OSTEOMETRY

Anthropometry of the skeletal parts (outside of the skull) is a fertile and fascinating field in which much as yet remains to be exploited and even explored. It is, moreover, a large field, which few workers may hope to cover in its entirety. Every bone of the body presents sexual, racial and individual variations, many of which remain to be thoroughly studied; and some of these features, according to indications, possess a very considerable phylogenetic and racial importance.

Investigations on the skeleton are for the most part of a more recent date than those on the skull or those on the living, and have been largely the work of anatomists. Descriptive observations, such as those on the sexual characteristics of the pelvis, or those on the perforated humerus, pilasteric femur, platycnaemic tibia, etc., preceded and accompanied measurements. The first serious attempts at osteometry were made essentially in France, and the first system of measurements was developed by Broca and his pupils in Paris.[1]

Since the early seventies a whole series of valuable contributions to the subject of bone study and osteometry have been made,[2] and

[1] See Broca (P.)—Sur les proportions relatives du bras, de l'avant bras et de la clavicule chez les Négres et les Européens. *Bull. Soc. d'Anthrop.* Paris, 1862, III, 162–172; ibid., 1867, 2 Sér., II, 641–653. Hamy (T.)—Recherches sur les proportions du bras et d'avant-bras aux differents âges de la vie. *Rev. d'Anthrop.* Paris, 1872, 79. Topinard (P.)—*Éléments d'Anthropologie générale*, 8°, Paris, 1885.

[2] Bello y Rodriguez (S.)—Le fémur et le tibia. *Thèse*, Paris, 1909. Bumüller (J.)—Das menschliche Femur. *Phil. Diss.*, München, 1899. Bertaux (T. A.)—L'humerus et le fémur considérés dans les espèces, dans les races humains, selon le sexe et selon l'âge. *Thèse*, Lille, 1891. Fischer (E.)—Die Variationen an Radius und Ulna des Menschen. *Z. f. Morph. & Anthrop.*, 1906, IX, 147. Lehmann-Nitsche (R.)—Ueber die langen Knochen der südbayerischen Reihengräberbevölkerung. *Phil. Diss.*, München; and *Beitr. z. Anthrop., & Urgesch. Bayerns*, 1894, XI, H. 3 & 4. Livon (M.)—De l'omoplate. *Thèse Méd.*, Paris, 1879. Hrdlička (Aleš)—Physical Anthropology of the Lenape or Delawares, and of the eastern Indians in General. *Bull.* 62, Bur. Am. Ethnol., Wash., 1916. Pfitzner (W.)—Beiträge zur Kenntniss des menschlichen Extremitätens-skeletes. *Morphol. Arb.*, 1892, I, 516; 1893, II, 93. Rollet (E.)—La mensuration des os longs des membres. *Thèse méd.*,

much work in this line, particularly in the United States, is as yet unpublished. The repeated discoveries of skeletal remains of early man have in particular stimulated research in this direction. Notwithstanding all this, however, we are still far from a satisfactory grasp of the evidence which the bones embody. The reasons are, in the first place, that the gathering of skeletal material has always lagged behind that of the skulls, so that even today most anthropological collections are relatively poor in that respect, which hinders comprehensive and conclusive investigations. Besides this, the bones of the skeleton present many features and correlations the study of which demands large series of specimens, and in many cases also the presence of all the important constituents of the skeleton or the bones of the two sides of the body, conditions which are realizable with difficulty even among the Whites, not to speak of other peoples. The field will long remain, therefore, one of a very considerable importance, and no pains should be spared to develop the technique of osteological investigation.

The scheme here presented rests on the same principles as those presented before for anthropometry and craniometry. It utilizes the most useful procedures of other scholars, supplements these where extensive individual experience warrants, leaves aside everything superfluous or of value only in special studies, and aims at the utmost simplicity.

INSTRUMENTS

The matter of osteometric instruments has already to some extent been dealt with in the section on Craniometry (Vol. II, 1919, p. 50). The essentials are few. They are the Broca's osteometric board (pl. 1), the small *compas glissiere* and for a few measurements also the large sliding compass; but other instruments may be needed for special investigations.

Lyon, 1889; *Intern. Monatschr. f. Anat. & Physiol.*, 1889, VI, 345. Soularue (M.)—Recherches sur les dimensions des os et les proportions squeletiques de l'homme. *Bull. Soc. d'Anthrop.* Paris, 1899, Sér. 4, X, 328. Turner (Sir Wm.)—Report on the human crania and other bones of the skeletons collected during the voyage of H. M. S. Challenger, 1873–6: II—The bones of the skeleton. *Challenger Reports*, Zool., 1886, Pt. XLVII. Verneau (R.)—Le bassin dans les sexes et dans les races. *Thèse Méd.*, Paris, 1875. Volkov (Th.)—Variations squelettiques du pied ches les primates et dans les races humaines. *Bull. Soc. d'Anthrop.* Paris, 1903, Sér. 5, IV, 622; 1904, V, 1, 201. Waldeyer (W.)—Das Becken. Bonn, 1899. Wetzel (G.)—Volumen und Gewicht des Knochens als Massstab für den phylogenetischen Entwicklungsgrad. *Arch. f. Entw. d. Organismen.* 1910, XXX, 507–537.

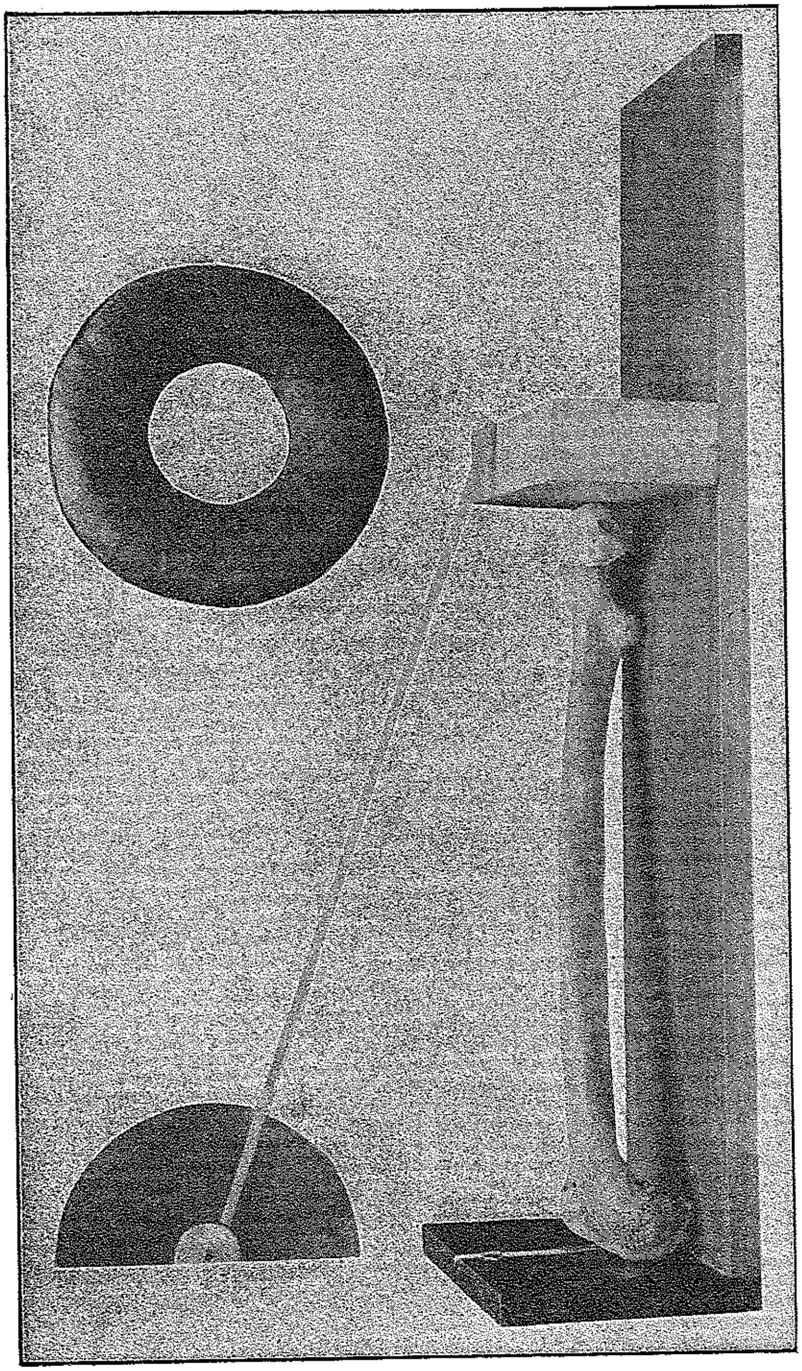

FIG. 18. Osteometric board with block; goniometer (translucent); leather ring, for support of skulls while being measured and examined.

The osteometric board is too well known to need special description; but for the original accessory square the writer uses a block of light wood (see fig. 18), which offers certain advantages. The block is 9.5 cm. high and 4.5 cm. thick, while its length equals the breadth of the board.

For description of instruments used on special occasions the student should consult the original sources.[1]

BLANKS

The matter of blanks in osteometry presents some difficulties on account of the many distinct bones each of which requires its own blank. An outline of a blank such as used for general purposes by the writer will be given separately with each bone. Such blanks may be made by the student himself, and their scope may be enlarged as demanded by the needs of the occasion. As they are they represent what invariably we should know of each of the bones.

OBSERVATIONS: TYPICAL BONE VARIANTS IN FORM

Before proceeding to the measurements, attention should be given to the important subject of bone variations in shape.

Each of the long bones, and also the scapulæ, first rib, etc., present a variety of forms which are reducible to definite types, and the frequency of these types differs from race to race. In the remainder of the skeletal parts similar variations occur, but they are less classifiable. The whole subject is of very considerable anthropological and phylo- as well as ontogenetic importance.

In the long bones the part that varies most in form is the shaft;[2] in the scapula it is in the contour of the bone. Bones of less consequence will be considered on other occasions.

[1] Besides the Memoirs of Broca and the textbooks of Topinard and Martin, see: Emmons (A. B.)—A study in the variations of the female pelvis. *Biometrica*, 1913, IX, 34–57. Garson (G.)—Pelvimetry. *J. Anat. & Physiol.*, 1882, XVI, 106–134. Frassetto (F.)—Lezioni di anthropologia, 1911–1913. Hepburn (D.)—A new osteometric board. *J. Anat. & Physiol.*, 1899, XXXIV, 111. Matthews (W.)—An apparatus for determining the angle of torsion of the humerus. J. Anat. & Physiol., 1887, XXI, 536–8. Russell (F.)—A new instrument for measuring torsion. *Am. Nat.*, 1901, XXV, 299.

[2] For original reports on this subject see Hrdlička (Aleš)—Study of the normal tibia. *Am. Anthrop.* 1898, XI, 307–312; *Proc. Ass. Am. Anat.*, 11 Sess., Wash. 1899, 61–66.—A further contribution to the study of the tibia, relative to its shapes. *Proc. Ass. Am. Anat.*, XII & XIII Ses. Wash. 1900, 12–13.—Typical forms of shaft of long bones. *Proc. Ass. Am. Anat.*, XIV Sess., Wash. 1901, 55–60. Also Bull. 62, Bur. Am. Ethnol., Wash. 1916. Consult also: Manouvrier (L.)—La platycnémie

Long Bones: The form of the shaft of the long bones is best differentiated at or near the middle of the bones, in adult individuals.

Variation in these shapes is greatest in the Whites. There are considerable racial and other group differences in the relative frequency of the different types of the shaft of the various bones; no one type, however, occurs exclusively or is completely absent in any of the human groups now existing. Some of the shapes are common to the anthropoid apes, and others occur far back in the animal kingdom.

The bones of the lower extremity show more numerous and better defined differentiations of form than those of the upper extremity. Of the individual long bones, the fibula presents the greatest variety of shapes; then follow in the order named, the tibia, femur, humerus, ulna, and radius.

Perfect representations of the various types of each bone are found whenever large collections are examined, but the less perfect and less clearly distinguishable types are always more common. Besides there is always a considerable percentage of bones which present intermediary or indefinite, and a small proportion which show combined forms.

The form of shaft common to all the long bones in man is the prismatic (No. 1). The outline of the cross-section of a shaft of this type approaches the equilateral triangle. This type is also common in apes, and more or less modified in lower mammals. The base of the prism is formed in the tibia, fibula, and humerus by the posterior surface; in the femur by the anterior surface; in the ulna by the internal, and in the radius by the external surface of the bone. In whites this type of shaft is most frequent in the humerus and tibia. In the fibula it is more or less modified by the narrow anterior surface of the bone.

The nearest modifications of type 1 are types of shaft Nos. 2 and 4. Type 2 occurs principally in the tibia, fibula and humerus, and is characterized by the obliquity of the posterior surface of the bone. The outline of the cross-section is a lateral triangle, a half lozenge (more or less). Type 4 occurs in all the long bones, and is charac-

chez l'homme et chez les singes. *Bull. Soc. d'Anthrop.* Paris, 1887, Sér. 3, X, 128.—Mémoire sur la platycnémie chez l'homme et chez les anthropoids. *Mém. & Bull. Soc. d'Anthrop.* Paris, 1888, Sér. 2, III, 469.—Étude sur les variations morphologiques du corps de fémur dans l'espece humaine. *Bull. Soc. d'Anthrop.* Paris, 1893, Sér. 4, IV, 111; *Rev. d'École d'Anthrop.* Paris, 1893, III, 389. And Graves (Wm. W.)—The scaphoid scapula. Med. Record, May 21, 1910; *Wien. klin. Woch.*, 1912, XXV, No. 6; *J. Cutan. Dis.*, etc., April, 1913; and others on same subject.

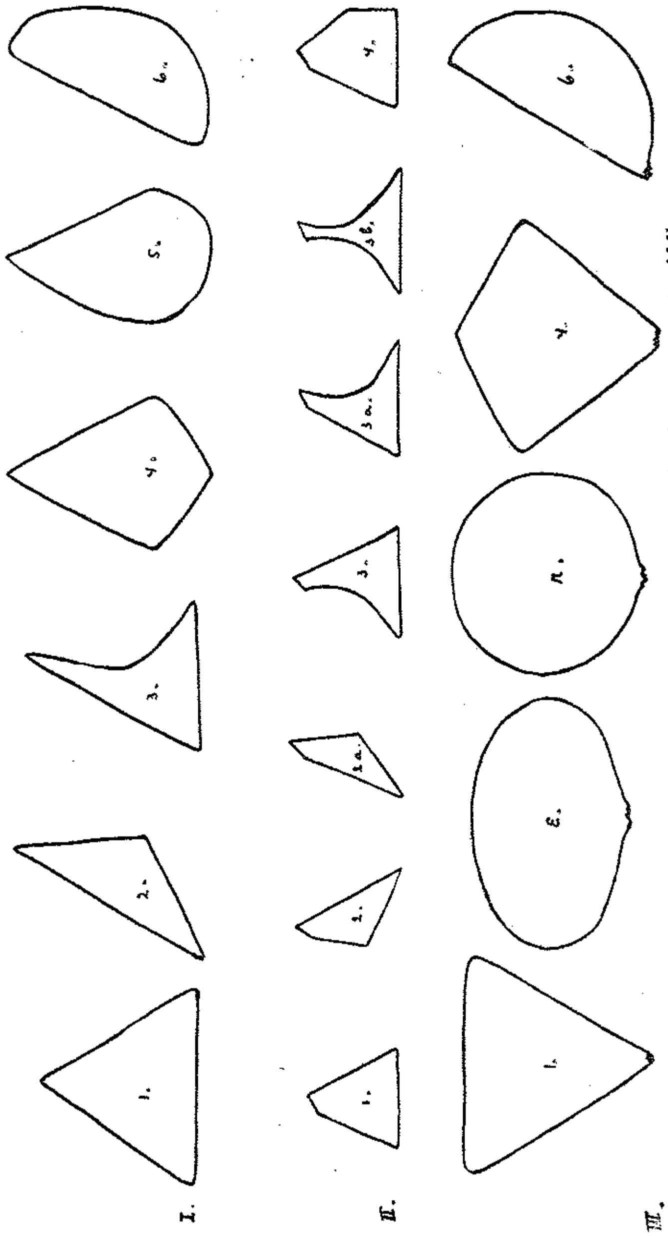

Fig. 19. Typical shapes of long bones of lower extremity, in cross-cut at middle. Upper row—Tibia; middle row—Fibula; lower row—Femur.

terized by the presence of a distinct additional surface on the shaft. The formation of the surface differs in the various bones. In the tibia the additional surface results from a division into two, by a vertical ridge, of the posterior surface; in the femur it is the anterior, in the radius the external, and in the ulna the posterior surface, which occasionally, through the influence of a vertical ridge, shows a formation of a distinct additional plane; in the humerus, finally, a new, anterior surface results occasionally by the broadening out of the anterior border of the bone. The cross section of the shaft in these cases differs from lozenge shape (more or less) to a more even quadrangle.

A special class of modifications of the form of the shaft is that where one or more surfaces of the bone show a pronounced concavity. We find such types (3, 3a, 3b,) particularly in the fibula, but also in the tibia, ulna and radius. In the fibula the concavity affects especially the external, but also the internal, and occasionally both the external and internal, and even the posterior surfaces; in tibia the character is observed on the external, and in the ulna and radius mainly on the anterior, flexor, surface.

Types 5, 6, *e* and *r*, are widely differing forms of the shaft of some of the long bones; all these types have, nevertheless, two features in common, and that is an indistinctness or complete absence of one or more of the borders of the bone, with marked convexity of two or all the surfaces.

Type 5 occurs occasionally in the tibia and frequently in the radius. It is marked by the convexity of the posterior tibial and external radial surface, and by indistinctness of the internal and sometimes also the external border in the tibia and the anterior and posterior borders in the radius. In both bones, but particularly in the tibia, this type of form represents a deficiency in the differentiation of the bone.

Type No. 6 occurs in the tibia, femur and humerus. The shaft is plano-convex. Types *e* (elliptical) and *r* (round, cylindrical) are found in the femur.

The condition of flatness in long bones occurs quite independently of the shape otherwise of these shafts. Flatness is not only found in the tibia, but also in the fibula (lateral), in the femur (antero-posterior of whole shaft, and, independently, antero-posterior of the upper part of the shaft, below the minor trochanter), and in the humerus (lateral). The flat femur (whole shaft) occurs almost exclusively in whites and independently of the flatness of other long bones. It is a

FIG. 19. Typical shapes of long bones of lower extremity, in cross-cut at middle. Upper row—Tibia; middle row—Fibula; lower row—Femur.

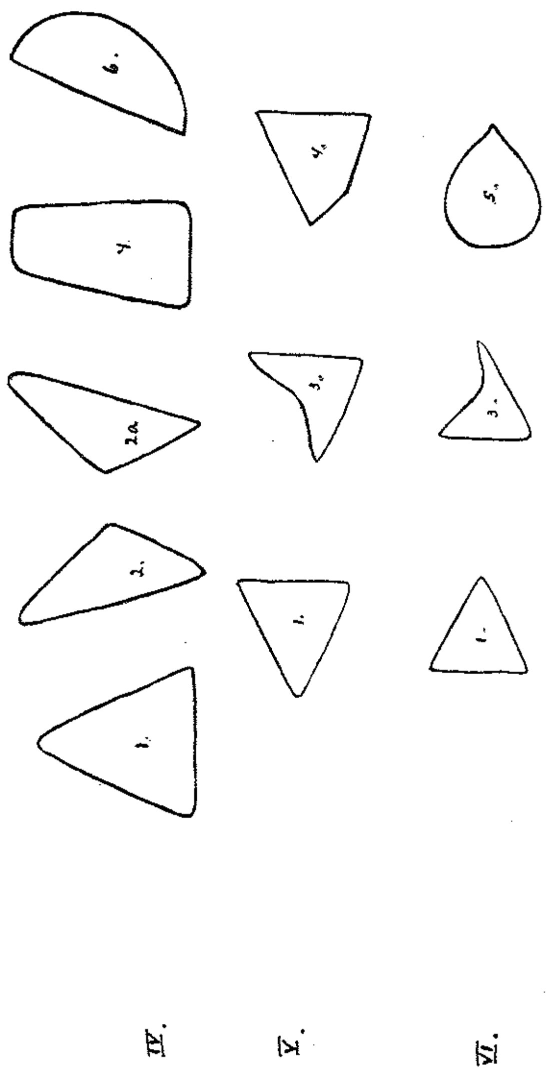

FIG. 20. Typical shapes of long bones of upper extremity, in cross-cut at middle. Upper row—Humerus; middle row—Ulna; lower row—Radius.

rare and possibly abnormal condition. A flat tibia is often accompanied by a flat fibula, and not seldom also by a platymeric (flat in upper part) femur.

The *scapula* presents three main shapes or types, namely, the triangular or wedge-shaped; the bi-concave, with its axillary and especially vertebral border concave (the "scaphoid" scapula of Graves); and the convex, with its vertebral border markedly convex.

Causes.—The shape of the bones is influenced by heredity, stage of development, sex, muscular activity, size of body, and pathological conditions.

Heredity: There are reasons to believe that certain types of bones run in families; and essentially through differences in heredity there are marked differences in the relative frequency of occurrence of the various types in different races.

Stage of life: During fetal life and early childhood, the shapes of bones are fewer in number, and do not always correspond to the shapes the bones will eventually have in the adult. Differentiation advances with age and the shape of a bone is probably not fully stabilized, particularly as to fluting, before advanced adult life.

Sex: Male bones show on the whole a greater differentiation of shapes than those of the females; also, some types of form are more common in one sex than in the other. Most, if not all these differences, may, however, be due to differences in muscular activities.

Race: The modern cultured Whites show more variation in shape of bones than the Indians, and the Indians more than the Negro or Negrito. The causes appear to be partly hereditary and partly occupational.

Muscular activity: Muscular peculiarities and muscular activites of the individual exercise a potent influence in modifying the shape of the bones.

Size of the body: The largest and the smallest bones of any variety show in general less differentiation than the average; and weak bones show more uniformity than the strongly developed.

Pathological: Very prolonged undernourishment or vitiated state of blood during fetal life or childhood may undoubtedly affect the general development as well as the shape differentiation of bones; but no proof exists that special pathological states are responsible for any special form-types of individual bones.

The sum of the observations points to the fact that the principal causes of the various shapes of the shafts of the long and bodies of other bones must be sought for, first, in original differences in the attachment of the various muscles to the shafts; and second, in an unequal development and work of the individual muscles during childhood and adolescence. The original differences in attachment, some of which can be clearly seen on the bones, are in all probability partly hereditary, partly early acquired conditions. The manner in which the differently attached or differently developed muscles affect the shape of bone must of course be largely if not entirely mechanical.

ADDITIONAL OBSERVATIONS

In addition to shape, the bones of the skeleton offer an array of highly interesting points for observation, and many of these, as already mentioned, are of phylogenetic importance. Of these, the main ones will be included in the blanks to be given.

MEASUREMENTS

Blank: HUMERUS

Tribe........... Locality........... Observer...........

Right Left

Cat. No.	Sex	Age	Length Max.	At Middle:			Observations:				
				Diam. Major (*a*)	Diam. Minor (b)	Index $\left(\frac{b \times 100}{a}\right)$	Shape of Shaft[1]	Perforation of Septum[2]	Supra-condylar Process[3]	Special	Patho-logical

[1] Type *1* = prismatic; *2*, *2a* = lateral prismatic (*2* = posterior surface facing backward and inward; *2a* = posterior surface facing backward and outward); *4* = quadrilateral (anterior border broadened out to a distinct fourth surface); *6* = plano-convex; *i* = intermediary or indistinct.

[2] *pp* = pin point; *sm* = small; *m* = medium; *l* = large. When double or multiple, state so.

[3] None (—); rough trace = *r. tr.*; ridge: slight, medium, pronounced (*r. sl-m-pr*); tubercle: slight, or medium (*tb. sl-m*); process: 1/3, 1/2, 2/3, etc., complete (*pr.* 1/3, 1/2, 2/3, etc.).

Notes.—The *length* is taken on the osteometric board. Apply head to the vertical, take hold of bone by left hand, apply block to distal extremity, and raising bone slightly, move up and down as well as from side to side until maximum length is determined.

Diameter major at middle.—C. g. Determine mid-point of shaft on osteometric board and mark with pencil Lay rod of compass to the antero-lateral surface and apply branches to the bone.

Diameter minor at middle.—Apply fixed branch of sliding compass to the antero-lateral surface at middle and take measurement.

Radius

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Max.	Shape[1]	Anomalies	Pathological	Radio—Humeral Index[2]	

Note: Maximum length is taken in same way as that of the humerus.

Ulna

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Max.	Shape[3]	Anomalies	Pathological	

Note: Maximum length is taken in same way as that of the humerus.

[1] *1* = prismatic; *2* = flexor surface concave (fluted); *5* = external surface convex, borders indistinct.

[2] $\frac{\text{Length of Radius} \times 100}{\text{Length of Humerus}}$.

[3] *1* = prismatic, *2* = flexor surface concave (fluted); *4* = quadrilateral (posterior) surface divided into two, so that the shaft presents four distinct surfaces, borders and angles.

Femur

Tribe............ Locality............ Observer............

Right

Cat. No.	Sex	Age	Length Bicondylar	Length Max.	Humero-femoral Index[1]	At Middle: Diam. Antero-Posterior Maxim.	Diam. Lateral	Index[2]

(*Continued*) Left

At Upper Flattening: Diam. Lateral Maxim.	Diam. Antero-posterior Minim.	Index[3]	Observations: Shape of Shaft[4]	Third Condyle[5]	Linea Aspera[6]	Anomalies	Pathological	

Notes: The *bicondylar length* of the femur is taken by adjusting both condyles to the vertical part of the osteometric board and, with the bone reposing on the board, applying the block to the other extremity.

The *length maximum* of the femur is measured in the same way as the maximum length of other bones (see under Humerus).

The *antero-posterior diameter at middle* (middle of shaft determined and marked beforehand) is the diameter maximum.

The *lateral diameter at middle* is taken so that the linea-aspera reposes on the stem of the sliding compass midway between the two branches of the same when these are applied to the bone.

[1] $\frac{\text{Length of Humerus} \times 100}{\text{Bicondylar length of femur}}$

[2] $\frac{\text{Diam. lat.} \times 100}{\text{Diam. ant.-post.}}$

[3] $\frac{\text{Diam. minimum} \times 100}{\text{Diam. maxim.}}$

[4] Type *1* = prismatic; *4* = quadrilateral (anterior surface divided by a vertical ridge in two); *r* = cylindrical (juvenile); *e* = elliptical; *pc* = plano-convex.

[5] *r* = ridge; *o. t.* = oblong tuberosity; *r. t.* = round tuberosity; *d* = depression; all: slight, moderate, or pronounced.

[6] sl., mod., pron.

In plano-convex and related femora the shaft is so deformed and the linea-aspera so displaced, that the measurement of the diameters is impractical and should be omitted.

Circumference of the shaft at middle as taken by some observers and contrasted with the length of the bone, gives data of some value for sexual identification; but the same may be done with the mean of the two diameters.

TIBIA

Tribe........... Locality........... Observer...........

Right

Cat. No.	Sex	Age	Length (Less Spine) (*T*)	Length Maxim.	Tibio-femoral Index[1]	At Middle: Diam. Antero-posterior Max. (*a*)	Diam. Lateral (*b*)	Index $\left(\frac{b \times 100}{a}\right)$

(*Continued*) Left

Observations: Shape[2]	Peculiarities	Pathological Curvature	Exostoses	Other	

Notes: To take the ordinary length of the tibia introduce the spine into the orifice provided for this purpose in the vertical part of the osteometric board, apply outer parts of the condyles to the vertical outside of the orifice, let body of the bone repose on the horizontal part of the board, and apply block to the most distant point (malleolus).

[1] $\frac{\text{T} \times 100}{\text{Bicond. } l. \text{ of femur}}$

[2] Type *1* = prismatic; *2* = lateral prismatic; *3* = external surface concave (fluted); *4* = posterior surface divided in two; *5* = posterior surface convex, internal border indistinct; *6* = plano-convex (gorilloid).

It is also useful to take the maximum length of the tibia. This is secured by placing the spine within the orifice as with the previous measurement, applying the most prominent point of the condyles to the vertical, taking hold of the body by the left hand and moving the bone from side to side as well as slightly upward and downward, while holding the block applied to the malleolus, until the maximum length is determined.

FIBULA

Tribe........... Locality........... Observer...........

Right Left

Cat. No.	Sex	Age	Length Max.	Shape[1]	Anomalies	Pathological	

SCAPULA

Tribe........... Locality........... Observer...........

Right

Cat. No.	Sex	Age	Height Total (*a*)	Height Infra-spinous (*b*)	Height Glenoid pt.–Infer. Angle (*x*)	Breadth (*c*)	Glenoid pt. Breadth *y*	Index: Total[2]	Index: Inferior[3]	Index (Hrdlička):[4]	Type[5]

Notes: The total height of the scapula is obtained by measuring in a straight line the distance from the superior to the inferior angle.

[1] *1* = Ordinary quadrilateral, approaching prismatic; anterior surface nearly absent to moderate; posterior surface facing directly backward or nearly so. *2* = Lateral prismatic; posterior surface facing backward and inward; medial surface much less in area than lateral; anterior surface narrow to broad. *2a* = relation between medial and lateral surface reversed, the latter being the narrower. *3* = medial surface fluted; *4* = lateral surface differentiated into two surfaces; *5* = lateral surface fluted; *6* = both medial and lateral surfaces fluted; *9* = all three surfaces fluted.

[2] $\frac{c \times 100}{a}$ [3] $\frac{c \times 100}{b}$ [4] $\frac{y \times 100}{x}$

[5] Type: *1* = triangular; *3* = biconcave ("scaphoid"), axillary and vertebral borders concave; *6* = convex, vertebral border convex.

SCAPULA

(*Continued*) Left

Observations:						
Shape of Superior Border[1]	Notch[2]	Vertebral Border[3]	Axillary Border[4]	Anomalies	Pathological	

The *infra-spinous height* is the height from the inferior angle to a point at which the spine transects the vertebral border of the bone. To determine this point hold scapula in left hand with dorsal surface up in such a way that the eye can follow the prolongation of the spine to the axillary border. Mark the mid point of the juncture of the spine with the border (and not the lower or upper limit).

The *glenoid point* height is the distance from the inferior angle to the center of the little roughness or fossa situated near the middle of the glenoid cavity.

The *breadth* of the scapula (*c*) is the diameter from the middle of the outer (dorsal) border of the glenoid cavity to the point where the spine intersects the vertebral border. (Broca, P. —Sur les indices de longueur de l'omoplate chez l'homme, les singes et dans la série des mammifères. *Bull. Soc. d'Anthrop.*, 1878, Sér. 3, I, 66.) The *glenoid point* breadth is that from this point.[5]

STERNUM[6]

Tribe............ Locality.......... Observer............

Cat. No.	Sex	Age	Total Length (Less Xiphoid) (*s*)	Length of Manubrium (*m*)	Manubrial Index $\left(\frac{m \times 100}{s}\right)$	Greatest Breadth of Body (*b*)	Sternal Index $\left(\frac{b \times 100}{s}\right)$	Maximum Thickness of Body	Number of Rib Facets *r.*	Number of Rib Facets *l.*	Anomalies	Remarks

[1] *1* = horizontal, at right angle, or near, with coracoid; *2* = moderate obliquity upwards, angle 55–80; *3* = pronounced obliquity, angle near 45; *4* = semiquadrate; *5* = semicircular; *6* = wavy.

[2] *1* = none; *2* = slight; *3* = moderate; *4* = nearly a foramen; *5* = foramen.

[3] *1* = straight; *2* = concave; *3* = convex: slightly—moderately—pronouncedly.

[4] *1* = straight; *2* = teres process slight; *3* = moderate; *4* = pronounced.

[5] The glenoid point is a less variable landmark than the glenoid border; also it is the more suitable in measurements of scapulæ of various animals. The $y - x$ index is the most stable index of the scapula.

[6] Consult: Anthony (R.)—Notes sur la morphogenie du Sternum chez mammifères.

Notes: The *length of the sternum* as well as that of the *manubrium* is best measured on the osteometric board; the breadth and thickness of the bone are measured with the sliding compass. The thickness of the body should be measured between the facets for the ribs.

Among the anomalies are to be observed especially the foramen or defect in the lower part of the bone, and the occurence of episternals.

The relative proportions of the manubrium and body of the sternum show sexual as well as group differences; and the same may be said in regard to the fusion of the manubrium with the body of the bone.

CLAVICLES[1]

Tribe........... Locality........... Observer...........

Right | Left

Cat. No.	Sex	Age	Length Maximum	Conoid Tuberosity	Strength[2]	Curvature[3]	Anomalies	

Notes: The *length of the clavicle* is best determined on the osteometric board, but may also be measured by the small or the large sliding compass.

The comparison of the length of the clavicle with the length of the humerus (*claviculo-humeral index*) is useful as an indication of the relative development of the thorax.

The acromial extremity may in rare cases be separated; a few other anomalies may also occur.

Bull. Soc. d'Anthrop. Paris, 1901, II, 19–43. Dwight (Thos.)—The Sternum as an index of sex, height and age. *J. Anat. & Physiol.*, 1890, XXIV, 527–535. Krause (W.)—Ueber das weibliche Sternum. *Intern. Monatsschr. f. Anat. & Physiol.*, 1897, XIV, 21–32. Parker (W. J.)—Structure and development of the Shoulder Girdle and Sternum in the Vertebrates. *Roy. Soc. Publ.*, Lond., 1868. Paterson (A. M.)—The human sternum. Liverpool, 1904; also *Brit. Med. J.*, 1902, II; and *J. Anat. & Physiol.*, 1900, XXXV, Pt. 1.

1 Consult Pasteau (E.)—Recherches sur les proportions de la Clavicule. *Thèse méd.*, Paris, 1879; also Parsons (F. G.)—On the proportions and characteristics of the modern English Claricle. *J. Anat., Lond.*, 1916, LI, 71–93.

2 *Sl* = slender; *m* = medium; *str* = strong; *mas* = massive.

3 *Sl* = slight; *m* = medium; *pron* = pronounced.

RIBS[1]

Tribe........... Locality........... Observer..........

Cat. No.	Sex	Age	Number Present		Anomalies	Fractures and Pathological	1st Rib Shape.[2]	Remarks
			R.	L.				

Notes: In skeletal material obtained from older graves the ribs are seldom all present and in good condition; nevertheless their examination should not be neglected. Cervical, supernumerary, bifid, bicipital and fused ribs are of special interest; and other anomalies may occur.

The first rib deserves special attention, particularly as to its shape. The development of the scalene tubercle may also be noted on the first rib.

SPINE[3]

Tribe........... Locality........... Observer...........

Cat. No.	Sex.	Age	Atlas:		Other Cervical:			Dorsal:			Lumbar:		
			Anomalies	Remarks	Number	Anomalies	Remarks	Number	Anomalies	Remarks	Number	Anomalies	Remarks

[1] Bardeen (Ch. R.)—Costo-vertebral variation in Man. *Anat. Anz.*, 1900, XVIII, 377–382. Hrdlička (Aleš)—Contribution to the Osteology of Ribs, *Proc. Ass. Am. Anat.*, XIV Sess., Wash., 1901, 61–68. Tredgold (A. F.)—Variations of Ribs in the Primates with especial reference to the number of sternal Ribs in Man. *J. Anat. & Physiol.*, 1897, XXXI, 288–302.

[2] *1* = curved (semilunar); *2* = monoangular or pistol-shaped (nearly straight neck, with nearly straight body); *3* = biangular (distinct angle in body, besides that between neck and body).

[3] Consult: Anderson (R. J.)—Observations on the diameters of human vertebrae in different regions. *J. Anat. & Physiol.*, London, 1883, XVII, 341–4. Bardeen (Chas. R.)—Numerical Vertebral Variation in the Human Adult and Embryo; *Anat. Anz.*, 1904, XXV, 497–519. Cunningham (D. J.)—Lumbar Curve in Man and the Apes. Dublin, 1886. Dubreuil-Chambardel (L.)—Variations sexuelles de l'Atlas. *Bull. & Mém. d'Anthrop.*, Paris, 1907, VIII, 399–404. Dwight (Thomas)—

Notes: Various measurements and many detailed observations are possible on the spine and its different constituents. As to measurements, the most interesting are the relative lengths of the cervical, dorsal and lumbar parts of the spine compared with the total length of the three. The length of these parts is best taken by the small and large sliding compasses, between the mid points anteriorly of the upper and lower border of the body of the first and last vertebra of each segment, with the bones held in a close and natural apposition.

The atlas should receive special attention, for it is subject to many independent variations, particularly in respect to blood vessel foramina and canals.

The lowest part of the dorsal and the uppermost as well as lowermost parts of the lumbar segment, are also of special interest, the former on account of occasional numerical variation, the latter on account of occasional separation of neural arch, a presence of a sacral element with more or less assimilation, etc.

The minor anomalies of the spine and its constituents should be reserved for special study.

SACRUM, PELVIC BONES, PELVIS

Tribe........... Locality........... Observer...........

Cat. No.	Sex	Age	Sacrum: Height Maxim.[1]	Breadth Maxim.	Sacral Index[2]	Number of Segments	Curvature[3]	Curvature Begins at[4]	Special

Description of the Human Spines showing numerical variation. Mem. Boston Soc. Nat. Hist., 1901, 237–312, also, *Anat. Anz.*, 1901, XIX, 332, 337–347; and *Anat. Anz.*, 1906, XXVIII, 33–40, 96–102. Hrdlička (Aleš)—The atlas of Monte Hermoso. In *Bull. 52, Bur. Am. Ethnol.*, Wash. 1912, 364–9. Papillault (G.)—Variations numériques des vertèbres lombaires chez l'homme. *Bull. Soc. d'Anthrop.*, Paris, 1898, IX, 198–222. Ranke (J.)—Zur Anthropologie der Halswirbelsäule. Sitz. math. phys. Cl. bayer. Akad. Wiss., 1895, XXV, 1–23. Ravenel (M.)—Die Maasverhältnisse der Wirbelsäule und des Rückenmarkes beim Menschen. *Inaug. Dissert.*, Leipzig, 1877, 1–27. Regalia (C. E.)—Sulla causa generale delle anomalie numeriche del rachide. *Arch. p. Antrop. & Etn.*, 1895, XXV, 149–219. Rosenberg (E.)—Ueber die Entwicklung der Wirbelsäule. *Gegenbaur's Morphol. Jahrb.*, Leipzig, 1875, I, 1–111. Soularue (G. Martial)—Etude des proportions de la colonne vertébrale chez l'homme et chez la femme. *Bull. Soc. d'Anthrop.* Paris, 1900, Sér. 5, I, 132–147. Zoja (G.)—Sulle varietà dell'atlante. *Bol. sci.*, 1881, Nos. 1 & 2, repr. 24 pp., Also C. R. R. Ist. Lomb., Cl. Sc. mat. & nat., 1881, XIV, 269–296.

SACRUM, PELVIC BONES, PELVIS

(Continued)

Ossa Innominata:						Pelvis:					
Height Maxim.		Breadth Maxim.		Mean Index[5]	Special Features	Breadth Maxim.[6]	Total Index[7]	Superior Strait: Breadth Maxim.	Diameter Antero-posterior Maxim.[8]	Pelvic Index	Remarks
Right	Left	Right	Left								

Notes: In measuring the height of the sacrum use sliding compass and apply points of instrument to middle of promontory and middle of anterior-inferior border of the fifth sacral vertebra. For general comparative purposes measure only sacra with five segments.

In measuring breadth apply stem of compass to the upper surface of the body of the first sacral vertebra and measure the greatest expanse of the lateral masses of the bone.

The height of the ossa innominata is best measured on the osteometric board. Apply ischium to the vertical part of the board, hold bone with left hand, apply block to iliac border with right hand and move bone up and down and from side to side until maximum measurement is obtained.

The breadth of the ossa innominata is best measured by the sliding compass. It is the distance between the anterior and posterior superior spines.

For measuring the pelvis as a whole articulate the bones, hold with both hands, invert, and secure breadth maximum of ilia on the osteo-

[1] Long branch of sliding compass applied ventrally, in median line, to anterior border of lower end and to promontory.

[2] $\frac{\text{Breadth} \times 100}{\text{Height}}$.

[3] Slight, moderate, pronounced.

[4] Name segment (from above).

[5] $\frac{\text{Mean breadth} \times 100}{\text{Mean height}}$.

[6] Pelvis held together with bones in natural position; the breadth is the bi-iliac maximum, and can be taken handily on the osteometic board, or by a second person with the large sliding compass.

[7] $\frac{\text{Breadth} \times 100}{\text{Mean height of ossa innominata}}$.

[8] From promontory of the sacrum to the nearest point on the ventral border of the pubic bones.

metric board. With the help of a pelviphore (such as that of Emmons) the taking of this measurement and of those of the brim becomes a simple matter.

To measure the diameters of the superior strait or brim of the pelvis without a pelviphore, hold pelvis in left hand, and use small sliding compass. The antero-posterior diameter is that between the mid point on the promontory of the sacrum and the nearest point on the ventral borders of the pubic articulation. The lateral diameter is the maximum transverse diameter of the brim.

A natural slight separation of the pubic bones should be retained during all measurements.

Short Bones

Patella.[1]

Tribe........... Locality........... Observer...........

Right Left

Cat. No.	Sex	Age	Height Maxim.	Breadth Maxim.	Thickness Maxim.	Breadth-Height Index $\frac{(B \times 100)}{H}$	Patellar Module $\frac{(H+B+T)}{3}$	Vastus Notch[2]	

Notes: All the measurements to be taken with the small sliding compass. In measuring the height and breadth of the bone, move the latter slightly from side to side between the branches of the compass until the maximum measurement is determined. The height is taken by applying the fixed branch to the anterior surface of the bone and bringing the movable branch posteriorly over its thickest parts.

The vastus notch shows interesting variations.

[1] Consult: Corner (E. M.)—Varieties and structure of the Patella of Man. *J. Anat. & Physiol.*, 1900, XXXIV, XXVII–XXVIII; also Ten Kate (H.)—Rotule. *Rev. Mus. La Plata*, 1896, VII, 12–16. Also *Bull. 62, Bur. Amer. Ethnol.*, Wash. 1916.

[2] — none; *sl* = slight; *m* = moderate; *l* = large.

CALCANEUS[1]

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Maxim.	Breadth Minim.	Height of Body	Breadth-Length Index $\frac{(B \times 100)}{L}$	Breadth-Height Index $\frac{(B \times 100)}{H}$	Height-Length Index $\frac{(H \times 100)}{L}$	Module $\frac{(L+B+H)}{3}$	Articular Facets for Astragalus	Anomalies	Remarks

Notes: All measurements to be taken with the small sliding compass. The taking of the maximum length will be self-evident. To secure the breadth, the branches of the compass should be applied to the sides of the bone in the region of the minimum thickness of its body. The most practicable height of the calcaneus is obtained by moving the bone from side to side between the branches of the compass, which are applied to what is seen to be the greatest constriction of the body (approximately its middle).

As to visual observations on the Os calcis, the greatest interest attaches probably to the number and conformation of the articular facets for the astragalus. These facets may be two in number, anterior and posterior. But the anterior facet may be divided into two by a ridge; or it may be replaced by two facets, anterior and median, completely separated by a narrow to moderately broad groove or space; or, finally, in place of the single oblong anterior facet there may be a small to rudimentary anterior and a medium-sized median facet, separated by a broad and deep notch.

An additional point of some interest is the development of the peroneal spine.

[1] See *Bull. 62, Bur. Amer. Ethnol.*, Wash., 1916.

ASTRAGALUS[1]

Tribe........... Locality........... Observer...........

Right Left

Cat. No.	Sex	Age	Length Maxim.	Breadth Maxim.	Height Maxim.	Breadth-Length Index $\frac{(B \times 100)}{L}$	Height-Length Index $\frac{(H \times 100)}{L}$	Module $\frac{(L+B+H)}{3}$	Facets for Calcaneus[2]	Special	

Notes: For length maximum, apply stem of sliding compass to lowest (most prominent) parts of the medial surface on the bone.

The maximum breadth is taken by applying the fixed branch of the sliding compass to the lowest (most prominent) parts on the medial surface of the bone.

The maximum height of the astragalus is best taken on the osteometric plane, on which the bone is placed so that all the three lowest points of its inferior surface touch the vertical part, while the block is applied to the most prominent part of the bone from the opposite direction.

A comparative study of the calcaneus facets on the talus with the corresponding facets on the latter bone, is of considerable interest, and shows some racial variations.

SCAPHOID[3]

Tribe........... Locality........... Observer...........

Right Left

Cat. No.	Sex	Age	Breadth Maxim.	Height Maxim.	Stoutness Maxim.	Height-Breadth Index $\frac{(H \times 100)}{B}$	Stoutness-Breadth Index $\frac{(S \times 100)}{B}$	Facet for Cuboid[4]	Facet for Talus, Form[5]	Tuberosity[6]	Additional	

[1] See *Bull. 62, Bur. Am. Ethnol.*, Wash., 1916.

[2] *1* = one facet not divided by any ridge; *2* = one facet divided into two by a ridge; *3* = two distinct facets, but slightly connected or completely apart.

[3] See *Bull. 62, Bur. Am. Ethnol.*, Wash., 1916.

[4] Present or absent.

[5] *pf* = pyriform; *q* = quadrilateral; *i* = intermediary or indefinite.

[6] *p* = pointed; *bl* = blunt (markedly); *sq* = squarish.

Notes: The maximum breadth of the bone is taken by the small sliding compass and is measured from the extremity of the tuberosity ad maximum.

To take the maximum height of the bone use the large sliding compass with broad branches; hold instrument vertically, lay bone on movable branch on its talus facet, raise the branch until the bone touches the under surface of the fixed branch and read measurement.

To measure the stoutness use same instrument as for height. Lay bone on the movable branch of the compass on its dorsal or superior surface, let it assume a natural position, and raise the branch until the most prominent part of the plantar surface of the bone touches the under surface of the fixed branch.

Cuboid[1]

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Maxim.	Breadth Maxim.	Thickness Maxim.	Breadth-Length Index $\frac{(B\times 100)}{L}$	Thickness-Length Index $\frac{(T\times 100)}{L}$	Module $\frac{(L+B+T)}{3}$	Facet for Cuneiform[2]	Facet for Talus[3]	Additional	

Notes: The maximum length of the bone is measured with the small sliding compass, between the most prominent point on the superior and inferior borders of the distal or metatarsal facet of the bone and the point at the inferior medial angle (calcanean process).

The maximum breadth is obtained with the cuboid resting on its medial surface in such a position as it naturally assumes. This and the next measurement are best taken by the large sliding compass with broad branches.

The maximum thickness is taken with the cuboid resting on its anterior surface in such position as it naturally assumes.

[1] *See Bull. 62, Bur. Am. Ethnol.*, Wash., 1916.

[2] *s* = single; *r* = divided in two by a well marked ridge; *3* = double (connected or not).

[3] Present or absent.

Internal Cuneiform[1]

Tribe........... Locality........... Observer...........

Right Left

Cat. No.	Sex	Age	Height Maxim.	Breadth Minim.	Breadth-Height Index $\frac{(B \times 100)}{H}$	Metatarsal Facet[2]	Additional	

Note: Measurements taken with sliding compass. Height maximum is secured by applying the fixed branch of the compass to the most prominent parts of the inferior surface of the bone and bringing the other branch into apposition.

The minimum breadth, in the middle of the bone, is obtained by applying the fixed branch of the compass so that it rests on both lips of the scaphoid facet, and bringing the other branch into apposition with the bone. It is the only practicable breadth in all specimens.

External cuneiform: Note frequency of absence of facet for fourth metatarsal, also for second metatarsal.

Middle Cuneiform: Note character of central ligamentous depression and canal running downward from this.

Bones of the Hand[3]

Tribe........... Locality........... Observer...........

Right Left

			Bones of Carpus:		Metacarpals:				Phalanges:		
Cat. No.	Sex	Age	Number	Observations	Number	Remarks	Length Max. of 1st Metacarpal	Metacarpo-Humeral Index[4]	Number	Remarks	

[1] See *Bull. 62, Bur. Am. Ethnol.*, Wash., 1916.

[2] Single or double.

[3] See *Bull. 62, Bur. Am. Ethnol.*, Wash., 1916.

[4] $\frac{\text{Max. length of 1st metacarpal} \times 100}{\text{Max. length of humerus}}$.

7 Calcaneus
Astragalus
Scaphoid
Cuboid
Internal cuneiform
External "
middle "

BONES OF THE FOOT[1]

Tribe........... Locality........... Observer...........

Right Left

Cat. No.	Sex	Age	Metatarsals:					Remarks	Phalanges:		
			Number	Observations	1st Metatarsal:				Number	Remarks	
					Length Maxim.	Pollux-Hallux Index[2]	Hallux Femur Index[3]				

ESTIMATION OF STATURE FROM PARTS OF THE SKELETON[4]

The International Agreement of Geneva stipulates that: "For the reconstruction of the stature with the aid of the long bones, the maximum length shall be measured in all cases save in those of the femur which is to be measured in the oblique position, and the tibia which is also be to measured in the oblique position, the spine being excluded."

Under these conditions and until something more serviceable may be provided, the student is advised to use Manouvrier's tables, which are here reproduced. These tables apply only to bones of adults; and a proper sexual identification is in each case of the greatest importance. All the long bones present should be measured and the mean length of each pair used for the approximations in the table, the mean of the total of approximations giving the stature.

[1] See *Bull. 62, Bur, Am. Ethnol.*, Wash. 1916.

[2] $\frac{\text{Max. length of 1st metacarpal} \times 100}{\text{Max. length of 1st metatarsal}}$.

[3] $\frac{\text{Max. length of 1st metarsal} \times 100}{\text{Bicondylar length of femur}}$.

[4] Dwight (Thos.)—Methods of estimating the height from parts of the skeleton. *Med. Rec.*, Sept. 8, 1894. (Gives data for estimating stature also from length of sternum and that of the spine.) Manouvrier (L.)—Détermination de la taille d'après les os longs. *Rév. Éc. d'Anthrop.* Paris, 1892, II, 227.—La détermination de la taille d'après les grands os des membres. *Mem. Soc. d'Anthrop.*, Paris, 1893, Sér. 2, IV, 347–411. Pearson (K.)—On the reconstruction of the stature of prehistoric races. *Philos. Trans. R. Soc.*, London, 1899 (Mathematical); CXCII, Ser. A, 169–244. Rollet (E.)—La mensuration des os longs des membres. *Thèse méd.*, Lyon, 1899 (Similar to Manouvrier). Topinard (P.)—De la restitution de la taille par les os longs. *Rev. d'Anthrop.*, Paris, 1885, VIII, 134.—Procédé des mensuration des os longs dans le but de réconstituer la taille. *Bull. Soc. d'Anthrop.* Paris, 1885, VIII, 73–83. Also *Éléments d'Anthropologie générale* (used maximum lengths throughout). Older data unreliable and lack precision of methods.

The final estimate will be the more reliable the larger the series of subjects involved. In single individuals the error, as Dwight has shown, may be very considerable, particularly in tall males (up to11.9 cm.).

The author obtained the following correspondences between the humerus and stature in 354 male and 82 female dissecting room individuals, Whites, 22–25 years of age, and where both humeri could be measured.

Mean Length of Humerus, in Percentage of Stature: $\frac{H \times 100}{S}$								
Percent of Bones	17.7	18.1 to 18.5	18.6 to 19	19.1 to 19.5	19.6 to 20	20.1 to 20.5	20.6 to 21	21.1 to 21.6
Males........	1.4	11.7	24.3	27.1	21.6	9	3.7	1.1
Females......	...	12.2	20.7	31.7	18.3	9.8	7.3	...

MANOUVRIER'S TABLES SHOWING THE CORRESPONDENCE OF BONE LENGTHS AMONG THEMSELVES AND WITH STATURE

Males						
Humerus	Radius	Ulna	Stature	Femur	Tibia	Fibula
cm.	cm.	cm.	cm.	cm.	cm.	cm.
295	213	227	1,530	392	319	318
298	216	231	1,552	398	324	323
302	219	235	1,571	404	330	328
306	222	239	1,590	410	335	333
309	225	243	1,605	416	340	338
313	229	246	1,625	422	346	344
316	232	249	1,634	428	351	349
320	236	253	1,644	434	357	353
324	239	257	1,654	440	362	358
328	243	260	1,666	446	368	363
332	246	263	1,677	453	373	368
336	249	266	1,686	460	378	373
340	252	270	1,697	467	383	378
344	255	273	1,716	475	389	383
348	258	276	1,730	482	394	388
352	261	280	1,754	490	400	393
356	264	283	1,767	497	405	398
360	267	287	1,785	504	410	403
364	270	290	1,812	512	415	408
368	273	293	1,830	519	420	413
Mean Coefficients for bones shorter than those shown in the Table:						
5.25	7.11	6.66	.....	3.92	4.80	4.82
Mean Coefficients for bones longer than those shown in the Table:						
4.93	6.70	6.26	.....	3.53	4.32	4.37

To determine from this table the stature of the living, add 2 mm. to each length; take the mean of the resulting statures, and subtract 2 mm. from the final height thus obtained.[1]

[1] Dwight found that a large proportion of the errors with the Manouvrier tables was due to this subtraction, and advocates that this recommendation be not followed. It should be stated by the worker whether or not it was followed.

MANOUVRIER'S TABLES SHOWING THE CORRESPONDENCE OF BONE LENGTHS AMONG THEMSELVES AND WITH STATURE—*Continued*

Females						
Humerus	Radius	Ulna	Stature	Femur	Tibia	Fibula
cm.	cm.	cm.	cm.	cm.	cm.	cm.
263	193	203	1,400	363	284	283
266	195	206	1,420	368	289	288
270	197	209	1,440	373	294	293
273	199	212	1,455	378	299	298
276	201	215	1,470	383	304	303
279	203	217	1,488	388	309	307
282	205	219	1,497	393	314	311
285	207	222	1,513	398	319	316
289	209	225	1,528	403	324	320
292	211	228	1,543	408	329	325
297	214	231	1,556	415	334	330
302	218	235	1,568	422	340	336
307	222	239	1,582	429	346	341
313	226	243	1,595	436	352	346
318	230	247	1,612	443	358	351
324	234	251	1,630	450	364	356
329	238	254	1,650	457	370	361
334	242	258	1,670	464	376	366
339	246	261	1,692	471	382	371
344	250	264	1,715	478	388	376
Mean Coefficients for bones shorter than those shown in the Table:						
5.41	7.44	7.00	.....	3.87	4.85	4.88
Mean Coefficients for bones longer than those shown in the Table:						
4.98	7.00	6.49	.....	3.58	4.42	4.52

ADDENDA

MEASUREMENTS OF TEETH

To express the proportionate size of the crowns of the premolars and molars to that of the skull in different races, Flower compared the distance from the front of the first premolar to the back of the last molar *in situ*, with the distance from the front of the foramen magnum to the naso-frontal suture (basi-nasal length), in the form of a "dental index."—

$$\text{Thus: } \frac{\text{Length of teeth x 100}}{\text{Basi-nasal length}} = \text{Dental index,}$$

and by this means he has divided the various races into *microdont* (index 42 to 43, Europeans, Egyptians, etc.), *mesodont* (index 43 to 44, Chinese, American Indians, Negroes, etc.), and *macrodont* (index 44 and upwards, Australians, Melanesians, etc.).[1]

[1] Flower (W. H.)—On the size of the teeth as a character of race. J. Anthrop. Inst. 1885, xiv, 183–187. See also Cunningham (D. J.)—Textbook of Anatomy, 3d ed., 1909, 1029.

Individual Teeth.—Valid measurements can be secured only on teeth that are normal and unworn (or worn only so that the dimensions we want to measure are not affected).

Incisors: Main measurements—The total length of the tooth, and the greatest breadth of the crown (at right angles to the long axis of the tooth). Additional measurements are the maximum antero-posterior diameter of the crown (at its base), the minimum breadth of the crown (also at its base), and the height of the crown (in median line on the labial surface).

Canines: Principal measurements—Total length, and height of crown (in median line, labial surface). A useful measurement is that of the total displacement of the tooth, in glycerine, oil or other liquid, in a graduated small jar or tube.

Premolars and molars: Essential measurements—Maximum height (with axis of the tooth vertical); length and breadth. The length and breadth measurements of these teeth are not as easy to make as might at first appear, which is particularly true of the anterior premolar in some of the lower forms of mammals. The most satisfactory rule is to measure the length along the median antero-posterior axis of the tooth as it lies or lay in the jaw; and the breadth at right angles to this axis.

The above measurements on individual teeth are of value both anthropologically and phylogenetically; but due to the care with which they must be taken and the time involved in getting the specimens, they should be reserved for special investigations.

The teeth of man, even more than any of his other structures, call for careful comparative work on Primates and lower mammals.

Measurements of Brain

Uniformity in brain measurements is equally as desirable as uniformity in the measurements of other parts of the body; but no attempt has yet been made at their international definition and regulation. Each author so far has followed his own inclinations, with the result that outside of weight but little comparison of the measurements is possible.

The brain is not an easy organ to measure. Due to its softness, from the moment it is exposed it tends to sag down more or less according to the condition of the body and the temperature, and it may readily be deformed if not given the best of care in preservation. Yet measurements that could be used for comparison both within and beyond the human phylum are highly desirable, and every effort should be made in this direction by those favorably situated for such studies.

The most common and easiest of brain measurements is the *weight*. The brain is weighed without the *dura mater*, immediately after extraction. Should any excess of liquid be evident, allow 5 to 15 minutes for drainage. If the main component parts are to be weighed separately use care in severing.

As to other measurements of the organ, in 1901[1] the author proposed a sensible scheme which he regards as the simplest, the most promising and the only universally applicable system so far suggested. It relates essentially to the cerebrum, and consists of taking the maximum antero-posterior diameter of each hemisphere as a basis and a horizontal, to which all other measurements are referred as so many verticals. Under this system each part of the brain and each location may be readily expressed or shown in a percentage of the horizontal, which gives us valuable data for comparison. The choice of the points from which to draw the verticals depends on the object of the study, but the principal points will doubtless become standardized by use, as well as by future agreements.

The method of procedure is simple. The appliance needed is a frame, the lower part of which consists of an adjustable platform for the cerebrum or a hemisphere, while the upper part resembles the rod of the sliding compass. It is graduated, and along it slides a needle which may be lowered or elevated as required. The observer ascertains with due care the frontal and the occipital poles, adjusts the platform of his frame so that the line connecting these points is horizontal, brings the frontal pole lightly into contact with the vertical part of the frame on the left (his zero), sees to it that the axis of the brain or hemisphere is parallel to the graduated rod above, marks on the hemisphere or hemispheres the points to which he wishes to measure and proceeds with the measurements. The up er part of the frame holding the needle is movable backwards and forwards so as to permit the bringing of the needle vertically over the different points from which the measurements are to be taken.

In the above way each measurement is like a section of the hemisphere and hence of its basic horizontal, and can readily be contrasted with the whole. We are comparing then antero-posterior segments of the brain, rather than simple linear dimensions.

[1] An Eskimo Brain. *Am. Anthrop.*, N. S., III, 454–500; also 8° N. Y., 50 pp.

The lateral and height measurements may, if desired be obtained similarly; and the length, breadth and height diameters may be supplemented by such surface arcs as may be deemed of importance.

The measurements may be taken on a fresh brain, but as there is always more or less sagging, it is preferable to take them on hardened specimens, in which the relative proportions of the parts will, if the specimen has not been deformed, remain the same as they were in the fresh brain.[1] The best specimens however for measurement are brains hardened *in situ* by near-freezing (temporary), or by 5 to 10 per cent formalin injections.

In all cases it is important to ascertain the endocranial maximum length (on each side), as well as the maximum breadth of the cranial cavity (lined by *dura*). These correspond to the measurements of the brain before extraction.

Internal Organs

No system of measurements has as yet been devised for the internal organs.

The weight is ascertained as a rule, and should further measurements be desired they would naturally include where possible the greatest length, breadth and thickness, with the displacement (or capacity), of the organ.

The study of the internal organs is greatly hindered by pathological alterations, notwithstanding which it is of considerable anthropological importance.[2]

Plaster Casts

In demonstrations and museum exhibits, as well as in original investigations, an important part is played by good casts. An ideal collection in physical anthropology ought to include a representation in good facial and other casts of every important branch and group of humanity. As it is, there is no institution that possesses casts of the various racial divisions of even the Whites alone. Nor could there be made as yet in any institution with an anthropological section an exhibit of any one nation, illustrating physical and developmental types, and such groups as that of the most beautiful individuals, the greatest athletes, the most talented men and women in that nation. More has really been done in this respect on primitive peoples than on

[1] For hardening brains see Hrdlička (A.)—Brains and Brain Preservatives. *Proc. U. S. Nat. Mus.*, 1906, XXX, 245-320*b*, 27 fig.

[2] Compare Bean (R. B.)—*Am. J. Phys. Anthrop.*, 1919, II.

those more civilized; but there is everywhere an opportunity for much further endeavor.

If an opportunity to make casts is limited, choose only adults of middle age; otherwise extend the work to all age groups. Very interesting series also are afforded by whole families.

Casts are made from plaster of paris. Efficiency in making casts is best acquired under an instructor. The process of making a facial cast, given here for those who may have a chance to practice it, is as follows:

Have the subject seated comfortably on a chair. See that the face preserves its most natural expression, the eyes being open, and warn the subject against moving, swallowing, coughing, sneezing or spitting. The features and lips should not be tight or puckered or the mouth distorted; endeavor to have the subject think of something peaceful, agreeable. Fasten a wide, ample piece of cloth on the neck of the subject; it should be long enough to cover his feet to prevent soiling by plaster. Brush hair backward without pulling the skin and fasten by moderately tightly applied band about 2½ inches broad, leaving but little hair exposed over the forehead and temples. Work into this exposed hair, and also into the eyebrows mustache and beard, enough soap paste to prevent inclusion into plaster. Use commercial green soap, or boil ordinary soap with water until the liquid thickens. Introduce a little cotton into each ear. Oil lightly with camel hair brush whole face and neck using light paraffin oil or any other non-viscid oil; also oil the hair band. Care must be exercised that no excess of the oil is left anywhere and that nothing enters the eye. This finishes the preparation. No nasal tubes.

The next step consists in mixing the plaster. Only the best dental or alabaster plaster should be used. Fill small basin with lukewarm or at least not too cold water, and add a pinch of common salt for quicker setting (if needed). Sift plaster on top of water by hand, without mixing, until moment when plaster stops sinking—the exact stage is learned from practice. Mix then without churning, with common spoon gather surface bubbles and dirt, and the liquid of cream consistency is ready for use.

The first layers of plaster are applied to the forehead, about the eyes and over the upper part of the face with the help of a little spoon or a spatula. The excess of the plaster flows down over the face and on to the apron, or the plaster basin which is held underneath.

The upper part of the face being covered, advance to ears and lower part of face. Fill one ear only, but carry plaster around far enough to show fully location of other ear. If plaster begins to thicken, strengthen what is already on without employing the slightest pressure, and make or have made rapidly a new supply, slightly thicker than the first. Then with the help of spatula or spoon and still avoiding pressure cover whole face.

While cast is drying add gently more about eyelids, taking again care to use no pressure and especially not to get any plaster into subject's eye where it would cause burning. Add also, if necessary, more plaster about nostrils. On the ear that is covered carry plaster a little over convex border.

Strengthen cast over forehead and median line of face; thickness of cast should range from about one-eighth to one-quarter of an inch.

When through with application of plaster, post yourself behind subject and gently support his head until cast is sufficiently hard. During hardening plaster will generate warmth, but this never becomes too inconvenient or dangerous.

Proper hardness of cast is learned through experience; it can be ascertained by tapping it with a finger or some harder object.

Removal may begin before hardening is complete at the hair ribbon, which is slowly drawn backward. Then proceed all along the edge of the cast and press skin back from it. Free helix of covered ear and draw ear backward. All this can be begun quite early to occupy subject's attention and satisfy him and it may be carried on so slowly that the plaster has ample time to harden. To take cast off, lay left hand on its top, grasp with the right its chin part, manipulate slowly and carefully up and down, and push and pull downward and forward until it slips off.

There is occasionally some difficulty on account of the beard or very large malars; or the subject may have tried to swallow or cough or has moved so that a part of the cast is cracked or imperfect; or a portion of the cast may be broken off through haste or maladroitness in removing it. All that can be advised in such contingencies is patient manipulation, or careful repair by fitting the separated parts and adding plaster to the outside of cast.

The finished cast is allowed to dry thoroughly, after which it is ready for packing. Mark on surface with sharp point whatever data are essential to go with cast. Pack carefully and tightly.

In this manner, after due preliminary practice, from eight to ten first class facial casts can be made in a day. To take a cast of the whole head is difficult and has no advantage. With a good facial cast, photographs and measurements, the head can be modelled almost to perfection.

Casts of the body should never be undertaken except by one well practised in the art, for the operation is not without danger to the subject. Casts of the lower part of the trunk and the limbs need experienced hands. The skin must in all instances be well oiled and the part to be cast must not be deformed by wrong position or pressure. A provision for the removal of the cast in sections is a necessity and is usually done by including in the first layer of plaster, along the line of intended separation, a linen thread and by cutting the cast with this as it begins to harden. The preparation of the plaster and other details are practically the same as in facial casting.

In packing casts, pad well and tightly with very dry hay or other suitable substance, and use only smaller boxes or barrels. In especially important cases, and where the casts are to be transported a great distance, individual little boxes for each cast, a number of which is then packed in a larger case, are of great advantage.

ANTHROPOMETRIC INDICES.

Under the term 'index' in anthropometry is understood the percental relation of two measurements. It is habitual to use the smaller measurement as the dividend and the larger as the divisor, so that the index is usually less than 100.

The index is the simplest expression of the geometric relation of two dimensions and as such is of much utility for the prompt conveyance of a notion as to the shape or relative size of parts. The index in general is also more permanent than the absolute dimensions of the parts, and therefore more valuable for group comparisons.

Due to their usefulness and stability, the indices in anthropometry have almost from the beginning assumed a great favor as well as importance. For the same reasons also they have become greatly multiplied, and their value—particularly that of the cephalic index—has been sometimes overrated. No index, it is plain, can have more stability than the physiological and mechanical conditions that control the relation of the parts concerned; and as these conditions are not immutable, so the indices are subject to change.

As in a large majority of cases the correlation of measurements is self-evident, there is a general agreement among workers as to the constituents of the indices; but in the course of time there have developed considerable differences of opinion as to the grouping of the indices and in the nomenclature of the resulting divisions.

In the examination of any large group of people it will be found that each given index will show a rather extended range of variation. A certain part of this range will embrace the normal average, together with the normal oscillations of the index for the anthropologically purest part of that particular group; but as few larger ethnic groups to-day are free from admixture, it may safely be expected that a certain proportion of the indices obtained on the group will express aberrations. Such aberrations may be detected by a proper seriation and mapping out of the indices. But we are assisted in expressing them, as in expressing the differences in the indices of separate ethnic and biologic groups, by definite subdivisions or classifications of the indices. That is why this subject has received so much attention.

But such classifications, to be of real value, should self-evidently be as little arbitrary as possible, and have the closest attainable relation to natural groupings.

These facts were well recognized from the start in anthropology, and earnest efforts were made to arrive at the most logical classifications. For guidance there were on the one hand the principal natural subdivisions or races of man, and on the other an augmenting and comprehensive supply of measurements. It could readily be seen that a classification of any index which would not harmonize with the distribution of the index in at least the principal groups of mankind would not be of any great utility. But it was also soon recognized that even the principal races of man were not in all respects far enough distant to give alone a sound basis for classification. It was then that recourse was had to mathematical procedure. By taking all the available indices on man regardless of racial subdivisions, ranges of indices could be obtained which applied to the human family as a whole; and these ranges gave certain averages as well as minima and maxima which could serve as bases of mathematical classification. From an insufficiency of data however and from other causes, there arose numerous individual differences of views among working anthropologists as to exactly where to establish the boundaries of the subdivisions of the various indices, and also as to the best terms for the different subdivisions, which gave rise to a considerable confusion.

To-day anthropology has ceased to regard the grouping and naming of the indices in the somewhat fetishistic light in which it looked upon them before. The arithmetic and graphic presentation of the distribution of each index has become the essential procedure in all anthropometric work, and divisions with terms, which in the nature of things must always retain something of the arbitrary, are now employed more for convenience than of necessity. Still, the classification of the various indices and its terminology are useful, and some day will doubtless become subject to proper international agreements.

In these pages no attempt will be made to treat the subject of anthropometric indices historically, or to give their different classifications. For these the student is referred to Broca's *Instructions*, Topinard's *Éléments d'Anthropologie générale*,[1] Martin's *Lehrbuch*, and similar publications in other languages. What will here be given with few exceptions are the most widely accepted and most frequently used indices, together with best known nomenclatures.

There is no limit to other legitimate indices, as there is none to possible measurements; and any index, as any measurement, may assume more or less of anthropological value if obtained on sufficiently large series and groups of individuals or specimens.

HEAD AND SKULL.

Cephalic (and Cranial) Index— $\frac{B \times 100}{L}$ —
- Dolichocephaly.....up to 74.9
- Mesocephaly............75–79.9
- Brachycephaly...........80 and above.

(On the skull the index is approximately 2 points lower than that on the head.)[2]

Mean Height Index (Cephalic and Cranial)— $\frac{H^3 \times 100}{\text{Mean of } L + B}$

Height—Length Index— $\frac{H \times 100}{L}$ —(of limited use).

Height—Breadth Index— $\frac{H \times 100}{B}$ —(of limited use).

Cephalic (or Cranial) Module— $\frac{L + B + H^3}{3}$

Physiognomic Index (on Head)— $\frac{\text{Diameter bizygomatic maximum} \times 100}{\text{Menton-Hair line diameter}}$

[1] Which is particularly rich in historic notes, p. 364 *et seq.*

[2] See on this point Topinard's *Éléments etc.*, 373; also Duckworth (W. L. H.)—*J. Anat.*, Lond., 1917, LI, 167–179.

[3] Height, on head, from line connecting floor of auditory meatus to bregma; on skull, basion-bregma. Not directly comparable.

Facial Index (on Head)— $\frac{\text{Menton-nasion height} \times 100}{\text{Diameter bizygomatic maximum}}$

Facial Index, Total (on Skull)— $\frac{\text{Menton-nasion height} \times 100}{\text{Diameter bizygomatic maximum}}$

Facial Index, Upper (on Skull)— $\frac{\text{Alveolar pt.—nasion height} \times 100}{\text{Diameter bizygomatic maximum}}$

Facial Angle—Angle between basion-alveolar point and alveolar point-nasion lines.

Alveolar Angle—Angle between basion-alveolar point and alveolar point-subnasal point lines.

Orbital Index— $\frac{\text{Mean height of orbits} \times 100}{\text{Mean Breadth}}$ —
- Microseme . . . . . up to 82.9
- Mesoseme 83–88.9
- Megaseme . . . . 89 and above.

Nasal Index: (on Head)— $\frac{B \times 100}{L}$ —
- Leptorhinic . . . . up to 69.9
- Mesorhinic 70–84.9
- Platyrhinic . . . . 85 and above.

Nasal Index: (on Skull)— $\frac{B \times 100}{L}$ —
- Leptorhinic . . . . up to 47.9
- Mesorhinic 48–52.9
- Platyrhinic . . . . 53 and above.

Ear Index: (on Head)— $\frac{B \times 100}{L}$

Palatal Index— $\frac{B \times 100}{L}$ —
- Dolichouranic . . . . below 110
- Mesuranic 110–115
- Brachyuranic . . . . above 115.

Dental Index— $\frac{\text{Dental length}^{1} \times 100}{\text{Basion-nasion diameter}}$ —
- Microdont . . . . up to 41.9
- Mesodont 42–44
- Megadont . . . . above 44.

BODY.

Sitting Height Index— $\frac{\text{HS} \times 100}{\text{Stature}}$

Height-Weight Index— $\frac{\text{Weight in grams}}{\text{Stature in centimeters}}$

Chest Index— $\frac{\text{Diam. antero-posterior (mean) at nipple height} \times 100^{2}}{\text{Diam. lateral (mean) at same level}}$

Pelvis—Shoulder Index— $\frac{\text{Maximum external breadth of pelvis} \times 100^{3}}{\text{Breadth of shoulders}}$

[1] Distance *in situ* between most anterior point on 1st premolar and most posterior point on normal 3rd molar.

[2] In female at the upper level of the 4th chondrosternal articulation.

[3] Between outer lips of iliac crests.

Hand Index— $\frac{B \times 100}{L}$[1] Foot Index— $\frac{B \times 100}{L}$[1]

SKELETAL PARTS.

Pelvis: Total Index— $\frac{\text{Mean max. height of ossa innom.} \times 100}{\text{Greatest external breadth of pelvis}}$[2]

Pelvic or Brim Index—

$\frac{\text{Antero-post. diam. of superior strait} \times 100}{\text{Greatest transverse breadth of the strait}}$ — Dolichopellic ....above 95; Mesatipellic...........95–90; Platypellic ......below 90.

Sacrum— $\frac{B \times 100}{L}$ — Dolichohieric ....up to 100; Platyhieric ....above 100

Radio-Humeral Index— $\frac{\text{Max. L of radius} \times 100}{\text{Max. L of humerus}}$ — Brachykerkik....less than 75; Mesatikerkik.............75–80; Dolichokerkik......above 80.

Tibio-Femoral Index— $\frac{\text{L of tibia (less spine)} \times 100}{\text{Bicondylar L of femur}}$ — Brachycnemic ....less than 83; Dolichocnemic ...83 and over.

Humero-Femoral Index— $\frac{\text{Max. L of humerus} \times 100}{\text{Bicondylar L of femur}}$

Intermembrae Index— $\frac{\text{L of radius} + \text{L of humerus} \times 100}{\text{Standard L of tibia} + \text{Bicondylar L of femur}}$

Platybrachic Index— $\frac{\text{Diameter minor of shaft of humerus at middle} \times 100}{\text{Diameter major}}$

Platycnaemic Index— $\frac{\text{Diameter minimum of shaft of tibia at middle} \times 100}{\text{Diam. maximum}}$

Platymesic Index— $\frac{\text{Diam. minimum at upper flattening of femur} \times 100}{\text{Diam. maximum}}$

Scapular Index (new)— $\frac{\text{B, glenoid point to spine point} \times 100}{\text{L, glenoid point to inferior angle}}$

Scapular Index: Total— $\frac{\text{B, m. of outer border of glenoid fossa to spine point} \times 100}{\text{L, from superior to inferior angle}}$

Infraspinosus Index— $\frac{B \times 100}{\text{L, from spine point to inferior angle}}$

Sternal Index— $\frac{\text{Greatest B of body} \times 100}{\text{Total L with manubrium but without xiphoid}}$

For other indices see text under the individual bones.

[1] For definition of measurements see text.
[2] Between outer lips of iliac crests.