WEIGHTS AND LINEAR MEASUREMENTS OF 105 HUMAN SKELETONS FROM ASIA

E. W. LOWRANCE AND HOMER B. LATIMER [1]

Department of Anatomy, University of Missouri

The human skeleton and its parts have been weighed and measured for many years and recently a fresh impetus is evident in the study of the relationship between stature and the lengths of some of the long bones. A few of these studies are: Telkka ('50), Dupertuis and Hadden ('51), Trotter and Gleser ('52) and Keen ('53). The report by Trotter and Gleser gives an excellent historical background and discussion of this problem. Earlier studies on linear measurements of long bones of the extremities include those of Pan ('24) and Stevenson ('29).

Estimation of skeletal weight from the long bones together with a review of this literature, has been published by Trotter ('54). The weights of 100 skeletons and of the individual bones from the Todd collection have been reported by Ingalls ('31). There are several detailed studies on individual bones; for example, on the scapula (Graves, '21, '22), humerus (Hrdlicka, '32), clavicle (Terry, '32) and sternum (Ashley, '56).

Many reports on human skeletons are based on laboratory material for which stature, sex and other information was available. Although the skeletons which form the basis of this report were obtained from a commercial source with nothing known of their stature, sex or other details, except the area of origin, they had been so carefully and uniformly prepared that it seemed best to study them while they were still in such excellent condition. Unfortunately the writers are presently committed to identify the geographic source of this material only as to the continent of origin.

[1] Present address: Homer B. Latimer, Department of Anatomy, University of Kansas, Lawrence, Kansas.

The first report on these skeletons presents the weights and lengths of the individual bones, their variability and the asymmetry of bones of the two extremities.

MATERIALS AND METHODS

The 105 disarticulated skeletons used in this study were purchased from Clay-Adams, Incorporated, for use in student loan sets. We are greatly indebted to Mr. Henry Gumpert, Head of the Natural Science Division, for his care in the preparation of this material. These complete skeletons are of Asiatic origin and had been completely macerated and partially degreased when received in this country, and after arrival here were thoroughly degreased in trichloroethylene vapor and then bleached. We have the assurance of Mr. Gumpert that each skeleton is from a single body with no bones substituted from other sources. The appearance of all of the bones, including the thin bony plates of the skull, indicates that they have not been subjected to excessive degreasing or bleaching. The skeletons are of unknown age and sex, but judging from their structure, all are fully mature and free of major pathology. The entire vertebral column including sacrum and coccyx; and the bones of the left hand and left foot also, were strung on nylon cord. Bone weight lost in drilling the holes probably about compensated for the weight of nylon cord. The skull cap had been cut off and attached by the usual hooks; likewise the mandible was attached by the usual springs. Samples of this hardware secured from Clay-Adams were weighed and weights of these metal parts, 3 gm on the skull and 4 gm on the mandible, were subtracted from the weights of skull and mandible respectively. Throughout this report the term skull is used to include all bones of the cranium and face except the mandible and the hyoid bone. Few skulls and mandibles lacked the full set of teeth, and in these few specimens no allowance was made for the weight of missing teeth. The numbers of teeth in each skull and mandible were counted and recorded, and the ribs and bones of the hands and feet likewise were counted to make sure that all were present. A few of the phalanges were fused but all of these bones were present in every skeleton.

The entire skeleton and all of the individual bones, except the hyoid, were weighed on a Troemner laboratory balance sensitive to 1 gm; the hyoid bone, on a laboratory balance sensitive to 0.1 gm.

The skull and mandible were weighed separately; their average weights are listed in table 1. The entire vertebral column was weighed as a unit as was the entire group of 24 ribs. The weight of the sternum includes manubrium, body and as much of the xiphoid as was ossified. Each of the paired long bones was weighed separately but the weights in table 1 are the combined weights of the right and left bones of each pair. The percentage weights of the unpaired bones, paired bones and groups of bones are percentages of their respective total skeletal weights. Each left hand and left foot, strung on nylon, was weighed as a unit. Similarly, the bones of each unmounted right hand and right foot first were weighed as a unit, then the respective groups of carpal and tarsal bones only were weighed. The two patellae were weighed together. The sums of the individual bone weights are compared with the weights of the entire skeleton in a following section.

Most of the linear measurements were made on an osteometric board, with the long axis of the bones parallel to the edge of the board; the bones were adjusted to insure maximum measurements. The methods described by Stewart ('52) were used for determining the maximum lengths of all long bones except the tibia, and its maximum length includes the intercondylar eminences. Both right and left bones of each pair were measured and recorded; the averages of these lengths are listed in table 2. In making some of the measurements, which will be described later, a straight-armed calipers was used and again the long axis of the bone was held parallel to the back of the calipers. All linear measurements were made to the nearest millimeter.

The width of the scapula was measured on the osteometric board with the lateral margin near the inferior angle and the inferior part of the glenoid cavity in contact with the foot-board and the maximum width to the medial margin measured. The length of the scapula was measured with the calipers from the supraglenoid tubercle, at the line of attachment of the capsular ligament, to the tip of the inferior angle, with the lateral margin of the scapula held parallel to the back of the calipers.

The total length of the sternum was measured with the calipers from the jugular notch to the attachment of the xiphoid process. If the xiphoid process was ankylosed to the body of the sternum, the tip of the arm of the calipers was held at the line of ankylosis of body and xiphoid process. The xiphoid process, or as much of it as was present, was always weighed with the rest of the sternum. The length of the manubrium then was measured. If the manubrium and corpus sterni were ankylosed, the line of union afforded a landmark for separating the manubrium and body of the sternum. All measurements of the sternum were made in the midline.

Maximum width and length of the os coxae were made on the osteometric board with the medial surface of the bone directed upward and with the ala held horizontally. Maximum width was obtained between the anterior superior and posterior superior iliac spines.

Both measurements of the sacrum were made according to the method of Stewart ('52). The length was measured from the base at the middle of the promontory to the apex at the middle of the antero-inferior border of the fifth sacral vertebra, with the back of the calipers forming a chord of the curvature of the bone. This is not the true length but the chord of its length. If vertebrae or elements of the coccyx were ankylosed, as observed in several cases, the lines of fusion were used for the limiting dimensions of the sacrum. The entire vertebral column was weighed together, hence these anomalies did not matter in making the ponderal measurements. The width of the sacrum is the maximum width between the lateral parts.

WEIGHTS

The weights of the entire skeleton and of its parts are shown in the first column of table 1 together with their standard deviations, and in the next column, the coefficients of variation. The third column shows the weights as percentages of total skeletal weight and their standard deviations. In the last column are the coefficients of variation of these percentage weights. The weights of all paired bones are the sums of the weights of the right and left bones, except the carpal and tar-

TABLE 1

Weights of the entire skeleton and of its component parts, and weights of these parts expressed as percentages of total skeletal weight. Weights of the paired bones include weights of both right and left bones. Numbers in parentheses following coefficients of variation indicate the order of increasing size of these coefficients.

	AVERAGE WEIGHT IN GM AND S.D.	COEFFICIENT OF VARIATION	PERCENTAGES OF SKELETAL WEIGHT AND S.D.	COEFFICIENT OF VARIATION
Skeleton	2882 ± 365	12.66 (1)		
Skull	514 ± 88	17.19 (6)	17.98 ± 2.99	16.64 (13)
Mandible	69.2 ± 11.6	16.80 (5)	2.42 ± 0.41	17.08 (14)
Hyoid	1.13 ± 0.49	43.61 (21)		
Vert. column	290 ± 48.2	16.63 (4)	10.06 ± 1.03	10.23 (3)
Ribs (24)	185 ± 37.2	20.09 (14)	6.42 ± 0.94	14.68 (11)
Sternum	13.5 ± 3.96	29.32 (20)	0.47 ± 0.14	30.99 (17)
Clavicle	30.23 ± 7.58	25.08 (18)	1.04 ± 0.20	18.90 (15)
Scapula	82.4 ± 18.2	22.05 (16)	2.84 ± 0.42	14.86 (12)
Humerus	185 ± 34.5	18.68 (10)	6.38 ± 0.66	10.29 (5)
Radius	63.1 ± 12.7	20.16 (15)	2.18 ± 0.27	12.52 (7)
Ulna	76.8 ± 14.8	19.20 (11)	2.66 ± 0.28	10.71 (6)
Hand	72.9 ± 13.1	18.02 (8)	2.53 ± 0.36	14.33 (10)
Carpals, right	7.73 ± 2.12	27.46 (19)	21.20 ± 3.95 [1]	18.61
Os coxae	226 ± 36.3	16.09 (3)	7.83 ± 0.68	8.73 (2)
Femur	510 ± 77.5	15.19 (2)	17.67 ± 1.15	6.50 (1)
Patella	16.4 ± 3.98	24.38 (17)	0.57 ± 0.12	20.34 (16)
Tibia	308 ± 59.3	19.24 (12)	10.63 ± 1.09	10.27 (4)
Fibula	71.3 ± 13.3	18.65 (9)	2.47 ± 0.31	12.56 (8)
Foot	167 ± 29.4	17.60 (7)	5.79 ± 0.74	12.79 (9)
Tarsals, right	52.4 ± 10.2	19.49 (13)	62.97 ± 2.28 [2]	3.62

[1] Right carpals as percentage of entire right hand skeleton.
[2] Right tarsals as percentage of entire right foot skeleton.

sal bones which are for the right side only. The skull weight is the weight of the skull without the mandible which was weighed separately.

The weight of the entire skeleton in this table is the average of the sums of the weights of the individual bones. All of the constituent parts of the entire skeleton were weighed together but this entire weight is not used in this table nor in finding the percentage weights. There are some differences in these total weights and the sums of the weights of the individual bones, and it seemed better to use the summation of the weights. These summation weights averaged 2882 gm as compared to an average of 2894 gm for the weights of all the bones weighed together. Thus there is an average difference of 12 gm or a percentage difference of only 0.42% between the two methods of obtaining the average skeletal weight.

This average weight of 2882 gm is but 58% of the 4957 gm reported by Ingalls ('31) and 65% of the 4459.9 gm listed by Trotter ('54). The weights of the individual bones listed by these authors are, as expected, all heavier than the weights shown in table 1 for these smaller skeletons. The skeletons used by Ingalls and by Trotter were obtained from embalmed bodies used in the dissecting room and this may have contributed to the greater weight of these skeletons compared to the freshly macerated, completely degreased and bleached skeletons of this Asiatic collection. While a part of this difference in weight may be explained by the difference in preparation of the skeletons, most of it probably is due to the smaller size of the Asiatic population from which these skeletons were obtained. A personal communication from Mr. Gumpert states that the height of the mounted skeletons from the same source as the ones in this collection varies from 4 feet 8 inches to 5 feet 3 inches.

The coefficients of variation for these weights in grams in table 1 range from 13% for the weight of the entire skeleton to a maximum of 44% for the hyoid bone. The numbers in parentheses to the right of the coefficients of variation of the weights show the numerical rank of these coefficients in increasing order of size.

The os coxae and the three long bones of the lower extremity are less variable than the pectoral girdle and the three corresponding bones of the upper extremity. The weights of the bones comprising the hand and foot are much alike in variability. The average of all these coefficients of variation is 20.84%.

The weights of the pairs of bones as percentages of the skeletal weight are shown in the third column for all parts except the carpal and tarsal bones, which are shown as percentages of the weight of the entire skeleton of the hand and foot respectively. The carpal and tarsal bones of the right side only were weighed. It is interesting to note that the carpals form but 21% of the total weight of the hand skeleton, while the tarsals comprise 63% of the foot skeleton. The hyoid is so small and forms such a small percentage of the total skeletal weight that its percentages are not listed. The last column of table 1 with the coefficients of variation of these percentage weights, shows that all but two of these coefficients (mandible and sternum) are lower than the corresponding coefficients of the weights in grams. The order of increasing variability for these coefficients of variation of the percentage weights is indicated by the numbers in parentheses at the right of the last column of table 1. The two bones having the lowest coefficients of variation for these percentage weights and also for the weights in grams are the femur and os coxae. The carpals are over 5 times as variable as the tarsal bones in their percentage values. The average of the coefficients of variation of the weights as percentages of skeletal weight is 13.93% compared to 20.84% for the weights in grams.

LINEAR MEASUREMENTS

Table 2, column 1, contains the linear measurements together with their standard deviations for all parts except the skull and mandible, and these measurements are being reserved for a later report. Both right and left bones of all the paired bones were measured and recorded but these measurements in this table are the averages of the two paired bones. The coefficients of variation of these dimensions are listed in the last column, together with the increasing order of these coefficients which are indicated by the numbers in parentheses at the extreme right. These linear dimensions are, as expected, less variable than the weights in grams in the preceding table. The average of these coefficients of variation is

TABLE 2

Average measurements of bones and their coefficients of variation. The numbers in parentheses following the coefficients indicate the order of their increasing size.

	AVERAGE LENGTH (MM) AND STANDARD DEVIATION	COEFFICIENT OF VARIATION
Sternum	129.2 ± 10.6	8.18 (14)
Manubrium	47.4 ± 4.7	9.92 (15)
Clavicle	137.0 ± 9.5	6.97 (12)
Scapula, length	147.9 ± 8.2	5.58 (9)
Scapula, width	93.6 ± 4.5	4.77 (3)
Humerus	302.2 ± 17.9	5.93 (10)
Radius	237.0 ± 12.8	5.38 (8)
Ulna	255.7 ± 12.9	5.06 (7)
Sacrum, length	97.2 ± 7.4	7.66 (13)
Sacrum, width	101.4 ± 6.2	6.09 (11)
Os coxae, length	190.4 ± 7.9	4.17 (1)
Os coxae, width	140.5 ± 6.9	4.90 (4)
Femur	426.1 ± 19.1	4.49 (2)
Tibia	361.9 ± 17.9	4.94 (5)
Fibula	351.4 ± 17.4	4.96 (6)

5.93% or approximately 28% of that of the ponderal measurements and 43% of the average of the coefficients of the percentage weights in table 1. It is interesting to note that the widths of the scapula and sacrum are less variable than their longitudinal dimensions, as shown by the coefficients of variation, while the reverse is true of the os coxae. The two dimensions of the os coxae and the length of the femur and tibia are the 4 least variable dimensions in this table, while in length the humerus is the most variable of the 6 long bones of the two extremities.

The linear measurements in table 2, as well as the weights and percentage weights in table 1, all show that the femur and the os coxae are the two least variable bones. The bones of the lower extremity and the os coxae are, in general, less variable in weight and in length than those of the upper extremity and the bones of the pectoral girdle. Trotter and Gleser ('52) report that the bones of the lower extremity give better results in estimating stature than the bones of the upper extremity. Unfortunately we have no way of verifying any stature estimated from the lengths of the long bones in this collection.

ASYMMETRY

The right and left bones of each pair were weighed, measured and recorded separately with the sums of the weights and the averages of the linear measurements listed in tables 1 and 2; and now the frequency of a heavier or longer right or left bone or bones of equal size is shown in table 3. These

TABLE 3

The asymmetry of the paired bones in weight and in length. For each bone or group of bones the asymmetry is expressed in the distribution of percentages of the total number of pairs of bones or groups.

	WEIGHTS (GM)			LENGTHS (MM)		
	WEIGHTS AS PERCENTAGES OF TOTAL NUMBER			LENGTHS AS PERCENTAGES OF TOTAL NUMBER		
	Right heavier	Left heavier	Same weight	Right longer	Left longer	Same length
Clavicle	20.0	19.0	61.0	19.0	70.5	10.5
Scapula, weight	61.0	10.5	28.5			
Scapula, length				40.0	23.8	36.2
Scapula, width				9.5	69.5	21.0
Humerus	83.8	10.5	5.7	73.3	17.2	9.5
Radius	57.1	18.1	24.8	78.1	11.4	10.5
Ulna	56.2	17.1	26.7	70.5	10.5	19.0
Hand	22.8	26.7	50.5			
Os coxae, weight	30.5	53.3	16.2			
Os coxae, length				16.2	55.2	28.6
Os coxae, width				34.3	25.7	40.0
Femur	40.0	53.3	6.7	30.5	50.5	19.0
Tibia	55.2	34.3	10.5	30.5	41.0	28.5
Fibula	36.2	26.7	37.1	38.1	39.0	22.9
Foot	25.7	48.6	25.7			

are all listed as percentages of the total number of pairs of bones.

The differences in weight and in length are often very small. However, the bones of the upper extremity appear to be heavier and longer on the right side and although there is less asymmetry in the three bones of the lower extremity, these tend to be heavier and longer on the left side, thus suggesting the "crossed symmetry" described by Schaeffer ('28).

The quantitative differences in weight and in length between right and left bones were studied following the method used by Trotter and Gleser ('52) and these differences (not shown) also suggest a crossed symmetry as shown in table 3.

DISCUSSION

Ingalls ('31) has reported the skeletal weight and the weights of the individual bones from a series of 100 skeletons from the Todd collection at Western Reserve University. He finds an average skeletal weight of 4957 gm which is 1.72 times the average of this present series of skeletons. A comparison of the weights of the individual bones of our series with Ingalls' series, shows that the bones of the appendicular skeleton average from 50% to 60% of those from his series. The two extremes of all the bones are, 44% for the sternum and 78% for the skull. The sternum is exceedingly variable in our series and it has a coefficient of variation of 27.79% in Ingalls' series; it is one of the most variable bones in both series of skeletons. These Asiatic skulls more closely approximate the weights of the American skulls, suggesting that the smaller races have relatively larger heads. The percentage weights of the American skeletons listed by Kulp *et al.* ('57) show that the skull and mandible, ribs and sternum are relatively lighter, and the femur, humerus and radius are relatively heavier than in these Asiatic skeletons.

Trotter ('54) reports an average skeletal weight of 4459.9 gm for 24 white male skeletons from the Terry collection, which is 1.55 times the average weight of these Asiatic skeletons.

In general, these Asiatic skeletons are lighter in weight than either the Todd or the Terry collections of American skeletons and most of the individual bones are correspondingly smaller. Probably a part of this difference in weight may be due to the degree of degreasing (Trotter, '54) and in larger part to the smaller sized race from which these bones have been derived.

TABLE 4

Average lengths (mm) of the 6 long bones of this and of other series

	HUMERUS	RADIUS	ULNA	FEMUR	TIBIA	FIBULA
Lowrance and Latimer (Present series, Asia)	302	237	256	426	362 [1]	351
Pan (India)	295	236	259	411	350	353
Stevenson (North China)	311	238		440	362	
Trotter and Gleser (Terry collection, American)	330	244	262	457	364	368
Trotter and Gleser (American military personnel)	336	252	270	473	378	381
Dupertuis and Hadden (Todd collection, American)	329	244		453	368	
Telkka (Finland)	329	227 [2]	231 [2]	455	362	361

[1] Intercondylar eminences included but not in other tibial lengths.
[2] Maximum length not used in these two measurements.

Seven series of measurements from the literature of the lengths of the long bones have been tabulated for comparison with the lengths of the long bones of this present series which are listed in the first line of table 4. The bones measured by Pan ('24) were taken from the anatomy laboratory of the Medical College of Calcutta, India, and they were measured in the fresh state and include the articular cartilages. These measurements are the shortest in this table with the exception of the ulna and fibula of our series. Stevenson ('29) has studied 4 of the long bones of male cadavers from North

China. These bones had been well macerated and then dried before measuring. This series is the third in length but still not as long as the American series. The lengths of the tibia in our series include the intercondyloid eminences which are not included in the American series.

The first series listed from Trotter and Gleser ('52) consists of bones of male Whites from the Terry collection and the second, comprise bones from American military personnel. This series of bones from American military personnel are the longest in this table, but it must be remembered that these are from a selected group of young men. The bones reported by Dupertuis and Hadden ('51) are from 100 White male skeletons from the Todd collection and these bones do not differ appreciably from those of the Terry collection. The lengths of ulna and fibula are not given in this report. The bones reported by Telkka ('50) likewise are dissecting room material from the University of Helsinki. The lengths of the radius and ulna are much shorter and not comparable to the measurements of these bones in the other series because they are not maximum lengths.

In addition to these studies listed in table 4, there are many reports dealing with but a single bone. A few of these contain quantitative data; for example, the lengths of the clavicle from English dissecting room cadavers (Parsons, '16) show that the left clavicles of both sexes are longer and less variable than the right. The coefficients of variation calculated from Parsons' data are respectively: 5.40% and 6.90% for the males and 6.02% and 6.21% for the females and all of these coefficients are lower than the 6.97% for the clavicles of our series. Terry ('32) gives no weights but lists the range of the lengths of the clavicles for White and Negro males and Negro females and all of these are greater than in our series. He reports the Negro clavicle longer on the average on the left side.

Linear measurements of the scapula have been studied by Graves ('21); and Hrdlicka ('32) has studied several measurements and indices of 4432 humeri of American Whites, Negroes and Indians. All of his average dimensions for the males are greater than in this series of Asiatic bones, but like these bones, he finds the right humerus longer than the left in both sexes and in all three groups. Holtby ('18) and Ingalls ('24) give average lengths of the femur longer than in our series and much like the data for the American bones in table 4. Holtby reports the left femur usually longer than the right.

The sternum is exceedingly variable in weight (table 1) and in length (table 2) and these variable dimensions are in agreement with the report of Ashley ('56), who after a study of 1400 human and 239 anthropoid sterna, states that the sternum of man as well as that of the gorilla and gibbon are markedly variable and are "in a plastic stage of phylogenetic development."

The weights of this present series of skeletons have an average coefficient of variation of 12.66% compared to 14.51% for Ingalls' skeletons ('31) and most of the weights of the individual bones are less variable in our series.

The lengths of the individual long bones of Hindu skeletons were tabulated by Pan ('24) and from these measurements the coefficients of variation were calculated for each of the 6 long bones. All of these are more variable in Pan's series and average 7.09% compared to an average of 5.93% for this present series.

Comparisons of the standard deviations of the lengths of long bones from the reports by Trotter and Gleser ('52) and Dupertuis and Hadden ('51) with our series are as follows: for our series, 1.60; the Todd series, 1.79; the American military personnel, 1.807 and for the Terry collection, 1.874. Thus the bones of this present collection are the least variable in weight and in length, with the exception of the Stevenson collection of Chinese bones.

Schaeffer ('28) and Leche ('33) have described a crossed physiological symmetry, and a crossed morphological symmetry is suggested by the series reported by Ingalls ('31), Dupertuis and Hadden ('51) and in our series. Ingalls however reports an increase in this asymmetry in the more distal parts of the upper extremity, with the greatest number of cases of heavier bones in the hand or in 82% compared to 71% for the humerus. Table 3 shows just the reverse for our series, or a maximum percentage of 84 for the weights of the humerus and but 27% for the hand. Trotter and Gleser ('52) have reported the bones of the left lower extremity slightly longer. Ingalls ('24) shows the right femur averaging slightly longer than the left but in the same table (table 4, Ingalls, '24) he includes average lengths from two other reports, both of which show the left femur slightly longer. Thus the preponderance of evidence points to heavier and longer bones in the upper right extremity and although the bones of the lower extremities are more symmetrical, yet the bones in the left lower extremity tend to be heavier and longer, with the greatest asymmetry in the femur.

SUMMARY

A series of 105 human skeletons of Asiatic origin were used in this study. The weight of the entire skeleton averages 2882 gm and this average is less variable (13%) than that of any of the individual bones. Most constant of the individual bones are the femur and os coxae and the two most variable, the sternum and hyoid. As percentages of total skeletal weight, all but two of the bones (mandible and sternum) are less variable than the weights in grams.

Fifteen linear measurements are less variable than the weights, averaging 5.93%. The averages of the coefficients of variation of the weights in grams are 20.84% and for the bones as percentages of total skeletal weight, 13.93%.

The frequency of a longer right or left bone or bones of equal weight or length was studied. These measurements show that the 3 long bones of the upper extremity are heavier and longer more frequently on the right side. The lower extremities are more symmetrical but with a tendency for the left side to be heavier and longer. This asymmetry is most noticeable in the femur of all of the bones of the lower ex-

tremity. The left scapulae are longer more frequently while the right are wider in 70%. The left os coxae are longer in 55%, but wider on the right side more frequently.

LITERATURE CITED

ASHLEY, G. T. 1956 A comparison of human and anthropoid mesosterna. Am. J. Phys. Anthrop., *14:* 449–465.

DUPERTUIS, C. W., AND J. A. HADDEN, JR. 1951 On the reconstruction of stature from long bones. Am. J. Phys. Anthrop., *9:* 15–53.

GRAVES, W. W. 1921 The types of scapulae. Am. J. Phys. Anthrop., *4:* 111–128, plates 2–5.

———— 1922 Observations on age changes in the scapula. Am. J. Phys. Anthrop., *5:* 21–33, plates 1–6.

HOLTBY, J. R. D. 1918 Some indices and measurements of the modern femur. J. Anat., *52:* 363–382.

HRDLICKA, A. 1932 The principal dimensions, absolute and relative, of the humerus in the white race. Am. J. Phys. Anthrop., *16:* 431–450.

INGALLS, N. W. 1924 Studies on the femur. Am. J. Phys. Anthrop., *7:* 207–255.

———— 1931 Observations on bone weights. Am. J. Anat., *48:* 45–98.

KEEN, E. N. 1953 Estimation of stature from the long bones. J. Forensic Med., *1:* 46–51.

KULP, J. L., W. R. ECKELMANN AND A. R. SCHULERT 1957 Strontium-90 in man. Science, *125:* 219–225.

LECHE, S. M. 1933 Handedness and bimanual dermatoglyphic differences. Am. J. Anat., *53:* 1–53.

PAN, N. 1924 Length of long bones and their proportion to body height in Hindus. J. Anat., *58:* 374–378.

PARSONS, F. G. 1916 On the proportions and characteristics of the modern English clavicle. J. Anat., *51:* 71–93.

SCHAEFFER, A. A. 1928 Spiral movement in man. J. Morph. and Physiol., *45:* 293–398.

STEVENSON, P. H. 1929 On racial differences in stature long bone regression formulae, with special reference to stature reconstruction formulae for the Chinese. Biometrika, *21:* 303–321.

STEWART, T. D. 1952 Hrdlicka's Practical Anthropometry. Philadelphia: Wistar. 241 pp.

TELKKA, A. 1950 On the prediction of human stature from the long bones. Acta Anat., *9:* 103–117.

TERRY, R. J. 1932 The clavicle of the American Negro. Am. J. Phys. Anthrop., *16:* 351–379.

TROTTER, M. 1954 A preliminary study of estimation of weight of the skeleton. Am. J. Phys. Anthrop., *12:* 537–551.

TROTTER, M., AND G. C. GLESER 1952 Estimation of stature from long bones of American Whites and Negroes. Am. J. Phys. Anthrop., *10:* 463–514.