Original Research Article

Morphometry of Tibia : The Determinant of Sexual Dimorphism

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Abstract

Aim: This study has been performed to determine the best parameter in metric diagnosis of sexing by using discriminant function analysis on adult human tibia. **Methods :** Upper end of 99 normal, dry, adult human tibia of known sex (63 males and 36 females) were measured by using osteometric board and manual vernier callipers. Mean, standard deviations and t – value was calculated to determine the percentage accuracy.
Results: The percentage accuracy of various tibial parameters is as follows: tibia length (68%), total transverse diameter (82%), transverse diameter of Medial condyle (73%), transverse diameter of Lateral condyle (70%), antero- posterior diameter of Medial condyle (75%), antero-posterior diameter of Lateral condyle (79%), and antero-posterior diameter of tibia (79%). (73 percent).**Conclusion:** From the above study, it can be concluded that according to the percentage of accuracy - Total transverse diameter (TTD) and Antero posterior diameter of Lateral condyle (APLC) are considered as best parameters of sex determination.

Keywords: sex determination, human tibia, anthropometry, discriminant functional analysis

Introduction

The determination of sex is regarded as essential in the identification of an individual in forensic analysis of skeletal remains [1]. The cranium and pelvic bones are the most desired in this sense[2], but long bones, especially the tibia and femur, are more valuable since they resist erosion and keep their anatomical shape long after death and burial[3]. The fact that long bones, particularly the tibia and femur, show significant sexual differences, which have been attributed to hormonal differences between males and females , is relevant to this[4].These differences provide substrates for forensic determination of an individual's sex by forensic analysts. It's also worth noting that mechanical stress is particularly high in the distal ends of these bones, resulting in considerable sexual differences, as well as differences in joint loading and muscle bulk [5]. However, there is no evidence that these dimensions have been used to determine sex from skeletal remains. Furthermore, due to the population differences produced by osteometric dimensions, formulas developed for one population are inapplicable to another[6]. Unfortunately, in some instances only some bare bones constitute the sole remains of a dead individual, especially when we are dealing with ancient population groups. It is therefore important to develop standards to determine sex from different parts of the post cranial skeleton. Long bones are easily obtainable, and they resist erosive stresses and maintain anatomical shape for a long period, 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 [7]. Epiphyseal measures, according to Iscan and Miller Shaivitz, are more reliable markers of sex since the functional demands of weight and musculature focus on these regions of the bone. [8].

The tibia is an ideal long bone of the limb which is used for sex determination, as it resists the erosive forces which act and it remains unaffected even after the burial of the body [9]. Sexual dimorphism in the tibia indicates not only the general growth and the musculo-skeletal activity, but also the genetic structure of the population [10]. Sexual dimorphism of distal epiphyseal breadth of tibia has been studied in different populations [11]. Present study was carried out to ascertain sexual dimorphism of proximal epiphyseal breadth of tibia and develop appropriate standards for sex determination from tibia.

Material and Methods

This prospective observational study was conducted in the department of Anatomy, at Nalanda Medical College and Hospital (NMCH) and Patna Medical College and Hospital (PMCH). The study was conducted over a period of 3 years and 6 months from January 2018 to June 2021. The scientific and ethics committee of the institution gave its approval to the project.

The study was approved by the institutional research and ethical committee. For the present study, 99 adult human dried tibia of known sex (63 males and 36 females) were procured from skeletal collection of Department of Anatomy.

Damaged bones those with pathological changes as well as which showed fractures were excluded from the study.

Instruments that were used in this study are Osteometric board and manual vernier calliper.

A total of 7 tibial dimensions were taken for each specimen. The measurements were repeatedly taken to ensure the accuracy. All measurements were measured in millimeters(mm).

1. Length of the tibia (L): This is measured by using osteometric board. Distance from the superior articular surface of the lateral condyle to the tip of medial malleolus. Rest all the parameters are measured by using manual vernier callipers.

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2. Total transverse diameter (TTD): Distance between the two most laterally projecting points on the medial and lateral condyles of the proximal particular region of the tibia.
3. Transverse diameter of the medial condyle (TDMC): The distance between the intercondylar eminences and the medial edge of the tibia's medial condyle. Antero – posterior diameter of medial condyle (APMC): Distance between anterior and posterior margins of medial condyle of the tibia.
4. Antero – posterior diameter of lateral condyle (APLC): Distance between anterior and posterior margins of lateral condyle of the tibia.
5. Antero – posterior diameter (APD): A straight line passes exactly through the middle of the medial and lateral tubercle of intercondylar eminence from most anterior to the most posterior point.

Statistical Analysis

Statistical analysis was done using SPSS 16.0. The two sample t test of significance was used to see difference between the sexes for all measurements. A significance level of 5 % ($p < 0.05$) was used to look for significant differences between the measurements for the two sexes.

Results

A total of 99 bones, 63 males and 36 females were subjected to morphometric analysis.

Table 1 shows the mean, standard deviations and t – value for all measurements. The t values for all the measurements were found to be statistically significant for difference between the sexes.

The results of sexual dimorphism based on discriminant functions are also summarized in Table 1. The result indicate that the total transverse diameter is the best measure for sexual differences among all the measured variables. The results show the constant, Wilk's lambda and correctly classified percentage for all the variables. Table 2 shows the comparison of present study with other studies.

Table 1: Descriptive variables and discriminant function of the variables

Variables	Mean		SD		t value	Raw Coefficient	Constant	Wilk's λ	Correctly classified
	Male (mm)	Female (mm)	Male	Female					(%)
Length	388.5	367.4	29.9	32.4	4.11	0.095	-0.213	0.758	68 %
TTD	69.8	61.3	4.5	4.7	6.93	0.41	0.631	0.407	82%
TDMC	32.1	30.2	4.4	4.5	5.10	0.286	-0.007	0.613	73%
TDLC	32	30.1	4.1	3.9	5.58	0.351	0.539	0.416	70%
APMC	41.8	36.6	3.8	4.0	4.90	0.462	0.426	0.457	75%
APLC	39.6	34.9	4.2	3.7	5.45	0.515	0.167	0.534	79%
APD	42.3	37.5	3.5	3.1	5.44	0.475	0.434	0.457	73%

Table 2: Comparison of means - For different parameters of tibia reported in the literature

Parameter		Gonazalez (12) *et al.*,	Murphy(13)	Iscan *et al.*, Whites (14)	Iscan *et al.*, Blacks (14)	Kazuhiro Sakaue(15)	Janamala *et al.* (16)	Present study
L	(M)	369.12	374.9	386.21	405.62	329.05	392.11	388.50
	(F)	334.71	351.0	357.28	371.07	308.18	365.29	367.40
TTD	(M)	77.51	71.3	79.00	79.39	74.45	70.78	69.80
	(F)	66.64	62.7	68.80	69.50	65.80	62.86	61.30
TDMC	(M)	-	-	-	-	31.43	33.92	32.10
	(F)					28.28	31.40	30.20
TDLC	(M)					31.35	33.47	32.00
	(F)					26.52	28.80	30.10
APMC	(M)					46.56	43.11	41.80
	(F)					41.5	39.66	36.60
APLC	(M)					39.86	39.47	39.60
	(F)					35.44	34.71	34.90
APD	(M)							42.3
	(F)							37.5

(L-length of tibia, TTD- Total transverse diameter, TDMC – Transverse diameter of medial condyle, TDLC- Transverse diameter of lateral condyle, APMC - Anteroposterior diameter of medial condyle, APLC - Anteroposterior diameter of lateral condyle, APD – Antero- posterior diameter of tibia.)

Discussion

The purpose of the study was to determine which variable of the upper end of tibia is best for metric diagnosis of sex. The result obtained are compared with available literature in Table 2.

Length of the tibia (L)

The tibial length in this study was determined to be 388.5mm in males and 367.4mm in females, which was close to Iscan et.al., whites, which was about 386.21 mm in males and 371.07mm in females. [14].

Total transverse diameter (TTD)

In present study TTD it is found to be 69.8 mm in males which is almost similar to the Murphy i.e 71.3 mm and the same was found in case of females i.e 62.7 mm. TTD of both males and females in the present study was found to be similar to the study done by Murphy [13].

Transverse diameter of medial condyle (TDMC)

In the present study TDMC was found to be lying in between the study of Kazuhiro Sakaue and Janamala [15, 16] i.e in males 32.1mm and females 30.2mm. No other literature was found in other studies.

Transverse diameter of lateral condyle (TDLC)

The measurements of TDLC in the present study in case of males was in accordance with study of Kazuhiro Sakaue and Janamala [15, 16] while in case of females it was on higher side. It measures 32mm in males and 30.1mm in females.

Antero- posterior diameter of medial condyle (APMC)

Both in case of males and females AP MC is found to be on the lower side i.e 41.8 mm & 36.6 mm when compared with other studies in Table 2.

Antero- posterior diameter of lateral condyle (APLC)

In the present study the APLC both in case of males and females was found to be also similar to the study done by Kazuhiro sakaue and Janamala [15, 16] i.e 39.6mm and 34.9 mm.

Antero – posterior diameter of tibia (APD)

In the present study, we have measured a new parameter i.e. APD of the upper end of tibia. Males had 42.3 mm and females had 37.5 mm. This variable can be used to discriminate sex with 73 % accuracy. There is no data about how this characteristic is used to sex the tibia.

The present study supports the conclusion drawn by other authors reported in various literature that total transverse diameter of upper end of tibia was better than other variable of that bone in sexual determination.

The present study depicts that tibial length is the least realiable variable for sexing of tibia.

Conclusion

Sex determination cannot be done by using any single variable. Although the tibia is not an ideal bone for sex determination, it can be used to determine sex with an accuracy of 80 to 85%. According to the % of accuracy Total transverse diameter (TTD) and Antero posterior diameter of Lateral condyle (APLC) are considered as best parameters of sex determination. According to their percentage of accuracy, various parameters are arranged in the order of discrimination of sex from best to least. The following is the order in which they are arranged: TTD > APLC > APMC> TDMC = APD > TDLC > L TTD > APLC > APMC

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