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Original communication

Estimation of length of humerus from its fragmentary portions

Sachidananda Mohanty MD, LL.B, Professor & Head *, Geeta Sahu MD, Assistant Professor, Sudeepa Das MD, Assistant Professor

Department of Forensic Medicine and Toxicology, Post Graduate Institute of Forensic Medicine and Toxicology, M.K.C.G. Medical College, Berhampur, Odisha 760004, India

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ABSTRACT

The objective of the present study was to estimate the length of humeri from measurements of their fragments in south Indian population. This is important in forensic investigations and in archaeological studies particularly when the fragmentary portions are examined. For this purpose 200 adult humeri, 100 each of either sex in dried and fully ossified condition were taken for study. Each of the humerus bone was fragmented into five fragments by drawing imaginary lines with reference to their specific anatomical landmarks. The fragments are H2 (a–b), H3 (b–c), H4 (c–d), H5 (d–e) and H6 (e–f). After applying necessary statistical analysis a definite mathematical correlation in forms of proportion and regression equation was established between each fragment to the total length of humerus (H1).

All the formulae thus derived for each of the fragments of bones are not only significant but also possess a high degree of prediction. Among all the fragments, the longest fragmentary portion i.e.H4 (c–d) predicts the highest percentage of accuracy ($H1 = 166 + 0.712$ H4 M, $H1 = 90.2 + 1.06$ H4F) followed by H2 (a–b) in calculating the total length of humerus ($H1 = 307 + 0.330$ H2M, $H1 = 243 + 1.73$ H2F). In conclusion, our study demonstrated that length of the humerus can be estimated from measures of different fragments.

1. Introduction

Identification of an unknown dead body is one of the important works of a forensic expert. Many factors are essential to establish the identity of an unknown dead body, stature is one of them. Efforts are on since the inception of Forensic anthropology to predict the stature from the length of long bones.

Since then anthropometric techniques are being used to estimate stature from bone length and unknown body parts by different anthropologists, medical scientists and anatomists.[1–3] Stewart[4] and Krogman and Iscan[5] have considered stature as a parameter of human biodemography. Working on this Steele[6] established a correlation between limb bone length and stature. Subsequently in 19th century Pearson[3] and in 20th century Trotter[7–9] pioneered the estimation of stature from lengths of long limb bones. Later on many authoritative works was carried out on different population at different areas by different workers on stature and were successful in estimating stature from length of long limb bones.

It is difficult to calculate stature from limb bones but it still becomes more difficult to estimate the stature form fragments of bones, available following mass disasters or even blast injuries. It is also seen very often fragments of bones are neglected by most of the forensic anthropologists assuming that no relevant information can be obtained from such fragments.

An answer to this problem was suggested long back in 1935 by Muller,[10] who provided scientific basis for the estimation of length of bone through the fragments.

Subsequently Steele and Mckern[11] realised the value of Muller's technique in estimating total length of bone from broken/fragmentary bones and employed the least square method of factor analysis to formulate sex specific regression equation for each segment. A year later, Steele[6] in 1970 used these segment lengths for direct estimation of stature thereby reducing the standard deviation and established sex and race specific standards for American whites and blacks.

Steele's method was revised later on by Simmons et al.[12] in 1990 to calculate the stature from fragmentary femuri through linear and transverse measurements since then researchers world over including some Indian forensic pathologists like Chandra et al.[13]

* Corresponding author. Tel.: + 91 680 2292533; +91 6802292261; + 91 94372 60015 (mobile); fax: +91 6802292809.
E-mail address: sachimohanty@rediffmail.com (S. Mohanty).

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and Mysorekar et al.[14–16] used these methods on different upper and lower limb bones and formulated regression equation for estimation of different bone lengths. Akman[17] while studying on the Turkish population also divided the humerus into five fragments and estimated the length of humerus. Chandra and Nath[18,19] on the other hand used a single transverse dimension of humerus and femur to compute a multification factor (MF) for the reconstruction of bone length. Rao et al.[20] in 1989 used linear segment lengths of upper extremity bones to reconstruct their respective lengths following Muller's method. Badkur and Nath[21] used a set of linear, transverse, saggital and circumferential dimensions of humerus and Ulna to formulate linear as well as multilinear regression equation for estimation of bone length. Gupta and Nath[22] and Udhaya et al.[23] in India used linear segment lengths of all major limb bones including humerus to reconstruct respective bone length from their fragmentary measurements.

Considering the causal relationship between the fragment and the total length of bone and inadequacy of this type of work involving this locality, an attempt in this present study has been made to formulate the sex specific proportion and linear regression formulae for the estimation of humeral length using a total of five fragmentary measurements.

2. Material and methods

The study was undertaken retrospectively over a period of 2 years in the Department of Forensic Medicine and Toxicology, M.K.C.G. Medical College, Berhampur, India from January 2008 to December 2009, with help and support from the Department of Anatomy.

Two hundred pieces of adult humeri, 100 each of either sex in dried and fully ossified state, taken from the collection of bones of the Department of Forensic Medicine and the Department of Anatomy for study. The Pathological bones were not included in the study. The sexing of bones to males and females were done by considering the general sexual differences and the biometric measurements. In the present study because of the unavailability of information about the individuals, their exact age, socioeconomic status and height of the person it was not possible to establish correlations between the measurements of the fragments of the humerus and the height of each person, rather correlation was established between length of humerus and its fragments. It is assumed that the bones were of ethnic Indians of adult age mostly belonging to the State of Odisha, present at the southern part of India.

All the measurements were made on the same osteometric board. Each humerus bone was positioned in such a manner that the highest point of the head was in contact with the fixed arm and the vertical wall of the board, the longitudinal axis of the bone being parallel to the longitudinal axis of the board. The movable arm was then brought into firm contact with the deepest point of the trochlea and the length of the bone read of the scale to nearest millimeter. A set-square with one edge parallel to the scale was then moved down, so that it touched the different anatomical landmarks and accordingly the fragments were measured. Five fragmentary portions were made of each humerus bone by allocating different anatomical landmarks, the details of which are given below in Fig. 1.

a – a is the most proximal point on the head;
b – b is the distal point of circumference of the head;
c – c is at the convergence of two areas of muscle attachment just below the major tubercle;
d – d is at the upper margin of the olecranon fossa;
e – e is at the lower margin of the olecranon fossa; and
f – f is at the most distal point on the trochlea.

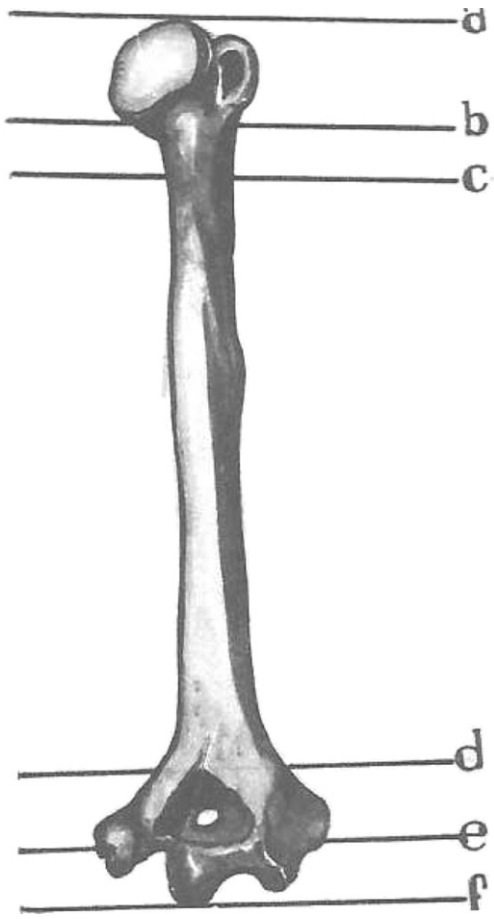

Fig. 1. Humerus in relation to different fragments.

The fragments are:

a–f = total length termed as H1
a–b = H2
b–c = H3
c–d = H4
d–e = H5
e–f = H6

3. Statistical analysis

The various measurements were analyzed by statistical package, of a computer. The regression equations were derived to correlate the different fragments to the total length of humerus. Amongst the several parameters the significant parameters like *t*-ratio, corr-coef and *p*-value were given due importance while calculating the length of humeri.

All the statistical calculations and comparisons have been carried out at 5% level of significance i.e. $P = 0.05$.

4. Results

Two hundred samples of humerus, 100 each of male and female bones were studied. Each humerus was divided into five fragments by taking into consideration of certain anatomical landmarks. In male the length of humerus varies from 312 mm to 334 mm with a mean of 317.98 ± 3.9 mm, while in females the length varies from 276 mm to 311 mm with a mean of 301.06 ± 4.49 mm. All the