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Percentage accuracy of sexing human adult tibia by Discriminant function analysis

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ABSTRACT

The present study attempts to determine sex of unknown adult human Tibia by using discriminant function analysis and to investigate best variable in metric diagnosis of sexing. Anthropometric variables of 71 human adult tibiae of unknown sex were subjected to FISHERS Z STATISTIC analysis to assume sex and standard deviation; t-value was calculated to determine the Percentage accuracy. The percentage accuracy of various tibial parameters are - Length (60%), Proximal epiphyseal breadth (77%), Distal epiphyseal breadth (76%), Antero-posterior diameter of medial articular surface (71%), Transverse diameter of medial articular surface (73%), Antero-posterior diameter of lateral articular surface (78%) and Transverse diameter of lateral articular surface (49%). The results obtained from the Basic Statistics and discriminant analysis of each variable were compared with available literature. Single parameter cannot be used for discrimination of sex. Only by combining all the parameters sex can be discriminated. With the use of Binary logistic multivariate discriminant analysis technique method 72% male and 57% female tibia can be sexed correctly.

1. Introduction

Determination of sex from skeletal remains is one of the important aspects of Osteometric analysis. Marked sexual dimorphism is exhibited by several bones and they are suitable for sexing skeletons with high accuracy. In adult skeleton sex determination is usually the first step of identification process as subsequent methods for age and stature estimation are sex dependent. The reliability of sex determination depends on the completeness of the remains and the degree of sexual dimorphism inherent in the population. The two most sexually dimorphic elements of the skeleton are pelvis and skull.

Skeletal collections permit the study of age, sex, stature and biological affiliation differences of both metrical and morphological skeletal features. They are well suited for the study of sexual dimorphism within and between populations. Only from the assessment of known skeletal series standards can be established to interpret remains from the past and to identify forensic cases of today and tomorrow.

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The sexing accuracy for various bones reported in literature is 80% - 92% for cranium, 90% for skull and mandible, 95 - 98% for pelvis and 80% for long bones [1]. Larger limb bones may provide clear evidence of sex particularly if other individuals of same race and of both sexes are available for comparison.

In some instances only some bare bones constitute the sole remains of a dead individual. The availability of long bones is common and they resist erosive forces and keep anatomical shape for a long time even after being buried. Long bones have been found to be highly dimorphic especially in areas such as head and distal epiphyses of femur, proximal epiphyses of tibia [2].

The present study was conducted for identifying the sex from an unknown sex of tibia by morphological appearance of bone and also by morphmetric parameters which were analysed stastically and compared with the available literature.

2. Materials and methods

The data consists of Anthropometric variables of 71 human adult tibiae of unknown sex collected from Department of Anatomy, Sri Venkateswara Institute of medical Sciences, Tirupati, Anthropology Department of SVU,Tirupati and Mamatha Medical College, Khammam. The bones that were free from fractures, osteoarthritis, periostitis and other pathological changes were selected. Instruments that were used in this study are Osteometric board and Vernier callipers.

For a total of 71 tibiae the following 7 parameters were taken for each specimen.

a) Length (L): Distance from the superior articular surface of the lateral condyle to the tip of the Medial malleolus.The instrument used here is osteometric board

All the remaining parameters were measured by using Vernier callipers.

b) Proximal epiphyseal breadth (PEB): Distance between the two most laterally projecting points on the medial and lateral condyles of the proximal articular region.

c) Distal epiphyseal breadth (DEB): Distance between the two most laterally projecting points on the medial mallelous and the lateral surface of the distal articular region.

d) Antero-posterior diameter of medial articular surface (APDMAS): Distance between anterior and posterior margins of the medial articular surface.

e) Transverse diameter of medial articular surface (TDMAS): Distance between intercondylar eminences to the medial edge of medial articular surface.

f) Antero-posterior diameter of lateral articular surface (APDLAS): Distance between anterior and posterior margins of the lateral articular surface.

g) Transverse diameter of lateral articular surface (TDLAS): Distance between intercondylar eminences to the lateral edge of lateral articular surface.

2.1.Statistical analysis:

Seventy one observations were discriminated in to male and female for each and every anthropometric variable by calculating FISHERS Z STATISTIC and the distance between them is minimum. For that we have calculated the mean and standard deviations for the raw data and assumed as Z, Where, Z=(X-Mean)/ Standard Deviation.

We have calculated Z1 and Z2 for (Z for males and females) using the formula (Males) Z1 = (X-Male Mean)/Male SD; (Females) Z2 =(X-Female Mean)/Female SD and obtained absolute values Z, Z1, Z2. The distance between Z, Z1, and Z, Z2 are obtained by using the formula; Abs (Z-Z1) and Abs (Z-Z2). Discrimination was made as the variable belong to Male if Abs (Z-Z1) < Abs (Z-Z2) otherwise it is belong to Female.

After discrimination in to Males and Females their mean and standard deviations are calculated. t-values of the 2-sample t-test were calculated in order to compare the relative significance of sexual difference between variables.

Discriminant analysis was conducted for each variable and the Wilks lambda and correctly classified percentage were calculated. The Wilks lambda is the ratio of the within group and total sum of squares. Values close to Zero imply high predictability of membership.

3. Results

In the present study 71 tibiae of both sides and of unknown sex were categorized sex wise by morphometric parameters. Accordingly 36 were identified as Male and 35 were identified as Female. Their means, standard deviations and statistical analysis were calculated and represented in Table (1).

4. Discussion

The purpose of this study was to discriminate the unknown sex of human adult tibiae and to determine which variable of tibia is the best for metric diagnosis of sex. The results obtained are compared with available literature Table(2).

Length of tibia (L):

In the present study the mean values for length of tibia were found to be somewhat nearer to the values reported by Iscan et .al. [3] in blacks (Table 2). Kazuhiro sakaue [1] reported 72% sexing accuracy in modern Japanese population. The correctly classified accuracy for length of tibia in the present study is 60% and males showed high accuracy (100%) than females (20%). But this parameter alone cannot be used for discrimination of sex as the correctly classified percentage of sex is less when compared to other parameters.

Proximal epiphyseal breadth (PEB):

The mean values of PEB in males and females observed by authors (1,2,3,4) and present study were reported in (Table 2) Gonzalez et.al.,[4] observed 94.9% of sexing accuracy for males to 98.3% for females was who showed more accuracy.

Holland [5] investigated sex determination with proximal tibia and noted that ends of tibia are subjected to heavy stress during individual's life and because the stress may have sexual component the ends should be useful in determining sex.

Iscan et.al.,[3] reported the Sexing accuracy of 87.3% for whites and 90.0% for blacks and Kirici et.al.,[6] reported 89% in right and 87% in left tibiae for distal and proximal epiphyseal dimensions. Kazuhiro sakaue [1] reported the sexing accuracy of 94%.

The mean values of present study are near to Murphy [2] (Table 2). Correctly classified percentage of present study reached 77%. In males it is 61% and in females it is 94% (Table 1).This parameter showed statically significant values and it is considered as the best discriminator of sex.

Judging from the t-values and discriminant analysis PEB of tibia can be considered to be most useful for diagnosing sex of the tibiae. The present study was in agreement with the previous authors (1, 3, 5, 6, 7, 8, and 9) who judged that PEB of tibia was the best discriminator for sexing of a long bone next to distal articular surface and distal epiphyseal breadth of humerus.

Table.1: Mean, SD and Discriminant functions of different variables

Variables	Mean		SD		t-Value	Discriminant functions			
	Males (in mm)	Females (in mm)	Males	Females		Raw coefficient	Constant	Wilks λ	Correctly classified (%)
L	392.11	365.29	31.95	35.49	3.35	0.12	0.00	0.86	60%
PEB	70.78	62.86	4.49	5.19	6.89	0.37	0.08	0.59	77%
DEB	45.11	39.97	4.65	3.40	5.30	0.46	0.11	0.71	76%
APDMAS	43.11	39.66	4.08	4.90	3.23	0.06	0.01	0.87	71%
TDMAS	33.92	31.40	3.25	4.99	2.52	0.27	0.06	0.92	73%
APDLAS	39.47	34.71	4.24	3.12	5.37	0.44	0.12	0.71	78%
TDLAS	33.47	28.80	3.95	3.24	5.44	0.24	0.07	0.70	49%

Values in the paranthesis denote number of animals. Values are Mean ± S.D. $p<0.001$ highly significant

Table 2. Comparison of means for various parameters of tibia reported in the literature.

Parameter		Gonzalez et.al., [3]	Murphy[6]	Iscan et.al., (7) Whites	Iscan et.al., (7) Blacks	Kazuhiro Sakaue [13]	Present study
L	**(M)**	369.12	374.9	386.21	405.62	329.05	392.11
	(F)	334.71	351.0	357.28	371.07	308.18	365.29
PEB	**(M)**	77.51	71.3	79.00	79.39	74.45	70.78
	(F)	66.64	62.7	68.80	69.50	65.80	62.86
DEB	**(M)**	44.78	-	52.80	53.27	34.38	45.11
	(F)	40.27		46.83	46.50	32.66	39.97
APDMAS	**(M)**	-	-	-	-	46.56	43.11
	(F)					41.35	39.66
TDMAS	**(M)**	-	-	-	-	31.43	33.92
	(F)					28.28	31.40
APDLAS	**(M)**	-	-	-	-	39.86	39.47
	(F)					35.44	34.71
TDLAS	**(M)**	-	-	-	-	31.35	33.47
	(F)					26.52	28.80

(L-length,PEB-Proximal epiphyseal breadth,DEB- Distal epiphyseal breadth,APDMAS- Anteroposterior diameter of medial articular surface,TDMAS- Transverse diameter of medial articular surface,APDLAS- Anteroposterior diameter of lateral articular surface,TDLAS- Transverse diameter of lateral articular surface).

But sexual difference in the size of the epiphyseal parts is not simply due to the difference of mechanical stresses that may occur at a particular joint. It is of interest to note that sexual dimorphism has been known to occur in the carrying angle of elbow and the bicondylar angle of femur reported by Kazuhiro Sakaue [1].

Distal epiphyseal breadth (DEB)

The mean values for DEB in males and females according to authors (1, 3, and 4) were reported in Table 2.The values in the present study are near to the values provided by Gonzalez [4]. In the present study we noticed 76% as correctly classified sexing accuracy. In males it is 69% and in females it is 82% (Table1). Maryna Steyn [10] showed 86-91% accuracy. He concluded that DEB is the best discriminator of sex.

In the present study although males showed broader DEB than females it is not significant as much as the PEB. This is in accordance with Gonzalez [4]. This parameter showed significant values but not considered as best discriminator because it showed relatively less t' values and less percentage of accuracy than PEB. But when compared to other parameters other than PEB and APDLAS it is high.

The present study supports the conclusion drawn by authors reported in literature [5, 7, 9] that epiphyseal breadth of tibia was better than the other variables of that bone in sexual diagnosis.

Anteroposterior diameter of medial articular surface : (APDMAS)

The mean values of APDMAS in males and females by Kazuhiro sakaue [1] and the present study were presented in (Table 2) Kazuhiro sakaue [1] noticed 84% of sexing accuracy and present study showed correctly classified sexing accuracy of 71%. In males it is found to be 52% and in females it is 91% (Table 1). Females showed high accuracy than males. These values are also nearer to the values reported by Kazuhiro sakaue [1].

The information about this parameter was very much less in literature. This parameter showed statistically significant values but not considered as best discriminator as it showed low t-values and high Wilks λ. Its sexing accuracy was also less when compared to other parameters.

Transverse diameter of medial articular surface :(TDMAS)

The mean values reported by Kazuhiro sakaue [1] and observed in the present study were presented in (Table 2). Sexing accuracy observed by Kazuhiro sakaue [1] was 86%. In the present study we observed correctly classified sexing accuracy of 73% and for males and females it is found to be 86 and 60% respectively (Table 1). They showed statistically significant values but among all the parameters TDMAS showed low t-value and high Wilks λ. Based on the present study this parameter is not considered as the best discriminator.

Anteroposterior diameter of lateral articular surface :(APDLAS)

The present study was in agreement with the statement of Dwight [11] that epiphyseal parts tend to be more useful for sex determination than length of bones. He pointed the size of articular surfaces of long bones as characteristic of sex. The present study was also in agreement with this study because APDLAS showed high t-value and low Wilks λ.

The mean values of APDLAS in males and females by Kazuhiro sakaue [1] and the present study were reported in (Table 2). Sexing accuracy observed by Kazuhiro sakaue [1] is 89%.I n the present study it recorded 78% accuracy. For males it is 72% and for females it is 83% (Table 1). The values are nearer to Kazuhiro sakaue [1].

This parameter recorded high percentage accuracy when compared to all other parameters. Its t-valve is high and Wilks λ is low. This statement was not mentioned by any author in the available literature. It was also considered as the best discriminator as it showed high accuracy than other parameters.

Transverse diameter of lateral articular surface :(TDLAS)

The mean values reported by Kazuhiro sakaue [1] and present study of TDLAS in males and females were presented in (Table 2). Kazuhiro sakaue [1] observed the percentage of accuracy is about 92%. In the Present study the correctly classified percentage is 49%. For males it is 91% and for females it is 8.57% (Table 1). The values are near to the Kazuhiro sakaue [1]. This showed significant values but not a best discriminator as they showed low t values and high Wilks λ and less percentage of accuracy.

5. Conclusions

· Single parameter cannot be used for discrimination of sex. Only by combining all the parameters sex can be discriminated.

· By application of Binary Logistic Multivariate Discriminant Analysis technique method 72% male and 57% female tibia can be sexed correctly. Males are more accurately classified than females. According to percentage of accuracy proximal epiphyseal breadth and Anteroposterior diameter of lateral articular surface are considered as the best discriminators of sex.

· From best to least variable in the order of discrimination of sex from their percentage of accuracy is APDLAS > PEB > DEB > TDMAS > APDMAS > L > TDLAS.

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