Original Article

METRIC ASSESSMENT OF FEMUR USING DISCRIMINANT FUNCTION ANALYSIS IN SOUTH INDIAN POPULATION

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ABSTRACT

Introduction: Sex determination from unidentified human skeletal elements is a challenge for forensic investigators and anthropologists. This study aims to detect the best variable for sex determination from different parameters of femur. **Materials and Methods:** Study was conducted with 75 (40 males and 35 females) femora of known sex from the Department of Anatomy. Eight parameters were measured and subjected to univariate statistics, multivariate analysis such as discriminant analysis and logistic regression analysis employing SPSS 13.00 version program. **Results:** The epicondylar breadth, antero-posterior diameter of lateral condyle, proximal breadth, vertical diameter of head and neck are statistically significant for dimorphism ($p<0.05$). Discriminant analysis shows an overall accuracy of 62.7% and stepwise discriminant analysis shows an accuracy of 65.3%.Under stepwise analysis epicondylar breadth was selected as the best discriminant variable for sex prediction. **Discussion:** Results implies that epicondylar breadth of femur is the best parameter for sex determination which agrees with available literature in different population. It can be correlated to delayed ossification of growing lower end in males giving higher value. Due to early maturity dimorphism is less in the upper end of the bone. **Conclusion:** The results of present study confirm that epicondylar breadth is one of the good parameters in femur for sexing in unidentified skeleton.

KEY WORDS: FEMUR; SEXUAL DIMORPHISM; DISCRIMINANT FUNCTION ANALYSIS; SOUTH INDIAN POPULATION.

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INTRODUCTION

Determination of sex from unidentified human skeletal remains is a challenge for anthropologists and forensic investigators. Skull and pelvis [1] are widely used for sex identification. In addition, mastoid [2-3], craniofacial region [4], mandible [5] and other bones of the human skeleton are used for sexing. Femur is the largest and heaviest bone of the human skeleton [6]. It is widely studied to determine the stature and locomotion patterns, for sex identification in skeletal remains [7-10] as it shows significant variation between individuals [11]. This difference could be attributed to difference in the duration of ossification of different centers in a developing femur of male and female [12]. Osteometric measurements are used for sex identification of which metric analysis is advantageous over non-metric method.

Discriminant function analysis is a statistical technique which applies combination of variables between the groups to explore the differences and gives the best variable to predict the sex. In this technique a discriminant function equation is developed which is population specific and hence is the best method for sex determination [13]. So, the purpose of this research study is to explore the osteometric difference between male and female femurs of South Indian population and compare with available literature.

MATERIALS AND METHODS

In the present study, 75 dry adult femora (40 males and 35 females) aged between 25-65yrs at time of death were utilized from the Department of Anatomy, Yenepoya Medical College, Yenepoya University, Mangalore, Karnataka, India. Only femur with good conditions with gender identified in book record were included and those which were damaged, incomplete or without identification were excluded from the study. A set of following eight anthropometric parameters were studied from right sided femur using sliding vernier calipers and osteometric board [Fig 1].

FIG 1: FEMUR SHOWING POINTS FOR MEASUREMENTS OF DIFFERENT PARAMETERS.

ML : Maximum length
PB : Proximal breadth
A – B : Vertical diameter of head
C – D : Transverse diameter of head
E – F : Vertical diameter of neck
MEC : Medial epicondyle
LEC : Lateral epicondyle
APDMC : Antero-posterior diameter of medial condyle
APDLC : Antero-posterior diameter of lateral condyle

1. Maximum length (ML) — it is the straight distance from highest point of the head and the lowest point on the lateral medial condyle.
2. Proximal breadth (PB) —is the distance from most medially placed point on the head to the most laterally placed point on greater trochanter.
3. Vertical diameter of head (VDH) — is the straight distance from the highest to the lowest point of the head.
4. Transverse diameter of head (TDH) — is the straight distance between the most laterally projected points perpendicular to the VDH.
5. Vertical diameter of neck (VDN) — is the minimum diameter of femoral neck in a plane perpendicular to the head–neck midline.
6. Epicondylar breadth (EB) — is the maximum distance between the medial epicondyle (MEC) and lateral epicondyle (LEC).
7. Antero-posterior diameter of lateral condyle (APDLC) — is the projected distance between the most posterior point on the lateral condyle and the lateral lip of the patellar surface taken perpendicular to the axis of the shaft.
8. Antero-posterior diameter of medial condyle (APDMC) — is the projected distance between the most posterior point on the medial condyle and the medial lip of the patellar surface taken perpendicular to the axis of the shaft.

STATISTICAL ANALYSIS: The data were analyzed using statistical software package SPSS 13.0 program [14]. Univariate analysis was done by mean standard deviation and by t test. p-value less than 0.05 considered as significant. Multivariate technique - discriminant function analysis and logistic regression analysis were performed to calculate specific discriminant function equation for all parameters.

RESULTS

As shown in Table 1, of the eight variables recorded in femur for sex differentiation, all values were higher in males while EB, APDLC are highly significant and PB, VDH, VDN are significant ($p < 0.05$). Table 2 shows the results of direct and stepwise discriminant analysis.

Femur variable	Male (n=40)	Female (n=35)	t-value	p-value
Maximum length	421.11± 31.41	431.90 ± 28.31	1.56	0.112
Proximal breadth	76.74± 5.73	79.78± 6.71	2.09	0.04
Vertical diameter of head	39.85± 3.55	41.75 ± 3.48	2.34	0.022
Transverse diameter of head	35.31± 2.90	36.81± 3.79	1.9	0.061
Vertical diameter of neck	28.43± 3.29	30.30± 3.76	2.27	0.026
Epicondylar breadth	70.19± 4.73	73.87± 5.51	3.08	0.003
Antero-posterior diameter of lateral condyle	55.89± 4.03	58.51± 4.34	2.69	0.009
Antero-posterior diameter of medial condyle	54.85± 3.96	56.72± 4.56	1.89	0.063

MEAN (mm) ± SD, P<0.05

TABLE 1: DESCRIPTIVE STATISTICS OF FEMUR PARAMETERS.

Variable	Unstandardised coefficients	Standardised coefficients	Wilk'slamda	Structure matrix	Constant	Centroid	Average accuracy %
Direct method							
ML	-0.009	-0.272	0.968	0.404			
PB	-0.015	-0.093	0.944	0.54			
VDH	-0.08	-0.28	0.93	0.604		Females-	Females -62.9
TDH	-0.212	-0.721	0.953	0.492	-10.224	-0.477	Males-
VDN	0.106	0.377	0.934	0.587		Males -	62.5
EB	0.302	1.559	0.885	0.797		0.418	
APDLC	0.223	0.937	0.91	0.696			
APDMC	-0.206	-0.882	0.953	0.488			
Stepwise method							
EB	0.194	1	0.885	1	-13.975	Females- -0.38 Males- 0.333	Females- 57.1 Males- 72.5

TABLE 2: DISCRIMINANT FUNCTION ANALYSIS FOR FEMUR PARAMETERS.

In direct method, EB has highly significant structure matrix (0.797) and Wilk's lamda (0.885) followed by APDLC, VDH, VDN and PB respectively. Univariate analysis provides an accuracy of 62.9% in case of females and 62.5% in males with an overall accuracy of 62.7%.By stepwise analysis only EB is selected as the best discriminant variable and has highly significant structure matrix (0.885) and Wilk's lamda (1.00). It shows an overall accuracy of 65.3% where in case of males it is 72.5% and 57.1% in females. Logistic regression analysis is also performed for all parameters to confirm the above results and only EB is found significant with Odd's ratio of 1.328. It states that EB is 1.328 times higher in males when compared to females.

DISCUSSION

The long bones of the human skeleton or their fragments considerably contribute for the establishment of sexual identity. Generally, the weight of the axial skeleton of males is heavier than females, because of which the articular surfaces are prominent in males for transmission of body weight [12]. In the present study, EB is the best parameter for sex determination which agrees with other published data in different population [11, 15 -19] which can be correlated to the delayed ossification of the growing lower end in males giving higher value [12]. Also due to early maturity, dimorphism is less in the upper end of the bone [20]. The percentage accuracy given by EB in this study is 72.5% for males and 57.1% for females. We received a total percentage accuracy of 62.7% in direct analysis and 65.5% in stepwise analysis which is less compared to available literature [11, 15-19]. In direct analysis, the accuracy for sex differentiation in males is 62.5% and in case of females is 62.9%. These values are less compared to published data [19, 21]. The results of our study when compared to North Indian population show lower value, which may be due to the differences existing between the populations. These dissimilarities could be due to the variations in the morphological characteristics between the two groups. The North Indian population consisting mainly of Caucasian race and South Indians belong to Proto-Australoid or Australoid race [22]. Also variation might be attributed to genetic factors, environment, physical activity and socioeconomic status of particular region. The present study may also be affected by the limited sample size.

CONCLUSION

The above study confirms that sex identification can be done using femur where breadth contributes more than the length of the bone. These findings could be used as standards for sex assessment from the femora of the South Indian population and in future this can be used as reference for sex identification from this region.

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