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Reconstruction of Humeral Length from Measurements of its Segments in South Indian Population

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Abstract: ***Background:*** ***Morphometric examination of skeletal remains of long bones is important in medico legal investigations in absence of pelvis or cranium to estimate the stature of the individual. The aim of present study was to determine the maximum length of humerus by measuring its segments, which may be useful for estimation of humeral length from the fragments and there by estimation of stature of the individual in various medico legal and archeological studies.*** ***Materials and Methods:*** ***250 dry humerus bones (250 left and 250 right) of unknown sex were collected and studied. The parameters measured were maximum humeral length (MHL); length of five different humeral segments viz. most proximal point on humeral head and greater tuberosity (H1), most proximal point on humeral head and lower margin of anatomical neck (H2), proximal and distal point on the edge of olecranon fossa (H3), distal point on the edge of olecranon fossa and distal point on the trochlea of humerus (H4) and proximal point on the edge of olecranon fossa and distal point on the trochlea of humerus; by means of osteometric board and digital vernier caliper. Simple linear regressions ($p < 0.01$) were made to correlate the length of segments with maximum humeral length.*** ***Results:*** ***In both left and right humerii, best estimates were observed with all the segments. Regression formulae were obtained to define the maximum humeral length from each segment from both sides.*** ***Conclusion:*** ***This present study demonstrated that maximum length of humerus can be determined by measurement of its segments. It helps in various medico legal and archeological studies, it also helps orthopedic surgeons in reconstruction of fragments in treatment of proximal and distal humerus fractures.***

Keywords: Humerus segments, anthropometry, regression analysis.

1. Introduction

Estimation of stature from bones of unidentified bodies or skeletal remains is important in medico legal investigations. Reconstruction of life from human skeletal remains and stature estimation remains a challenge for many anthropologists and forensic experts [1]. In absence of pelvis and cranium, morphometric analysis carried on the remains of long bones of individual, remains the best way for the assessment of living stature of the individual [2]. Long bones of upper limb viz. humerus, radius and ulna can be used for estimation of stature of an individual, either humerus alone or collectively with other bones of upper limb [3], [4]. When whole long bones are not available, total length of humerus can be determined by measurements of different segments [5]. Estimation of bone length from incomplete long bones was first described by Muller; she defined five segments for the humerus based on margins of articular surfaces and key points of muscle attachment [4].

In this present study on South Indian population, we determined regression equations for calculating maximum humeral length from its segments, which may be useful for estimation of humeral length from the fragments and thereby estimation of stature of an individual in various medico legal and archeological studies.

2. Materials and Methods

250 dry humerus bones of both sides (125 left and 125 right) free from pathological changes and of unknown sex were obtained from Department of Anatomy, J. J M. Medical College, Davangere. Maximum Humeral Length (MHL) was determined using osteometric board and the lengths of humeral segments were measured using a digital vernier caliper. All measurements were obtained in millimeters (mm) and Mean and Standard deviation were calculated.

Six measurements were taken along the longitudinal axis of humerus as shown in Figure 1.
MHL (A-F) → Maximum Humeral Length i.e., the distance between the most proximal point on the humeral head and the most distal point on the trochlea of humerus (Figure 2).
H1 (A-B) → The distance between the most proximal point on the humeral head and the most proximal point on the greater tuberosity.
H2 (A-C) → The distance between the most proximal point on the humeral head and lower margin of the anatomical neck of humerus.
H3 (D-E) → The distance between the most proximal point and the most distal point on the edge of olecranon fossa.
H4 (E-F) → The distance between the most distal point on the edge of olecranon fossa and the most distal point on the trochlea of humerus.
H5 (D-F) → The distance between the most proximal point on the edge of olecranon fossa and the most distal point on the trochlea of humerus.

The association between the humeral segments and maximum humeral length was calculated by means of Pearson's correlation coefficient (r) and later linear regression was applied considering left and right humerii separately. A probability (p) of less than 0.01 was considered

statistically significant.

Figure 1: Measurements of segments of humerus

Figure 2: Osteometric board used for measurement of Maximum humeral Length (MHL)

3. Results

a. Descriptive statistics

Table 1 shows mean and standard deviation values of maximum humeral length (MHL) and different segments of humerus (H1, H2, H3, H4 and H5) in left and right humerii.

Table 1: Morphometric measurements of humerus segments (Mean ± SD in mm). MHL = Maximum Humeral Length; H1, H2, H3, H4 & H5 – different humeral segments.

Parameter	Left (n=125)	Right (n=125)
MHL	293.71±20.39	303.78±18.69
H1	5.12±1.45	5.76±1.43
H2	32.15±2.94	32.88±3.43
H3	18.26±1.59	17.62±1.67
H4	14.44±1.43	14.02±1.32
H5	32.70±2.51	31.64±2.30

b. Simple linear regression

Table 2 and Figure 3 shows the simple linear regression involving different segments of humerus (H1, H2, H3, H4 and H5) in left and right humerii.

Table 2: Simple linear regression coefficient (r), in correlation between the Maximum Humeral Length (MHL) and Segments of humerus (H1, H2, H3, H4 & H5) on left and right sides. Significant level $p < 0.01$

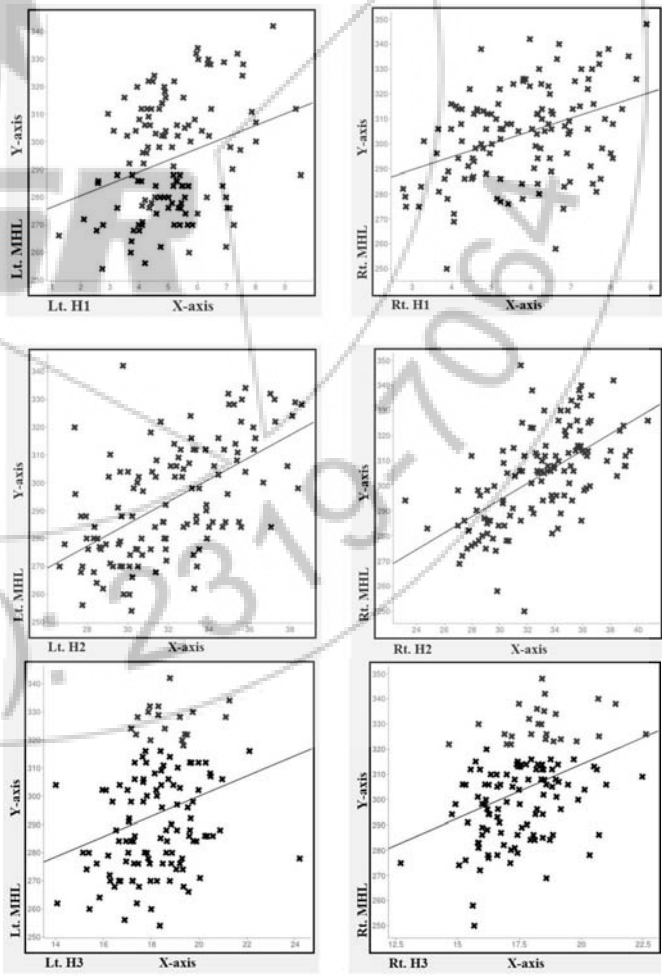
	H1	H2	H3	H4	H5
Left (n=125)	r = 0.301	r = 0.574	r = 0.279	r = 0.480	r = 0.451
	p = 0.0006	p < 0.0001	p = 0.0016	p < 0.0001	p < 0.0001
Right (n=125)	r = 0.396	r = 0.603	r = 0.382	r = 0.486	r = 0.557
	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001

c. Simple regression formulae

Table 3 shows regression formulae for the estimation of maximum humeral length from its different segments.

Table 3: Regression Formulae for calculating Maximum Humeral Length (MHL) relative to different segments of humerus (H1, H2, H3, H4 & H5)

Left Humerus (n=125)	*Right Humerus (n=125)*
MHL = 272.08 + [4.22(H1)]	MHL = 273.94 + [5.18(H1)]
MHL = 165.18 + [3.98(H2)]	MHL = 195.66 + [3.29(H2)]
MHL = 228.27 + [3.58(H3)]	MHL = 228.49 + [4.27(H3)]
MHL = 194.74 + [6.85(H4)]	MHL = 207.17 + [6.89(H4)]
MHL = 173.97 + [3.66(H5)]	MHL = 160.43 + [4.53(H5)]



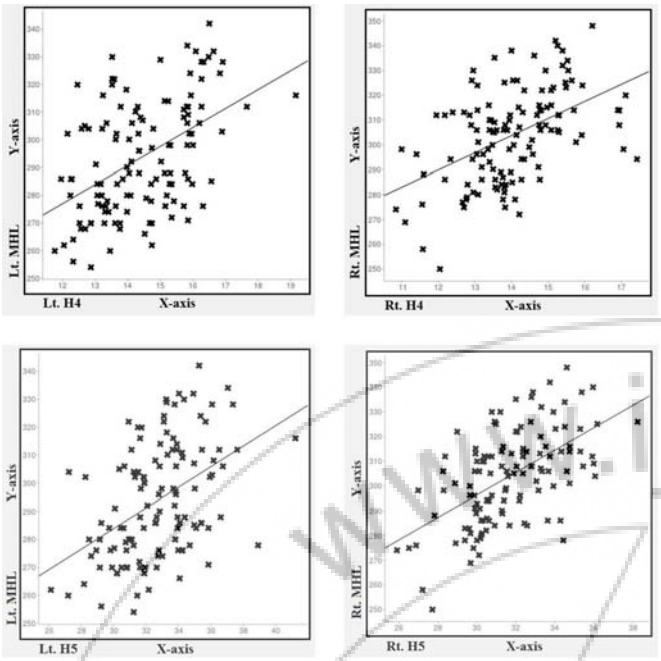


Figure 3: Scatter diagram showing linear regression of left and right humerus with different humeral segments. MHL = Maximum Humeral Length; H1, H2, H3, H4 & H5 – different humeral segments.

4. Discussion

It has been shown that in forensic and archeological studies, the mean value of total humerus length gives an important evidence to indicate the characteristic features of a population as a whole [4], [5]. In our study, the mean values of the maximum humeral length (MHL) of adult humerus in South Indian population were found to be 293.71±20.39 mm on left side and 303.78±18.69 mm on right side. In previous studies MHL were found to be 304.8±18.9 mm on left side and 307.1±20.8 mm on right side in Turkish population [6]; 299.6±22.5 mm on left side and 309.6±20.6 mm on right side in Indian population [7].

Measurements of proximal humerus segments becomes important in cases of proximal humeral fractures, which extends along the epiphyseal lines of proximal humerus and its segments, causing their displacement to various degrees [8].

In our study, the mean values of H1 segment in South Indian population were found to be 5.12±1.45 mm on left side and 5.76±1.43 mm on right side. In previous studies mean length of H1 segment were found to be about 6 - 8 mm which is slightly higher than the present study [8], [9] and [6]; and our study is in correlation with study of Somesh MS et.al., where mean length of H1 segment is 5.8±1.5 mm on left side and 5.9±1.1 mm on right side [7].

In our study, the mean values of H2 segment in South Indian population were found to be 32.15±2.94 mm on left side and 32.88±3.43 mm on right side. In previous studies mean length of H2 segment was 40.9±3.9 mm on left side and 41.0±5.1 mm on right side in Turkish population [6], and 37.74±4.5 mm on left side and 37.14±4.82 mm on right side in Indian population [7], which is slightly higher than the present study; and our study is in correlation with study of Wright LE and Vasquez MA, where mean length of H2 segment is 32.8±2.7 mm [5].

The distal segment of humerus articulates with the bones of the forearm and fractures involving it may pose several reconstructive problems and complications. Therefore these fractures gain special attention for orthopedic surgeons [10]. Fractures of the distal fragments of the humerus involving olecranon can also occur as a result of hyperextension trauma to the elbow joint [11].

In our study, the mean values of H3 segment in South Indian population were found to be 18.26±1.59 mm on left side and 17.62±1.67 mm on right side. In previous studies mean length of H3 segment was 20.3±1.3 mm on left side and 20.2±1.9 mm on right side in German population [12], and 23.9±2.6 mm on left side and 24.2±2.0 mm on right side in Turkish population [6], which is slightly higher than the present study; and our study is in correlation with study of Somesh MS et.al., where mean length of H1 segment is 19.0±2.9 mm on left side and 20.1±3.4 mm on right side [7].

In our study, the mean values of H4 segment in South Indian population were found to be 14.44±1.43 mm on left side and 14.02±1.32 mm on right side. In previous studies mean length of H4 segment was 19.7±2.5 mm on left side and 20.0±2.2 mm on right side in Turkish population [6], and 16.82±2.20 mm on left side and 17.37±3.36 mm on right side in Indian population [7], which is slightly higher than the present study; and our study is in correlation with study of Wright LE and Vasquez MA, where mean length of H4 segment is 14.2±1.8 mm [5].

In our study, the mean values of H5 segment in South Indian population were found to be 32.70±2.51 mm on left side and 31.64±2.30 mm on right side. In previous studies mean length of H5 segment was 39.7±3.4 mm on left side and 40.6±3.3 mm on right side in Turkish population [6], and 35.72±4.30 mm on left side and 37.26±4.71 mm on right side in Indian population [7], which is slightly higher than the present study.

In the present study, we intended to estimate the maximum humeral length from the measurements of the segments of humerus that will help in forensic or archaeological investigations. Results obtained on the right side were different from those observed on the left side, since they did not belong to the same individuals. For this reason, direct comparisons between mean values of right and left sides were not accomplished. Positive results in the estimate were observed with all the segments. In a previous study by Salles et.al., [13] significant positive correlation with the humeral length was found in some fragments of both sides considering the proximal and distal ends and they could estimate the humeral length from these fragments. However in our study only the longitudinal measurements and the associated proximal and distal segments of the humerus are considered.

Analysing skeletal remains from forensic exhumations in Guatemala by Wright LE and Vasquez MA (2003) found

significant correlations between fragments and máximum length of humerus. As there is no information regarding the height of the individuals in the obtained anatomical collections of the present study, it was not posible to establish correlations between measurements of segments of humerus and height of the person.

5. Conclusion

Morphometric analysis of humerus segments suggests some differences within different populations. By the regression equations obtained it is possible to estimate maximum length of humerus with relative accuracy in South Indian population. Knowledge of morphometric values of humerus segments is important in forensic and archeological investigations in order to identify stature from skeletal remains. It is also helpful for the orthopedic surgeon in treatment of proximal and distal humerus fracture and in reconstruction of fragments during surgery.

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