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Original Article

ESTIMATIONOF TOTAL LENGTH OF HUMERUS FROM ITS FRAGMENTS IN SOUTH INDIAN POPULATION

Lakshmi Kantha.B.M *[1], Roopa Kulkarni [2].

[*1] Assistant Professor in Anatomy, BGS Global Institute of Medical Sciences, Uttarahalli Road, Kengeri, Bangalore, India.

[2] Senior Professor in Anatomy, M.S.Ramaiah Medical College, MSR Nagar, Bangalore, India.

ABSTRACT

Aim: To obtain the lengths of the humeral segments and compare with total length of humerus in South Indian population, That helps in estimating the stature of individual using standard regression formulae and to compare these data with the study conducted in other countries for the use in forensic and archeological studies.

Materials and Methods: 150 (75 left and 75 right) adult, fully ossified, dry and processed humerii were taken to analyze the morphometric details of the humeral segments which were measured using osteometric board and scale. The length of six different segments namely, from most proximal point in the head to most distal point of the circumference of the head (segment-1), from most distal point of the circumference of the head to the convergence of two areas of muscle attachment (segment-2),the convergence of two areas of muscle attachment to the deltoid tuberosity (segment-3), from deltoid tuberosity to upper margin of the olecrannon fossa (segment-4), from upper margin of olecrannon fossa to lower margin of olecrannon fossa (segment-5), from lower margin of olecrannon fossa to most distal point on the trochlea (segment-6) and maximum length of humerus were measured to the nearest millimeter.

Results: The values obtained in mm (mean±S.D) in total length of humerus segments -1,2,3,4,5 and 6 were recorded. The proportion of segments to the total length was also calculated which will help for the stature estimation using standard regression formulae.

Conclusion: This study helps in forensic, anatomic and archeological fields in order to identify unknown bodies as well as for the orthopedic surgeons for the treatment of proximal and distal humerus fractures for their reconstruction in case of extensive damage to those parts of the humerus.

KEYWORDS: Humerus; Stature estimation, Fragments of bone; Total length.

Address for Correspondence: Dr Lakshmi Kantha.B.M, Door no 1156, 21st main road, 22nd cross road, Banashankari 2nd stage, Bangalore-560070, India. Mobile phone no: +919481475336.
E-Mail: drchandan24@gmail.com

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BACKGROUND

In a vast and thickly populated country like India, establishment of an identity for a deceased person assumes great medico legal importance. Anatomists and forensic experts have been consulted frequently regarding identification of skeletal remains found under suspicious circumstances and are asked to pronounce an opinion which may form an important evidence in the court of law. One of the factors in establishing the identity of a person is the stature. The estimation of the skeletal samples of the burials is often fragmentary and are found in mixed lots. For this reason there is a need for developing a technique for stature estimation on skeletal parts. First to estimate their total length using their fragmentary bone length, second to employ them in stature formulae, thus

to estimate the total length of the individual [1]. Excavation of graves, mass casualties and cases, where grossly mutilated skeletal remains are found, becomes difficult and challenging for both the forensic pathologist and physical anthropologist. In India, exposed and unidentified dead bodies are often mutilated by wild animals gnawing the skeletal remains. Bone fragments, often with ends destroyed, are brought for forensic case works.

In both Archeological and forensic practice, fragments of long bones are often presented as the only available source to establish identity. Estimation of stature becomes the most important job in such a setting. In case of absence of most of the bones of skeleton, long bone with intact ends can be overcome by applying the derived method to the available fragment of bone. This will help to solve medico legal problems giving due consideration to regional factors [2].

The application of osteometry is of utmost importance in forensic medicine. Medico legal investigation for achieving the goal of estimating age at the time of death, sex, race, ancestry, ethnicity, stature, body weight, body built, details of individualizing characteristics .i.e. amputation, fractures, ankylosis, deformities and bone pathologies and to some extent the course of death if reflected in the skeletal remains. The objective is to enable the law enforcement agencies to achieve the ultimate goal of personal identification.

The four parameters i.e. age, sex, race and stature are considered as the “big fours” of forensic anthropology [3].

Proximal humeral fractures are common injuries. They occur along the epiphsyeal lines of the proximal humerus and within its segments. Soft tissue attachment including the insertions of the rotator cuff tendons and the deltoid, pectoralis major, latissimus dorsi and teres major muscles can cause displacement of the various parts in proximal humeral fractures and likewise isolated displaced fractures of the greater tuberosity. In anatomic studies it was reported that the highest point on the articular segment of the humeral head is found to be 6 to 8mm above from the most proximal point of the greater tuberosity. This relationship is important because the relative height of the greater tuberosity determines the amount of subacromial clearance as 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. The lesion might be the result of indirect or direct trauma, especially forced hyper extension 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. Various implants are available for the diverse fracture patterns observed in the distal humerus and these are contoured specifically for the anatomy of this region. Several companies have developed anatomically based precontoured condylar plate systems that can assist with fracture reduction [4].

We believe that knowledge of the morphometric values of humerus segments is important in order to identify unknown bodies and stature. It is also helpful for the clinician in the treatment of proximal and distal humerus fracture.

MATERIALS AND METHODS

Source of data: Random collection of 150 dry and processed humerii of both the sides.

Fully ossified dry and processed humerii bones from the skeletal sets of medical students.

Study design: Cross sectional study.

Study area: M.S.Ramaiah medical college, Bangalore.

Study subject: 150 fully ossified and processed dry humerii bones from the skeletal sets of medical students and bones from the Department of Anatomy, M.S.Ramaiah Medical College, Bangalore

Sample size: 150 fully ossified, processed and dry humerii. Bones from the skeletal sets of medical students and bones from the Department of Anatomy. This was estimated based on pilot study considering that segment-1 length (3.716cm ± 0.343) with a precision of 5% a error and 1.5% of mean as minimum expected difference.

Method of collection of data:

In order to compare all measurements of the segments of humerus which have been divided into 6 segments by taking the following landmarks as the basis of morphological characters of humerus from the top of the head to the distal point of trochlea.i.e. a-b; b-c; c-d; d-e; e-f; f-g. This enables us to take the advantage of numbers of segments and make a study with broad perspective [figure No. 1].

a) The most proximal point of the head.

b) The most distal point of the circumference of the head.

c) The convergence of two areas of muscle attachment just below the major tubercle.

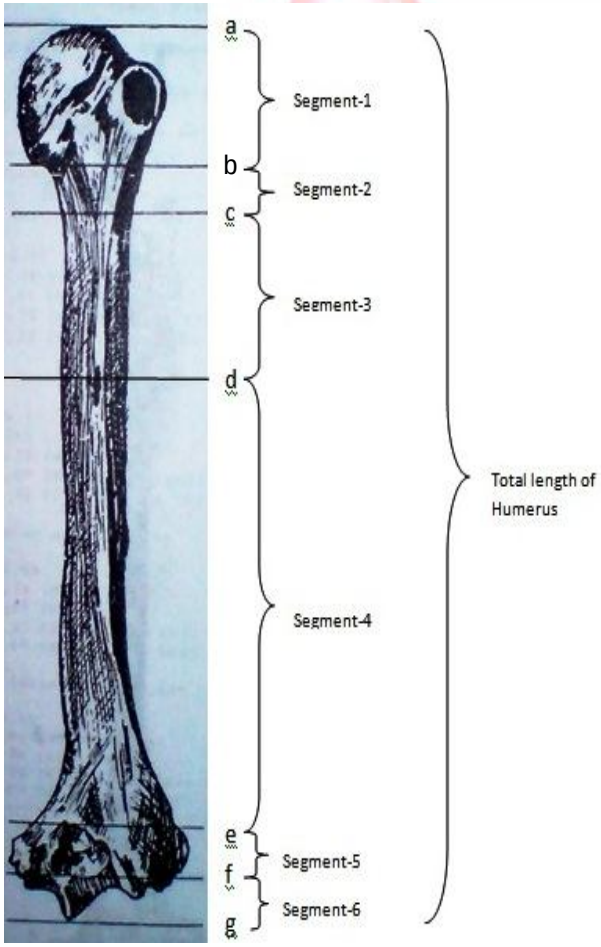
d) The lower end of the deltoid tuberosity.

e) The upper margin of the olecrannon fossa.

f) The lower margin of the olecrannon fossa.

g) The most distal point on the trochlea.

Fig. 1: Linear proportions taken in left Humerus taken in the present study.



In this way, with the help of above landmarks, the whole length of humerus is divided into 6 segments i.e. a-b; b-c; c-d; d-e; e-f; f-g and most of the land mark selected would be easily taken and the length of the segment where measured with the help of specially designed equipment "osteometric scale" to the nearest millimetre.

Thus the maximum total length of all 150 humerii bones measured with the standard procedure and linear measurement of all segment mentioned above were taken simultaneously to the nearest millimetre.

Inclusion Criteria: 150 fully ossified and processed dry humerii bones of both the sides irrespective of age, sex and race.

Exclusion Criteria: Unossified bones, Bones with diseases and injuries.

Statistical Analysis:

1) Descriptive statistics like mean and S.D of segment-1, segment-2, segment-3, segment-4, segment-5, and segment-6 were calculated.

2) Independent 't' test was used to compare the segment-1, segment-2, segment-3, segment-4, segment-5, segment-6 length of left and right humerii bones.

Method of Statistical Analysis:

The following methods of statistical analysis have been used in this study.

The results were averaged (mean $\pm$ standard deviation) for each parameter at different time interval.

One way analyses of variance were used to test the difference between groups. When comparing more than two means, an ANOVA F-test tells whether the means are significantly different from each other, but it does not tell which means differ from which other means. Multiple comparison procedures (MCPs), also called mean separation tests, give more detailed information about the differences among the means. In case of F value, when not significant it indicates that there is no significant difference between the groups.

Comparison of Two variance S_a^2 and S_b^2, estimated for two groups N_a and N_b subjects respectively. Uses F test

$$F = \frac{Sa^2}{Sb^2}$$

With N_a-1 and N_b-1 degrees of freedom.
In all above test P value less than 0.05 was taken to be statistically significant. The data was analyzed using SPSS package.

RESULTS AND TABLES

The total of one hundred and fifty humerii where studied of which seventy five humerii where of the left side and seventy five humerii are of the right side. The statistical analysis was carried out and the results have been tabulated and represented in the form of histograms. Various parameters thus obtained where compared

Table 1: Showing the mean lengths of six segments of the left and right Humerii along with the standard Deviation, 'F' and 'p' values.

Side		N	Mean Length	Std. Deviation	Minimum	Maximum	'F' value	'p' value
Left	Segment 1	75	36.08	3.494	29	44	3320.499	<0.001
	Segment 2	75	54.32	6.025	42	74		
	Segment 3	75	65.31	5.519	52	78		
	Segment 4	75	113.33	9.503	91	139		
	Segment 5	75	21.56	2.088	16	26		
	Segment 6	75	13.31	2.354	7	23		
	Total Length	75	303.91	19.282	268	346		
Right	Segment 1	75	35.55	3.273	28	44	3019.392	<0.001
	Segment 2	75	56.17	6.285	41	71		
	Segment 3	75	61.24	7.025	43	79		
	Segment 4	75	119.05	10.303	97	140		
	Segment 5	75	19.75	2.761	14	26		
	Segment 6	75	14.43	2.176	8	19		
	Total Length	75	306.19	18.023	258	343		

Table 2: Showing the proportion between the Mean length of Humerus and the humeral segments along with the standard Deviation, 'F' and 'p' values of the segments of humerus.

Side		N	Mean % to Total Length	Std. Deviation	Minimum	Maximum	'F' value	'p' value
Left	Segment 1	75	11.872	0.8681	10.1	14.4	6542.695	<0.001
	Segment 2	75	17.861	1.4657	14.5	22.2		
	Segment 3	75	21.504	1.4864	18.2	26.3		
	Segment 4	75	37.289	1.9763	32.7	41.6		
	Segment 5	75	7.101	0.6124	5.4	8.3		
	Segment 6	75	4.373	0.6734	2.4	6.7		
Right	Segment 1	75	11.609	0.817	9.3	13.7	5252.313	<0.001
	Segment 2	75	18.336	1.6436	14.4	22		
	Segment 3	75	20.008	2.0338	14.2	24.6		
	Segment 4	75	38.861	2.1146	32.9	43.6		
	Segment 5	75	6.46	0.8926	4.3	8.5		
	Segment 6	75	4.727	0.7567	2.9	6.3		

Table 3: Showing the comparison between the mean lengths of corresponding left segments and right segments of the humerii along with the standard Deviation,'t' and 'p' values of the segments of humerus.

Segment	Side	N	Mean Length	Std. Deviation	Minimum	Maximum	't' value	'p' value
Segment 1	Left	75	36.08	3.494	29	44	0.931	0.336
	Right	75	35.55	3.273	28	44		
Segment 2	Left	75	54.32	6.025	42	74	3.399	0.067
	Right	75	56.17	6.285	41	71		
Segment 3	Left	75	65.31	5.519	52	78	15.542	<0.001
	Right	75	61.24	7.025	43	79		
Segment 4	Left	75	113.33	9.503	91	139	12.49	0.001
	Right	75	119.05	10.303	97	140		
Segment 5	Left	75	21.56	2.088	16	26	20.582	<0.001
	Right	75	19.75	2.761	14	26		
Segment 6	Left	75	13.31	2.354	7	23	9.157	0.003
	Right	75	14.43	2.176	8	19		
Total Length	Left	75	303.91	19.282	268	346	0.56	0.456
	Right	75	306.19	18.023	258	343		

Table 4: Showing the comparison between the mean proportions of corresponding left segments and right segments of the humerii along with the standard Deviation,'t' and 'p' values of the segments of humerus.

Segment	Side	N	Mean % to Total Length	Std. Deviation	Minimum	Maximum	't' value	'p' value
Segment 1	Left	75	11.872	0.8681	10.1	14.4	3.64	0.058
	Right	75	11.609	0.817	9.3	13.7		
Segment 2	Left	75	17.861	1.4657	14.5	22.2	3.498	0.063
	Right	75	18.336	1.6436	14.4	22		
Segment 3	Left	75	21.504	1.4864	18.2	26.3	26.463	<0.001
	Right	75	20.008	2.0338	14.2	24.6		
Segment 4	Left	75	37.289	1.9763	32.7	41.6	22.119	<0.001
	Right	75	38.861	2.1146	32.9	43.6		
Segment 5	Left	75	7.101	0.6124	5.4	8.3	26.344	<0.001
	Right	75	6.46	0.8926	4.3	8.5		
Segment 6	Left	75	4.373	0.6734	2.4	6.7	9.116	0.003
	Right	75	4.727	0.7567	2.9	6.3		

DISCUSSION

The skeletal remains are found either accidentally or when there is exhumation of the buried cadaver. The identification of the individual has to start from the scratch. The first and foremost feeling comes to the mind is, whether it is human skeleton or not. Second is the site where the bones were found. Then the identification of the individual begins. One of the information required for the identification is the height of the individual. For that the length of long bones is taken into consideration to assess the height of individual. The long bones thus obtained may not be intact. If segments of

long bones are obtained then it is required to assess the length of the bone by that fragment and calculate the height of the individual. Therefore the present study deals with the assessment of the ratio between various segments of humerus, with the length of the humerus bone. Once the length of the bone is obtained, the height of the individual can be calculated using various standard regression formulae [1].

In the present study the humerus was divided into 6 segments using the anatomical landmarks which varied from the previous work where the humerus was divided into 5 segments only. This will help in studying the number of fragments of varying length, as is the case in many samples sent for forensic studies. In the present study, observations were made on 150 humerii, both left and right separately, in equal numbers (75 left humerii and 75 right humerii).

In the present study the mean length values of the total humerus length was identified as 303.91±19.28mm and 306.19±18.02mm on the left and right side respectively. When we compare our findings with other study that is study conducted by S. Deniz Akman in the year 2005 on Caucasian humerii of Turkish population, our values where lower when compared to other authors [4]. The following table shows the comparison of the present work with other authors.

Table 5: Shows the comparison of Mean total length of humerii of the present work with other authors.

Author/Authors	Mean total length of right humerii	Mean total length of left humerii
S.Deniz Akman.et.al	307.1±20.8mm	304.8±18.9mm
Shilpa.K.	309.6±20.6mm	299.6±22.5mm
Present study	306.19±18.02mm	303.91±19.28mm

Our values almost coincided with the values of S.Daniz Akman et al, but, when the present study was compared with the study conducted by Shilpa.k.et.al on south Indian population in Mangalore region, it was found that on right side the total length of humerii was lesser but on the left side the total length of humerii was more [5].

In the present study, the bone was divided into 6- segments using imaginary plane at the level of the anatomical landmarks. They are as follows Segment-1 is between the most proximal point of the head and most distal point of the circumference of the head, Segment-2 is between the most distal point of the circumference of the head and the convergence of two areas of muscle attachment just below the major tubercle, Segment-3 is between the convergence of two areas of muscle attachment just below the major tubercle and the lower end of the deltoid tuberosity, Segment-4 is between the lower end of the deltoid tuberosity and the upper margin of the olecrannon fossa, Segment-5 is between the upper margin of the olecrannon fossa and the lower margin of the olecrannon fossa and Segment-6 is between the lower margin of the olecrannon fossa and the most distal point on the trochlea.

In a study conducted by S.Deniz Akman with Caucasian humerii samples, the distance from the proximal point on the articular surface of the caput humerii to the most distal point of circumference of the head (or collumanatomicum) was 40.9±3.9mm and 41.0±5.1mm on the right and left respectively [4]. In another study conducted by Shipa.K.et.al the distance from the proximal point of the head of the humerus and surgical neck of humerus was 37.1±4.8mm and 37.7±4.4mm on right and left side respectively. In the present study this distance corresponded to the segment-1 which measured 35.55±3.273 and 36.08±3.494 on right and left side respectively [5]. Therefore there are some differences in the mean values of measurement between our study and the rest because of different landmarks. Here in the present study the proportion of segment-1 to total length of humerus was calculated it was 11.87±0.86% and 11.06±0.81% on left and right side respectively which varied from the previous study done by Muller where they had combined both right and left 100 humerii and it was 11.44% [6]. This can be used for estimation of stature of individual by using Steele's regression formulae.

In the present study the segment-2 was the distance between the most distal points of the circumference of the head to the point of convergence of two areas of muscle attachment just below the tubercle which was compared with total length of humerus. It gave proportion

of segment-2 that was 17.86%±1.46% and 18.34±1.64% on left and right side respectively which when compared to previous study conducted by Muller was more in this study. In Muller study it was 7.60%.This is because of the difference in race, growth pattern as well as nutrition [6].

In the present study we had taken extra segments 3 and 4 between the point of convergence of two areas of muscle attachment and at the upper margin of the olecrannon fossa by using deltoid tuberosity as landmark dividing these two segments. This new segments have not been taken in any other study. The segment-4 was the one which is more reliable and is larger segment when compared to rest. Its mean length was 113.33±9.5mm and 119.05±10.3mm on left and right respectively. Its proportion to total length of humerus was also more that is 37.29±1.97% and 38.86±2.11% on left and right humerii respectively. This has further scope to derive a regression equation using this segment-4 in living individual.

Olecrannon fractures occur in 10% of all upper extremity lesions. The lesion might be the result of indirect or direct trauma, especially forced hyper-extension of the elbow joint. In an study conducted by S.Deniz Akman.et.al in Turkish population the distance between the proximal and distal margin of olecrannon fossa was identified as 24.2±2.07mm and 23.9±2.63mm on right and left humerii.[4]In another study conducted by Shilpa.k.et.al in Mangalore the findings was 20.1±3.4 mm and 19±2.9mm on right and left humerii respectively [5]. This was corresponding to segment 5 of our study which measured around 19.75±2.76mm and 21.56±2.08mm on right and left side respectively. We also measured the distance between distal margin of olecrannon fossa and trochlea. In our study, segment-6 was 14.43±2.17mm and 13.31±2.35mm on right and left humerii respectively but this was slightly more in previous studies. In the observations made by S.Deniz Akman.et.al. the segment-6 measured 20±2.2mm and 19.7±2.5mm on right and left side respectively.[4] Whereas in the study conducted by Shilpa.K.et.al, the measurements of segment-6 were 17.3±3.3 on right side and 16.8±2.2mm on left side [5]. The knowledge of both the measurements can be used by orthopedic surgeons in the reconstruction of complex distal humerus fractures in order to avoid injury to the nerve and blood vessels. These measurements are also useful in preparation of various implants for South Indian population [4].

The proportion of segments 5 and segment 6 to the total length of humerus was also calculated in which segment-5 measured 7.10±0.61% and 6.46±0.89% on left and right humerii respectively. These values almost coincided with that of Muller study where it was 6.26% of both side together. In the present study segment -6 was 4.37±0.67% and 4.72±0.75% on left and right humerii respectively. These values were higher in Muller study [5.47%] when compared to our study [6].

Some differences are also found in the mean value of the height of olecrannon fossa. Total length of humerii when compared to other studies was due to the result of factors such as age, sex, race and also environmental factors affecting bone growth, such as nutrition, physical development and genetic factors. Moreover these diversities could depend on the differences in the reference points which are taken as criteria in the measurements.

In the present study comparison was made between the segments of both right and left sides using student't' test which shows that the mean length and proportions of segments-3,4 and 5 are more reliable in estimating the stature of the individual.

CONCLUSION

In the present work it has been endeavored to ascertain the total length of the humerus from various segments. Varying from studies of some original workers the humerus has been divided into 6 segments by imaginary plane taking some obvious points as landmarks for measurements. This will help in studying the number of fragments of varying length, as is the case in many samples sent for Forensic studies. In the present study extra segments 3 and 4 were taken among which segment-4 is one of the largest segments of all the segments; hence it can be statistically better segment for the results. There is further scope to calculate regression formulae using

segment-4 in future. The knowledge of the proportion of other segments can be used for estimating the stature of individual by using standard regression formulae.

The knowledge of the morphometric values of humerus segments is important in forensic, anatomic and archeological cases in order to identify unknown bodies and stature. It is also helpful for the clinician in the treatment of proximal and distal humeral fractures. Therefore the present study supplies the mean values of the different morphometric measurements from the humerus. As a result, these measurements may help to indicate the characteristic morphological features of humeral segments in south Indian population and also help the orthopedic surgeon to place the various implants in the reconstruction of humeral fractures.

In the present study the sample size is 150 with 'p' value of <0.001 especially in segments 3, 4 and 5. So, the results are reliable but further study needs to be designed to get more accurate estimates in population, considering the age and sex factors as well as the race, region and nutritional status.

Conflicts of Interests: None

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