

A STUDY ON SEXUAL DIMORPHISM OF THE HUMERUS IN CENTRAL GUJARAT

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ABSTRACT

Introduction: Anthropometric techniques have been commonly used to estimate the stature from bones and play an important role in identifying unknown bodies by anthropologists and anatomists for over hundred years. Forensic experts and anthropologists often have a task of identification of sex of skeletal remains which is an aspect of the biological profile of an individual. The humerus is among the long bones which have been found to remain in better condition after the death of the individual and can be used for analysis of sex of the individual.

Aim: To assess the role of multivariate analysis of humerus metric parameters for sex differentiation of adult male and female humerus.

Materials and Methods: This cross-sectional observational study was done on 102 adult human humeri of known sex available in the bone bank of the Department of Anatomy, Smt.B.K.Shah Medical institute & Research Centre Piparia, Vadodara, Central Gujarat, India

Results: A total 102 Adult humerus 64 Male and 38 Female were studied in present study. Twenty five measurements were taken from each humerus. The accuracy rate for sex determination by discriminant analysis using the five parameters i.e., weight, total length, vertical diameter of head, transverse diameter of the head and the circumference of midshaft of the humerus.

KEYWORDS: Humerus bone; Morphometry, Sexual dimorphism.

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INTRODUCTION

Determination of sex is an important first step in the development of the biological profile in human osteology, whether analyzing a forensic case or an archaeological population. Without an accurate determination of sex, we cannot accurately estimate age at death, as rates of growth, development and degeneration vary by sex as well as population.

The determination of sex of an individual is primary criteria of identification. The osseous skeleton is the only structure to resist this effect for long time. The osseous skeleton therefore maintains its morphological features long after the soft tissue have been destroyed [1].

Identifying the sex of a body and estimating the body's stature are considered the most important factors in establishing the identity of

indefinite dead bodies, parts of bodies, or even skeletal fragments [2].

Many researchers studied the sexual dimorphism of adult skeletons [3-5] using the dimensions of the skull, face [6,7], long bones [8,9], hands, feet [10,12], and pelvis [13,14]. Scholars proved that a specific study is needed for each population to gain accurate results for the sexual identification of a skeleton [15]. Discriminant function analysis had been used to estimate the sex from bones if they are suspected to be sexually dimorphic [16,17]. The pelvis was considered to be the most accurate bone for sex determination, as it allows for parturition in females.

The humerus is the bone of the arm, and is the strongest and longest bones of the upper extremity. It presents upper and lower ends, and an intervening shaft [18]. Nutrient foramen is an opening in the shaft of humerus. The nutrient artery enters through nutrient foramen through cortex into the medullary cavity of the humerus [19].

Almost all bones of the human skeleton show some degree of sexual dimorphism. The accuracy of sex determination depends on the type and condition of the bone, age of the subject, the degree of fragmentation of the bones and biological variability. Obvious sex differences do not become apparent until after puberty, though specialized measurements on the pelvis can indicate sex even in fetal material. It is recognized that long bone cross-sectional area is greater in males as compared to females which reflects more rapid periosteal bone growth in boys [19].

MATERIALS AND METHODS

This cross-sectional observational study was done on 102 adult human humeri of known sex available in the bone bank of the Department of Anatomy, Smt.B.K.Shah Medical institute & Research Centre Piparia, Vadodara, Central Gujarat, India. The convenience sample may not be representative of reference population from the region, it provides an important data related to humerus features and its utility in sex differentiation. All the humeri were dry, free of damage or deformity and were fully ossified. The instruments used for the measurements of various parameters of the humerus were: scale,

sliding vernier calliperosteometer, scientific balance and weight, standardised and flexible steel tape, non-elastic threads, marker pencils and pens.

Following measurement were taken:

Total Length (L): The functional length of the humerus, i.e., the distance between the upper and lower end in anatomical position was recorded with the help of osteometer and the length was recorded in mm. The midpoint of the shaft was marked simultaneously. It may also be called as maximal length

Weight (W): Weight of each dried humerus was recorded with the help of scientific balance and weight. It was recorded in grams.

Vertical diameter of head: This is the maximum diameter of the head in the vertical plane (coronal), it was measured with the help of vernier calliper in mm

Transverse diameter of head: This is the maximum diameter of the head, in the transverse plane of the head of the humerus. It was also measured by vernier calliper, in mm.

Circumference of midshaft (mSC): It was measured with the help of non-elastic thread at the midpoint of the shaft by the procedure as for the other circumferences. Length of the thread was measured on the scale, in mm

Length of the Shaft of humerus: It is measured between two lines; upper and lower. Upper line was drawn at a distance of 1 cm below the lowest point on articular margin of head; this point was in line with medial epicondyle.

Circumference of head at Anatomical neck (CA): The circumference of anatomical neck of humerus was measured by marking a fixed point at groove opposite the Greater tubercle on anatomical neck with a marker pencil and running the non-elastic thread along the groove starting from the fixed point and back to it. The length of thread then recorded on scale in mm.

Circumference of Surgical neck: It was measured at a point 1 cm below the lowest point on margin of articular surface of head of humerus; It was measured with the help of non-elastic thread by same method as that of CA.

Maximum Width of upper end of humerus: It was recorded by placing the upper end of humerus transversely with lesser tubercle facing upwards in osteometer and recording the distance shown on osteometer scale in mm.

Width of Bicipital groove: It was the distance between two lips of bicipital groove measured at the level of surgical neck with the help of vernier calliper.

Anteroposterior diameter of midshaft: The anteroposterior distance of midshaft of humerus is measured at the level of midpoint of shaft with the help of vernier caliper in mms.

Transverse diameter of midshaft of humerus: The maximum transverse diameter of midshaft is measured at midshaft point by holding humerus in anatomical position by vernier calliper in mm.

Bi-epicondylar distance: Distance between two epicondyles of lower end of humerus is measured with the help of vernier calliper in mm.

Trochlear Width: It was measured by vernier calliper as anteroposterior width of trochlea at medial margin of medial flange of trochlea, recorded in mm.

Capitulum Width: It was measured as maximum anteroposterior distance of capitulum. It was recorded in mm on vernier calliper scale with limbs of vernier calliper parallel to humerus.

Width of Articular Surface of lower end of humerus: It was measured with vernier calliper as a maximum width of articular surface at lower end of humerus.

Height of medial Flange of trochlea: It was measured with the help of vernier calliper as maximum length of medial flange of trochlea on inferior aspect.

Circumference of Shaft distal to deltoid tuberosity (Cdt): It was measured at a point 1 cm distal to midshaft point with same method as above. It was also defined as second one-third portion of the humeral diaphysis, distal to deltoid tuberosity (minimum circumference).

Trochlear distance: The measurement from the location of the known minimum circumference to the trochlea. It was measured with the help of non-elastic thread, the length of which was measured on scale.

Distance of Articular margin from the Apex of greater tubercle (L1N): It was measured with the help of vernier calliper as a distance between highest point on greater tubercle and nearest point on articular margin.

Distance between the nearest Point of margin of lesser tubercle and Articular margin of head (L2n): It was measured with the help of vernier calliper as distance between nearest point on lesser tubercle and articular margin.

length index (li): This was obtained by dividing the functional length with the length of shaft.

Length Index (LI) = Functional length (L)/Length of shaft

Circumference (Ci): This was obtained by dividing the circumference of anatomical neck with the circumference of mid shaft.

Circumference Index (CI)=Circumference of shaft of the humerus.s



RESULTS

A total 102 Adult humerus 64 Male and 38 Female were studied in present study. Twenty five measurements were taken from each humerus. The accuracy rate for sex determination by discriminant analysis using the five parameters i.e., weight, total length, vertical diameter of head, transverse diameter of the head and the circumference of midshaft of the humerus.

Table 1:Weight of humerus.

Gender	Mean (g)	SD	P value
Male (64)	102.22	± 18.36	<0.001
Female (38)	86.24	± 14.21	

As shown in table 1 the weight of male humerus is more than female.

Table 2:Length of humerus.

Gender	Mean (mm)	SD	p value
Male (64)	311	± 15.24	<0.001
Female (38)	274	± 16.85	

As shown in table 2, the length of male humerus is more than female.

Table 3:Vertical and transverse diameter of head of humerus.

Gender	Vertical diameter		Transverse diameter		p value
	Mean (mm)	SD	Mean (mm)	SD	
Male (64)	42.26	±2.05	39.85	±1.99	<0.001
Female (38)	38.54	± 2.54	34.01	±2.28	

As shown in table 3, the vertical and transverse diameter of humerus in male is more than female.

Table 4:Various measured humerus parameters.

Parameters	Male (64) mm		Female (38) mm		p value
	Mean	SD	Mean	SD	
Midshaft of humerus	59.26	3.62	54.21	4.05	<0.001
Length of shaft	236.22	11.65	219.1	13.85	<0.001
Circumference of head at anatomical neck	130.45	6.1	114.84	7.74	<0.001
Circumference of surgical neck	90.65	6	79.54	6.85	<0.001
Maximum width of upper end	47.88	3.44	41.21	3.41	<0.001
Anteroposterior diameter of mid shaft	19.01	1.27	17.04	1.65	<0.001
Transverse diameter of midshaft	18.16	1.05	15.81	0.98	<0.001
Width of bicipital groove	10.09	1.28	8.94	1.25	<0.001
Bi-Epicondylar distance	58.89	3.74	51.85	4.01	<0.001
Trochlear Width	23.84	1.28	20.88	1.46	<0.001
Capitulum Width	22.25	1.02	20.68	1.65	<0.001
Width of articular surface of lower end	40.09	2.1	35.1	2.51	<0.001
Height of medial flange of trochlea	7.25	1.05	8.21	1.26	<0.001
Circumference of Shaft distal to deltoid tuberosity	59.85	3.41	52.1	4.27	<0.001
Trochlear distance	124.8	14.2	114.2	7.8	<0.001
Distance of Articular margin from the Apex of greater tubercle	10.19	1.24	9.47	2.14	<0.001
Distance between the nearest Point of margin of lesser tubercle and Articular margin of head	18.65	1.24	18.05	1.92	<0.001
Length index	1.28	0.37	1.18	0.24	<0.001
Circumflex index	2.34	0.15	2.09	0.84	<0.001

As shown in table 4 all measures parameters related with humerus were higher in male compared with female.

DISCUSSION

It is an established fact that, standard metrical values derived for sexing the skeletal in one region if applicable 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 102 Adult humerus 64 Male and 38 Female were studied to obtain the standard metrical values in the central Gujarat region. The metric values of all parameters were higher in males as compared to females in the present studied humeri. Research from India and other parts of the world also reflects that the dimensions of the humerus are larger in males as compared to females.

Table 5:Comparison findings of length of humerus of present study with other study.

Authors	Male Mean (mm)	Female Mean (mm)
Present study	311	274
Shaikh Siraj Ahmed et al [20]	312	283
Reddy BB et al [21]	310.79	278.15
Anil kumar reddy et al [22]	310	260

In the present study, the Maximum length of humerus is highly significant parameter there is a considerable amount value difference is found between males and females. Our findings are in conformity with the findings reported by Singh S (1972) [23], DeryaAtamturk, (2010) [24] and Iscan M.Y et al (1998) [25], and Girish patil (2011) [26] study on south Indians, show statistically significant sex differences between

mean of Maximum length in males and female. Soni G et al., study conducted on 40 male and 40 female right humeri measured six parameters. The mean values of five out of these six measurements were significantly lower in females as per results of univariate analysis. The combination of parameters of vertical head diameter of the shaft and epicondylar width provided 85% accuracy in male and 90% accuracy in female humerus bones [26].

The trochlear width in present study was 23.84 ± 1.28 mm in males and 20.88 ± 1.46 mm in females; anatomical neck circumference in males was 130.45 ± 6.10 mm and in females was 114.84 ± 7.74 mm and the BED in males was 58.89 ± 3.75 and 51.85 ± 4.01 mm in females. The study by Shaikh Siraj Ahmed et al was 24.56 ± 1.39 mm in males and 21.22 ± 1.71 mm in females; anatomical neck circumference in males was 131.83 ± 6.15 mm and in females was 115.2 ± 7.88 mm and the BED in males was 59.95 ± 3.45 and 52.57 ± 4.36 mm in females²⁰. The study by Reddy B and Doshi MA reported similar trochlear width of 24.70 ± 1.12 mm in males and 20.96 ± 1.58 mm in females; the anatomical neck circumference reported in males was 131.27 ± 5.51 mm and in females was 112.78 ± 8.07 mm; the BED in males was 60.5 ± 3.05 mm and 52.17 ± 3.78 mm in females [21].

Thus, the present data regarding humerus measurements described are in line with literature from Indian population with differences in humerus measurements data from other continent populations. The difference in measurements across different population groups has been attributed to difference in diet patterns, genetic differences and environmental factors affecting the growth patterns [28]. Multivariate analysis with similar parameters has been found to be able to differentiate male and female humerus bones with reasonable accuracy in different population groups.

Conflicts of Interests: None

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