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Morphometric variation between right and left human Tibia: A cross-sectional study in Bankura district of West Bengal.

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Abstract: *Anthropometry is a precise method for evaluation of different measurements of dried bones and has been used as a technique to bring out regional and racial differences all over the world. Being an important anatomic unit, different morphological studies have been undertaken on the tibia. A cross-sectional study with 83 human tibia bones was carried out for one month to estimate different morphometric parameters of tibia in Bankura district of West Bengal and to compare between the parameters of right and left sided tibia. Data were collected by anthropometry using requisite instruments and predesigned proforma. Collected data were summarized to compute six parameters of tibia bone. Unpaired 't' test was used for analyses of data. The estimated values (mean±SD) of Cross- Section Index, Cnemicus Index, and Length- Thickness Index of right and left tibia were found to be 80.85± vs 76.17±, 80.43± vs 75.59± and 30.05± vs 29.71±, respectively. Cross-Section Index and Cnemicus Index were found to be significantly different across the side.*

Key words: *anthropometry, tibia, cross- section index, length thickness index, Cnemicus index*

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I. Introduction

Anthropometry is a branch of science dealing with measurement of the human body in terms of the dimensions of bone, muscle and adipose (fat) tissue. Anatomy deals with human structure and by measuring it anthropometry leads us to understand the well being. Anthropometry helps to correlate the variations in functional perspective and in no doubt it acts as a better tool in learning living anatomy.[1]

Though it is a highly reliable tool in the expert hands of anthropometrists, still it retains its importance in Forensic Science as the traditional method of identification of unknown human remains.[2]

Many studies of tibia have been reported on various populations of the world.[2, 3] Tibia anthropometry among different populations have revealed great variations due to the fact that measurements from different areas of the world are likely to be affected by variations in race, diet, heredity, climate and other factors related to lifestyle.[4] Anatomists and forensic experts have separately worked on various measurements of tibia to bring out significant differences in the morphometry of the right and left tibia as well as sexual dimorphism.[2, 4] However, since the sex of the dried bones under study was undetermined, this factor could not be taken into account.

The tibia (shinbone), situated in the anteromedial side of the leg is the second largest bone in the body.[5] On the posterior surface of the tibia a large vascular groove adjoins the end of the soleal line and descends distally into a nutrient foramina.[6] The nutrient canal runs inferiorly in tibia before opening into the medullary cavity.[5]

The objective of this study was therefore two folds:- a) to estimate different morphometric parameters of tibia in Bankura district of West Bengal and b) to compare between the parameters of right and left sided tibia.

II. Materials and Methods

It was a cross-sectional descriptive study conducted for a period of one month with 83 human adult tibia bones obtained from the bone bank of the department of Anatomy, Bankura Sammilani Medical College (BSMC). Tibia with obvious defects and deformities or which showed signs of previous fracture were excluded from the study. Data relating to the morphology of tibia bones were collected using a predesigned proforma and measuring equipments. Instrument like Digital Vernier Caliper, Osteometric Board, Measuring Tape were used to obtain all the measurements in centimeters.The number of nutrient foramina for Tibia of both sides were noted. A total of six parameters were estimated for the shaft of the tibia according to standard anthropometric method.[7,8] The data were analysed by mean, standard deviation (SD) and statistical inference was drawn based on the results of unpaired 't' test. P value of <0.05 was considered significant at 95% confidence interval with 5% precision.

The estimates regarding the following variables of tibia were obtained:

1) Number of nutrient foramina
2) Transverse diameter in middle of Bone : To determine Cross-Section Index
3) Maximum diameter in middle of Bone
4) Maximum girth of shaft : To measure Length - Thickness Index
5) Total length of Tibia
6) Transverse diameter at level of Nutrient Foramen : To measure Cnemicus Index
7) Sagittal diameter at level of Nutrient Foramen

Formulae used in this study were:

Cross-Section Index in Middle = (Transverse diameter in middle of Bone/ Maximum Diameter in middle of Bone) x 100

In this formula Transverse diameter in the middle of the Bone was calculated as the straight distance from the medial border of the tibia to the interosseous crest at the level of nutrient foramen. Maximum diameter in the middle of bone measures the straight distance of anterior crest from the posterior surface in the middle of the bone.

Fig.1: Measuring Cross Section Index

Cnemicus Index = (Transverse Diameter at level of Nutrient Foramen/ Sagittal Diameter at level of Nutrient Foramen) x 100

Transverse Diameter at level of Nutrient Foramen is the straight distance from the medial border to the interosseous crest at the level of nutrient foramen. Sagittal Diameter at level of Nutrient Foramen measures straight distance of anterior crest from the posterior surface at the level of nutrient foramen.

Fig.2: Measuring Cnemicus Index

Length - Thickness Index = (Maximum Girth of shaft/Total length of Tibia) x 100

Where Maximum Girth of shaft is maximum circumference of shaft wherever found. Total length of Tibia measures straight distance from the lateral condyle to the tip of medial malleolus.

Fig.3: Measuring Length-Thickness Index

III. Results:

Out of 83 tibias examined, majority i.e. 45(54.3%) belonged to the right side and, only *one* (1.2%) of right sided tibia presented double nutrient foramina.

Table-1: Distribution of tibias of both limbs as per transverse & maximum diameter in middle as well as transverse diameter at level of nutrient foramina.

Variables	Rt Tibia [n_1=38]	Lt Tibia [n_2=45]	Unpaired 't', p at df 81
Transverse diameter in middle[mean±sd]	1.958±0.238	2.009±0.187	1.086,0.281
Maximum diameter in middle [mean±sd]	2.432±0.256	2.658±0.290	**3.7089, 0.0004**
Transverse diameter at level of nutrient foramen [mean±sd]	2.253±0.265	2.219±0.232	0.6162, 0.5395

Analysis failed to reveal any statistically significant difference across the sides to which the study elements i.e. tibias belonged in regard to the transverse diameter in middle and at level of nutrient foramen. However, a highly significant two-tailed P value of 0.0004 reflected the fact that there was a between side variation in the maximum diameter in the middle of the bones and the left sided tibias shown to have higher value than that of the right side. [Table-1]

Table-2: Distribution study elements in respect to their Sagittal diameter, maximum girth and total length (N=83)

Variables	Rt Tibia [n_1=38]	Lt Tibia [n_2=45]	Unpaired 't', p at df 81
Sagittal diameter at the level of nutrient foramen[mean±sd]	2.82±0.33	2.98±0.46	1.90, 0.0752
Maximum girth of shaft [mean±sd]	10.69±0.65	10.81±0.88	0.682, 0.4996
Total length of tibia [mean±sd]	35.58±1.50	36.39±2.17	1.94, 0.0555

No difference could be elicited between the tibias belonged to two sides of the human body in respect to their Sagittal diameter at the level of nutrient foramen. Similar observations were also made during analysis about the 'maximum girth of shaft' and 'total length of tibia'. [Table-2]

Table-3: Distribution of tibias based on values of Cross section index in the middle, Cnemicus index and Length Thickness Index

Variables	**Rt Tibia [n_1=38]**	**Lt Tibia [n_2=45]**	**Unpaired 't', two tailed p at df 81**
Cross section index in the middle [mean±sd]	80.85±8.55	76.17±8.79	2.4179, **0.0179**
Cnemicus Index [mean±sd]	80.43±8.69	75.59±10.25	**2.274, 0.0257**
Length Thickness Index [mean±sd]	30.05±1.59	29.71±1.98	0.849, 0.3983

It was revealed that the tibias of both sides were shown to differ according to their Cross-section index. The right tibia was found to have statistically significant higher value compared to that of the left.
Similarly, the right sided tibia was also found to have significantly higher Cnemicus Index compared to their counterpart.
In regard to the Length Thickness Index the tibias were found to be alike having no statistically significant difference across the sides. [Table-3]

IV. Discussion

Morphometric measurements of tibia are considered to be of medico-legal importance because it provides stature and group specific formulae for the determination of 'personal identity' in circumstances of unknown and unclaimed human remains.[2, 3, 9] In addition, the combined use of tibial and ulnar lengths has been recommended for exact modeling of stature.[10]

In present study, the values of Cnemicus and Cross section indices showed significant statistical variation across the sides. As per the present study the estimated values of Cross-sectional, Cnemicus and Length-thickness indices for right and left tibias were 80.85±8.55, 80.43±8.69 and 30.05±1.59 versus 76.17±8.79, 75.59±10.25 and 29.71±1.98, respectively. The figures for respective indicators were 102.90±22.78, 66.17±10.68 and 24.21±0.96 versus 124.31±25.06, 67.31±7.35 and 24.43±1.78, respectively as reported by Bokariya P et al.[2] However, Nazir F et al. observed these values as 78.83±7.35, 68.19±5.23 and 31.95±2.12 versus 80.01±8.54, 68.02±7.48 and 31.34±2.08, respectively.[4]

The values of various indices calculated showed remarkable difference with that of humerus and femur.[11, 12]

These values may be of help in medicolegal issues where sometimes identity is to be established from part of bone only.[13, 14] The variation in the values of the indices calculated from the morphometric measurements of tibia across the studies including the present one might partly be due to the differences in factors such as age, sex, race, geographical area and also environmental factors affecting bone growth, such as nutrition, physical development and genetic factors. Almost universal presence of single nutrient foramen throughout the bone samples studied (except 1.2%) was a remarkable observation as compared to other long bones of human body.[11,15] Bhatnagar S et al. conducted a study on 60 tibiae and observed that 95% tibia had a single nutrient foramen. Double nutrient foramina were observed in 5% of tibia.[16] Tejaswi H L et al. reported that in 94.87% tibiae contained single foramen and in 1.28% tibiae there were two nutrient foramen.[17] However, Bokariya P et al. and Nazir F et al. showed single foramen in 98.33% and 98.0% of tibias.[2, 4] It is noteworthy that in all cases the double foramina was found in right tibia.

In view of the extensive anatomy of the tibia, there is much reference to the role of embryological development to tibial morphology and morphometry.[18] As a characteristic long bone, the tibia is derived from the mesenchymal tissue of limb buds and ossifies via endochondral ossification during 7 to 12 weeks of fetal development.[18,19] The structural stages in the formation of the tibial diaphyseal and epiphyseal regions are characterized by the presence and apposition of the primary and secondary ossification centers, respectively.[18] As a result, the natural course of ontogenesis has been identified as the rate-enhancing determinant of bone morphology and morphometry which is specific to the individual in terms of genotype, occupational habits and metabolic changes.[20,21]

However, this study might have limited external validity as it was conducted on a small sample of bones and for the purpose of comparison and drawing inference further large scale studies involving other race groups may be required.

V. Conclusion

Values of different morphometric indices of tibia as estimated in this study may help to indicate the morphological features of tibia in the population of Bankura district of West Bengal. It may be a useful guide to the expert of forensic medicine, archaeology and clinicians in medicolegal issues and anthropological survey where identification of unknown bodies and stature is required as well as understanding of living anatomy for therapeutic purpose.

Finding regarding almost universal single nutrient foramen place the tibia separately from other long bone of humans. Since the vascular supply is a pivotal factor in ensuring the success of orthopedic procedures and other techniques such as bone grafting, tumour resection and management of traumas, the understanding about single nutrient foramina of the tibia may provide important surgical landmarks necessary to avoid injury to such regions during surgery which could result in complications.

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