International Journal of Anatomy and Research,
Int J Anat Res 2017, Vol 5(4.1):4454-69. ISSN 2321-4287
DOI: https://dx.doi.org/10.16965/ijar.2017.368

Original Research Article

HUMERAL MORPHOMETRICS: A STUDY IN EASTERN INDIAN POPULATION

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ABSTRACT

Background: Estimation of stature from bones plays an important role in identifying unknown dead bodies, parts of bodies or skeletal remains. Anthropometric techniques have been commonly used to estimate stature and bone length from these. Various implants are available for the diverse fracture patterns observed in both ends of humerus, which are contoured on the basis of morphometry of the concerned part. The present study focuses on determining the total length, mid shaft girth, breadth of distal and proximal ends, maximum transverse diameter of head, maximum vertical diameter of head, breadth of trochlea and capitulum & comparing these parameters between two sides.

Aims : This study focuses on analysing some important bony features of right & left humerus & compare them.

Materials and Methods: Random collection of 100 dry and processed humerus of both sides, from the skeletal sets of medical students and the Department of Anatomy, IPGME&R, Kolkata were done, by purposive sampling technique. This was a cross-sectional observational study. Dry bones were collected. Un-ossified and diseased bones were excluded from the study. Measurements were taken with the help of osteometric board, electronic digital calliper and measuring tape. Lengths and breadths were measured in millimetres. Data was summarized by routine descriptive statistics. All numerical variables analyzed were normally distributed by Kolmogorov-Smirnoff goodness-of-fit test. Comparison between left and right cohorts was done by Student's independent samples t test.

Results and Conclusions: Mean total length of the bone was 295.97±19.19mm. Mean value of breadth of proximal & distal ends were 45.53±3.59 mm & 56.76±3.69 mm, mid shaft girth 60.28±4.21 mm, maximum transverse & vertical diameter of head were 38.94±2.97 mm & 35.37±3.31mm, breadth of trochlea & capitulum were 22.88±3.20 mm 16.32±1.63 mm. No significant difference was observed between humeri of two sides. However,this study might be helpful in designing newer prostheses for elbow as well as shoulder replacement surgeries.

KEY WORDS: Morphometry, Humerus, Mid shaft girth, Prostheses, trochlea, capitulum, head.

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Quick Response code	Web site: International Journal of Anatomy and Research ISSN 2321-4287 www.ijmhr.org/ijar.htm	
DOI: 10.16965/ijar.2017.368	Received: 26 Jul 2017 Peer Review: 27 Jul 2017 Revised: None	Accepted: 05 Sep 2017 Published (O): 01 Oct 2017 Published (P): 01 Oct 2017

INTRODUCTION

Humerus, like almost all bones of human skeleton shows some degree of sexual dimorphism. It is recognized that cross-sectional area of humerus is greater in males compared to females. However, it is not very much clear whether these findings reflect gender variation in bone size or shape. Previous studies recorded the factors which affect the long bone dimensions and explained the phenomenon of difference in lengths between the right and left humerus [1-3]. Estimation of stature from bones plays an important role in identifying unknown dead bodies, parts of bodies or skeletal remains. Anthropometric techniques have been commonly used to estimate stature and bone length from the skeletal remains and unknown body parts by Anthropologists, Medical Scientists and Anatomists for over a hundred years [4-7]. The humerus offers important advantages over other long bones in that its entire outline can readily be traced on total body X-ray absorptiometry (DXA) images, and its shape can be modelled as a cylinder with reasonable accuracy [8].

Studies from India and abroad have attempted to predict the maximum length of humerus from its different segments and found significant correlations between maximum length and segments of humerus. In anatomical studies it was reported that the highest point on the articular segment of the humeral head is found to be 6 to 8 mm above from the most proximal point of the greater tuberosity [9].

This relationship is important because the relative height of the greater tuberosity determines the amount of subacromial clearance when the arm is elevated. Moreover in clinical assessment this point is important for treatment of isolated greater tuberosity fractures. Olecranon fractures occur in 10% of all upper extremity lesions [4].

The lesion might be the result of indirect or direct trauma, especially forced hyperextension of the elbow joint. Complex distal humerus fractures provide reconstructive problems and complications such as damage to the nerve and blood vessels. Therefore these fractures are difficult for orthopedic surgeons to treat [9]. Various implants are available for the diverse fracture patterns observed in the distal humerus and these are contoured specifically according to the anatomy of this region [4-9]. Based on the above facts, it is evident that knowledge of the morphometric analysis of humeral segments is important in order to identify unknown bodies and estimation of stature. It is also helpful for the clinician in the upliftment of treatment of proximal and distal humeral fractures [9].

Akpinar and colleagues performed a morphometric study on the humerus for intramedullary fixation [10]. In a Turkish study in 2006, Akman and colleagues included 120 (56 left side and 64 right side) male adult dry Caucasians' humerus to measure the morphometric properties of humerus segments [4]. DeLude et al. conducted a study which was to describe the extramedullary humeral morphology in paired humeri to determine whether geometric differences exist from side to side in the same individual [11]. Seventy-six cadaveric humeri were investigated to study the three-dimensional morphometric data based on CT scan by Aroonjarattham and colleagues [12]. Selvakumar et al. conducted a study to determine handedness from the morphometry of intertubercular sulcus of humerus [13]. Somesh and colleagues performed morphometric analysis of segments of humerus [14]. Lokanadham and colleagues conducted a morphometric analysis of dry humerus bones in Indian population and compared the parameters between both the sex [15]. The present study focuses on deteremining the total length, mid shaft girth, breadth of distal and proximal ends, maximum transverse diameter of head, maximum vertical diameter of head, breadth of trochlea and capitulum & comparing these parameters between right and left humerus.

MATERIALS AND METHODS

The study was conducted in a Government Medical College of Kolkata using 100 fully ossified and properly processed dry specimen of human humerus bone, irrespective of their age and genders. Unossified bones & bones with diseases and injuries were excluded from the present study. Measurements were taken with the help of osteometric board, electronic digital calliper and measuring tape. Lengths and breadths were measured in millimetres. Breadth of proximal and distal end, breadth of capitulum and trochlea, maximum vertical and transverse diameters were measured by electronic digital calliper (Image 1). The mid shaft girth was measured with the help of a measuring tape.total length of humerus was recorded with help of osteometric board. The following parameters were described for analysis in this study:

Breadth of proximal end: It is the distance between lateral most point of greater tuberosity and the medial most point of the head.

Breadth of distal end: It is the transverse distance between two epicondyles parallel to the previous measurement.

Mid shaft girth: It is the circumferential length at the middle of the shaft.

Maximum transverse diameter of head: It is the linear distance between the most anterior and most posterior points on the articular surface of the head transverse to the vertical diameter.

Maximum vertical diameter of head: It is the linear distance between the highest and lowest points on the articular surface transverse to the transverse diameter of the head.

Breadth of capitulum: It is measured as the linear distance between the most lateral point of the capitulum and the deepest point between the capitulum and trochlea.

Breadth of trochlea: It is the distance between the midpoint of the medial margin of trochlea and the medial margin of the capitulum.

Length of the bone: It is the direct distance from the most superior point on the head of the humerus to the most inferior point on the trochlea.

RESULTS AND ANALYSIS

100 (48 Right and 52 Left) dry humerus were included in the present study. Among the various measurements mean total length of the bone was 295.97±19.19mm. Other mean measurements were as follows: Breadth of proximal end of humerus was 45.53±3.59 mm, breadth of distal end 56.76±3.69 mm, mid shaft girth 60.28±4.21 mm, maximum transverse diameter of head 38.94±2.97 mm, maximum vertical diameter of head 35.37±3.31mm, 16.32 ±1.63mm, breadth of trochlea 22.88±3.20 mm, breadth of capitulum 16.32±1.63 mm. Figure 1 & Table 1 shows descriptive statistics of numerical variables.Comparison between left and right cohorts (sides) (as in Table 2) was done by Student's independent samples t test. Right and left humerus was compared for all the descriptive variables. No significant difference was observed between humeri of two sides with respect to the concerned variable.

Data was summarized by routine descriptive statistics, namely range, mean with standard deviation, median with interquartile range and 95% confidence interval of the mean. All numerical variables analyzed were normally distributed by Kolmogorov-Smirnoff goodness-of-fit test. Comparison between left and right cohorts was done by Student's independent samples t test. Statistical version 6 [Tulsa, Oklahoma: StatSoft Inc., 2001] and MedCalc version 11.6 [Mariakerke, Belgium: MedCalc Software 2011] software were used for statistical analysis.

Fig. 1: Image showing procedure of measuring one of the parameters.

Graph 1: Bar Diagram showing descriptive statistics of selected numerical variables.

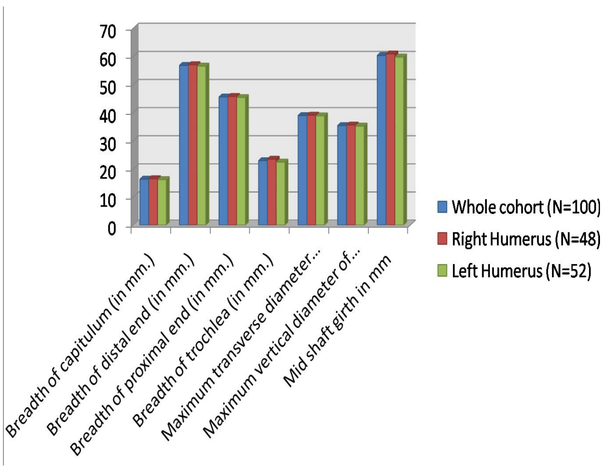

Table 1: Descriptive statistics of numerical variables – whole, right, and left cohort.

Variables		Minimum (in mm)	Maximum (in mm)	Mean (S.D.)
Breadth of proximal end	Whole Sample (N=100)	36.47	55.65	45.53 (3.59)
	Right (N=48)	36.47	50.72	45.73 (3.49)
	Left (N=52)	38.07	55.65	45.35 (3.70)
Breadth of distal end	Whole Sample (N=100)	48.48	64.42	56.76 (3.69)
	Right (N=48)	48.62	62.95	57.02 (3.58)
	Left (N=52)	48.48	64.42	56.52 (3.81)
Mid shaft girth	Whole Sample (N=100)	48	69	60.28 (4.21)
	Right (N=48)	52	68	60.85 (3.73)
	Left (N=52)	48	69	59.75 (4.59)
Maximum transverse diameter of head	Whole Sample (N=100)	31.43	44.18	38.94 (2.97)
	Right (N=48)	31.43	44.14	39.06 (3.26)
	Left (N=52)	33.33	44.18	38.82 (2.71)
Maximum vertical diameter of head	Whole Sample (N=100)	27.05	42.42	35.37 (3.31)
	Right (N=48)	27.05	42.21	35.56 (3.26)
	Left (N=52)	27.7	42.42	35.19 (3.38)
Breadth of capitulum	Whole Sample (N=100)	12.12	21.21	16.32 (1.63)
	Right (N=48)	12.42	20.12	16.49 (1.54)
	Left (N=52)	12.12	21.21	16.16 (1.70)
Breadth of trochlea	Whole Sample (N=100)	14.15	28.82	22.88 (3.20)
	Right (N=48)	14.15	28.82	23.44 (3.10)
	Left (N=52)	14.32	27.27	22.38 (3.23)
Length of the bone	Whole Sample (N=100)	257	332	295.97 (19.19)
	Right (N=48)	263	332	299.29 (19.86)
	Left (N=52)	257	324	292.90 (18.19)

Table 2: Comparison of numerical variables between right and left cohort.

Variables	Mean (Rt. cohort) in mm	Mean (Lt. Cohort) in mm	t-value	P (significance)
Breadth of proximal end	45.73	45.35	0.529	0.598
Breadth of distal end	57.02	56.52	0.668	0.505
Mid shaft girth	60.85	59.75	1.312	0.192
Maximum transverse diameter of head	39.06	38.82	0.404	0.687
Maximum vertical diameter of head	35.56	35.19	0.548	0.585
Breadth of capitulum	16.49	16.16	0.999	0.32
Breadth of trochlea	22.88	23.44	1.66	0.1
Maximum length of the bone	299.29	292.9	1.678	0.096

Table 3: Comparison of descriptive data between index study and three other studies conducted by other researchers.

Variables	Sidedness	Index Study	Study by Akman et al. [4]	Study by Rai et al. [16]	Study by Somesh et al. [14]
Length (in mm)	Right	299.29 ±19.86	307.1±20.08	302±21.4	309.6± 20.6
	Left	292.90 ±18.19	304.8±18.9	297.5±21.1	299.6± 22.5

Table 4: Comparison between various measurements of humerus.

Variables	Study by Lokanadham et al [33] [Males (n=71)]	Study by Lokanadham et al [33] [Females (n=29)]	Index study
Breadth of proximal end (in mm)	47.19± 0.34	41.67± .49	45.53 ±3.59
Breadth of distal end (in mm)	59.74± .54	53.57 ± 3.25	56.76 ±3.69
Mid shaft girth (in mm)	63.91± .68	57.82± .9	60.28 ±4.21
Maximum transverse diameter of head (in mm)	43.78± 4.2	34.92 ± .42	38.94 ±2.97
Maximum vertical diameter of head (in mm)	32.66± .31	29.6± .41	35.37 ±3.31
Breadth of capitulum (in mm)	16.38± .17	15.21± .22	16.32 ±1.63
Breadth of trochlea (in mm)	23.39± .22	20.92± .34	22.88 ±3.20
Length of bone	319.7± 1.55	286.5 ±1.53	295.97 ±19.19

DISCUSSION

Morphometric measurements of long bones play a vital role in estimation of stature of an individual. Humerus is the longest bone of the upper limb and its morphometric measurements can be useful for descriptive and comparative purpose. Many studies have been conducted in India and abroad focussing on morphometric measurements of humerus [4,9,14,15,16]. . Those described different measurements of humerus, compared them between both sides. However, there is dearth of data from Eastern India. The index study conducted a morphometric analysis of cadaveric dry humerus bones in a tertiary care teaching hospital of Eastern India. Table 3 shows the comparison of descriptive data of index study with similar studies conducted by other authors from India and abroad.

The measurements of the index study were in keeping with other Indian studies with lesser values for certain variables. As there is no other study from Eastern India it was difficult to draw any conclusion regarding this lower value in the index study. A study was conducted by Lokanadham et al. on the morphometric measurements of humerus[15]. They measured 100 dry humerus including 71 male and 29 female humerus. They recorded the sexual dimorphism in different measurements. Comparison between the measurements of the abovementioned study and the index study is depicted in

Table 4. In that comparison we have seen that this index study have given a value in each parameter that is in between the values of the males and females in the study of Lokanadham et al. This study haven't considered any sexual dimorphism, though overall findings are at par with the aforesaid study [15].

In some previous studies conducted in India and abroad, right - left asymmetry could not be established [4,17]. On the contrary, some studies noted the asymmetry in different morphometric measurements between two sides [11,13,18]. The present study did not show any significant right-left asymmetry.

Thus, whether the humerus might serve as a tool for determining sex by forensic experts is still debatable, as the sexual dimorphism is evident in some studies while others did not find any significant variations among opposite genders. The present study is inconclusive in this respect, as sex has not been considered as a parameter for the morphometry. Also, the laterality is very difficult to be ascertained depending on these morphometric parameters, since there has not been any significant difference among the right or left sided humerus in the index study. But, some of the previous studies have concluded the importance of these measurements in determining the laterality of this bone, which again opens up a door for further investigations in this matter as well.

In Forensic and Archeological studies, the mean value of total humerus length gives important evidence to indicate the characteristic features of a population [4,19]. The estimated length of humerus might have a strong correlation with the segmental or fragmental morphometry of this bone and that needs to be considered in future studies. Past literatures relating to anatomy of this bone and human anthropometric studies have convincingly proved that humeral length has predictive value for actual human stature determination. Thus, segmental morphometry of humerus can sub-serve a better criterion for ascertaining the stature of an individual, as often the whole bone might not be always available for smooth operation of the forensic experts and criminal inquest. Apart from the anthropometric aspect, human joint prostheses are gaining much importance in the era of advancement of medical science and biomechanical science. Complicated fractures of upper or lower end of humerus are not very uncommon now-a-days. Manufacturing of prostheses have been primarily the domain of economically developed countries and they have been marketed in the developed countries for quite some time. These manufacturers are coming up with prosthetic designs which are in concordance with the morphometric data of the population of their own country [20]. Since these prostheses are also used in populations of different ethnic and morphological structure, there appears a general incompatibility between the features of the prosthesis and the morphometric data of the population where they are used. As a result, additional efforts are being given during the replacement surgeries like curettage of the bone structure and associated loss of tissue develops, which has a negative effect on clinical progress and success [21,22]. These problems could be overcome by manufacturing prostheses as per the requirements of various ethnic and racial groups throughout the whole world.

CONCLUSION

Morphometric measurements of humerus might be of particular importance to the prosthesis manufacturing units or authorities, in designing the same on basis of racial and ethnic variations. Analysis of morphometric measurements of humerus among eastern Indian population might also be very helpful to the forensic experts to determine the sexual dimorphism as well as the laterality of the bone. Not only that, the further scope is open to correlate these data with radiological data and formulate new techniques for effective remodelling of the prosthesis.

ACKNOWLEDGEMENTS

This work would not have been possible without the constant support of cadaver laboratory assistants and the faculty members of the Department of Anatomy, Institute of Post-Graduate Medical Education & Research, Kolkata have guided us throughout the study period, lest we could not have solved many a difficulties faced during materialising the work.

Conflicts of Interests: None

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How to cite this article:

Moumita Chatterjee, Iman Sinha, Ratnadeep Poddar, Asis Kumar Ghosal. HUMERAL MORPHOMETRICS: A STUDY IN EASTERN INDIAN POPULATION. Int J Anat Res 2017;5(4.1):4454-4459. **DOI:** 10.16965/ijar.2017.368