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Original Research Article

Right humerus; An equation to estimate the length from its fragments

P S Bhusaraddi[1], Vijay Kumar Shinde[1], Pratik Khona[1,*]

[1] *Dept. of Anatomy, Gadag Institute of Medical Sciences, Gadag, Karnataka, India*

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ABSTRACT

Introduction: Many professionals including anthropologists, medical scientists and anatomists had been using the anthropometric technique to estimate the body size since decades or even centuries. The study which we have conducted in North Karnataka of South Indian was to estimate the length of the right humerus from the dimension of proximal and distal segments of humerus using a regression equation. This is absolutely essential for archeologists, anthropologists and forensic investigators, even when a fragment of bone is available. The current study was therefore focused on the measurement of proximal and distal segments of humerus from which the length of the humerus was estimated.

Materials and Methods: The maximum lengths of the right humeri (MHL) were measured and the mean values were calculated. The different measurements of proximal and the distal segments of 53 right humeri were noted and used in our study. Maximum length of humerus, vertical and transverse diameter of proximal segment, transverse diameter and biepicondylar width of distal segment were measured using anthropometric techniques. A regression equation was formulated to calculated the length of the entire humerus provided we can access the measurements of different fragments available.

Results: With the measurements obtained analysis was done using descriptive statistics. Regression equation for right humeri was derived to estimate the length of the right humerus. On applying the regression analysis, among 53 right humeri, it was proved that, the vertical diameter of superior articular surface had significant role in estimating the maximum humeral length with maximum correlation co-efficient of 0.94($p<0.05$).

Conclusion: Thus we can conclude that the length of the right humerus can be estimated from the measures of proximal and distal segments of right humerus.

1. Introduction

Anthropologists, medical scientists and anatomists are using the anthropometric technique to estimate the body size since hundreds of years.[1] The estimation of stature from the remnants of the human skeleton is an important step in assessing general body size trends in the given populations and also plays an important role in the identification of missing persons in investigations of medico legal cases.[2] When the pelvis and cranium become unavailable in certain instances, morphometric analysis is frequently carried out on the remains of te long bones in anthropology and forensic science investigations. The femur and tibia of the lower limb together remain the best for the assessment of living stature of the individual.[3,4] The next bone in hierarchy for the assessment is the longest upper limb bone which is the humerus. The humerus is a long bone in the arm, that connects the shoulder to the elbow. Anatomically speaking, it connects the scapula and the forearm. The humerus has three main parts namely proximal end, the shaft and the distal end.[5–7]

With this pretext , we attempted to do a study to estimate the humeral length from the dimensions of its proximal and distal segments.

* *Corresponding author*.
E-mail address: drpratikkhona@gmail.com (P. Khona).

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2. Aims and Objectives

1. To study the correlation between the proximal and distal segment measurements with maximum humeral length (MHL).
2. To derive regression equations to calculate maximum humeral length from proximal and distal segment parameters.

3. Materials and Methods

The data were collected from the Anatomy Department, of Gadag Institute of Medical Sciences, Gadag, which were randomly selected fully ossified dry right humeri irrespective of sexes. We found 53 right side humerus with unknown sex of all age groups. This study excluded those bones with skeletal deformities due to diseases or injuries also those with broken ends. With the help of osteometric board and vernier calipers, the fol lowing parameters are measured:-

1. **Maximum length of the humeru**s **(MHL)**- top of the humeral head to the distal point of trochlea.
2. **Vertical diameter of the superior articular surface (PS-VD of SAS)** - maximum distance between two points on the humerus in vertical plane passing through greater tuberosity tip.
3. **Transverse diameter of the superior articular surface (PS-TD of SAS)**- Maximum width between two points on the head of the humerus in transverse plane of head anteroposteriorly.
4. **Transverse diameter of the inferior articular surface (DS-TD of IAS):** maximum combined width of the trochlea and the capitum on the anterior surface.
5. **Biepicondylar width (DS-BECW)**: Maximum distance between the medial and the latera ;l epicondyles.

Three readings for all the above measurements were taken to the nearest millimeter. If the readings differed, then the average of the three readings was considered as the final reading.

4. Results

4.1. *Descriptive analysis*

The mean of the maximum length of the right humeri (MHL) and the different measurements as mentioned above in methodology of proximal and the distal segments of 53 right humeri were noted. These minimum and maximum value s along with mean and Standard deviation values are in Table 1.

From Table 1 it is clear that the PS-VD of SAS ranged from 3.4-4.7cm with the mean of 4.08+ 0.25cm. The PS-TD of SAS ranged from 3.1-4.2 cms with the mean of 3.71 + 0.25 cms. The range of DS-TD of IAS was from 3.3-4.5 cm with the mean of 3.97 + 0.25 cms. The minimum

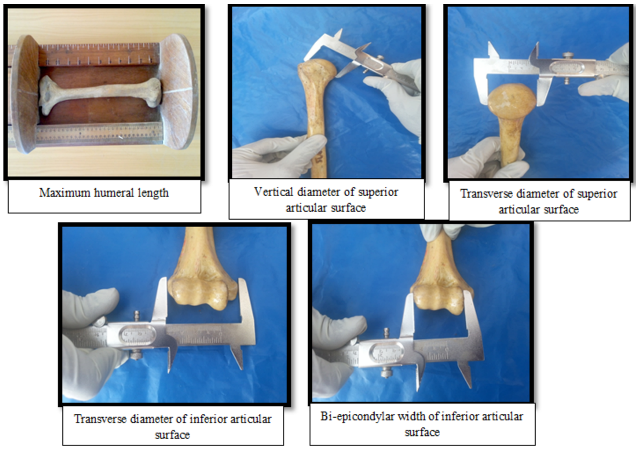
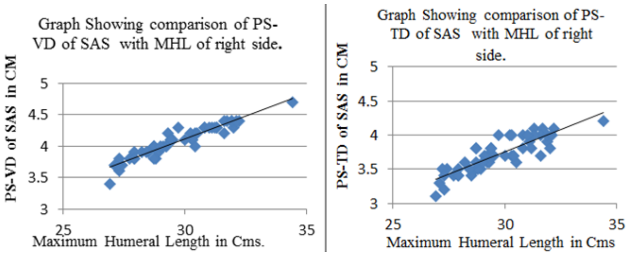


Fig. 1: Figures showing the procedure of measuring the dimensions.

and maximum bi- epicondylar width of distal segment were 5 cms and 6.3 cms respectively. The mean was 5.65 + 0.29 cm. The maximum humeral length ranged from 26.9-34.4cm width the mean of 29.69 + 1.63 cm.

On analysis of the correlation co-efficient of right humeral fragments with the maximum humeral length, we observed that, all the measured fragments are strongly and positively correlating with maximum humeral length, since the correlation co-efficient is close to +1, Among the measurements taken in our study, the vertical diameter of superior articular surface of the proximal segment is very close to +1 and hence is more strongly correlating than any other parameters considered same is depicted in the belowGraph 1.



Graph 1:

4.2. *Simple linear regression*

[Table-2 shows the regression Co-Efficient (COE) and the significance (P value) for the dimensions of the proximal and the distal segments of right humeri.

From the above table, it is clear that the p value is less than 0.05 and hence the regression coefficient derived are statistically significant for all the parameters on both sides.

Table 1: Showing the Max, Min, Mean+SD of various parameters in 53 right humeri

Parameters	N	Min	Max	Mean	Std. deviation
PS - VD of SAS	53	3.4	4.7	4.08	0.25
PS - TD of SAS	53	3.1	4.2	3.71	0.25
DS - TD of IAS	53	3.3	4.5	3.97	0.25
DS – BECW	53	5	6.3	5.65	0.29
MHL	53	26.9	34.4	29.69	1.63

Table 2: Showing correlation co-efficient between the parameters and MHL in 53 right humeri

Parameters		N	Correlation co-efficient	Remarks
PS - VD of SAS	**P1**	53	0.94	Strong positive correlation
PS - TD of SAS	**P2**	53	0.86	Strong positive correlation
DS - TD of IAS	**D1**	53	0.86	Strong positive correlation
DS – BECW	**D2**	53	0.79	Strong positive correlation

Table 3: The regression co-efficient and their P-value for various parameters in present study.

Parameters	N	Regression co-efficient	P – Value
PS - VD of SAS	53	6.14	< 0.05
PS - TD of SAS	53	5.63	< 0.05
DS - TD of IAS	53	5.69	< 0.05
DS – BECW	53	4.49	< 0.05

4.3. Simple linear regression equations

All around the world, the regre ssion formulae have been approved as an important way of determination of stature from various anthropometric dimensions. In the present study, regression formula was related to the dimensions of the proximal and the distal segments of the humerus. It was derived as shown in Table 4 :

As the bones were of unidentified sex, the inference based on sexual dimorphism could not be studied.

5. Discussion

The length of long bone plays an important role in the estimation of an individuals's stature. In archaeological point of view, stature is estimated from the remnants of human skeletal system. This acts as a key in assessing – health, general body size and sexual dimorphism. The humerus is the largest and the longest bone in the upper limb and estimation of the length of the humerus from the segmental dimensions plays an important step. Steele and Mcken had defined a method based on the proportionality between the determined distances among the fixed points of the bones on the proportionality between the determined distances among the fixed points of the bones and their total length.[8] According to the anthropometric studies, the mean value of the humerus length gives a vital evidence to indicate the characteristic features of a population.[9–11]

Regression analysis is a more appropriate method for defining the relationship between the length of the long bones and living height of individuals.[12] Estimation of the length of long bone from its fragments is done by using the accurate landmarks as mandatory criterion. In usual practice, the transverse diameters of diaphysis are not the most appropriate for estimating the length because of their inability in defining the precise landmarks. Therefore, the only left over location points is measured on the fragments of proximal or distal diaphysis. Hence, in our study doen in North Karnataka, the dimensions of the proximal and the distal segments of the humeri alone were selected. In our study, we used regression equations to measure the length of the humerus, of the North Karnataka population, which have not yet reported. Considering all the proximal measurements, in comparison the vertical diameter of the superior articular surface alone showed significanvce in estimating the maximum length of the humerus on the right side.

On comparison of correlation co-efficient of present study with the previous workers in right humeri, it was viewed that all measurements had positive correlation (correlation co-efficient > 0.5) but in the present study it was more which ranged from 0.79 to 0.94. The difference in correlation co-efficient may be due to regional and racial variation. The difference was statistically significant ($P < 0.05$) for all parameters when we compared the values with study by K Udhaya et al. But the difference showed statistical significance only for the vertical diameter of superior articular surface of proximal segment (PS-VD of SAS) when we compared the values with other study conducted by Salles AD et al.[13,14]

Regression equation was derived from the available measurements of the fragment of right humeri. This showed that MHL=4.67+6.14A, 8.79+5.63B, 7.09+5.69C, 4.3+4.49D.

Table 4: Showing the regression equations derived for the various parameters in the present study.

Parameters	Right humeri N	Regression equation
PS - VD of SAS	53	MHL=4.67+6.14A
PS - TD of SAS	53	MHL=8.79+5.63B
DS - TD of IAS	53	MHL=7.09+5.69C
DS – BECW	53	MHL=4.3+4.49D

where A- PS - VD of SAS, B- PS - TD of SAS, C- DS - TD of IAS , D- DS – BECW. When compared with other study conducted by K Udhaya and Salles AD, the regression equation was 11.81+4.57A, 13.20+4.55B, 12.99+4.45C, 16.89+2.44D and 14.1+3.94A+1.46, 12.9+4.61B+1.44, 14.0+4.28C+1.39, 14.8+2.84D+1.64 respectively.

The difference in equations of present study with previous workers may be because of difference in correlation co-efficient. This indicates that we have to consider different equations for calculating the maximum humeral length (MHL) in different regions and races.

6. Conclusion

The parameters of proximal and distal segment of 53 humerus studied showed strong positive correlation with the maximum humeral length (MHL). The strongest among the positive correlations was observed between vertical diameter of superior articular surface of proximal segment (PS-VD of SAS) with maximum humeral length (MHL). On comparison of present study with the previous workers, it showed that there is regional and racial variations in the regression equations derived for calculating maximum humeral length (MHL). The regression equation thus derived can be useful for the measurement of maximum humeral length (MHL) from the fragments of humerus which can be a break through in many medico legal cses and during body identifications after a disaster where only fragments of the body can be retrieved.

7. Source of Funding

None.

8. Conflict of Interest

None.

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Author biography

P S Bhusaraddi Professor and Head

Vijay Kumar Shinde Associate Professor

Pratik Khona Assistant Professor

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