

Sexual Diamorphism of Humerus: A Study in Marathwada Region

Kshirsagar S.V.*

Chavan S.K. **

Makhani C.S. ***

Kamkhedkar S. G. ***

ABSTRACT

Sexual dimorphism of bones has been extensively studied in different regions by numerous authors. It is established that, the regional variations exists in the statistical values of the parameters. The present study is done to find out the standard statistical values for the sex determination with humerus. In the present study, the length, epicondylar width, mid-shaft circumference and vertical diameter of the head have been measured in 212 adult humeri of known sex (142 males and 70 females) from the Marathwada region of Maharashtra state. Index (I) was calculated and data was generated for each parameter. The data was also analysed by multivariate analysis method. The mean values of the parameters differed from those of previous studies for other regions. In the present study, the length of the humerus was found to be the most significant parameter for the sex determination. From the data, 42.26% right and 38.66% left male humeri could be sexed correctly and in case of female 25.71% right and 31.42% left humeri could be sexed correctly. Also, by using multivariate technique, the percentage of the humeri that could be sexed correctly markedly increased. 97% right and 96.5% left male humeri could be sexed correctly while 97.5% right and 91% left female humeri could be sexed correctly.

Key words: Sexual dimorphism, humerus, marathwada region, demarking points, multivariate analysis.

INTRODUCTION

Identifying the deceased is the most common and critical problem frequently encountered by Anatomist, Anthropologist and Medicolegal Experts. Determination of the identity of a person is a process of recognition of an individual utilizing unique physical features and biological

parameters, which are specific to each individual. The factors that play a key role in establishing the identity of a person are age, sex, race, stature, finger prints, foot prints, photo ID, clothing, personal affects, dental examination, radiology of ossification centers, specific personal features like tattoo, scars, deformity, previous surgery etc and DNA finger printing. One of the cardinal parameters for identification is determination of sex¹⁻⁶.

Invariably anatomists, forensic anthropologists and medico-legal experts are asked to examine fragmented skeletal remains and generate data which would facilitate establishing their identity. The determination of sex is the first step in skeletal analysis since the estimation of age at death as well as race and stature to an extent depends upon the sex of the deceased.

Author's Affiliations: *Associate Professor, Department of Anatomy, Bidar Institute of Medical Sciences, Bidar, Karnataka, **Associate Professor, Department of Anatomy, Rural Medical College of Pravara Institute of Medical Sciences (DU), Loni, Ahmednagar, M.S., ***PG Student, Department of Forensic Medicine, Rural Medical College, Pravara Institute of Medical Sciences (DU), Loni, Ahmednagar, M.S., ***Associate Professor, Department of Anatomy, NDMVPS Medical College, Nashik, M.S.,

Reprints requests to: Dr. Kshirsagar S.V, Associate Professor, Dept. of Anatomy, Bidar Institute of Medical Sciences, Bidar, Karnataka.

Assessment of sexual dimorphism in the bones is an established fact, through numerous studies conducted earlier. Most of the older studies of sexual dimorphism in the skeleton were centered on morphological traits in a descriptive manner, while newer studies focus on morphometry in a largely quantitative and statistical sense.

The statistical data for identification of sex from the humerus by using various parameters was made available by researchers like Krogman⁷, Thieme⁸, Dwight⁹, S. Singh¹⁰ and others⁶⁻¹⁸.

Regional variations in the standard statistical values for determination of sex are an established fact. Numerous factors such as genetics/inheritance, environmental, racial etc are responsible for these variations. The present study was carried out to obtain the data for sex determination by using various parameters of humerus in the Marathwada region. Also the data was analysed by using multiple discriminant analysis method.

MATERIALS AND METHODS

In the present study, 212 adult humeri of known sex (142 males and 70 females) from Marathwada region were studied. The following measurements were taken.

- 1.Length: measured by using the osteometric board.
- 2.Epicondylar width: the maximum distance between medial and lateral epicondyles was measured by vernier calliper.
- 3.Midshaft circumference: the circumference of the shaft in the middle was measured with the help of a millimetre graph paper.
- 4.Vertical diameter of the head: was taken in the plane of the tip of greater tuberosity, as maximum distance between two points on the head of humerus, with the help of vernire calliper.
- 5.A new index i.e. Index I was obtained

Length in mm X Epicondylar length in mm

$$\text{Index I} = \frac{\text{Length in mm} \times \text{Epicondylar length in mm}}{100}$$

A multivariate discriminant analysis technique was applied and discriminant functions were generated.

RESULT

As shown in table-I, the length of right humerus ranged from 296 – 361 mm in male and 260 – 302 mm in female while on left side it varied from 283 – 357 mm in male and 268 – 304 mm in female.

It was observed that the demarking point for males was > 316.9 mm on the right and > 319.3 mm on left side while in females it was < 275.9 mm and < 274.9 mm on right and left respectively.

From these demarking points, 42.26% right and 38.66% left male humeri could be identified and in case of females 25.71% right and 31.42% left humeri could be sexed correctly.

As shown in table-II, the epicondylar width of right humerus ranged from 54 – 69 mm in male and 44 - 59 mm in female while on the left side it varied from 52 - 67 mm in males and 40 - 59 mm in females.

It was observed that the demarking point for males was > 62.66 mm on the right and > 63.02 mm on the left side while in female it was < 47.98 mm and < 50.84 mm on right and left side respectively.

From these demarking points, 17.91% right and 16% left male humeri could be correctly sexed and in case of females 25.71% right and left humeri could be sexed correctly.

As shown in table-III, the midshaft circumference of right humerus ranged from 56 - 72 mm in males and 50 - 59 mm in females while on the left side it ranged from 54 - 71 mm in males and 50 - 61 mm in females.

It was observed that the demarking point for males was > 62.72 mm on the right and > 63.54 mm on the left side while in females it was < 51.50 mm and < 51.23 mm on the right and left side respectively.

Table No. I: Showing measurements of length.

Sex	Male		Female	
	Right	Left	Right	Left
Range	54 - 69	52 - 67	44 - 59	40 - 59
Mean	57.67	60.17	54.14	52.23
S. D.	3.23	3.11	2.84	3.6
Calculated range	47.9 - 67.4	50.8 - 69.5	45.6 - 62.7	41.4 - 63.0
Demarking point	>62.66	>63.02	<47.98	<50.84
% beyond Demarking point	17.91	16	25.71	25.71

Table No. II: Showing measurements of epicondylar width

Sex	Male		Female	
	Right	Left	Right	Left
Range	54 - 69	52 - 67	44 - 59	40 - 59
Mean	57.67	60.17	54.14	52.23
S. D.	3.23	3.11	2.84	3.6
Calculated range	47.9 - 67.4	50.8 - 69.5	45.6 - 62.7	41.4 - 63.0
Demarking point	>62.66	>63.02	<47.98	<50.84
% beyond Demarking point	17.91	16	25.71	25.71

Table No.III: Showing measurements of Midshaft circumference.

Sex	Male		Female	
	Right	Left	Right	Left
Range	56 - 72	54 - 71	50 - 59	50 - 61
Mean	62.5	61.03	54.82	54.06
S. D.	3.67	3.24	2.62	3.16
Calculated range	51.5 - 73.5	51.23 - 70.7	46.9 - 62.7	44.6 - 63.5
Demarking point	>62.72	>63.54	<51.50	<51.31
% beyond Demarking point	41.79	21.33	20	27.71

From these demarking points, 41.79% right and 21.33% left male humeri and 20% right and 25.71% left female humeri could be sexed correctly.

As shown in table-IV, the vertical diameter of head of right humerus ranged from 40 - 49 mm in males and 34 - 44 mm in females while on left

side it varied from 40 - 48 mm in males and 32 - 48 mm in females.

It was observed that the demarking points for males was > 46.12 mm on the right and > 45.99 mm on the left side while in females it was < 37.91 mm and < 37.53 mm on right and left respectively.

From these demarking points, 35.82% right and 25.33% left males humeri and 28.57% right and

Table No. IV: Showing measurements of vertical diameter of head.

Sex	Male		Female	
Side	Right	Left	Right	Left
Range	56 - 72	54 - 71	50 - 59	50 - 61
Mean	62.5	61.03	54.82	54.06
S. D.	3.67	3.24	2.62	3.16
Calculated range	51.5 - 73.5	51.23 - 70.7	46.9 - 62.7	44.6 - 63.5
Demarking point	>62.72	>63.54	<51.50	<51.31
% beyond Demarking point	41.79	21.33	20	27.71

34.28% left female humeri could be sexed correctly.

As shown in table-V, the Index I of right humerus ranged from 159.8 - 247.7 in males and 134.3 - 174.6 in females while on left side it varied from 147.2 - 234.3 in males and 118 - 177.6 in females.

It was observed that the demarking point for males was >185.11 on the right and >188.51 on the left side while in females it was < 144.92 and < 144.45 on the right and left side respectively.

From these demarking points, 68.17% right and 54.66% left male humeri could be identified and in case of female 28.57% right and 40.0% left humeri could be sexed correctly.

MULTIVARIATE ANALYSIS METHOD

By using multivariate analysis method, 97% right and 96.5% left male humeri and 97.5% right and 91% left female humeri could be sexed accurately.

DISCUSSION

It is an established fact that, standard metrical values derived for sexing the skeleton in one region if applied to the other region may not give 100% accuracy. Therefore it is imperative to obtain standard metrical values which are specific to a region.

In the present study 212 humeri (142 males and 70 females) were studied to obtain the standard metrical values in the Marathwada region of Maharashtra.

The observations of various workers regarding the sexual differences in the various parameters are shown in comparative table no. VI, VII and VIII.

In table no. VI, it is seen that, the mean length of the humerus is more in the present study as compared with that observed by S. Singh¹⁰ but less than the mean length stated by Thieme⁸ and Krogman⁷. Thus regional variation is present in the mean length of the humerus. It is also seen

Table No. V: Showing measurements of Index I

Sex	Male		Female	
Side	Right	Left	Right	Left
Range	159.8 - 247.7	147.2 - 234.3	134.3 - 174.6	118 - 177.6
Mean	194.87	190.66	153.46	148.73
S. D.	16.65	15.40	10.55	13.26
Calculated range	144.9 - 244.8	144.5 - 236.9	121.8 - 185.11	108.9 - 188.5
Demarking point	>185.11	>188.51	<144.92	<144.5
% beyond Demarking point	68.17	54.66	28.57	40.0

that the percentage beyond D. P. is more in the present study.

In the table VII, it is seen that, the mean epicondylar width of the humerus in the present

study was less than the mean length stated by Thieme ⁸ and Krogman ⁷. But the difference in the mean values is less as compared with Singh S ¹⁰. The regional variation exists in the mean epicondylar width of the humerus. It is also seen

Table No. VI: Comparison findings of length of humerus of present study with other studies

Authors	Mean				% beyond D. P.			
	Male		Female		Male		Female	
	Right	Left	Right	Left	Right	Left	Right	Left
Present study.	318.37	316.53	283.37	284.57	42.26	38.66	25.71	31.42
S. Singh (1972)	313.9	313.3	279.8	279.7	27	19	24	5
Thieme (1957)	338.98		305.89		-	--	--	--
Krogman (1955)	336.6		317.0		-	--	--	--

that the percentage beyond D. P. is more in the present study.

In the table VIII, it is seen that, the mean midshaft circumference of the humerus is more in the present study as compared to that observed by. Singh S¹⁰. The regional variation was present in the mean midshaft circumference of the humerus also. The percentage beyond D. P. was more in the present study.

To increase the accuracy in the sex determination, the technique of multivariate analysis was applied. It was found that percentage of humeri that could be sexed correctly was increased. In fact 97% right and 96.5% left male humeri and 97.5% right and 91% left female humeri could be sexed accurately.

In the present study the demarking points obtained for various parameters for the Marathwada region of Maharashtra differ from

those obtained by the researchers for other regions. This was because, the mean values of various parameters show regional variations. Such regional variations were also observed by previous researchers like Krogman ⁷, Thieme ⁸, Dwight ⁹, and Singh S. ¹⁰. These regional variations are due to genetic, environmental, dietary and racial factors. Hence the mean values and demarking points obtained by the researchers in other regions cannot be generalized and applied to other regions. So in the present study the mean values and demarking points were obtained for the Marathwada region of Maharashtra. The vertical diameter of head and the total bone length were most significant parameters for sex determination from humerus. The same has been verified in

studies conducted by Mall et al¹⁷ in German population and by Steyn M and Yasar M ¹⁶ in South African population.

By using multivariate technique, the percentage of the humeri that could be sexed correctly markedly increased.

CONCLUSION

Humerus the longest and most robust bone of the upper limb plays an important role for determination of the sex of unidentified skeletal remains. The various parts of the bone and their dimensions are useful for the same, with the vertical diameter of the humeral head being the most significant. The data generated in this study

Table No. VII: Comparison of Values of Epicondylar Width of present study with other studies

Authors	Mean				% beyond D. P.			
	Male		Female		Male		Female	
	Right	Left	Right	Left	Right	Left	Right	Left
Present study.	57.7	60.2	54.1	52.2	17.9	16.0	25.7	25.7
S.Singh (1972)	61.4	60.4	52.7	52.4	0	8	11	11
Thieme (1957)	83.89		56.76		-			

Table No. VIII: Comparison of values of Mid-shaft circumference of present study with other studies.

Author	Mean				% beyond D. P.			
	Male		Female		Male		Female	
	Right	Left	Right	Left	Right	Left	Right	Left
Present study.	62.51	61.03	54.82	54.06	41.79	21.33	20	25.71
S.Singh (1972)	60	58.5	49.8	49.1	14	2	11	11

would be a useful reference for practical application in future forensic and anthropological studies in Marathwada population.

REFERENCES

1. Dogra TD, Rudra A, Identification. In: Lyon's Medical Jurisprudence & Toxicology, 11th edn Delhi: Delhi law house, 2004: 396-416.

2. Parikh C.K. Identification. In: Parikh's Text Book of Medical Jurisprudence and Toxicology, 5th edn, New Delhi: CBS publishers and Distributors, 1992: 30-49.
3. K Mathiharan, Amrit K Patnaik, Personal Identity. In: Modi's Textbook of Medical Jurisprudence, 23rdedn. New Delhi: Lexis Nexis Butterworths, 2006: 263-287.
4. Vij K. Identification. Textbook of Forensic Medicine and Toxicology Principles and Practices, 4th edn. New Delhi: Elsevier, 2008: 48-57.
5. Dikshit PC. Identification. Textbook of Forensic Medicine and Toxicology, 1st edn. New Delhi: Peepee, 2007: 47-60.
6. Reddy KSN. Identification. In: The Essentials of Forensic Medicine and Toxicology 24th edition. Hyderabad: K Sugna Devi, 2005: 47-68.
7. Krogman. W. N. The human skeleton in legal medicine: Medical aspects. In; Levinson S. A. ed. Symposism on Medicolegal problems, series 2, Lippincot, Philadelphia 1949.
8. Thieme. F. P. Sex in Negro skeletons. J. Forensic Med; 1957; 4: 72 - 81.
9. Dwight, T. The size of the articular surfaces of the long bones as characteristic of sex; an anthropological study. American Journal of Anatomy; 1905; 4: 19 - 35.
10. Singh Shamer and S. P. Singh. Identification of Sex From the humerus. Indian Journal of Medical Research; Jul 1972.
11. Santiago Genoves, T. Revaluation of age, stature, and sex of Tepexpan Remains, Mexico, American Journal of Physical Anthropology; 1960;18: 205.
12. Singh. S. P., and Singh. S. The sexing of adult femora - Demarking points for Varanasi zone. Journal of the Indian Academy Forensic Sciences; 1972; 13: 10 - 16.
13. Singh. S. P., and Singh. S. Identification of sex from the head of the femur - The demarking points for Varanasi zone. Indian Medical Gazette; 1972; 11: 45 - 49.
14. Wilczak CA. Consideration of sexual dimorphism, age, and asymmetry in quantitative measurements of muscle insertion sites. Int Jou of Osteoarcheology; 1998; 5: 311-325.
15. Robinson, Stacy M. The skull and humerus in the determination of sex: reliability of discriminant function equations. Forensic Sci Int 2009; 186 (1-3): 85.
16. Steyn M, Yasar M . Osteometric variation in the humerus: Sexual dimorphism in South Africans. Forensic Sci Int. 1999; 106 (2): 77-85.
17. G. Mall, M. Hubig, A. Büttner, J. Kuznik, R. Penning and M. Graw. Sex determination and estimation of stature from the long bones of the arm. Forensic Sci Int. 2001; 117 (1-2): 23-30.