This study also attempts to find whether any correlation exists between bicondylar angle, epicondylar breadth and femoral length. On the right side, the bicondylar angle shows a moderately negative correlation with the epicondylar breadth and a strong negative correlation with the femoral length [Table 4]. This correlation is significant at 0.01 level. So, larger the bicondylar angle, lesser the epicondylar breadth and femoral length. This further asserts our findings above that females have a higher bicondylar angle.

The bicondylar angle of femur exhibits inter and intrapopulation variations.As shown in Table 6 and Table 7, the mean values of bicondylar angle in males in the present study is lower than the studies in Gujarat [11] and Punjab[7] and higher than the findings in Madhya Pradesh[6]. The mean values in females are lower than the values observed in Gujarat[11], similar to the findings in Punjab[7] and higher than the findings in Madhya Pradesh [6].

An anthropometric study on bilateral differences in femur of South African population noted high degree of bilateral differences in morphological features of femur. The study proposed that the morphology of the left leg is best suited to withstand axial forces , hence weight bearing whereas the right leg is used for other purposes[13].

Forensic scientists are often left with fragments of bones for determination of sex and stature as intact bones are not always available. Modern forensic analysis of the skeletal remains does not include the bicondylar angle as a parameter for sex determination. This may be because of lack of a consistent and reliable method to accurately measure the angle. Also, the differences in the bicondylar angle noted between the sexes was not found to be significant enough to be used for sex differentiation[14].

Although our study confirms the finding of other studies regarding the existence of sexual dimorphism in the femoral bicondylar angle, further research has to be undertaken on a large sample to assess the extent to which it can be used to as a parameter to determine the sex.

CONCLUSIONS

The bicondylar angle on the right side is$7.26^0 \pm 1.67$ in males and $8.71^0 \pm 1.58$ in females. The bicondylar angle on left side is $7.39^0 \pm 1.40$ in males and $8.96^0 \pm 1.49$ in females. The difference in the bicondylar angle between males and females is found to be statistically significant on both sides .On the right side, the bicondylar angle shows a moderately negative correlation with the epicondylar breadth and a strong negative correlation with the femoral length and the correlation is significant at 0.01 level. So, larger the bicondylar angle, lesser the epicondylar breadth and femoral length which further supports our finding that females have higher bicondylar angle than men. Further research has to be done on the extent to which bicondylar angle can be used for sex determination.

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