This is to confirm that the University of Adelaide has the authority in lending and copying the thesis on

" The pelvic girdle and femur of the Australian aborigine."

V.Davivongs

Department of Anatomy,

The University of Adelaide.

THE PELVIC GIRDLE AND FEMUR OF THE AUSTRALIAN ABORIGINE

VIRAPUNT DAVIVONGS, M.B.

Thesis for M Sc

Department of Anatomy

University of Adelaide

Adelaide

South Australia

December, 1962

CONTENTS

SUMMARY

1. This paper presents a study of the characters and measurements of the pelvic girdle and femur in Australian aborigines. One purpose of the study is to provide an aboriginal standard for comparison with other ethnic groups. The other purpose is to assess the value of various features of the bones as sex determinants.

2. The aboriginal bones surveyed in this work do not show any marked differences from those of other ethnic groups when the means and ranges of variation are taken into account. In differentiating the aboriginal innominate bones from those of the Caucasoids and Eskimos, the pubic length is the best to be used. Some peculiarities, such as a six-segmented sacrum, sacral spina bifida and femoral platymeria, while perhaps more prevalent are not unique to Australian aborigines.

3. There are some few measurements that show no significant sex differences of the means. They are:

a. The maximum breadth of the sacrum.

b. The index of the body of the first sacral vertebra.

c. The platymeric index of the femur.

d. The angle of the femoral neck.

e. The angle of torsion of the femur.

4. Those mean measurements which show statistically significant sex differences were evaluated for sexing purposes by means of the histograms showing frequency distributions in the male and female series. The overlapping percentage of the male and female ranges was determined.

5. Sex determination by the sacrum alone is never satisfactory. The overlap of the male and female ranges is very extensive in every measurement of this bone, even in the sacral and corporo-basal indices.

6. For sex determination by the innominate bone and femur, the following criteria are recommended because they betray a small overlap between the ranges of both sexes:

a. The ischium-pubis index.
b. The length O-B of the greater sciatic notch.
c. The index II of the greater sciatic notch.
d. The vertical and antero-posterior diameters of the femoral head.
e. The circumference of the femoral head.
f. The transverse condylar breadth of the femur.

7. By one of these six criteria, the sex of 70-75 per cent of cases can be determined. By rejection of some few aberrant bones, the overlapping percentage decreases and the sex of bones, 90 per cent or more, can be identified.

8. A combination of these methods yields very much better results than using any single one. So, it is suggested in sex determination of a complete skeleton or an incomplete skeleton with several bones available.

This thesis was written from the result of my study on Australian aboriginal skeletons at the Department of Anatomy, University of Adelaide and the South Australian Museum. The work was carried out under supervision of Professor A.A. Abbie, the Elder Professor of Anatomy and Histology, University of Adelaide, with the aid of a Fellowship from W.H.O. and later from the Colombo Plan. The thesis contains no material which has been accepted for the award of any other degree or diploma in any University. There is no material previously published or written by another person except that which has been specifically indicated.

Department of Anatomy,
University of Adelaide.

INTRODUCTION

Australian aboriginal sacra, innominate bones and femora are studied and presented in this paper for two main purposes. One purpose is to find out the mean measurements and ranges of variation as an aboriginal standard for comparison with other ethnic groups. The other purpose is an attempt to determine the sex by these skeletal parts. Many measurements and indices used for the latter purpose will be evaluated.

Apart from the studies on skulls, very few works were made upon the remainder of Australian aboriginal skeletons. Turner (1886) made a study on skulls and other parts of skeletons of several ethnic groups including Australian aborigines. In his series Australian aboriginal pelves and femora were included. Unfortunately the number of bones was so few; only six adult males, an adult female and a juvenile male of this group were examined. Hepburn (1896) also employed the same collection of the aboriginal skeletons in his study on the platymeric, pilastric and popliteal indices of the femur. Stirling and Watson (1896) in their report on the work of the Horn Scientific Expedition to Central Australia recorded the measurements of the bones

of an aboriginal male skeleton obtained from Alice Springs. The bones examined were the femur, tibia, clavicle, scapula, humerus, radius, ulna, pelvic girdle, ribs and vertebrae. About these particular parts of the body, i.e. the pelvis and lower limbs, Abbie (1951) described that typical aboriginal males and females have narrow hips and long thin shanks. He also pointed out that Australian aborigines are obviously amongst the longer-legged of ethnic types. Relative sitting heights of four different groups spread across the continent, i.e. Yalata, Pintubi, Wailbri and Burera, are well under 50 per cent by means (Abbie, 1961).

Sex determination of skeletons is of great importance in the fields of anatomy, physical anthropology, forensic medicine and others. Certainly, it is possible to differentiate the sex by most of skeletal parts within limited capacity. The following statements are very important and must be cited here before concerning the problems of sex determination.

1. As a general rule, male skeletal parts are larger and more massive than female ones. The crests, ridges, tuberosities and lines attached by muscles and ligaments are more strongly marked in males. The same rule also governs the size of joints and articular surfaces.

2. The pelvic girdle bears more sex differences than those from the general rule. The differences of female pelves from male pelves are due to the female reproductive functions mainly influenced by sex hormones. It is accepted by Stewart (1954) and many others that the sex is more difficult to determine from the skull than from the pelvis.

3. Hrdlicka (Stewart, 1952) pointed out an important axiom that is the overlap of ranges of variation of male and female bones on the basis of development of sexual features. Bones in the male series would range from the hypo- to the hyper-masculine, in the female one from the hypo- to the hyper-feminine and the overlap of the two series takes place in the hypo-masculine and hypo-feminine cases. In a series of whole skeletons or any bony parts, the overlapping portion would offer difficulty or even impossibility of definite sex determination.

Dealing with some particular parts of the skeleton, the female sacrum tends to be wider but shorter than the male. In other words, the sacral index, $\frac{\text{maximum breadth of sacrum}}{\text{maximum length of sacrum}} \times 100$, is greater in the female. Another sex difference of the sacrum shown by Fawcett (1938), is the proportion of the transverse diameter of

the body of the first sacral vertebra to the maximum breadth of the sacrum. In the female, the body of the first sacral vertebra is relatively small, occupying only a little more than one-third of the maximum breadth. In the male, it is relatively very large and occupies almost one-half of the maximum breadth. So, the corporo-basal index, $\frac{\text{transverse diameter of body of S1}}{\text{maximum breadth of sacrum}} \times 100$, is generally greater in the male sacrum.

The innominate bone seems to be more valuable than the sacrum in sex determination. The important parts of this bone for the purpose belong to the ilium and pubis. One of distinguishing features of the human ilium is the proportion of the sacral part to the pelvic part of the chilotic line (Derry, 1923)(Fig. 6). Derry worked out the different means of the chilotic index, $\frac{\text{sacral portion of chilotic line}}{\text{pelvic portion of chilotic line}} \times 100$, in the two sexes. Owing to the greater area of the iliac tuberosity which is included in the sacral portion of the line and also to the narrower pelvic portion in the male, the chilotic index is usually greater in the male ilium.

Although the sex differences of the pelvic girdle were shown to be present in foetuses (Thomson, 1899), infants and children (Reynolds, 1945, 1947); it is certain that to identify the sex of adult skeletons is much easier than the young ones. This is

positively true in sex determination by the innominate bone. At puberty and certainly after that, the pubic length in the female is much greater than that in the male. This is the reason why the more obtuse subpubic angle and the triangular form of the obturator foramen are more common in the female. The public length compared with the ischial length which varies directly with stature is greater in the female than in the male. The ischium-pubis index, $\frac{\text{pubic length}}{\text{ischial length}} \times 100$, devised by Schultz (1930) tends to be greater in the female. Washburn (1948, 1949) believes that the sex of over 90 per cent of skeletons can be determined by the ischium-pubis index alone and that if it is combined with sex difference in the greater sciatic notch, the sex of the vast majority of skeletons can be determined. Further, in determining the sex of Negro skeletal material, Thieme (1957) suggested the ischium-pubis index as the best discriminating character. He also added other measurements: the oblique length of the femur, femoral head diameter, humeral length, epicondylar width of the humerus, clavicular length, sternal width and sciatic notch opening, in order to obtain better results.

The greater sciatic notch is of great interest in sex determination. In comparison with the other primates, man has a more developed sciatic notch with

the sex difference in it. The sex difference is not found in the sciatic notch of the others (Straus, 1929). Washburn (1948) pointed out that the sex difference in the greater sciatic notch belongs to a different system from that in the pubic bone and that it is not correlated with the subpubic angle. He also claimed that the sex of over 75 per cent of adult pelves can be determined by this notch alone. Unfortunately, there is no proper method to measure or describe the notch in order to clarify sex different features. Thomson (1899) described that this notch in the female is usually wider and shallower than in the male and the form of the notch depends on the relation of the sacrum to the innominate bone, its shape being modified by the degree of curvature of the sacrum. Derry (1909, 1923) has the same conclusion that the notch is relatively deep and narrow in the male and in the female the posterior margin of the notch slopes backwards in such a way as to form a wide shallow arch in striking contrast to that of the male. Letterman (1941) found that the mean greatest width of the notch is greater in the female, that the mean greatest height is greater in the male and that the distance from the posterior inferior iliac spine to the point at which the greatest height line intersects the greatest width line is shorter in the male series.

The last measurement seems to be an important sexual character. The method of study of this notch by measuring the angle formed by its anterior and posterior margins was suggested by Hanna and Washburn (1953). Allbrook and Sibthorpe (1961) in their study of pelvic dimensions in the Ganda, measured the sciatic notch angle in 66 Ganda pelvic skeletons (35 males and 31 females) by a photoscopic method. They obtained the mean value of 67° (range 55°-83°) in the male and 83° (range 73°-103°) in the female. The histogram shows that whilst the male and female distribution curves are distinct from each other, more than 50 per cent of specimens cannot be distinguished by the sciatic notch angle alone. Stewart (1954) reminded us about the incorrect expressions of this notch. By the methods mentioned above, the contour and other features of the notch would be missed. The best way that he suggested is to describe it as the eye can see. The preauricular sulcus should be recorded in this procedure. The sulcus is more common and better developed in the female. In contrast, it is infrequent and poorly developed in the male. It is, however, not a definite sex determinant as it was believed to be.

Besides its importance in estimation of stature, the femur is also useful in sex determination.

For sexing, the human femur obeys the general rule as well. Those of males are generally larger and stronger than those of females and have more pronounced muscular and ligamentous markings. But the more important feature of this bone for sex determination suggested by Dwight (1905) is the size of articular surfaces, i.e. of the femoral head and both condyles. He found that the heads of both femur and humerus are relatively small in the female and both are very valuable as a guide to the sex. Parsons (1914, 1915) in his monumental work on the characters of the medieval English femora, considered the following features in endeavouring to ascertain the sex of bones: the greatest diameter of the femoral head, femoral head index, transverse condylar breadth, least transverse diameter of the shaft, platymeric index and maximum length of the bone.

MATERIAL AND METHODS

The bones examined were: 100 sacral bones (50 males and 50 females), 100 pairs of innominate bones (50 males and 50 females) and 130 pairs of femora (75 males and 55 females). Some belong to the Department of Anatomy, University of Adelaide but most are in the South Australian Museum. All of them are from adults but their ages and sexes are not recorded. Preliminary determination of the sex was mainly based on the pelvic girdle. Most of them had complete pelvic girdles, i.e. a pair of innominate bones and a sacrum. The pelvic girdles were re-articulated for examining the subpubic angles which are helpful in sexing. The greater sciatic notches were also employed in this preliminary sexing. Whenever necessary, other skeletal parts such as skulls were examined and misdetermination of the sex would be assumed in very few cases of such a series. All skeletal parts were taken at random; only damaged bones and those with pathological changes being excluded.

The methods of measurements are those of Wilder (1920) except where stated otherwise. Each linear measurement was recorded to the nearest millimeter.

1. MEASUREMENTS OF SACRUM

Maximum length (Wilder's mid-ventral straight length)
The length from the median point of the sacral promontory to the median point of the anterior inferior border of the fifth sacral vertebra. Measured in a straight line with the sliding calipers (Fig. 1, A-B).

Maximum breadth (Wilder's anterior straight breadth)
The greatest breadth of the sacrum, measured along a line perpendicular to that of the maximum length at the level of the two alae with the sliding calipers (Figs. 1 & 2, C-D).

Mid-ventral curved length The length between the two termini of the maximum length, but this time measured along the median line on the curved anterior surface of the bone with a tape-measure.

Antero-posterior and transverse diameters of body of first sacral vertebra Taken with the sliding calipers (Fig. 2, A-E & F-G).

Indices of Sacrum

Some indices of the sacrum were calculated by the following formulae:

1. Sacral index = $\frac{\text{maximum breadth}}{\text{maximum length}} \times 100$

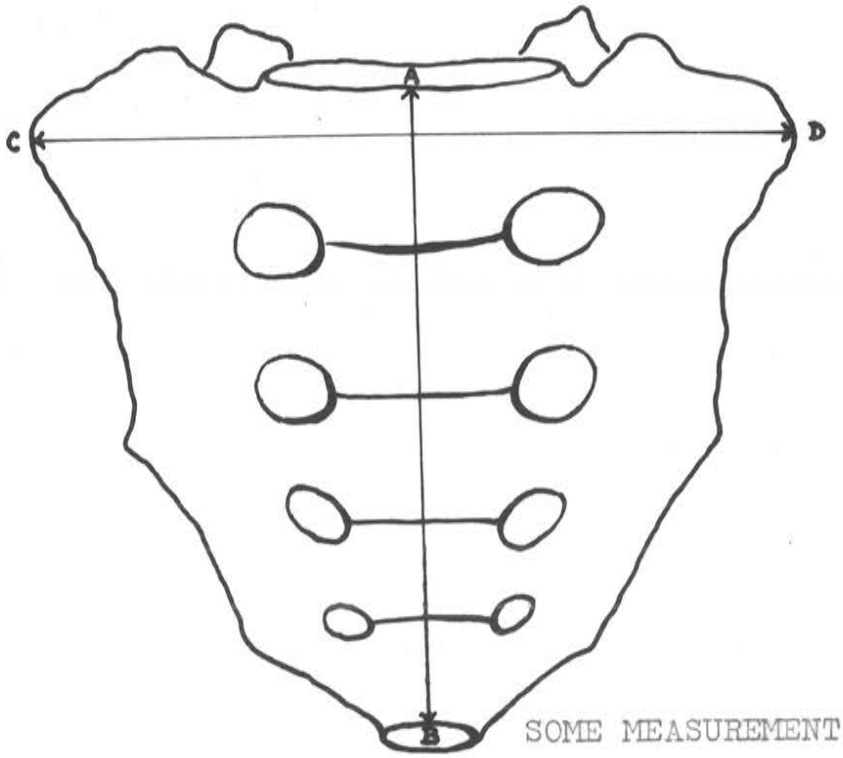


FIG. 1

SOME MEASUREMENTS OF SACRUM IN FIGS. 1 & 2

AB = Maximum length

CD = Maximum breadth

AE = A-p. diam. } of body

FG = Transverse diam. } of S.I

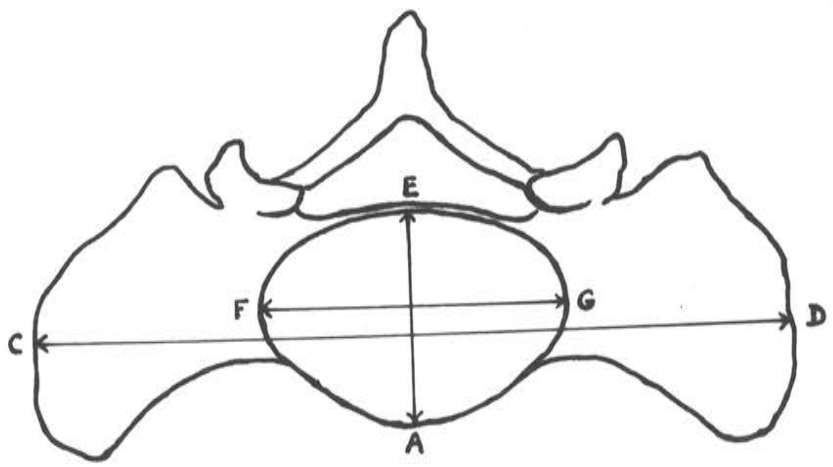


FIG. 2

2. Curvature index = $\frac{\text{maximum length}}{\text{mid-ventral curved length}} \times 100$

3. Index of body of S1 =

$$\frac{\text{antero-posterior diameter of S1}}{\text{transverse diameter of S1}} \times 100$$

4. Corporo-basal index =

$$\frac{\text{transverse diameter of S1}}{\text{maximum breadth}} \times 100$$

(Fawcett, 1938)

The number of sacral segments and certain abnormalities, i.e. the sacral spina bifida and sacralization of the last lumbar vertebra were also recorded.

2. MEASUREMENTS OF INNOMINATE BONE

Maximum length The greatest length from the iliac crest to the ischial tuberosity, taken with the osteometric board (Fig. 3, A-B).

Breadth of ilium The distance from the anterior superior iliac spine to the posterior superior iliac spine, taken with the spreading calipers (Fig. 3, C-D).

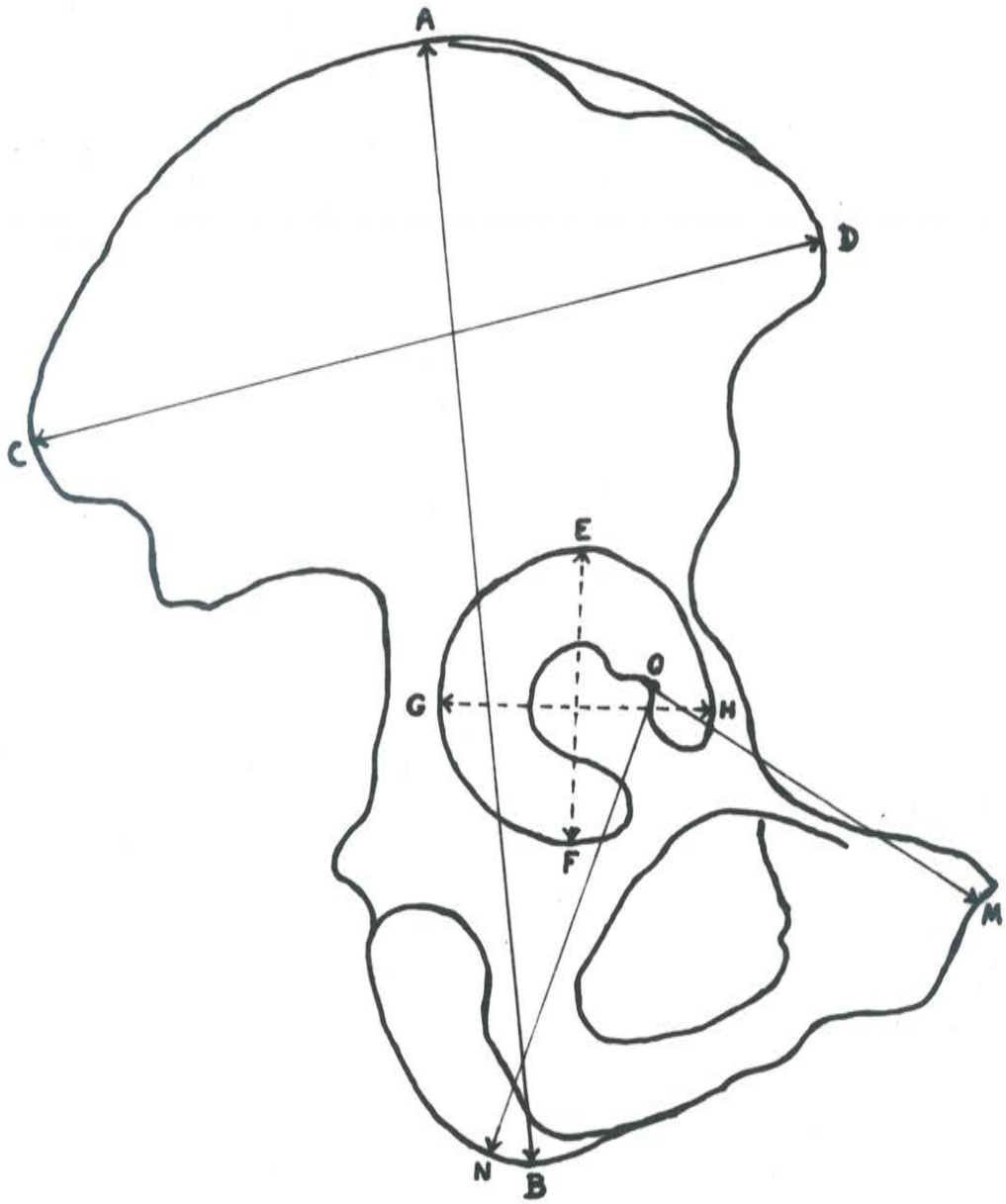


FIG.3 SOME MEASUREMENTS OF INNOMINATE BONE

AB = Maximum length
CD = Breadth of ilium
EF & GH = Vertical and transverse diameters of acetabulum
OM = Pubic length
ON = Ischial length

Length of pubic symphysis The length of the symphyseal surface of the pubis, measured with the sliding calipers.

Vertical and transverse diameters of acetabulum These two measurements are different from those of Wilder. Measured with the sliding calipers; instead of taking the middle point of the acetabular notch, it is more convenient to take from the marginal points near the two ends of the lunate articular surface to the opposite marginal points (Fig. 3, E-F & G-H).

The central point of the acetabulum was located before making further measurements. In all primates, according to Schultz (1930), this point lies approximately at the intersection of the inner edge of the articular surface of the acetabulum with a straight line prolonging the lower part of the acetabular border of the ilium downward (Fig. 3, point O). This is the point where the three main pelvic elements, the ilium, ischium and pubis, meet and is better seen before the union of these bones. Mostly, there is a notch in the inner border of the articular surface of the acetabulum at this point in the adult (Washburn, 1948).

Pubic length The maximum length from the central point of the acetabulum to the symphyseal surface of the pubis,

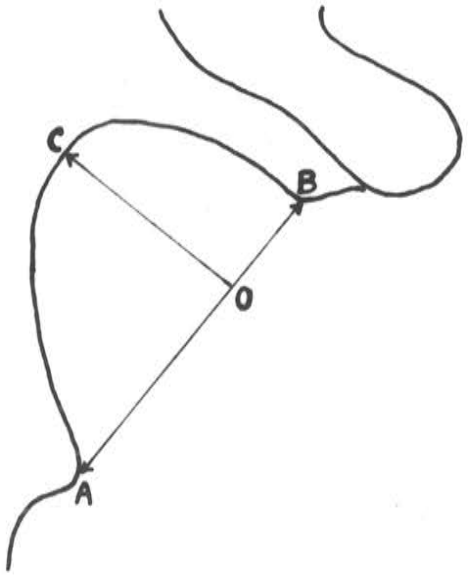


FIG.4 MEASUREMENTS OF GREATER SCIATIC NOTCH

AB = Greatest width
OC = Greatest height

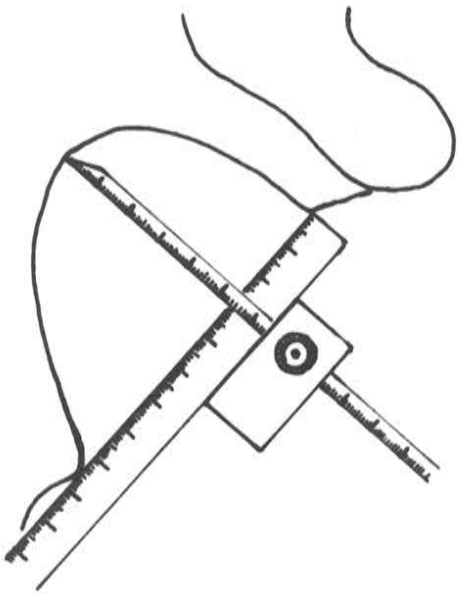


FIG.5 INSTRUMENT FOR MEASURING GREATER SCIATIC NOTCH

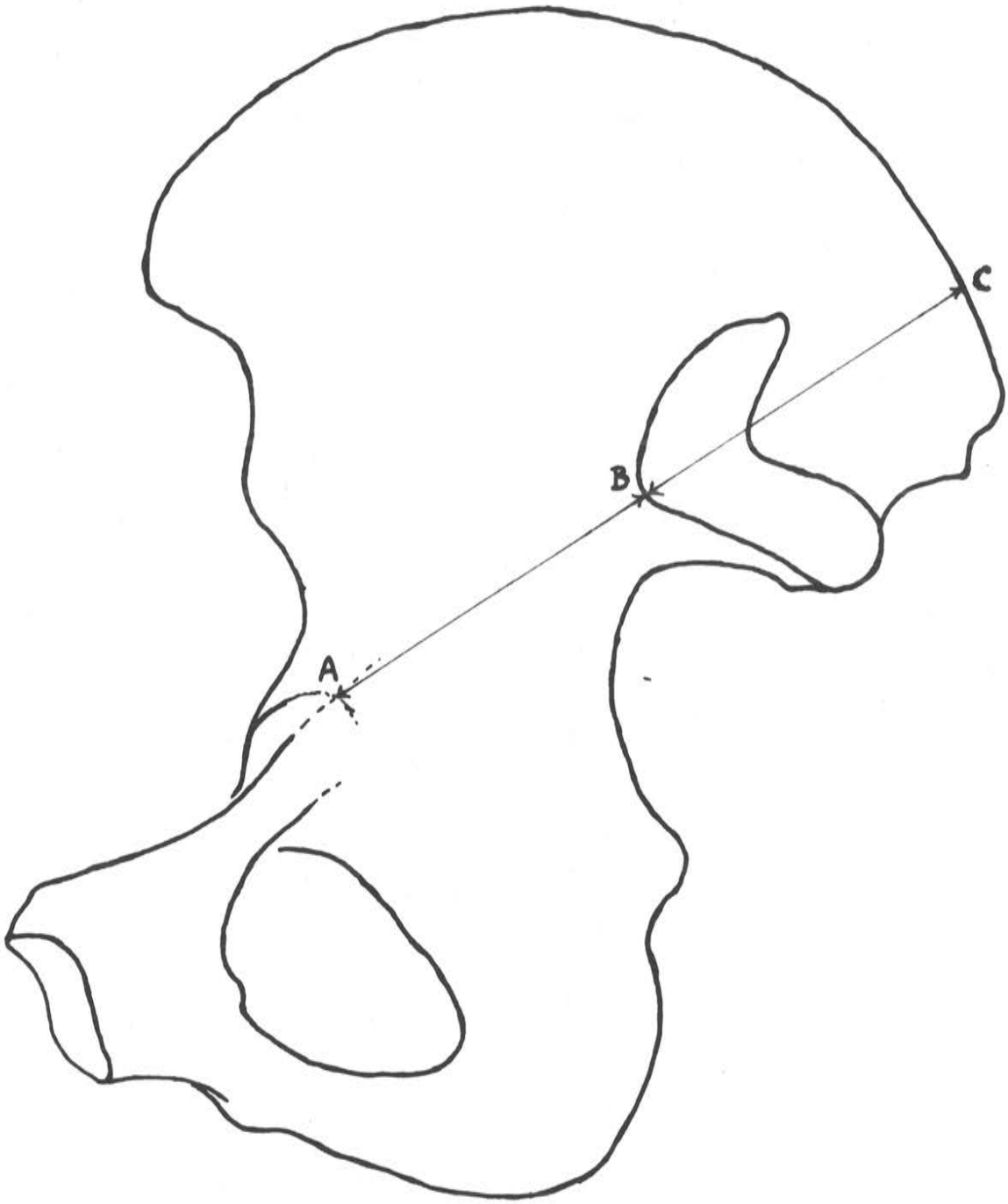


FIG.6 AC = Chilotic line of ilium
AB = Pelvic portion } of chilotic line
BC = Sacral portion }

taken with the sliding calipers (Fig. 3, O-M).

Ischial length The maximum length from the central point of the acetabulum to the lowest point on the ischial tuberosity, taken with the sliding calipers (Fig. 3, O-N).

Greater sciatic notch

As shown in Figure 4, the greatest width (A-B), the greatest height (O-C), (Olivier, 1960) and the distance from the posterior inferior iliac spine to the point at which the greatest height line intersects the greatest width line (the length O-B) were taken with the instrument seen in Figure 5.

The preauricular sulcus was also recorded.

Chilotic line of ilium (Derry, 1923) (Fig. 6)

At first, the pubo-iliac and auricular points were located. As described by Derry, the pubo-iliac point (A) is situated on the ilio-pectineal line at the site of original union of the pubis and ilium. Sometimes the site is ill-defined and the ilio-pectineal eminence is very useful in that case. The auricular point (B) is on the anterior margin of the auricular facet where this approaches nearest to the pubo-iliac point. The line joining these two points and then continued to the iliac crest is the chilotic line (A-C). The pelvic (A-B) and sacral (B-C) portions of the line

were measured with the sliding calipers.

Indices of Innominate Bone

From certain measurements of the innominate bone, the following indices were calculated:

1. Coxal index = $\frac{\text{breadth of ilium}}{\text{maximum length}} \times 100$

2. Ischium-pubis index = $\frac{\text{pubic length}}{\text{ischial length}} \times 100$

(Schultz, 1930)

3. Index I of greater sciatic notch =

$$\frac{\text{greatest height of notch}}{\text{greatest width of notch}} \times 100$$

(Olivier, 1960)

4. Index II of greater sciatic notch =

$$\frac{\text{length O-B}}{\text{greatest width of notch}} \times 100$$

5. Chilotic index = $\frac{\text{sacral part of chilotic line}}{\text{pelvic part of chilotic line}} \times 100$

3. MEASUREMENTS OF FEMUR

Lengths

1. Maximum length (Wilder's absolute length) The greatest length from the femoral head to the medial condyle, taken with the osteometric board.

2. Oblique length (Wilder's physiological length) Taken in the "oblique position" with the osteometric

board. The two condyles were placed in contact with the fixed vertical piece. The bone then lay obliquely on the board and the movable piece was slid until it touched the femoral head.

3. Trochanteric length The distance from the upper border of the greater trochanter to the most distal point of the lateral condyle, taken with the spreading calipers.

Measurements of femoral shaft

1. Subtrochanteric region Measured at a level of 3 cm. distal to the lesser trochanter. The antero-posterior and transverse diameters were taken with the sliding calipers. Then the platymeric index was calculated.

$$\text{Platymeric index} = \frac{\text{antero-posterior diameter at this level}}{\text{transverse diameter at this level}} \times 100$$

2. At middle The pilastric index was calculated from the antero-posterior and transverse diameters measured at the middle of the shaft.

$$\text{Pilastric index} = \frac{\text{antero-posterior diameter at this level}}{\text{transverse diameter at this level}} \times 100$$

3. Supracondylar region At a level of 4 cm. proximal to the posterior limit of the articular surface of the condyles, the antero-posterior and transverse diameters were measured with the sliding calipers and the popliteal index was calculated.

Popliteal index =

$$\frac{\text{antero-posterior diameter at this level}}{\text{transverse diameter at this level}} \times 100$$

Femoral head

1. Vertical diameter The greatest diameter of the femoral head measured in the vertical plane perpendicular to the axis of the femoral neck.

2. Antero-posterior diameter Measured along the antero-posterior line perpendicular to the vertical diameter and also perpendicular to the axis of the femoral neck.

These two diameters were taken with the sliding calipers.

The femoral head index was calculated as follows:

Femoral head index =

$$\frac{\text{vertical diameter of femoral head}}{\text{oblique length}} \times 100$$

Femoral condyles

Femoral condyles

1. Transverse condylar breadth (Wilder's greatest medio-lateral breadth across epicondyles or Parsons' width of lower end) Measured across the lower part of the two condyles with the sliding calipers.

2. Greatest antero-posterior diameters of lateral and medial condyles Taken with the sliding calipers.

The condylar breadth index was calculated.

Condylar breadth index =

$$\frac{\text{transverse condylar breadth}}{\text{oblique length}} \times 100$$

Circumferences

All measured with a tape-measure:

1. Circumference of the femoral head.
2. Subtrochanteric circumference of the shaft.
3. Circumference of the middle of the shaft.

Angles

1. Angle of the femoral neck (Collo-diaphysial angle or angle of inclination) The obtuse angle which the axis of the shaft forms with the axis of the head and neck of the femur. The two axes were determined by the eye on the anterior surface of the bone and long steel needles were fixed along the axes with plasticine.

The angle was measured at their intersection with a transparent protractor.

2. Angle of obliquity (Condylo-diaphysial angle)

This angle is formed by a line drawn across the condyles distally and the axis of the shaft. The angle was determined by the same procedure as above.

3. Angle of torsion (Angle of declination) This angle is formed by the axis of the femoral head and neck projected upon that of the two condyles, measured with Martin's parallelograph.

RESULTS

1. SACRUM OF AUSTRALIAN ABORIGINE

Table 1 shows the number of sacral bones examined, the means, ranges of variation and standard deviation of the male and female series. It also shows statistical significance of sex difference of each mean measurement. The detailed data appear in Appendix A.

Maximum length, maximum breadth and sacral index

For the male series, the maximum length varies from 77 to 110 mm., with a mean of 96.52 mm. For the female series, this length varies from 71 to 105 mm. which is narrower in the range than the male, with a mean of 88.12 mm. So, in average the male sacrum is longer than the female one and the sex difference of the mean lengths is highly significant.

The maximum breadth in the male series ranges from 85 to 109 mm., with a mean of 99.92 mm. In the female, the breadth varies from 92 to 113 mm., with a mean of 101.24 mm. The sex difference of the mean maximum breadths bears no statistical significance.

Because of relative shortness of the female aboriginal sacrum when compared with the male, although the mean maximum breadths are nearly the same, the mean

TABLE 1. SACRUM OF AUSTRALIAN ABORIGINE

Measurement and Index	MALE				FEMALE				Significance of sex difference
	No.	Mean	Range	Standard Deviation	No.	Mean	Range	Standard Deviation	
Maximum length	50	96.52	77 - 110	8.80	50	88.12	71 - 105	6.87	* * *
Maximum breadth	50	99.92	85 - 109	5.02	50	101.24	92 - 113	5.12	n.s.
Sacral index	50	104.16	86.9-123.2	8.93	50	115.49	96.2-140.0	10.39	* * *
Mid-ventral curved length	50	104.34	82 - 115	7.10	50	97.08	81 - 110	6.74	* * *
Curvature index	50	92.46	81.6-98.2	3.74	50	90.80	81.0-98.8	4.22	*
Body of S1									
Antero-posterior diameter	50	29.78	25 - 37	2.29	50	27.58	25 - 31	1.48	* * *
Transverse diameter	50	47.40	36 - 53	3.99	50	44.10	36 - 50	3.68	* * *
Index of S1	50	63.03	54.9-72.5	4.40	50	62.84	54.2-72.2	6.25	n.s.
Corporo-basal index	50	47.42	41.2-55.4	3.24	50	43.62	36.4-52.0	3.66	* * *

Linear measurements in mm.

Degrees of significance in Tables 1, 2, 3a and 3b: n.s. = not significant, P 0.05; * = P 0.01; * * = P 0.001; * * * = P 0.001.

sacral index in the female series would be greater than in the male. For the male, the sacral index varies from 86.9 to 123.2, with a mean of 104.16. For the female, this index has a range from 96.2 to 140.0, with a mean of 115.49. The female range of the index is also wider than the male. The sacral index is an interesting point of the study of the sacrum, especially for ethnic comparison and sex differentiation. Classification of the sacrum by the sacral index is as follows:

	Sacral index
Dolichohieric (narrow sacrum)	up to 99.9
Subplatyhieric	100 to 105.9
Platyhieric (wide sacrum)	106 and over (Comas, 1960)

By the mean value, the sacrum of the male Australian aborigines falls in the subplatyhieric group. The Japanese, Ainu and Fuegian are also in this group with the means of the index of 101.5, 102.6 and 102.6 respectively in the male series. Moreover, the means of the female sacral indices of these three groups and the Australian aboriginal females fall in the platyhieric group (Martin, 1928). For the European sacrum, both males and females fall into the platyhieric group, with a mean of 112.4 in males and 114.8 in females (Martin, 1928).

When the ranges of variation of the sacral index are considered, the sacrum of both sexes of Australian aborigines ranges from the dolichohieric to platyhieric type. Thus, ethnic differentiation by the means of both series seems to be useless. Sex differentiation by this index, again, seems to be difficult because the overlap of the male and female ranges is rather extensive. The latter problem will be considered later.

Mid-ventral curved length and curvature index

For comparison of longitudinal curvatures of the male and female sacra, the mid-ventral curved length was measured and compared with the maximum length in the form of the curvature index.

The mid-ventral curved length in the male series has a range from 82 to 115 mm., with a mean of 104.34 mm. This length in the female series ranges from 81 to 110 mm., with a mean of 97.08 mm. The female range is narrower and falls almost entirely within the male range.

The curvature index in the male varies from 81.6 to 98.2, with a mean of 92.46. For the female, this index ranges from 81.0 to 98.8 with a mean of 90.80.

The curvature seems to be more pronounced in females as indicated by the smaller mean index in this sex. However, significance of sex difference by this index is very slight and the overlap of ranges of males and females is almost complete. The small value for sex determination by the curvature index is expected.

Dimensions of body of first sacral vertebra

Because the superior surface of the body of the first sacral vertebra takes part in the lumbo-sacral articulation, therefore, according to the general rule, it is larger in the male than in the female. For the male series, the antero-posterior diameter of this surface varies from 25 to 37 mm., with a mean of 29.78 mm. and the transverse diameter varies from 36 to 53 mm., with a mean of 47.40 mm. For the female, the antero-posterior diameter ranges from 25 to 31 mm., with a mean of 27.58 mm and the transverse diameter has a range from 36 to 50 mm., with a mean of 44.10 mm. On mean values, both diameters are smaller in the female. The female ranges of the two dimensions are narrower than those of males and all fall within the male ranges. In the other words, separation of any female sacrum from the male series by these diameters is impossible.

The index of the body of the first sacral vertebra in the male has a range from 54.9 to 72.5, with a mean of 63.03. This index in the female series ranges from 54.2 to 72.2, with a mean of 62.84. The means and ranges of variation of this index in both sexes are quite close and bear no significance for sex differentiation.

Corporo-basal index

For the male series, the corporo-basal index ranges from 41.2 to 55.4, with a mean of 47.42. It ranges from 36.4 to 52.0, with a mean of 43.62 in the female series. It shows a high degree of significance of sex difference. Evaluation of this index for sex determination will be considered later.

Number of segments

From the male series of 50 sacra, there were 10 six-segmented bones (20 per cent) and 40 five-segmented bones (80 per cent). Only two six-segmented sacra (four per cent) were observed in the female series of the same number of the bones and the rest of them, 48 bones (96 per cent), were five-segmented. The higher percentage of the six-segmented sacrum in males should be noted.

Smith (1903) described a graduated series in

Australian aboriginal sacra from four segments, which is not uncommon, through four and a half, five, five and a half, to six segments. He also suggested that they illustrate the transitional character at the junction of the lumbar and sacral regions.

It should be also mentioned that the longer mean maximum length in the male series is not effected by the more common six-segmented sacrum in this sex. When the maximum length of the sacrum of this type was measured, the sixth sacral segment was excluded.

Spina bifida and lumbar sacralization

Two types of abnormalities of the sacrum were recorded in this survey. The spina bifida which the sacral canal is open posteriorly for its whole length was found in four male sacra (eight per cent of the male series)(Plate I) and nil in the female series. The bilateral lumbar sacralization was found in a male sacrum and one of the female bones had unilateral sacralization on the right side (Plate II).

In fact, the lumbar sacralization differs from the six-segmented sacrum merely by a degree of transformation from the characters of the fifth lumbar vertebra to those of the first sacral segment. If transformation was complete or nearly complete, it was recorded as a six-

TABLE 2. INNOMINATE BONE OF AUSTRALIAN ABORIGINE

Measurement and index	MALE				FEMALE				Significance of sex difference
	No.	Mean	Range	Standard Deviation	No.	Mean	Range	Standard Deviation	
Maximum length	99	197.65	178 - 221	9.39	96	181.96	165 - 195	7.27	***
Breadth of ilium	97	147.99	133 - 167	7.12	94	142.16	126 - 161	7.24	***
Coxal index	96	74.77	70.1-80.9	2.46	91	78.04	71.1-83.7	2.83	***
Length of Pubic Symphysis	84	36.25	27 - 44	3.41	62	34.52	29 - 42	3.09	**
Acetabulum -									
Vertical diam.	99	51.47	45 - 58	2.79	100	45.92	41 - 50	2.00	***
Transverse diam.	95	50.75	45 - 57	2.86	89	45.53	40 - 50	1.89	***
Pubic length	89	63.31	54 - 73	4.53	72	69.24	60 - 80	5.07	***
Ischial length	89	81.18	74 - 91	3.92	72	74.72	64 - 83	3.57	***
Ischium-pubis index	89	77.98	70.9-86,8	3.76	72	92.72	81.1-107.4	5.99	***
Greater Sciatic Notch:									
Greatest width	100	45.23	37 - 55	4.06	100	50.86	42 - 60	3.84	***
Greatest height	100	24.97	18 - 31	3.02	100	26.05	21 - 34	2.68	**
Length O-B	100	6.11	(-2)-13	2.93	100	17.27	9 - 27	3.78	***
Index I	100	55.68	37.5-77.5	8.54	100	51.38	37.9-67.3	5.54	***
Index II	100	13.45	(-4.0)-28.6	6.55	100	33.78	19.6-50.9	6.34	***
Chilotic line:									
Sacral part	97	64.01	50 - 77	5.24	97	56.74	47-68	4.66	***
Pelvic part	97	49.91	36 - 58	4.09	97	58.23	49 - 70	4.64	***
Chilotic index	97	129.26	94.3-197.2	16.46	97	98.16	73.1-138.8	12.41	***

Linear measurements in mm.

segmented sacrum. If only the transverse processes of the fifth lumbar vertebra were enlarged and articulated with a part of the upper surface of the lateral mass of the sacrum, it was recorded as the lumbar sacralization. Furthermore, the sacralization might be limited to one or other side.

The sacral spina bifida was also observed by Smith (1903) in a female aboriginal sacrum together with the unilateral sacralization on the left side of the same bone.

2. INNOMINATE BONE OF AUSTRALIAN ABORIGINE

The findings are shown in Table 2 in the separate male and female series together with the significance of sex difference. The detailed data appear in Appendix B.

Maximum length, breadth of ilium and coxal index

For the male series, the maximum length of the innominate bone ranges from 178 to 221 mm., with a mean of 197.65 mm. For the female, it has a narrower range from 165 to 195 mm., with a mean of 181.96 mm. The breadth of the ilium in the male varies from 133 to 167 mm., with a mean of 147.99 mm. For the female series, it ranges from 126 to 161 mm., with a mean of

142.16 mm. As the general rule, these two mean dimensions in males are greater than in females and show high degrees of the significance for sex differences.

The coxal index in the male series ranges from 70.1 to 80.9, with a mean of 74.77. This index in the female series ranges from 71.1 to 83.7, with a mean of 78.04. The greater mean coxal index in females indicates the relative broadness of the ilium in this sex.

Although the mean maximum length, iliac breadth and coxal index are highly significant for sex difference, the male and female ranges overlap so widely that the three features have very little value in sex identification.

Length of pubic symphysis

This length in the male series varies from 27 to 44 mm., with a mean of 36.25 mm. In the female, it ranges from 29 to 42 mm., with a mean of 34.52 mm. Sex difference of the mean lengths is significant in a moderate degree. However, the female range is narrower and falls entirely within the male range so that separation of the female bones from the male is impossible.

Diameters of acetabulum

According to the general rule, the hip joint tends to be larger in the male, thus the male acetabulum is expected to be larger than the female acetabulum. In the male series, the vertical diameter of the acetabulum varies from 45 to 58 mm., with a mean of 51.47 mm. and the transverse diameter ranges from 45 to 57 mm., with a mean of 50.75 mm. For the female, the vertical diameter has a range from 41 to 50 mm., with a mean of 45.92 mm. and the range of the transverse diameter is from 40 to 50 mm., with a mean of 45.53 mm. In both sexes the mean transverse diameter is slightly smaller than the mean vertical diameter. High significance of sex difference is obvious in both diameters. Their value for sex determination will be analysed later.

Pubic length, ischial length and ischium-pubis index

For the male series, the pubic length ranges from 54 to 73 mm., with a mean of 63.31 mm. and for the female series, it ranges from 60 to 80 mm., with a mean of 69.24 mm. The mean pubic length is longer in females.

The ischial length in the male series varies from 74 to 91 mm., with a mean of 81.18 mm. For the female series, the length ranges from 64 to 83 mm., with

a mean of 74.72 mm. This time, the mean ischial length is shorter in females.

The ischium-pubis index in the male has a range from 70.9 to 86.8, with a mean of 77.98. For the female series, it ranges from 81.1 to 107.4, with a mean of 92.72. It should be noted that the range of the female series is wider than that of the male and the overlap of the ranges is very small. The sex difference of these mean indices is quite obvious. The value of the index for sex determination will be considered.

Greatest width, greatest height and index I of greater sciatic notch

The fact that the female greater sciatic notch is wider than the male notch (Thomson, 1899, Derry, 1923 and Letterman, 1941) is confirmed by the present work. For the male, the range of the greatest width of the notch is from 37 to 55 mm., with a mean of 45.23 mm. For the female, it is from 42 to 60 mm., with a mean of 50.86 mm. The sex difference of the means is highly significant.

The greatest height in the male series ranges from 18 to 31 mm., with a mean of 24.97 mm. In the female series, it is from 21 to 34 mm., with a mean of

26.05 mm. The mean greatest height is greater in the female and the sex difference of the means is moderately significant. This result is not comparable to Letterman's work (1941) which he found that the mean greatest height is greater in the males.

The index I which is the ratio of the greatest height to the greatest width per 100, for the male series, has a range from 37.5 to 77.5, with a mean of 55.68. The range is narrower in the female series and all cases fall within the male range. For the female series, it is from 37.9 to 67.3, with a mean of 51.38.

Sex differences are obvious by these two measurements and the index I. Even so, the value for sex determination by them seems to be unsatisfactory because of the wide overlap of male and female ranges. Especially for the index I, all cases in the female series fall within the male range. Therefore, it is impossible to separate any female bone from the male series by using this index alone.

Length O-B and index II of greater sciatic notch

When a large number of the greater sciatic notches are examined in both male and female series, it reveals that many of male bones have a form of the notches which is different from that of the female notches.

The typical male greater sciatic notch is J-shaped (Plate III, Fig. A) whereas the typical female notch is parabolic (Plate III, Fig. B). One of the metrical characters that expresses this difference is the distance from the posterior inferior iliac spine to the point where the greatest height line meets the greatest width line: the length O-B (Fig. 4). This length is expected to be shorter in males and very much longer in females. It is also expected a number of the bones in both series to possess an intermediate form of the notch (Plate III, Figs. C & D) and these bones will cause overlap.

For the male series, the length O-B ranges from -2 to + 13 mm., with a mean of +6.11 mm. This length in the female ranges from 9 to 27 mm., with a mean of 17.27 mm. The sex difference is highly significant and the overlap of the ranges is small.

The index II of the notch in the male series has a range from -4.0 to +28.6, with a mean of +13.45. This index in the female series ranges from 19.6 to 50.9, with a mean of 33.78. Again, the sex difference of the means is obvious and the overlap of the ranges is small.

Chilotic line and chilotic index

The length of the sacral part of the chilotic line in the male ranges from 50 to 77 mm., with a mean of 64.01 mm. It ranges in the female series from 47 to 68 mm., with a mean of 56.74 mm. The female range is narrower and the mean length is also shorter than males.

The length of the pelvic part of the line in the male varies from 36 to 58 mm., with a mean of 49.91 mm. For the female, the range is from 49 to 70 mm., with a mean of 58.23 mm. This time the mean length in females is longer.

The chilotic index in the male series has a range from 94.3 to 197.2, with a mean of 129.26. In the female series, it is from 73.1 to 138.8, with a mean of 98.16. The mean chilotic index is smaller in the female. The female range of variation is also narrower than the male range. The overlap between the male and female ranges is small which indicates the great value for sex determination.

The mean value of the length of the chilotic line, obtained from summation of the mean sacral and pelvic chilotic lengths, in the male series is 113.92 mm. It is 114.97 mm., which is slightly longer, in the

female. This result is different from Derry's (1923) findings. In his paper, the mean total lengths of the line in English innominate bones from Whitechapel and Egyptian bones, both dynastic (2500-2000 B.C.) and predynastic, are longer in the male than in the female. However, in his series of Kerma in the Sudan the male and female lengths are nearly the same.

Preauricular sulcus

Observation on the preauricular sulcus gives an interesting result. In 100 male innominate bones, a small and shallow sulcus was found in 49 (49 per cent), while the remaining 51 (51 per cent) showed no trace of the sulcus. In contrast, from the same number of female bones, absence of the sulcus was observed in only 10 (10 per cent), a small and shallow sulcus was found in 31 (31 per cent) and 59 (59 per cent) had a very deep and wide sulcus. While the male and female innominate bones have the small shallow sulcus or absence of the sulcus in common, only in the female bones have the deep and wide sulci.

3. FEMUR OF AUSTRALIAN ABORIGINE

Measurements and indices of the femur are shown in Tables 3a and 3b and the detailed data are in Appendix C.

TABLE 3a. FEMUR OF AUSTRALIAN ABORIGINE

Measurement and index	MALE				FEMALE				Significance of sex difference
	No.	Mean	Range	Standard Deviation	No.	Mean	Range	Standard Deviation	
Maximum length	150	447.73	405-502	18.55	110	423.59	378-470	20.83	***
Oblique length	150	444.13	405-498	18.00	110	419.21	374-470	25.06	***
Trochanteric length	149	423.66	385-478	18.52	110	402.47	358-456	20.49	***
Subtrochanteric region:									
Antero-posterior diam.	150	22.91	18-29	1.88	110	20.40	16-25	1.86	***
Transverse diam.	150	29.01	24-34	2.06	110	25.95	23-29	1.69	***
Platymeric index	150	79.18	62.1-100.0	6.52	110	78.81	62.1-96.2	7.42	n.s.
Circumference	150	83.05	72-95	5.21	110	74.44	64-85	4.36	***
Middle of shaft									
Antero-posterior diam.	149	27.56	21-37	2.62	109	23.88	18-30	2.62	***
Transverse diam.	149	24.65	21-29	1.67	109	22.41	19-26	1.30	***
Pilastric index	149	111.99	84.6-134.6	9.95	109	106.61	86.4-131.6	9.80	***
Circumference	149	82.45	70-105	5.93	109	72.83	61-84	4.87	***
Supracondylar region									
Antero-posterior diam.	149	26.93	22-34	2.01	109	22.88	19-28	1.78	***
Transverse diam.	149	36.85	31-45	3.33	109	34.02	27-44	3.41	***
Popliteal index	149	73.36	60.5-90.6	5.37	109	67.40	56.4-82.1	4.79	***

Linear measurements in mm.

TABLE 3b. FEMUR OF AUSTRALIAN ABORIGINE (cont.)

Measurement and index	MALE				FEMALE				Significance of sex difference
	No.	Mean	Range	Standard Deviation	No.	Mean	Range	Standard Deviation	
Femoral Head									
Vertical diam.	150	43.05	39 - 50	2.09	110	38.16	35 - 42	1.30	***
Antero-posterior diam.	150	42.72	39 - 50	2.10	110	37.87	35 - 41	1.22	***
Femoral Head index	150	9.70	8.9-10.7	0.38	110	9.11	8.1 - 10.1	0.38	***
Circumference	150	136.15	124 - 158	6.60	110	120.62	110 - 130	3.87	***
Femoral Condyles									
Transverse Cond. breadth	148	69.88	60 - 84	2.81	106	61.32	54 - 67	2.74	***
A-P diam of lateral Cond.	148	60.49	50 - 70	3.17	107	54.96	49 - 59	2.32	***
A-P diam of medial Cond.	149	59.85	51 - 72	3.42	105	53.49	49 - 60	2.47	***
Condylar breadth index	148	15.74	13.7-17.4	0.80	106	14.66	13.1-15.9	0.58	***
Angles									
Angle of neck	150	127.83	117 - 142	4.25	110	127.26	114 - 139	4.99	n.s.
Angle of obliquity	150	9.01	3 - 13	1.78	110	9.96	4 - 15	2.19	***
Angle of torsion	149	22.29	3 - 43	7.95	109	24.38	2 - 50	8.91	n.s.

Linear measurements in mm.

Appendix 2.

Lengths

The maximum length of the femur in the male series ranges from 405 to 502 mm., with a mean of 447.73 mm. In the female, the maximum length has a range of 378 to 470 mm., with a mean of 423.59 mm.

The oblique length in the male ranges from 405 to 498 mm., with a mean of 444.13 mm. and in the female series from 374 to 470 mm., with a mean of 419.21 mm.

For males the trochanteric length ranges from 385 to 478 mm., with a mean of 423.66 mm. and for females from 358 to 456 mm., with a mean of 402.47 mm.

The male femur as indicated by the three mean lengths is longer than the female one. The significance of sex difference of the means is high. Unfortunately, all of them betray the wide overlap of the male and female ranges and the value of these lengths in sex determination is therefore very small. In Plate IV, the male and female aboriginal femora of the average lengths and other average dimensions are shown for comparison. The great discrepancy in size between the male and female femoral heads should be noted in the photograph.

In comparison of the oblique length between the right and left sides, the mean oblique length on the right side is 444.04 mm. and on the left side is 444.23 mm. for the males. For the females, it is 419.18 mm. on the right side and 419.24 mm. on the left. In both sexes the left femur is more frequently longer than the right. Garson (1879) reported the inequalities in length of the femur, tibia and lower limbs: he found that the left femur and left lower limb are more commonly longer than those on the right. He also found that the inequalities were not confined to any particular age, sex or race.

Shaft dimensions

According to the general rule, the shaft of the femur at any level in males is more robust than in females. The antero-posterior and transverse diameters and also the circumference of the shaft should reveal this.

1. Subtrochanteric region

The antero-posterior diameter at this region of the shaft in the male series has a range from 18 to 29 mm., with a mean of 22.91 mm.; in the females, the range is from 16 to 25 mm., with a mean of 20.40 mm. For the male series, the transverse diameter ranges from

24 to 34 mm., with a mean of 29.01 mm. and for the females it ranges from 23 to 29 mm., with a mean of 25.95 mm. The results in both diameters support the general rule. In both dimensions the female ranges of variation are narrower than the male. The circumference of the shaft in the male series ranges from 72 to 95 mm., with a mean of 83.05 mm. For the females, it varies from 64 to 85 mm., with a mean of 74.44 mm. The mean circumference in the males is certainly greater than in the females.

In males the platymeric index has a range from 62.1 to 100.0, with a mean of 79.18. For the female series, the index has a narrower range from 62.1 to 96.2, with a mean of 78.81. The female mean index is slightly smaller than that of the male, but sex difference of the means is not significant.

Platymeria and the platymeric index must be discussed here in brief. According to the platymeric index, the femur is classified into three groups:

	Platymeric index
Platymeric	up to 84.9
Eurymeric	85 to 99.9
Stenomeric	100 and over

(Comas, 1960)

It is known that platymeria is much more

common in prehistoric races (Townsley, 1946). Platymeria was also found in the medieval English femora (Parsons, 1914). At present, it is not uncommon in some ethnic groups. According to the mean index, the femur in the present aboriginal series is in the platymeric group in both sexes. The femur of the New Zealand Maori is more platymeric than that of the Australian aborigine, the mean index being 65.2 for male Maoris and 62.4 for females (Schofield, 1959). When the platymeric index is viewed from the aspect of the range of variation: in the present series both male and female aboriginal femora vary from platymeric to eurymeric forms, while in the males two bones are well in the stenomeric group. The wide normal range of variation of this index is quite apparent. Abbie (1951) concluded that the occurrence of platymeria and platycnemia and a corresponding narrowing of the humerus are now known to hold no ethnological significance, being probably of nutritional origin (Buxton, 1938).

So far as sex determination is concerned, all measurements at this region of the shaft and the platymeric index have very little value because of the wide overlap of male and female ranges.

2. Middle of shaft

At the middle of the shaft, the mean antero-

posterior and transverse diameters and the mean circumference are greater in the males. The antero-posterior diameter in the males varies from 21 to 37 mm., with a mean of 27.56 mm. and it ranges in the females from 18 to 30 mm., with a mean of 23.88 mm. For the male series, the transverse diameter ranges from 21 to 29 mm., with a mean of 24.65 mm. and in the female series from 19 to 26 mm., with a mean of 22.41 mm. The circumference in the male series has a range from 70 to 105 mm., with a mean of 82.45 mm.; in the female series the range is narrower, from 61 to 84 mm. with a mean of 72.83 mm.

The pilastric index in the males ranges from 84.6 to 134.6, with a mean of 111.99 and in the females it has a narrower range from 86.4 to 131.6, with a mean of 106.61. The mean index is obviously greater in males. The linea aspera is also more pronounced in males and many of male bones show the so-called pilaster.

These three measurements and the pilastric index, however, have a little value for sex determination because the overlap of male and female ranges is very extensive. Especially for the pilastric index, the whole female range falls within the male range; hence separation of the female bones from the males by this index alone is impossible.

3. Supracondylar region

The antero-posterior diameter at the supra-condylar region in the males varies from 22 to 34 mm., with a mean of 26.93 mm. and in the females it varies from 19 to 28 mm., with a mean of 22.88 mm. For the male series, the transverse diameter ranges from 31 to 45 mm., with a mean of 36.85 mm. and for the female series from 27 to 44 mm., with a mean of 34.02 mm.

The popliteal index in the male series ranges from 60.5 to 90.6, with a mean of 73.36 and in the females from 56.4 to 82.1, with a mean of 67.40.

Both mean diameters and the mean popliteal index are greater in males and the sex differences of the means are highly significant. But all of these have widely overlapping male and female ranges and they are not useful sex indicators.

Femoral head

According to Dwight (1905), the femoral head is important for sex determination. In the present study on the Australian aboriginal femora, the size of the femoral head as determined by the vertical and antero-posterior diameters and the circumference is greater in males than in females.

In Plate V (Fig. A) two male femora of the

largest and the average-sized femoral heads were taken together with two female femora of the average- and the smallest-sized heads for comparison. From the photograph which shows gradation in size of this particular part, the discrepancy in size of the average male and female femoral heads is very obvious and can be easily detected by the eye.

The vertical diameter of the femoral head in males ranges from 39 to 50 mm., with a mean of 43.05 mm. and in females from 35 to 42 mm., with a mean of 38.16 mm. For the male series, the antero-posterior diameter ranges from 39 to 50 mm., with a mean of 42.72 mm. and for the female series, it ranges from 35 to 41 mm., with a mean of 37.87 mm. The femoral head circumference in males has a range from 124 to 158 mm., with a mean of 136.15 mm.; in females the range is from 110 to 130 mm., with a mean of 120.62 mm.

An important finding in these three measurements is the markedly small overlap of male and female ranges. This indicates a high value for sex determination and it will be determined later.

The femoral head index in the male varies from 8.9 to 10.7, with a mean of 9.70 and in the female from 8.1 to 10.1, with a mean of 9.11. The overlap between male and female ranges is rather wide and this index

seems to have a little value for sexing.

Femoral condyles

In males the transverse condylar breadth varies from 60 to 84 mm., with a mean of 69.88 mm. and in females from 54 to 67 mm., with a mean of 61.32 mm. The antero-posterior diameter of the lateral condyle in the male ranges from 50 to 70 mm., with a mean of 60.49 mm. and in the female it has a range from 49 to 59 mm., with a mean of 54.96 mm. The antero-posterior diameter of the medial condyle in the male varies from 51 to 72 mm., with a mean of 59.85 mm.; in the female the range is from 49 to 60 mm., with a mean of 53.49 mm.

In all measurements of the condyles, the female mean is smaller than the male and the female range is much narrower than the male range. There is a wide overlap of male and female ranges in the antero-posterior diameters of both condyles. The overlap in the transverse condylar breadth series, on the other hand, is rather small. So, the latter might be used as an indicator of the sex. The lower ends of the four femora previously selected for comparing the size of the femoral head are shown in Plate V (Fig. B). Differences in size of the lower ends can be noticed in the photograph.

The condylar breadth index in males ranges from 13.7 to 17.4, with a mean of 15.74 and in females from

13.1 to 15.9, with a mean of 14.66. The mean index in the female is smaller and the female range is narrower. The wide overlap between male and female ranges indicates a low value of this index for sex determination.

Angle of femoral neck

About the sex difference of this angle, Humphry (1889) found that it is smaller in short bones than in long bones and likely to be small when the pelvis is wide. The combination of these two conditions, then, renders it usually smaller in females than in males. In contrast, the figures given by Martin (1928) and by Schofield (1956) show the average male angles smaller than those of females. The latter is from a study of femora of Maoris. The mean angle for Maori male femora is 136.3° and for females 137.6°. Both means are greater than those of Australian aborigines. Parsons (1914) in measurements of 300 medieval English femora found the male mean angle 126.4°, with a range from 112° to 140° and the female 125.5°, with a range from 114° to 134°. He concluded that the angle of the neck is of no value as an indication of the sex.

In the present study on the Australian aboriginal femora, this angle in the male series ranges

from 117° to 142°, with a mean of 127.83°. In the female, it ranges from 114° to 139°, with a mean of 127.26°. There is no significant sex difference in this angle. The result supports Parson's statement.

Angle of obliquity

For males this angle varies from 3° to 13°, with a mean of 9.01° and for females from 4° to 15°, with a mean of 9.96°. It is obvious that the female mean angle is greater than the male mean. The result is quite comparable to those of Parsons (1914) and Schofield (1959). The greater obliquity of the femoral shaft in females is partly caused by the wider pelvis and shorter femur in this sex. So far as sex determination is concerned, however, this angle is valueless because of the wide overlap of male and female ranges.

Angle of torsion

In the male series, the angle of torsion ranges from 3° to 43°, with a mean of 22.29°. The range in females is from 2° to 50° which is wider than males and the mean is 24.38°. There is no significant sex difference of the means.

Extraordinarily wide ranges of variation in this angle were observed in both sexes. A similar

result was shown by Parsons (1914). In his report, the male range of this angle is from -13° to $+40^{\circ}$, with a mean of $+13.0^{\circ}$ and in the female from -12° to $+34^{\circ}$, with a mean of $+17.0^{\circ}$. Pick et al (1941) also gave support to this finding in their study on 150 femora of which about 5 per cent are female. The angle of torsion ranges from -18° to $+41^{\circ}$, with a mean of $+14.01^{\circ}$.

In the present series of Australian aborigines, only positive angles were observed. Schofield (1959) also found no negative torsional angle in Maoris.

4. Evaluation of some measurements for sex determination

Most of the means of the measurements and indices have been shown statistically to bear significant sex differences. Those which show high degrees of significance and at the same time show small overlapping ranges of variation are selected for the purpose. Evaluation of these measurements and indices for sex determination can be carried out by using the histograms showing frequency distributions in the male and female series and percentage of the overlap between both series will be obtained. The value for sex determination varies inversely with percentage of the overlap, that is when the percentage is small the value is high and vice versa.

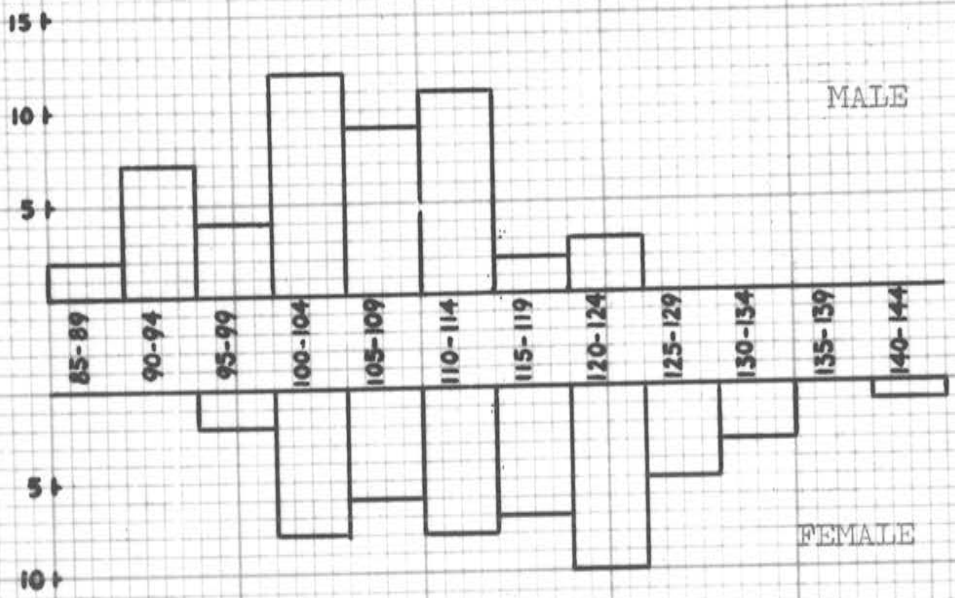


FIG.7 DISTRIBUTION OF SACRAL INDEX

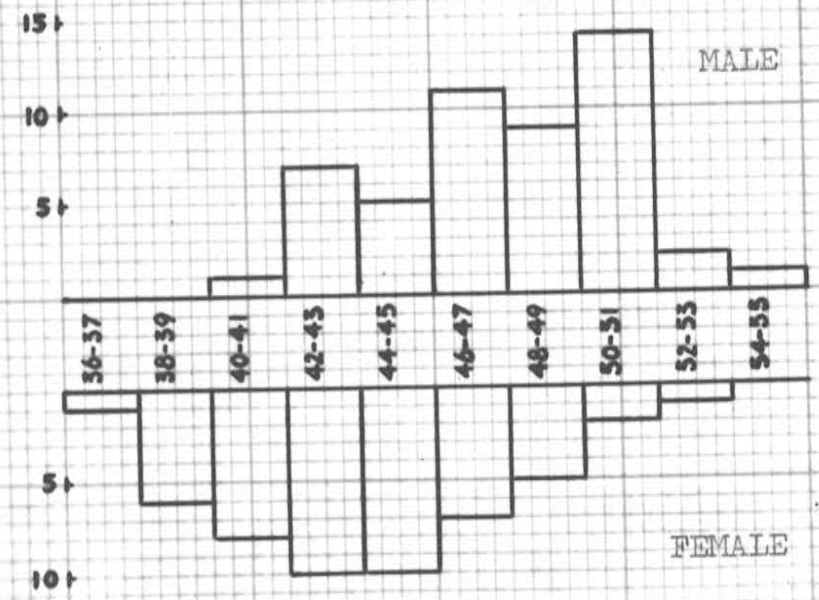


FIG.8 DISTRIBUTION OF CORPORO-BASAL INDEX OF SACRUM

A. SACRUM

Sacral and corporo-basal indices

Frequency histograms of the sacral index in both sexes (Fig. 7) show a wide overlapping range from 95 to 124. The number of sacra that lie in the overlapping area is 82 (82 per cent). Little value for sex determination would be expected from the sacral index. An even worse result is obtained when using the corporo-basal index (Fig. 8). The range of the overlap in this series is from 40 to 53 and the number of bones in this range is 92 (92 per cent).

Other measurements of the sacrum yield more overlapping ranges than these two indices. It must be concluded that sex determination by the sacrum in Australian aborigines is unsatisfactory and unreliable.

B. INNOMINATE BONE

Ischium-pubis index

A better sexual distinction is obtained with the ischium-pubis index. From the total of 161 innominate bones in both sexes, 45 bones (28 per cent) fall within the overlap which ranges from 80 to 87 (Fig. 9). At the index level of 80-81, there are 17 males and only one female or the chance to be the male is greater than

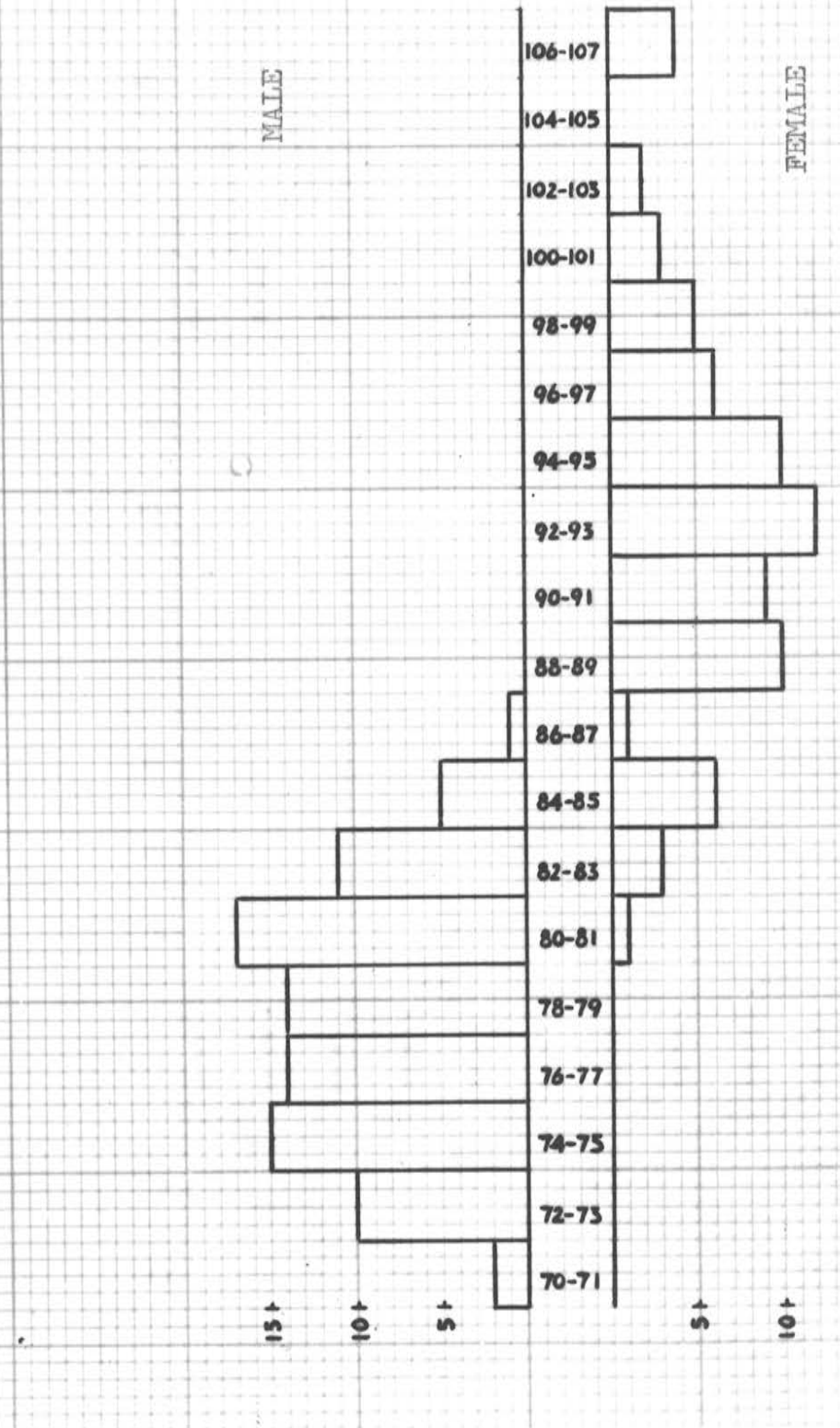


FIG.9 DISTRIBUTION OF ISCHIUM-PUBIS INDEX

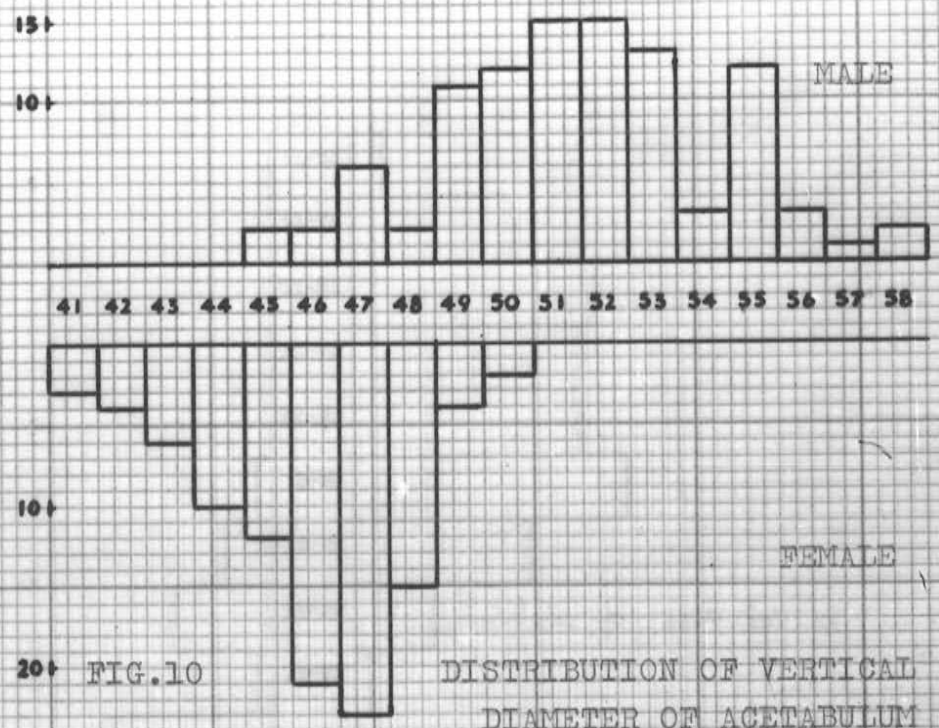


FIG.10 DISTRIBUTION OF VERTICAL DIAMETER OF ACETABULUM

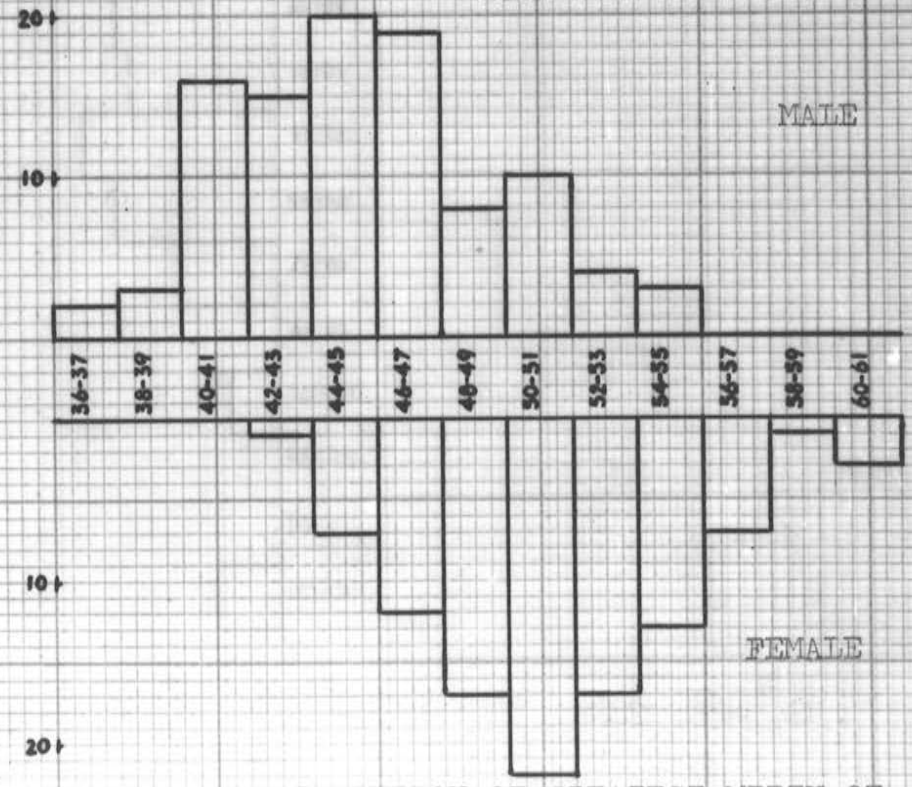


FIG.11 DISTRIBUTION OF GREATEST WIDTH OF GREATER SCIATIC NOTCH

the female by a ratio of 17 to 1. If this aberrant female bone is removed the percentage overlap drops to 17 per cent. The index is very valuable for sex determination.

Vertical diameter of acetabulum and greatest width of greater sciatic notch

The size of the acetabulum is a poor sex indicator. As seen from the frequency histograms of the vertical diameter of the acetabulum (Fig. 10), the bones in the overlapping area are 112 (56 per cent) from the total of 199. Again, when the greatest width of the greater sciatic notch is analysed by the same way (Fig. 11), the overlap is up to 84 per cent, i.e. 168 bones in the overlap, hence the low value for sex determination.

Length O-B and index II of greater sciatic notch

Although the greatest width and also the greatest height of the greater sciatic notch have a low value for sex determination, the contour of the notch is very helpful. The typical J-shaped form in males, the typical parabolic form in females and also the intermediate form in both sexes have already been described. The length O-B (Fig. 4) and the index II of the notch have been proposed for differentiation of these two typical forms.

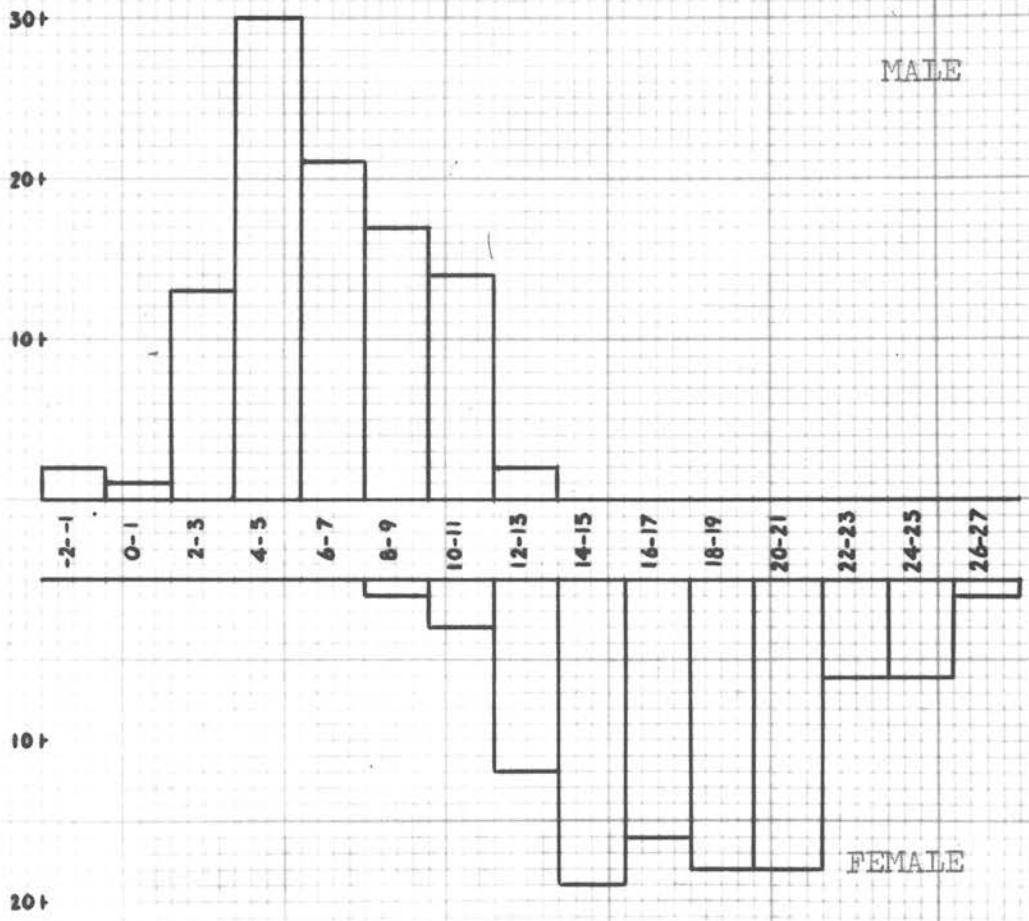


FIG.12 DISTRIBUTION OF LENGTH O-B OF GREATER SCIATIC NOTCH

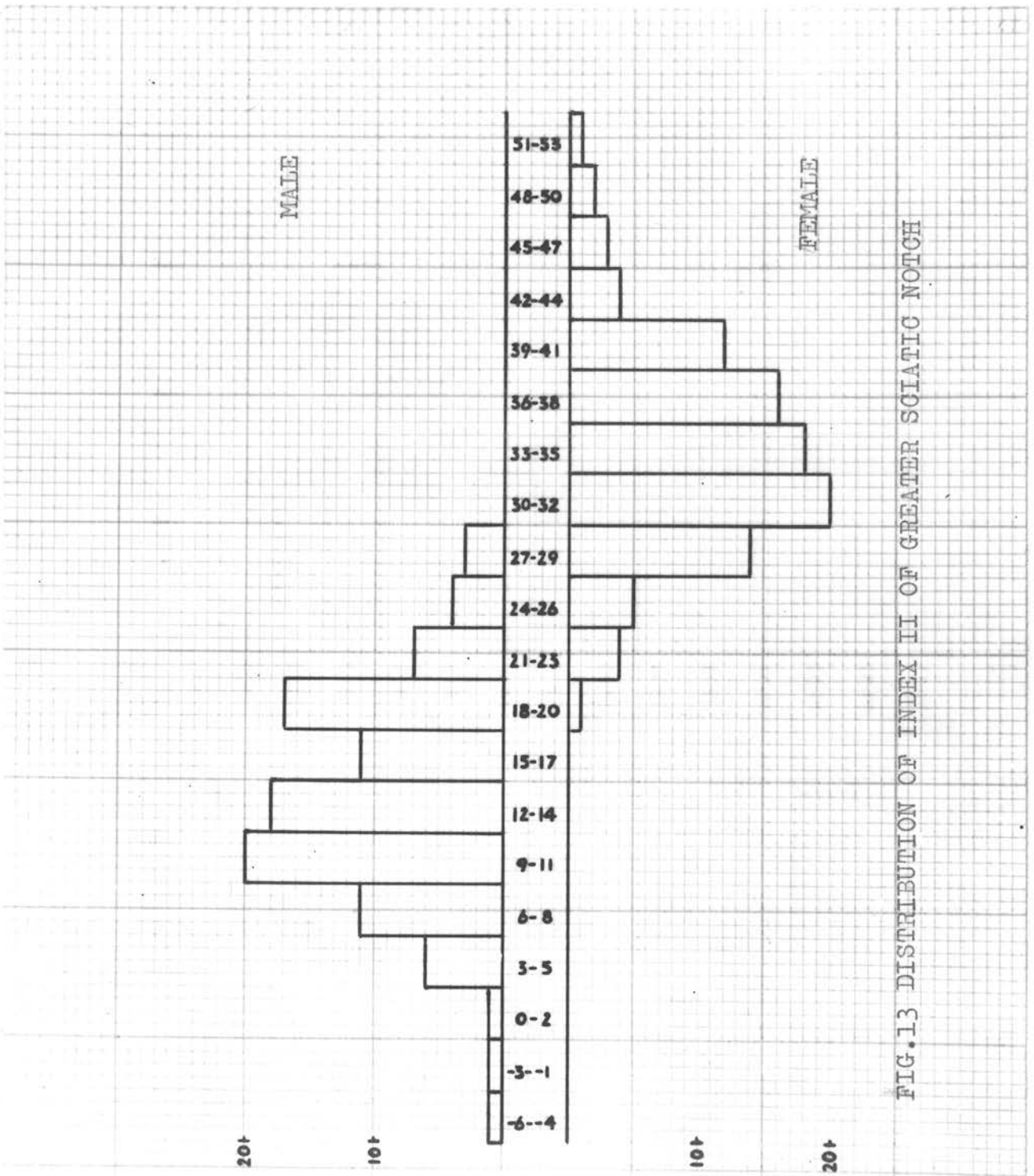


FIG.13 DISTRIBUTION OF INDEX II OF GREATER SCIATIC NOTCH

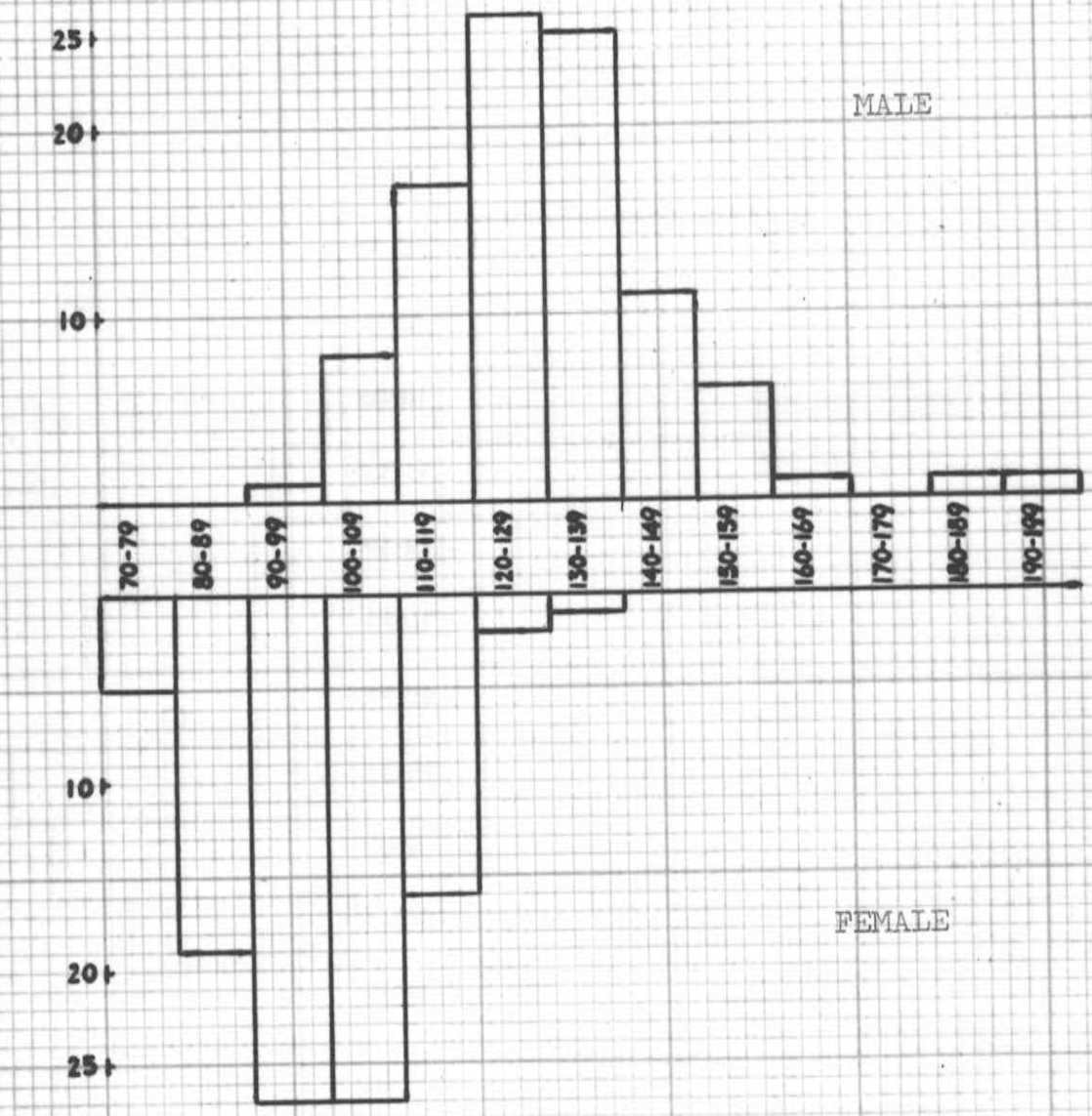


FIG.14 DISTRIBUTION OF CHILOTIC INDEX OF INNOMINATE BONE

As shown by the frequency histograms of the length O-B (Fig. 12) and the index II (Fig. 13), the overlapping parts are very small. In the former case the overlapping area has 49 innominate bones from the total of 200, i.e. 24.5 per cent. This rather high percentage is due to three aberrant bones. When a female bone of the length (O-B) of 8-9 mm. and two male bones of 12-13 mm. are rejected, the bones in the overlap are only 17 or 8.5 per cent. As far as the index II of the notch is concerned, the originally overlapping part has 55 bones or 27.5 per cent and after removal of four scattered bones, i.e. a female bone of the index of 18-20 and three male bones of 27-29 index range, the bones left in the overlap are 20 or only 10 per cent.

Chilotic index

The chilotic index is less valuable for sex determination because of a high percentage of overlap. There are 150 bones from the total of 194, i.e. 77 per cent in the overlap (Fig. 14). Thus, only 23 per cent of the whole series can be definitely sexed by this index.

C. FEMUR

Maximum length

The length of any long bone is known to be a very poor sex indicator. In this series the frequency

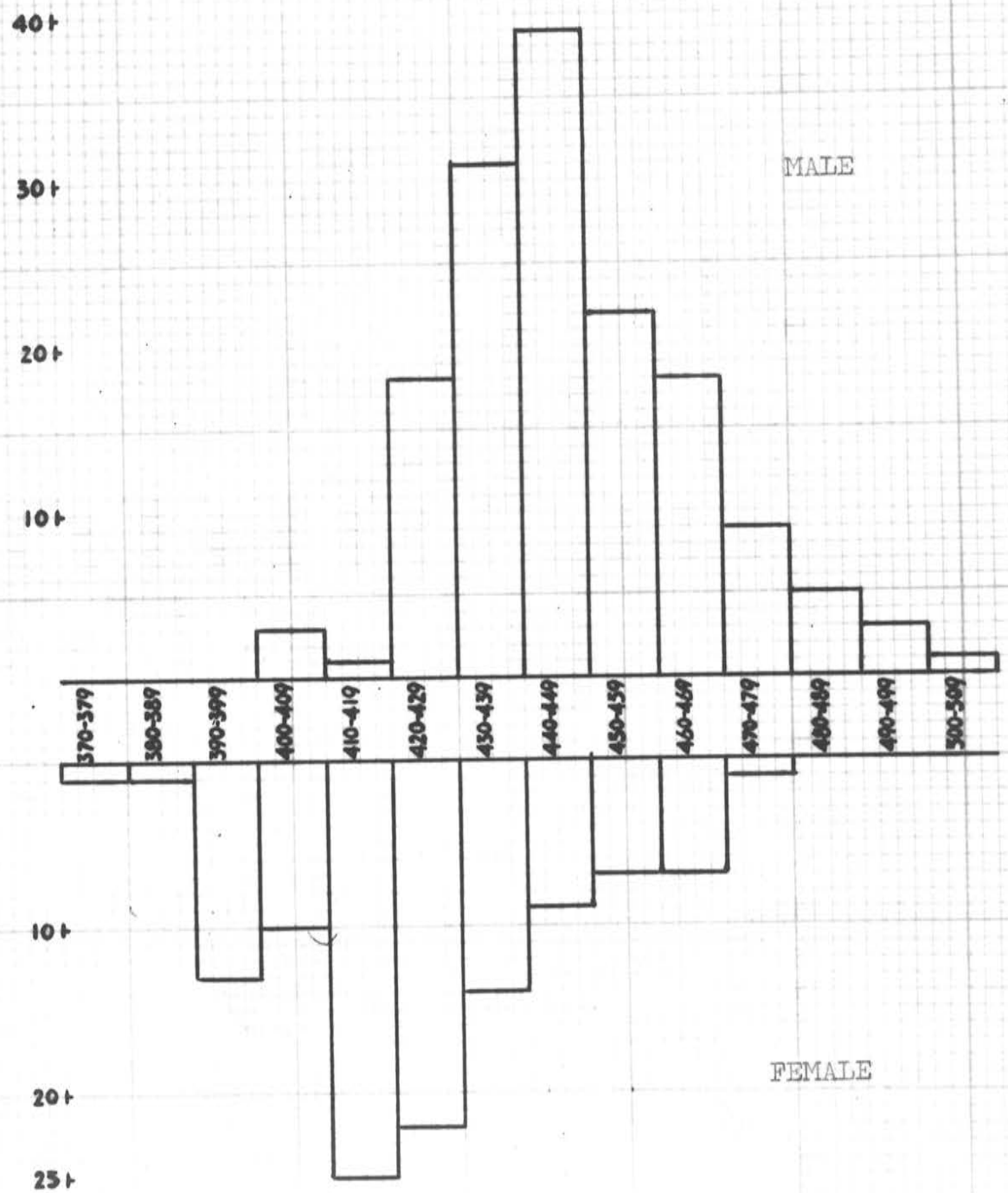


FIG.15 DISTRIBUTION OF MAXIMUM LENGTH OF FEMUR

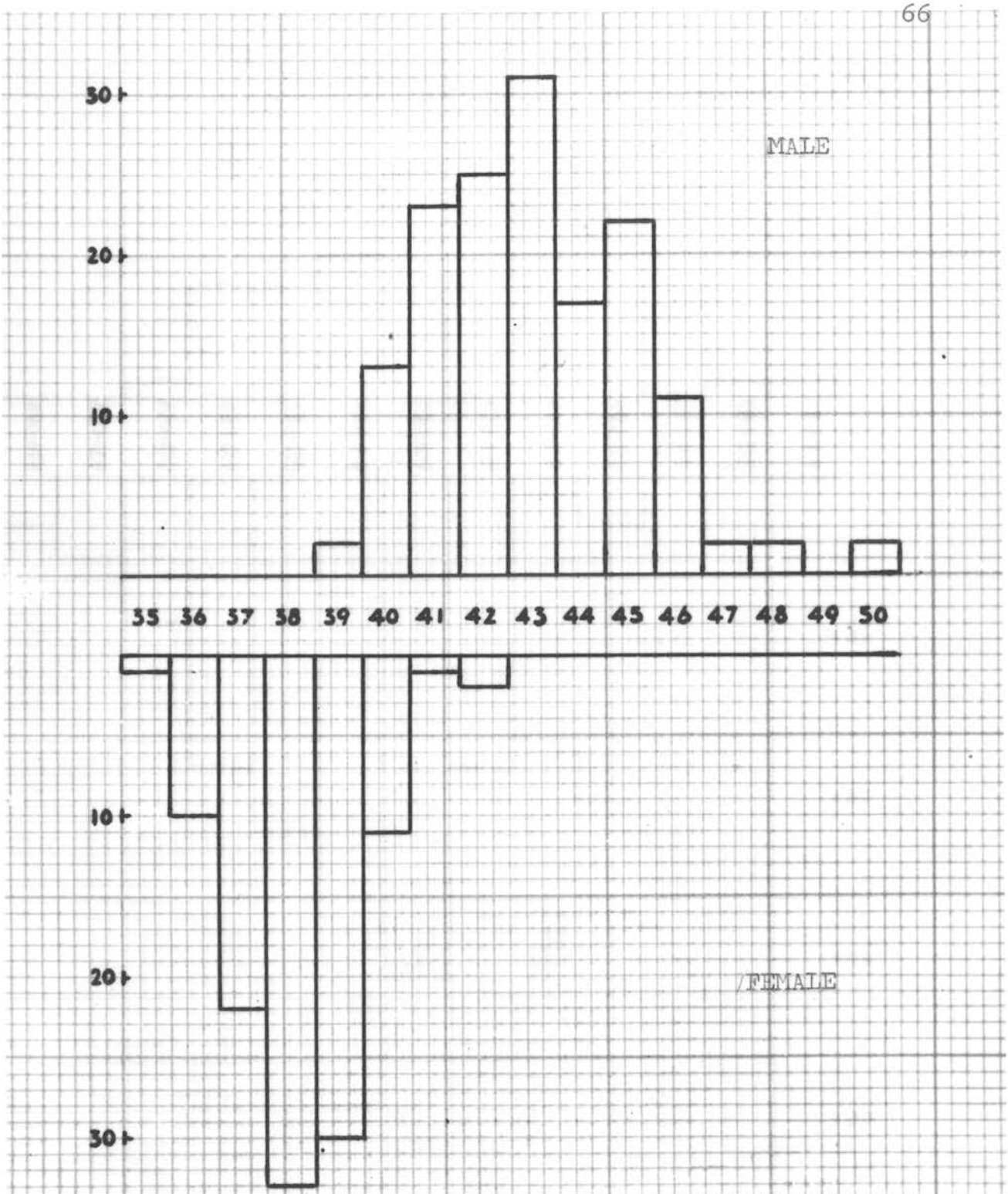


FIG.16 DISTRIBUTION OF VERTICAL DIAMETER OF FEMORAL HEAD

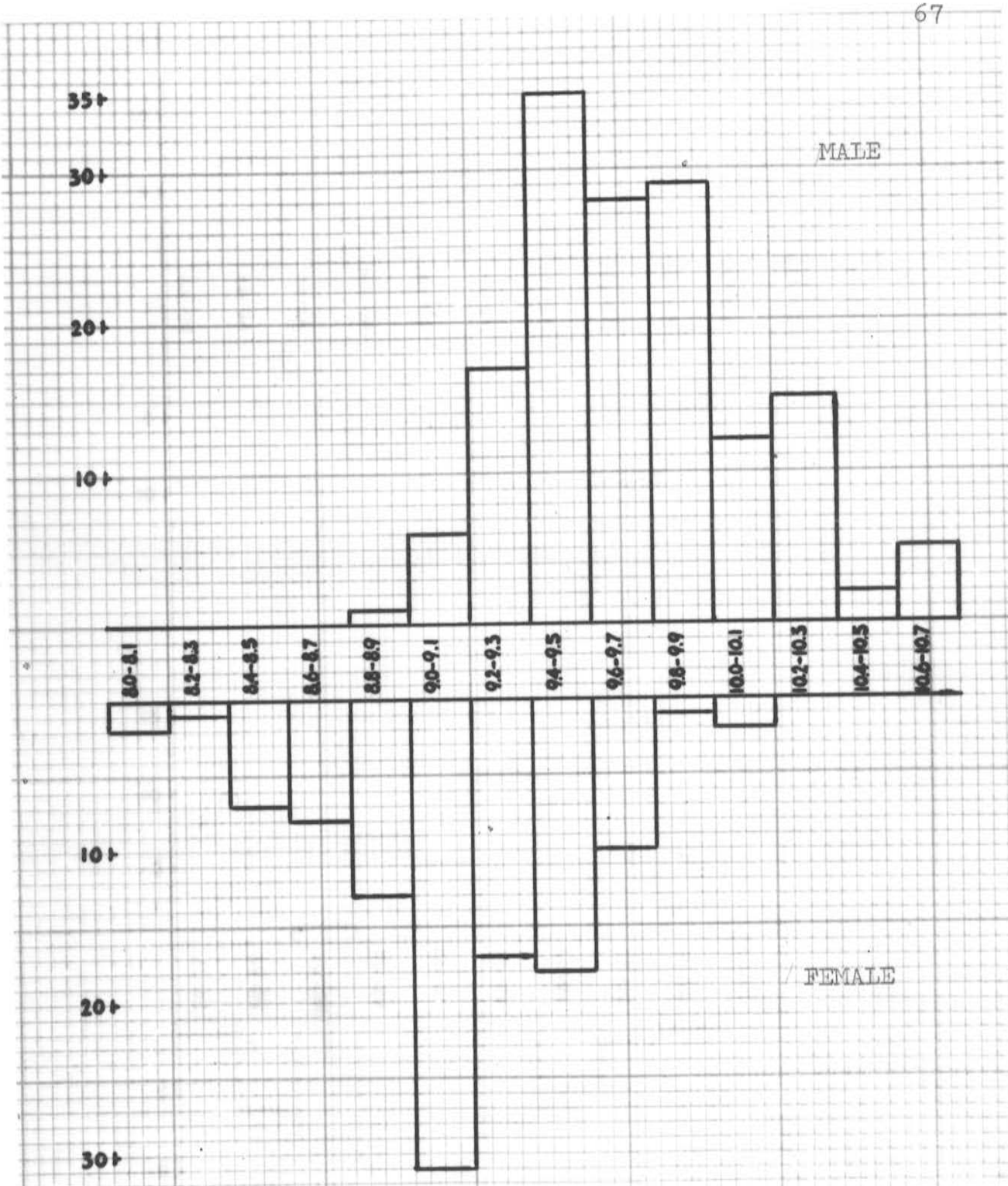


FIG.17 DISTRIBUTION OF FEMORAL HEAD INDEX

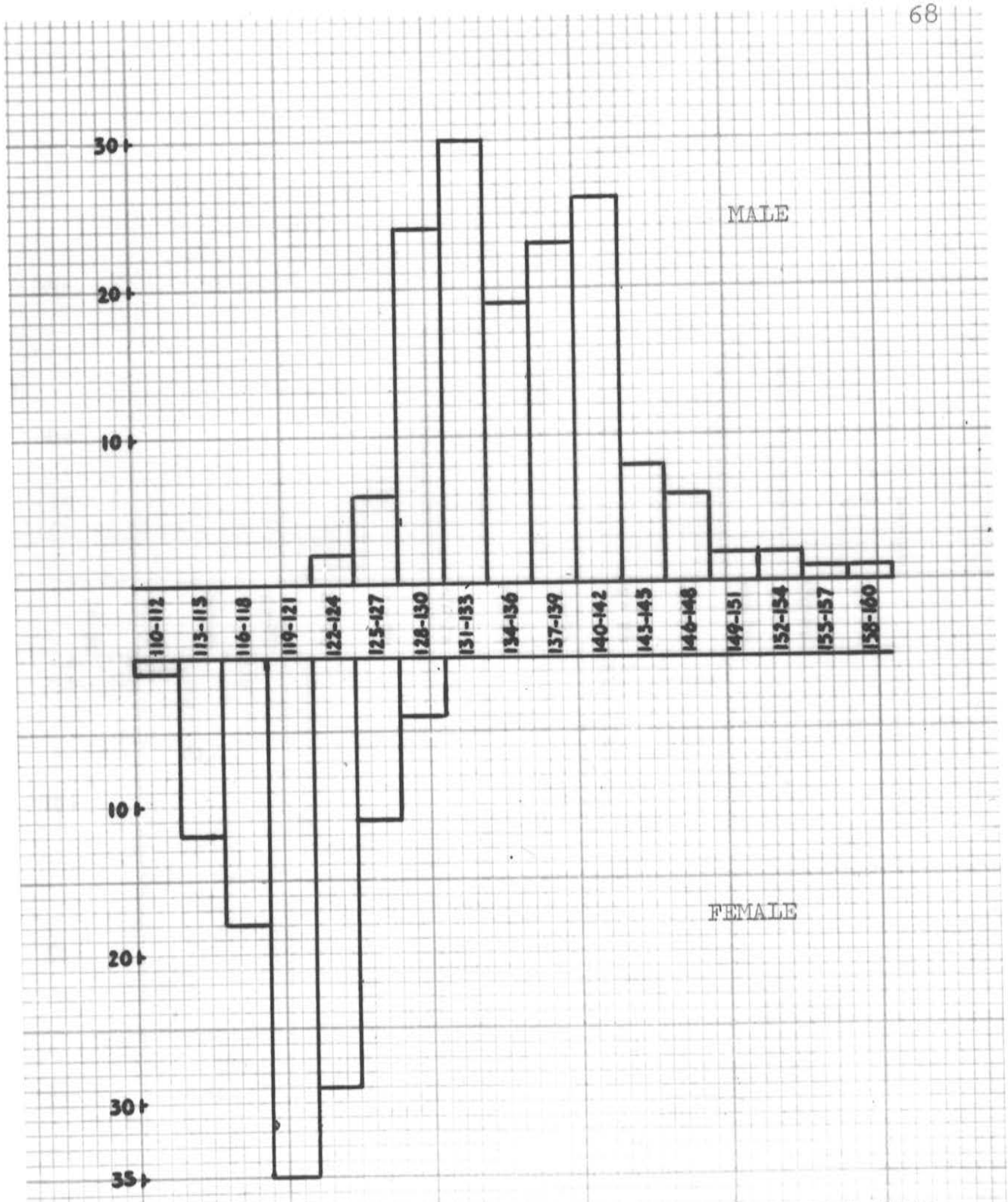


FIG.18 DISTRIBUTION OF CIRCUMFERENCE OF FEMORAL HEAD

histograms of the maximum length of the femur are given as an example. The result is obviously confirmative. Only 24 femora in the series of 260, i.e. 9 per cent, can be definitely sexed. In other words, the overlap is as much as 91 per cent which is very high percentage (Fig. 15).

Femoral head

The vertical diameter and the circumference that express the size of the femoral head are very valuable for sex determination. From the histograms of the vertical diameter (Fig. 16), the overlap is originally 41 per cent or 107 bones from the total of 260 in the overlapping range. The rather high percentage of overlap is due to a few aberrant bones. After removal of two male bones of 39 mm., two female bones of 42 mm. and a female bone of 41 mm. in diameter, the number of bones in overlap drops to 24, or only 9 per cent.

The femoral head circumference gives a better result than the diameter (Fig. 18). The original overlap is only 29 per cent or 76 bones in the overlapping range. After removing two scattered male bones of 122-124 mm. and four female bones of 128-130 mm. in circumference, the overlap decreases to 6.5 per cent, that means only 17 bones still remain in the overlapping part.

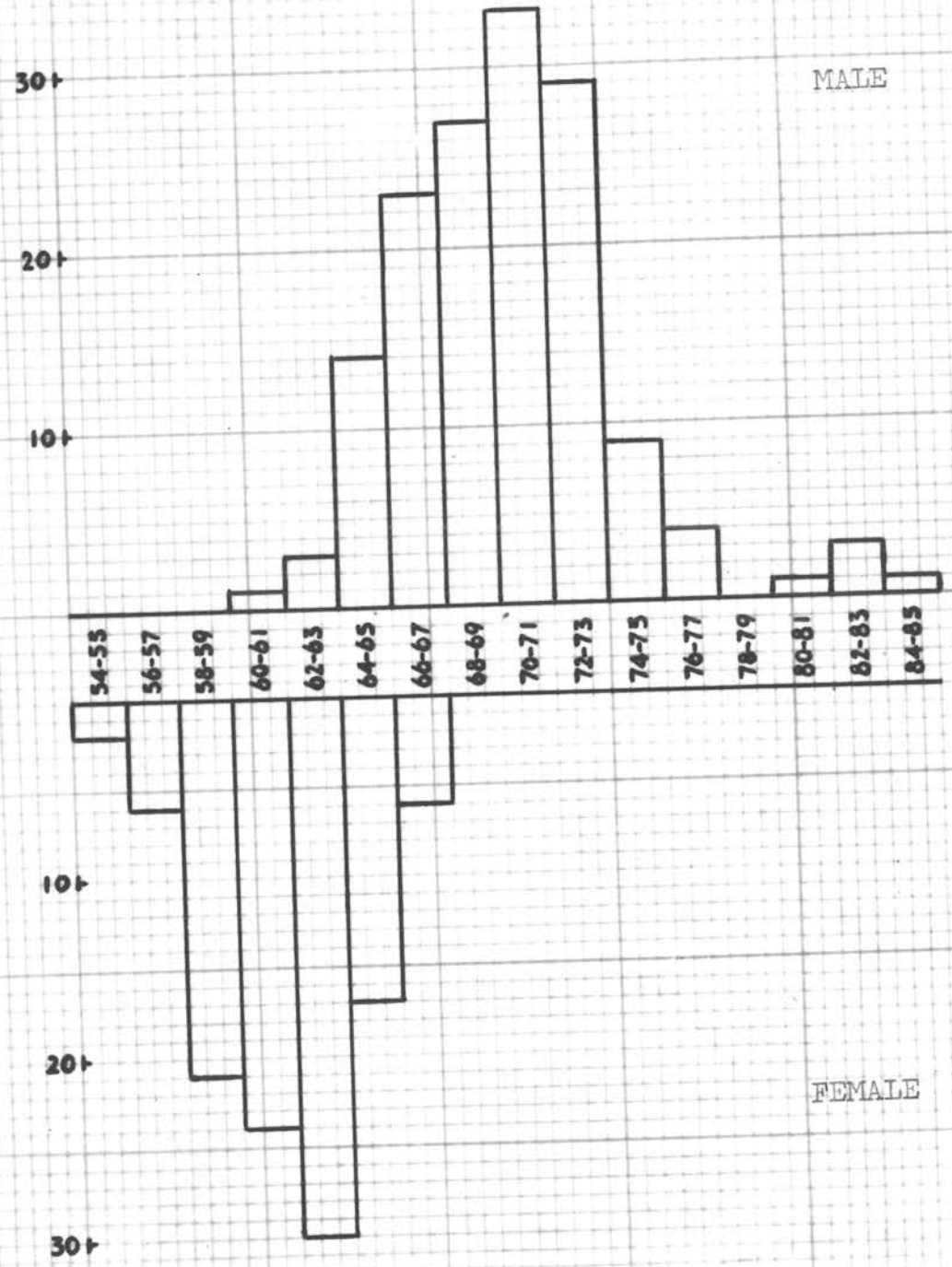


FIG.19 DISTRIBUTION OF TRANSVERSE CONDYLAR BREADTH OF FEMUR

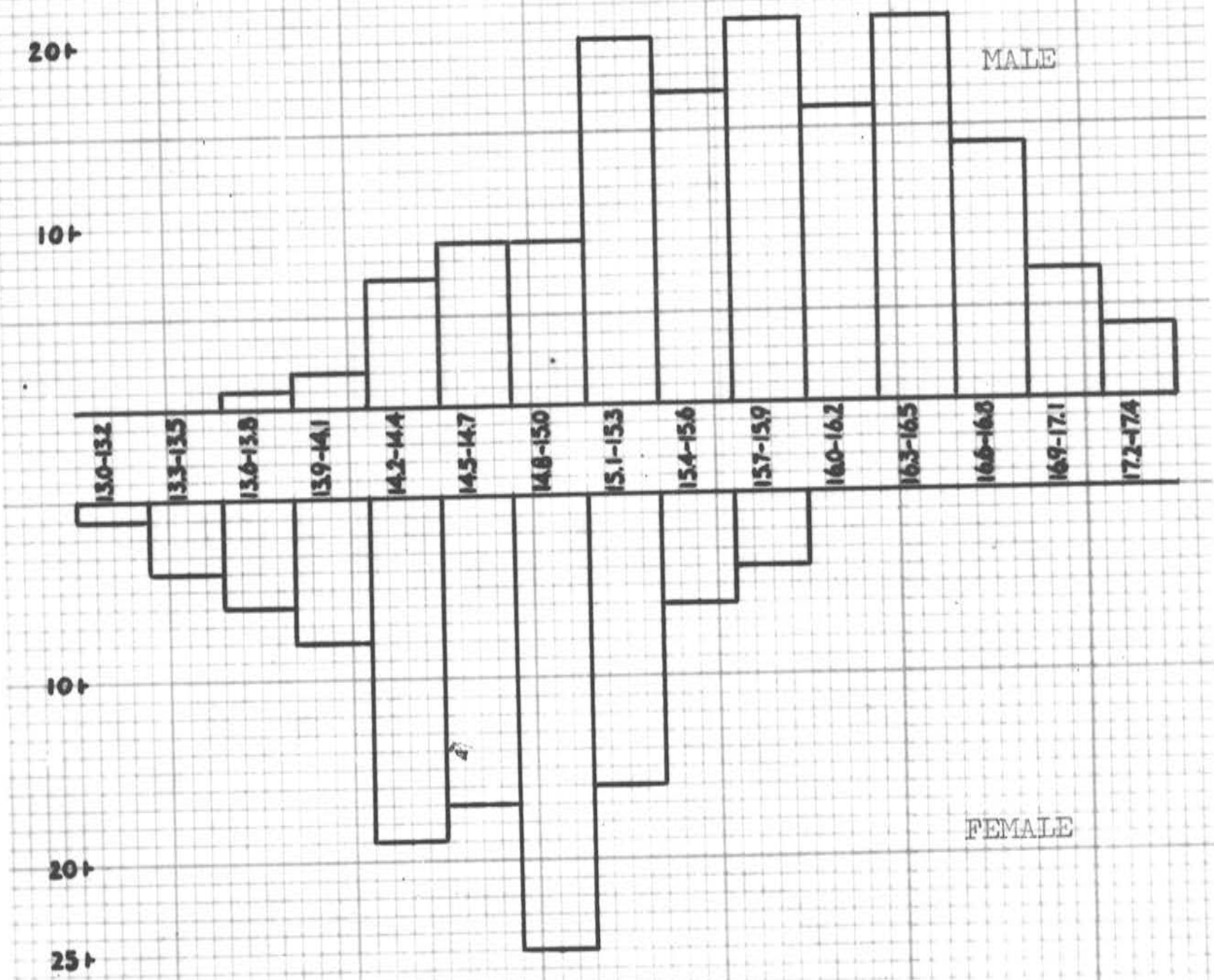


FIG.20 DISTRIBUTION OF CONDYLAR BREADTH INDEX OF FEMUR

The frequency distributions of the femoral head index in the two sexes (Fig. 17) show a high percentage of overlap. From the total 260 femora, the bones in the overlapping range are 220, i.e. 84.6 per cent. So, it makes sex determination by this index unsatisfactory.

Transverse condylar breadth and condylar breadth index

By the transverse condylar breadth, the original percentage of overlap is 46.5 or 118 bones from the total of 254 (Fig. 19). Again, the percentage decreases to 23.6 when four male bones of 60-63 mm. in breadth are excluded. The measurement is valuable for sex determination.

Unfortunately, when this breadth is expressed in percentage ratio of the oblique length, that is the condylar breadth index, the value for sex determination decreases. From the frequency histograms of the condylar breadth index, the bones in the overlapping part are 187 from the total of 254, i.e. 74 per cent (Fig. 20).

DISCUSSION

On Ethnic Comparison and Identification

In order to find out the ethnic differences or similarities among Australian aborigines and other groups, some mean measurements and indices of the femur and pelvic girdle are presented in Tables 4, 5 and 6. The value of these measurements for identification will be considered here. The figures in the tables were collected from previous works with sufficient numbers of bones examined, i.e. having reliable means.

Table 4 shows that the mean oblique length of the femur in the male aborigines is shorter than every group of the Caucasoids except the French. The Maori femora are in turn shorter than the aboriginal femora on the average. On the other hand, this mean length in the female aborigines surpasses all of the Caucasoids, that brings, in Australian aborigines, the female mean closer to the male mean than any other groups. Although the means are so different among the groups, the ranges of variation, when analysed in any pairs of groups, show a wide overlap. As shown in this table, the aboriginal ranges in both sexes are in the same order of those of medieval and modern English and American White. So, the oblique length of the femur cannot be used for ethnic identification.

TABLE 4. OBLIQUE LENGTH OF FEMUR IN VARIOUS ETHNIC GROUPS

Group	Source	MALE			FEMALE		
		No.	Mean mm.	Range mm.	No.	Mean mm.	Range mm.
Swiss Alemanns	Schwerz, quoted by Pearson and Bell (1919)	170	462.7	-	170	419.0	-
Medieval English (Rothwell)	Parsons (1914)	177	454.7	404 - 538	103	416.5	356 - 471
Modern English (Dublin)	Holtby (1918)	56	454.3	403 - 521	44	412.6	358 - 461
American White	Dwight (1905)	100	449.5	400 - 510	100	415.5	340 - 470
English, 17th Century (london)	Pearson and Bell (1919)	416	444.9	-	330	405.8	-
Maori	Schofield (1959)	43	441.3	-	33	414.9	-
Modern French	Quoted by Pearson and Bell (1919)	62	441	-	38	396	-
Australian Aborigine	Present series	150	444.1	405 - 498	110	419.2	374 - 470

TABLE 5. MEASUREMENTS OF FEMORAL SHAFT AT THE MIDDLE IN VARIOUS ETHNIC GROUPS

Group	Source	MALE				FEMALE			
		No.	A-P Diam. mm.	Tran. Diam. mm.	Robus-ticity index	No.	A-P Diam. mm.	Tran. Diam. mm.	Robus-ticity index
Medieval English (Rothwell)	Parsons (1914)	184	31.6	29.6	13.5	106	28.0	26.5	13.1
English, 17th Century (London)	Pearson and Bell (1919)	487	29.1	28.0	12.8	381	25.6	25.3	12.5
Maori	Schofield (1959)	43	29.5	25.3	12.4	33	26.1	23.1	11.9
Ainu	Koganei, quoted by Pearson and Bell (1919)	46	27.8	26.6	-	26	24.7	24.4	-
Japanese	Koganei, quoted by Pearson and Bell (1919)	20	25.0	24.6	-	20	21.5	21.8	-
Australian Aborigine	Present series	149	27.6	24.7	11.8	109	23.9	22.4	11.0

During the examination of the femoral shafts of Australian aborigines, they have been observed that most of them are more slender than those of European femora. Therefore, the antero-posterior and transverse diameters at the middle of the shaft and also the robusticity index of the shaft :

$$\frac{\text{antero-posterior + transverse diameters at this level}}{\text{oblique length of femur}} \times 100$$

in several ethnic groups are compared in Table 5.

It is obvious that the means of both diameters in the male and female aborigines are smaller than those in the English, Maori and Ainu. Japanese femora have even smaller diameters than the aborigines. Again, the robusticity index of the aboriginal femora in both sexes is smaller than that of the English and Maori. Evaluation of these measurements for ethnic identification is impossible here because the range of variation for each group is lacking.

For the pelvic girdle, figures of the pubic and ischial lengths are available from Washburn's and Hanna's reports. The lengths and the ischium-pubis index of the Eskimo, American White, American Negro and Bantu are listed in Table 6. Measurements of Bushman bones in Washburn's report are excluded because the number of cases examined is insufficient.

TABLE 6. PUBIC LENGTH, ISCHIAL LENGTH AND ISCHIUM-PUBIS INDEX IN VARIOUS ETHNIC GROUPS

Measurement index and group	Source	MALE			FEMALE		
		No.	Mean	Range	No.	Mean	Range
PUBIC LENGTH (mm)							
Eskimo	Hanna and Washburn (1953)	129	74.1	63 - 85	95	80.1	73 - 90
American White	Washburn (1948)	100	73.8	65 - 83	100	77.9	69 - 95
American Negro	Washburn (1948)	50	69.2	60 - 88	50	73.5	63 - 86
Bantu	Washburn (1949)	82	66.2	57 - 78	70	73.2	66 - 84
Australian aborigine	Present series	89	63.3	54 - 73	72	69.2	60 - 80
ISCHIAL LENGTH (mm)							
Eskimo	Hanna and Washburn (1953)	129	88.4	79 - 98	95	81.0	72 - 89
American White	Washburn (1948)	100	88.4	75 - 98	100	78.3	69 - 93
American Negro	Washburn (1948)	50	86.6	79 - 96	50	77.5	67 - 86
Bantu	Washburn (1949)	82	80.3	71 - 92	70	74.8	68 - 84
Australian aborigine	Present series	89	81.2	74 - 91	72	74.7	64 - 83
ISCHIUM-PUBIS INDEX							
Eskimo	Hanna and Washburn (1953)	129	83.9	73 - 92	95	98.8	91 - 109
American White	Washburn (1948)	100	83.6	73 - 94	100	99.5	91 - 115
American Negro	Washburn (1948)	50	79.9	71 - 88	50	95.0	84 - 106
Bantu	Washburn (1949)	82	82.5	70 - 91	70	98.1	87 - 107
Australian aborigine	Present series	89	78.0	71 - 87	72	92.7	81 - 107

By the mean pubic length, all members in both sexes can be divided into three groups. The first group, having the longest pubic length, includes the Eskimos and American Whites. The second group, the American Negroes and Bantus, has an intermediate length. The third, the Australian aborigines, has the shortest pubic length which more or less reflects the narrow hips. Physical differences among the groups seem to be obvious when we compare these groups by the mean length alone. The differences, however, become less evident when the ranges of variation are considered. Nevertheless this length can be employed in separating the bones of the two extreme groups from each other. These are the Eskimo and American White in the first group and the Australian aborigine in the third group. Comparison of Australian aborigines with Eskimos gives an example. In the male series, the pubic length of Australian aborigines has a range from 54 to 73 mm. and from 63 to 85 mm. in Eskimos. Therefore, the range of overlap is from 63 to 73 mm. In this overlapping range there are 52 aboriginal innominate bones or 58 per cent of the total. It means that about 42 per cent of the aboriginal bones can be separated from the Eskimo bones by the pubic length. In the female series on the same basis, a better result is obtained, about 71 per cent of the

aboriginal bones can be differentiated from the Eskimo bones. The exact number of the Eskimo bones in the overlapping range cannot be ascertained because of the lack of detailed data.

The mean ischial lengths of the Eskimos, American Whites and Negroes in both sexes are quite comparable and the ranges of variation are also of the same order. The Bantus and Australian aborigines belong to another group with shorter mean ischial lengths. But when the ranges of variation and the overlaps are analysed, it appears that separation of the Bantus or Australian aborigines from members of the former group is largely impossible. In the male series, there are 73 per cent of the aboriginal bones in the range of the Eskimos and 97 per cent in that of the American Whites. Also in the female series, there are 83 and 96 per cent of the aboriginal bones in the Eskimo and American White ranges respectively. Therefore, the ischial length is not recommended for ethnic identification.

The mean ischium-pubis index of each group in the same sex shows a very small discrepancy. The ranges of variation are also comparable. The difference between the sexes in the same ethnic group is much more obvious. Thus, the index is valuable for sex determination but not at all for ethnic identification.

Now, it can be concluded that the ethnic difference of these two skeletal parts and probably of any other parts of the post-cranial skeleton are minor as compared with the sex differences. An attempt to differentiate any ethnic group by using these bones is less satisfactory than an attempt to distinguish the sexes. Certainly, the wide overlap of the ranges of variation among the groups is the cause. Further, this extensive overlap is undoubtedly due to the wide normal range of variation that exists in every group of mankind. The Australian aborigines are no exception to this. They betray a fairly wide range of physical variation and such variation is intratribal (Abbie, 1960).

So far as the ethnic identification is concerned the good result, but not better than that of sex determination, is obtained in differentiating the two groups which possess some extremely different characters, such as the narrow pelvis in Australian aborigines and the wide pelvis in Caucasoids. The pubic length or its equivalents can be used for differentiation.

It should be mentioned that the skull is more helpful than the post-cranial skeleton in ethnic identification. Howells (1960) wrote the following :

> "....the bones (post-cranial parts) have no really characteristic differences from race

to race. Mankind is very uniform in this regard,... And the anthropologist who looks at a headless skeleton and ventures a guess as to the race it represents is making a stab in the dark, nothing more.

He will do better with the skull and particularly its facial parts, if he has some experience."

On Sex Determination

As has been shown, sex determination by skeletons or by some skeletal parts alone is actually possible. Only a few characters of the femur and pelvic girdle, such as the platymeric index, the angle of the femoral neck and the index of the body of the first sacral vertebra, disclose no difference between the sexes. The major parts of measurements and indices of these bones in Australian aborigines exhibit sex differences with a high degree of significance. For sex determining purposes, measurements and indices which show small overlaps of male and female ranges are listed in Table 7.

TABLE 7. USEFUL MEASUREMENTS AND INDICES FOR SEX DETERMINATION

Measurement and Index	Male	Overlapping range	Female
Ischium-pubis Index	less than 80	80 - 87	more than 87
Length O-B of Gr.Sciatic Notch (mm.)	less than 8	8 - 13	more than 13
Index II of Gr.Sciatic Notch	less than 18	18 - 29	more than 29
Vertical Diam.of Femoral Head (mm.)	more than 42	39 - 42	less than 39
Circumference of Femoral Head (mm.)	more than 130	122-130	less than 122
Transverse Condylar Breadth (mm.)	more than 67	60 - 67	less than 60

It should be noted that there is no measurement or index of the sacrum in the list. Only those of the innominate bone and femur are valuable for sex determination. At certain levels in the overlapping range of every measurement listed, the bones have a greater tendency to belong to males than to females or vice versa. This is readily seen in the frequency distribution histograms (Figs. 9, 12, 13, 16, 18 & 19). As an example, at 80-81 of the ischium-pubis index (Fig. 9), the bones are liable to belong to males by a ratio of 17 to 1.

It is clear that by one of the six criteria, about 70-75 per cent of cases can be definitely sexed. After removal of some few scattered bones, the percentage becomes higher. It will be 76 per cent for the transverse condylar breadth, 83 per cent for the ischium-pubis index and 90-93 per cent for the rest. The result is quite comparable to Hooton's assertion (1946), " ... the determination of the sex from the postcranial skeleton in adults is easy and certain in about 80 per cent of cases, difficult but possible in another 10 per cent of cases and quite dubious in the remainder."

Washburn's studies (1948, 1949) of sex differences in the pubic bone of American Whites, American Negroes, Bantus and Bushmen by means of the

ischium-pubis index, seem to yield more favourable results. In his American White series, only 10 per cent of the bones are in the overlapping portion of the male and female ranges, i.e. 90 per cent of the bones can be undoubtedly sexed by this index. In the Negro and Bantu series, 83 and 86 per cent of the bones are not in the overlapping ranges and can be definitely sexed. In the Bushman series, no overlap of the male and female ranges takes place and he claims that the sex of only one Bushman skeleton is left in doubt. This last series sounds very doubtful to the rule of overlap but the number of bones in this series is only 55 (26 males and 29 females). Absence of overlap may be due to an insufficient amount of material. If more Bushman bones were available, the ranges of variation would be extended and then the overlap might turn up.

Where a whole skeleton or several parts of a skeleton is available for sex determination, it seems unwise to rely solely on any single sexual feature such as the ischium-pubis index. Other valuable sexual characteristics should be used in combination and judgment of the sex should be based on a combination of concordant findings. Thieme (1957) already showed

that the sex of 40 of 200 Negro skeletons were not correctly determined by the ischium-pubis index alone. When the femoral head diameter was used upon these obscure bones, only two cases were not sorted.

When dealing with sex determination of skeletons from burial grounds, certain parts of these bones which show sex differences such as the pubis and the head of the femur are thin and friable. The head of the femur as well as the femoral condyles consists of a thin layer of compact bone covering trabeculae of cancellous bone. These portions are easily destroyed under the ground. In such cases knowledge of the sexual characters of several other parts of the skeleton is ultimately needed for sex determination.

ACKNOWLEDGEMENTS

I am greatly indebted to Professor A.A. Abbie for his valuable advice and helpful criticism of this work. I am grateful to Mr. N.B. Tindale, the Acting Director of the South Australian Museum for his kind permission to examine the material in the Ethnological Collection. Grateful thanks are due to Mr. and Mrs. P.D. Kempster for providing certain instruments and for the photographs and also to Mr. I.R. Goodwins for copying the diagrams and photographs.

LITERATURE CITED

Abbie, A.A. 1951 The Australian aborigine. Oceania, 22: 91-100.

Abbie, A.A. 1960 Doctor Ruggles Gates and the aboriginal Australian. Nature, 187: 375-376.

Abbie, A.A. 1961 A preliminary survey of the growth pattern of Central Australian aboriginal males. Oceania, 31: 215-221.

Allbrook, D. and E.M. Sibthorpe, 1961. A study of pelvic dimensions related to infant size in the Ganda of East Africa. S.Afr.J.Med. Sci., 26: 73-83.

Buxton, L.H.D. 1938 Platymeria and platycnemia. J.Anat. Lond., 73: 31-36.

Comas, J. 1960 Manual of Physical Anthropology. Revised and enlarged English ed. Charles C. Thomas, Springfield.

Derry, D.E. 1909 Note on the innominate bone as a factor in the determination of sex: with special reference to the sulcus preauricularis. J.Anat. and Physiol. Lond., 43: 266-276.

Derry, D.E. 1923 On the sexual and racial characters of the human ilium. J.Anat.Lond., 58: 71-83.

Dwight, T. 1905 The size of the articular surfaces of the long bones as characteristic of sex; an anthropological study. Am.J.Anat., 4: 19-31.

Fawcett, E. 1938 The sexing of the human sacrum. J. Anat.Lond., 72: 633.

Garson, J.G. 1879 Inequality in length of the lower limbs. J.Anat. and Physiol. Lond., 13: 502-507.

Hanna, R.E. and S.L. Washburn. 1953 The determination of the sex of skeletons, as illustrated by a study of the Eskimo pelvis. Human Biol., 25: 21-27.

Hepburn, D. 1896 The platymeric, pilastric and popliteal indices of the race collection of femora in the Anatomical Museum of the University of Edinburgh. J.Anat. and Physiol.Lond., 31:116-156.

Holtby, J.R.D. 1918 Some indices and measurements of the modern femur. J.Anat.Lond., 52: 363-382.

Hooton, E.A. 1946 Up from the Ape. Revised ed. Macmillan Co., New York.

Howells, W.W. 1960 Mankind in the Making, Secker and Warburg, London.

Humphry, G.M. 1889 The angle of the neck with the shaft of the femur at different periods of life and under different circumstances. J.Anat. and Physiol. Lond., 23: 273-282.

Letterman, G.S. 1941 The greater sciatic notch in American Whites and Negroes. Am.J. Phys.Anthrop., 28: 99-116.

Martin, R. 1928 Lehrbuch der Anthropologie. 2 te Auf. Gustav Fischer, Jena.

Olivier, G. 1960 Pratique Anthropologique. Vigot Freres, Paris.

Parsons, F.G. 1914 The characters of the English thigh-bone. J.Anat. and Physiol. Lond., 48: 238-267.

Parsons, F.G. 1915 The characters of the English thigh-bone: Part II The difficulty of sexing. J.Anat. and Physiol. Lond., 49: 345-361.

Pearson, K. and J. Bell. 1919 A study of the long bones of the English skeleton: Part I The Femur. Draper's Co. Research Mem., Biometric series X, Cambridge Univ. Press.

Pick, J.W., J.K. Stack and B.J. Anson. 1941. Measurements on the human femur: I lengths, diameters and angles. Quart. Bull., Northwestern

Univ.M.School, 15: 281-290.

Reynolds, E.L. 1945 The bony pelvic girdle in early infancy. Am.J.Phys.Anthrop., n.s. 3: 231-354.

Reynolds, E.L. 1947 The bony pelvis in prepuberal childhood. Am.J.Phys.Anthrop., n.s. 5: 165-200.

Schofield, G. 1959 Metric and morphological features of the femur of the New Zealand Maori. J.R.Anthrop.Inst., 89: 89-105.

Schultz, A.H. 1930 The skeleton of the trunk and limbs of higher primates. Human Biol., 2: 303-438.

Smith, W.R. 1903 Abnormalities in the sacral and lumbar vertebrae of the skeletons of Australian aborigines. J.Anat. and Physiol. Lond., 37: 359-361.

Stewart, T.D. 1952 Hrdlicka's Practical Anthropometry. 4th ed. Wistar Institute, Philadelphia.

Stewart, T.D. 1954 Sex determination of the skeleton by guess and by measurements. Am.J.Phys. Anthrop., n.s. 12: 385-392.

Stirling, E.C. and A. Watson, 1896. Report on the work of the Horn Scientific Expedition to Central Australia: Part IV Anthropology. Ed. by B. Spencer, pp. 149-153 Dulau Co., London.

Straus, W.L. Jr. 1929 Studies on primate ilia. Am.J. Anat., 43: 403-460.

Thieme, F.P. 1957 Sex in Negro skeletons. J.Forensic Med., 4: 72-81.

Thomson, A. 1899 The sexual differences of the foetal pelvis. J.Anat. and Physiol. Lond., 33: 359-380.

Townsley, W. 1946 Platimeria. J.Path. and Bact., 58: 85-88.

Turner, W. 1886 Report on the human crania and other bones of the skeletons collected during the voyage of H.M.S. Challenger in the years 1873-1876: Part II The bones of the skeleton. Zoology. The Stationery Office, London.

Washburn, S.L. 1948 Sex differences in the pubic bone. Am.J.Phys.Anthrop., n.s. 6: 199-207.

Washburn, S.L. 1949 Sex differences in the pubic bone of Bantu and Bushman. Am.J.Phys. Anthrop., n.s., 7: 425-432.

Wilder, H.H. 1920 A Laboratory Manual of Anthropometry. Blakiston, Philadelphia.

PLATE I

FOUR MALE SACRA WITH SPINA BIFIDA

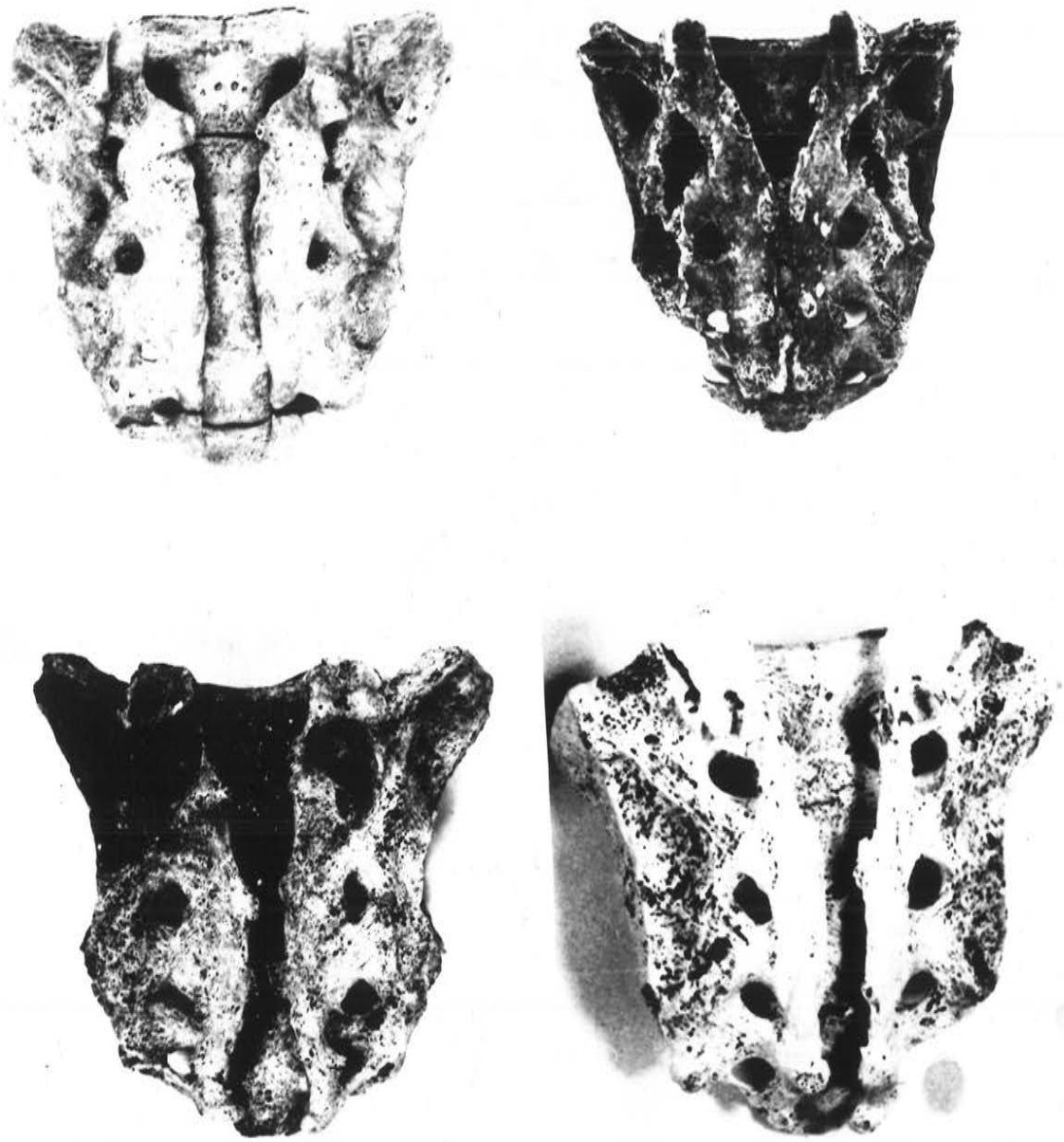


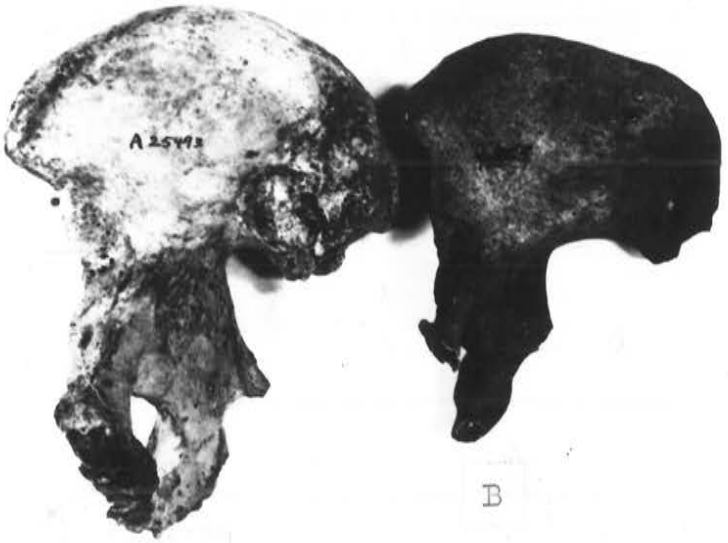
PLATE II

A. BILATERAL SACRALIZATION IN A MALE SACRUM

B. RIGHT UNILATERAL SACRALIZATION IN A FEMALE SACRUM

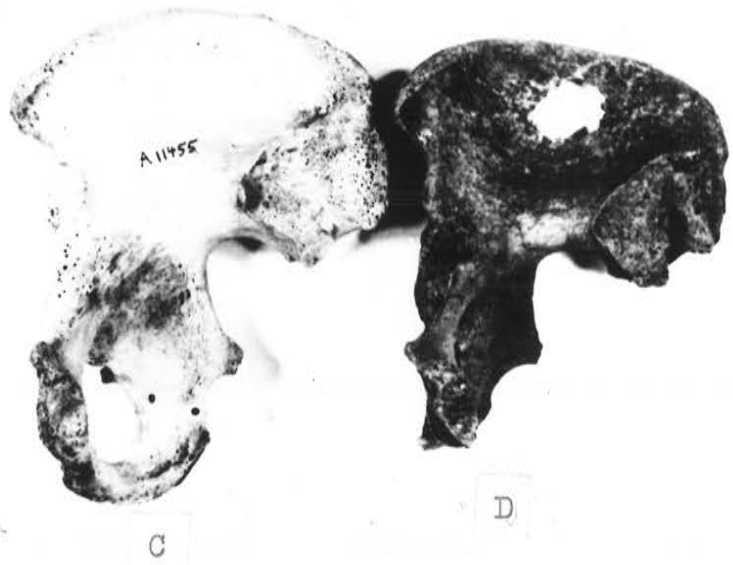
PLATE III

FORMS OF GREATER SCIATIC NOTCH



A. MALE, TYPICAL J-SHAPED FORM

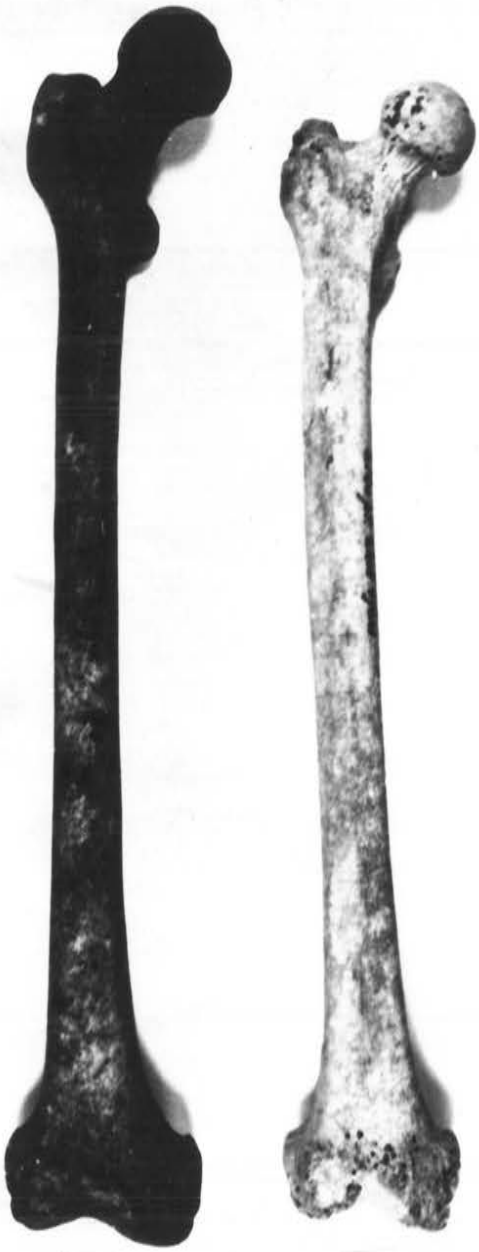
B. FEMALE, TYPICAL PARABOLIC FORM



C. MALE, INTERMEDIATE FORM

D. FEMALE, INTERMEDIATE FORM

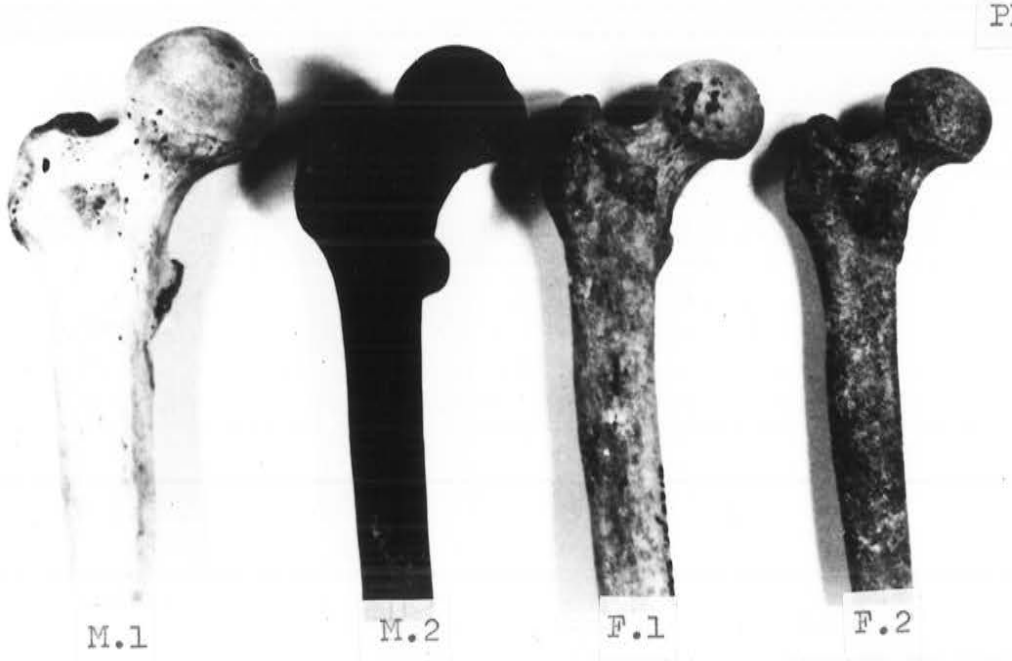
PLATE IV



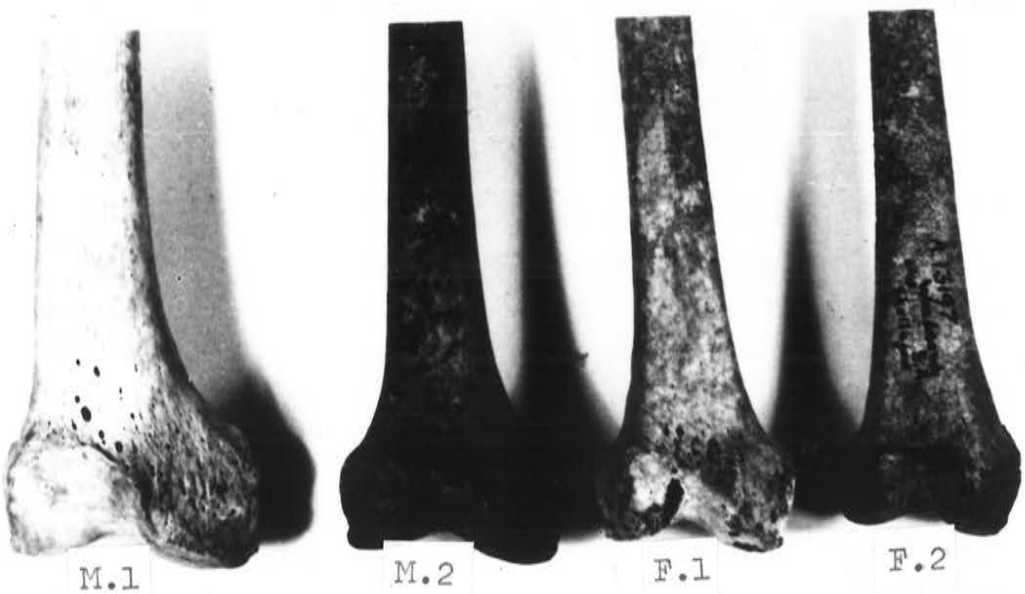
M. F.

MALE AND FEMALE FEMORA OF AVERAGE DIMENSIONS

PLATE V



A. COMPARISON OF SIZES OF PROXIMAL ENDS OF FEMORA



B. COMPARISON OF SIZES OF DISTAL ENDS OF FEMORA

M.1 = Largest male femur

M.2 = Average-sized male femur

F.1 = Average-sized female femur

F.2 = Smallest female femur

APPENDIX A. MALE SACRUM

(Linear measurements in mm.)

Serial Number	Number of Segments	Maximum length	Maximum breadth	Sacral index	Mid-ventral curved length	Curvature index	Body of S1			Corporo-basal index	Abnormalities
							A-P Diam.	Transverse Diam.	Index		
1	5	101	101	100.0	104	97.1	31	50	62.0	49.5	
2	5	99	103	104.0	110	90.0	34	51	66.7	49.5	
3	5	100	92	92.0	106	94.3	29	51	56.9	55.4	
4	5	92	103	112.0	95	96.8	29	44	65.9	42.7	
5	6	101	102	101.0	105	96.2	30	47	63.8	46.1	
6	5	92	99	107.6	100	92.0	29	48	60.4	48.5	
7	5	93	103	110.8	108	86.1	32	51	62.7	49.5	
8	5	92	103	112.0	102	90.2	29	51	56.9	49.5	
9	5	97	100	103.1	102	95.1	30	43	69.8	43.0	
10	5	102	109	106.9	110	92.7	28	51	54.9	46.8	Spina bifida
11	5	100	107	107.0	106	94.3	32	46	69.6	43.0	
12	6	102	92	90.2	105	97.1	28	43	65.1	46.7	
13	6	101	106	105.0	111	91.0	31	52	59.6	49.1	
14	5	89	90	101.1	98	90.8	29	43	67.4	47.8	Spina bifida
15	5	98	100	102.0	107	91.6	28	47	59.6	47.0	
16	5	90	100	111.1	102	88.2	30	44	68.2	44.0	
17	5	84	99	117.9	103	81.6	30	49	61.2	49.5	
18	5	104	108	103.8	107	97.2	30	53	56.6	49.1	
19	5	105	108	102.9	115	91.3	32	53	60.4	49.1	
20	5	101	107	105.9	109	92.7	31	53	58.5	49.5	
21	5	96	92	95.8	104	92.3	30	49	61.2	53.3	
22	5	83	100	120.5	93	89.2	27	45	60.0	45.0	
23	5	91	101	111.0	105	86.7	29	51	56.9	50.5	

MALE SACRUM

Serial Number	Number of Segments	Maximum length	Maximum breadth	Sacral Index	Mid-ventral curved length	Curvature index	Body of S1			Corporo-basal index	Abnormalities
							A-P Diam.	Transverse Diam.	Index		
24	5	93	102	109.7	102	91.2	31	49	63.3	48.0	
25	5	84	97	115.5	92	91.3	29	43	67.4	44.3	
26	5	99	99	100.0	111	89.2	30	49	61.2	49.5	
27	5	101	103	102.0	108	93.5	32	50	64.0	48.5	spina bifida
28	5	95	102	107.4	106	89.6	31	48	64.6	47.1	
29	5	88	100	113.6	104	84.6	27	43	62.8	43.0	spina bifida
30	5	77	85	110.4	82	93.9	26	36	72.2	42.4	
31	5	82	101	123.2	94	87.2	32	45	71.1	44.6	
32	6	106	106	100.0	111	95.5	34	53	64.2	50.0	
33	6	96	100	104.2	100	96.0	32	50	64.0	50.0	
34	5	82	100	122.0	89	92.1	28	46	60.9	46.0	
35	6	110	104	94.5	115	95.7	37	52	71.2	50.0	
36	5	107	100	93.5	112	95.5	31	51	60.8	51.0	
37	5	107	93	86.9	112	95.5	25	43	58.1	46.2	
38	5	88	95	108.0	92	95.7	29	45	64.4	47.4	
39	5	98	103	105.1	107	91.6	31	48	64.6	46.6	
40	6	110	101	91.8	114	96.5	32	53	60.4	52.5	
41	5	87	98	112.6	92	94.6	29	47	61.7	48.0	
42	6	110	99	90.0	112	98.2	30	49	61.2	49.5	
43	5	104	94	90.4	110	94.5	28	45	62.2	47.9	
44	5	108	102	94.4	114	94.7	28	51	54.9	50.0	
45	5	88	99	112.5	101	87.1	26	42	61.9	42.4	
46	5	96	106	110.4	106	90.6	32	50	64.0	47.2	
47	5	102	98	96.1	111	91.9	28	44	63.6	44.9	
48	6	105	93	88.6	109	96.3	29	53	67.4	46.2	
49	6	99	94	94.9	103	96.1	25	40	62.5	42.6	
50	5	91	97	106.6	101	90.1	29	40	72.5	41.2	Sacralization

FEMALE SACRUM

Serial Number	Number of Segments	Maximum length	Maximum breadth	Sacral Index	Mid-ventral curved length	Curvature index	Body of S1			Corporo-basal index	Abnormalities
							A-P Diam.	Transverse Diam.	Index		
1	5	89	97	109.0	104	85.6	27	49	55.1	50.5	
2	5	89	99	111.2	95	93.7	30	46	65.2	46.5	
3	5	81	101	124.7	90	90.0	28	43	65.1	42.6	
4	5	80	94	117.5	89	89.9	29	43	67.4	45.7	
5	5	88	107	121.6	100	88.0	30	50	60.0	46.7	
6	5	90	103	114.4	97	92.8	27	39	69.2	37.9	
7	5	85	105	123.5	94	90.4	27	44	61.4	41.9	
8	5	81	96	118.5	99	81.8	30	42	71.4	43.8	
9	6	98	102	104.1	101	97.0	26	39	66.7	38.2	
10	5	90	92	102.2	94	95.7	26	40	65.0	43.5	
11	5	81	101	124.7	89	91.0	28	44	63.6	43.6	
12	5	91	113	124.2	105	86.7	31	46	67.4	40.7	
13	5	81	103	127.2	100	81.0	28	45	62.2	43.7	
14	5	88	100	113.6	100	88.0	29	52	55.8	52.0	
15	5	75	105	140.0	87	86.2	27	47	57.4	44.8	
16	5	90	106	117.8	100	90.0	27	48	56.3	45.3	
17	5	97	106	109.3	103	94.2	28	50	56.0	47.2	
18	5	86	104	120.9	105	81.9	27	45	60.0	43.3	
19	5	85	99	116.5	91	93.4	28	42	66.7	42.4	
20	5	87	95	109.2	96	90.6	26	40	65.0	42.1	
21	5	91	95	104.4	100	91.0	26	46	56.5	48.4	R Sacralization
22	5	82	99	120.7	94	87.2	26	36	72.2	36.4	
23	5	86	104	120.9	96	89.6	26	45	57.8	43.3	
24	5	82	100	122.0	89	92.1	29	41	70.7	41.0	
25	5	97	104	107.2	102	95.1	29	42	69.0	40.4	

Serial Number	Number of Segments	Maximum length	Maximum breadth	Sacral index	Mid-ventral curved length	Curvature index	Body of S1			Corporo-basal index	Abnormalities
							A-P Diam.	Transverse Diam.	Index		
26	5	89	107	120.2	100	89.0	29	46	63.0	43.0	
27	5	90	94	104.4	102	88.2	25	45	55.6	47.9	
28	5	95	99	104.2	102	93.1	25	38	65.8	38.4	
29	5	93	94	101.1	99	93.9	28	42	66.7	44.7	
30	5	88	102	115.9	96	91.7	25	40	62.5	39.2	
31	5	95	108	113.7	107	88.8	30	46	65.2	42.6	
32	5	87	109	125.3	91	95.6	27	47	57.4	43.1	
33	5	93	97	104.3	97	95.9	25	40	62.5	41.2	
34	5	92	109	118.5	97	94.8	27	43	62.8	39.4	
35	5	85	95	111.8	86	98.8	26	48	54.2	50.5	
36	6	105	101	96.2	107	98.1	29	48	60.4	47.5	
37	5	90	98	108.9	100	90.0	29	46	63.0	46.9	
38	5	91	97	106.6	95	95.8	26	41	63.4	42.3	
39	5	91	104	114.3	104	87,5	29	48	60.4	46.2	
40	5	97	101	104.1	103	94.2	28	44	63.6	43.6	
41	5	82	99	120.7	91	90.1	27	46	58.7	46.5	
42	5	84	107	127.4	94	89.4	29	48	60.4	44.9	
43	5	94	110	117.0	106	88.7	27	45	60.0	40.9	
44	5	97	109	112.4	107	90.7	29	44	65.9	40.4	
45	5	78	101	129.5	85	91.8	27	49	55.1	48.5	
46	5	75	100	133.3	90	83.3	28	45	62.2	45.0	
47	5	71	92	129.6	81	87.7	27	44	61.4	47.8	
48	5	101	98	97.0	110	91.8	28	39	71.8	39.8	
49	5	89	100	112.4	91	97.8	27	40	67.5	40.0	
50	5	84	101	120.2	93	90.3	27	39	69.2	38.6	

APPENDIX B. MALE INNOMINATE BONE

(Linear measurements in mm.)

Serial number and side	Maximum length	Breadth of ilium	Acetabulum		Pubic length	Ischial length	Gr. sciatic notch			Chilotic line	
			Vertical Diam.	Transverse Diam.			Gr. width	Gr. height	Length O-B	Sacral Part	Pelvic Part
1R	201	153	55	55	67	83	47	25	5	66	47
L	199	155	56	54	64	81	47	24	2	66	49
2R	205	152	55	54	70	88	42	23	4	71	38
L	204	153	55	54	69	87	45	24	5	71	36
3R	193	154	50	49	59	78	41	23	5	62	53
L	-	152	51	-	-	-	37	25	3	62	48
4R	190	146	50	49	59	79	45	24	8	64	48
L	190	145	49	49	59	79	45	28	9	68	43
5R	192	152	50	51	62	80	40	25	7	63	47
L	191	151	50	51	63	79	40	25	8	63	47
6R	198	149	55	54	66	82	41	31	7	63	49
L	199	150	54	55	66	81	39	30	5	63	50
7R	206	153	55	53	73	88	47	21	5	69	52
L	208	150	57	54	73	90	47	27	4	69	54
8R	190	140	52	-	-	-	45	22	3	64	50
L	195	138	52	52	59	80	46	26	4	66	47
9R	187	143	50	50	59	80	46	22	5	61	50
L	187	138	51	50	58	80	49	21	3	58	53
10R	194	150	51	50	66	85	41	21	3	63	47
L	196	148	52	53	63	83	40	28	6	63	45
11R	209	150	53	51	63	84	52	28	7	73	56
L	210	149	52	51	64	84	49	27	6	73	58
12R	199	145	50	52	65	83	46	20	10	66	51
L	202	143	52	51	-	-	43	25	6	67	49
13R	178	135	46	46	56	76	40	22	2	58	47
L	178	134	45	45	56	76	40	23	5	58	48

MALE INNOMINATE BONE

Serial number and side	Maximum length	Breadth of ilium	Acetabulum		Pubic length	Ischial length	Gr. sciatic notch			Chilotic line	
			Vertical Diam.	Transverse Diam.			Gr. width	Gr. height	Length O-B	Sacral Part	Pelvic Part
14R	205	153	53	52	65	81	53	23	4	70	55
L	205	152	53	53	-	-	54	23	4	72	52
15R	181	-	49	48	58	77	45	20	8	-	-
L	182	-	49	48	-	-	47	20	9	-	-
16R	206	146	55	55	68	85	47	23	3	68	50
L	206	150	55	54	68	83	47	21	2	70	52
17R	186	146	47	46	62	76	41	26	9	53	53
L	186	146	46	45	62	76	42	26	10	55	55
18R	198	144	53	54	63	84	51	22	5	62	48
L	197	144	53	54	64	84	49	25	6	63	46
19R	202	144	51	52	65	81	53	27	10	65	55
L	205	152	-	-	-	-	51	27	9	67	51
20R	212	162	58	57	67	87	46	30	11	75	54
L	217	162	58	56	67	87	46	29	11	74	50
21R	206	146	53	50	70	84	52	28	6	65	54
L	210	148	53	51	-	-	51	28	8	65	58
22R	184	133	51	48	58	75	46	29	9	56	45
L	189	137	51	48	59	76	42	26	7	54	51
23R	184	139	51	48	56	74	42	27	12	59	51
L	184	142	50	49	56	76	41	30	11	58	49
24R	204	153	55	53	62	82	47	30	7	70	46
L	209	155	56	54	62	83	45	27	2	71	47
25R	208	157	51	50	65	84	44	22	2	66	47
L	208	158	51	51	64	83	43	20	2	68	47
26R	199	-	50	51	59	80	44	29	8	-	-
L	201	141	51	51	60	82	47	28	10	61	54
27R	202	150	52	52	65	82	45	23	5	67	49
27L	203	148	52	53	64	81	48	25	5	67	44

MALE INNOMINATE BONE

Serial Number and side	Maximum length	Breadth of ilium	Acetabulum		Pubic length	Ischial Length	Gr. sciatic notch			Chilotic line	
			Vertical Diam.	Transverse Diam.			Gr. width	Gr. height	Length O-B	Sacral Part	Pelvic Part
28R	196	153	53	54	-	-	54	23	6	60	50
L	196	153	53	54	66	84	51	23	4	63	47
29R	200	154	49	49	-	-	47	27	13	63	53
L	200	149	49	48	65	80	45	25	6	64	49
30R	196	144	54	51	64	78	51	24	6	62	49
L	195	142	53	53	63	80	51	23	5	62	43
31R	204	156	52	52	69	81	51	25	10	67	56
L	206	154	52	51	70	86	50	25	10	64	55
32R	197	147	51	49	65	78	43	25	5	60	49
L	199	148	51	49	65	81	44	23	6	58	48
33R	192	142	52	50	65	77	45	28	6	63	44
L	191	140	53	50	-	-	45	29	5	61	45
34R	190	145	48	47	61	75	40	31	9	56	53
L	186	144	47	47	61	75	42	28	10	57	53
35R	192	148	50	50	62	78	45	25	8	62	52
L	191	150	50	51	62	79	44	25	6	63	52
36R	221	166	55	56	67	89	49	21	-1	76	48
L	217	167	54	54	66	91	50	21	-2	77	46
37R	202	148	52	52	65	80	41	29	5	65	50
L	202	147	52	52	65	83	40	26	4	63	51
38R	196	141	47	48	56	78	47	29	10	57	50
L	194	136	48	47	57	79	47	29	10	50	53
39R	209	155	53	52	70	86	48	25	6	69	47
L	212	154	53	53	68	87	48	18	4	69	48
40R	190	142	52	51	59	80	40	21	5	68	43
L	192	143	51	51	57	80	40	23	6	61	48

MALE INNOMINATE BONE

Serial Number and side	Maximum length	Breadth of ilium	Acetabulum		Pubic length	Ischial length	Gr. sciatic notch			Chilotic line	
			Vertical Diam.	Transverse Diam.			Gr. width	Gr. height	Length O-B	Sacral Part	Pelvic Part
41R	188	142	49	50	58	80	42	23	7	64	51
L	188	140	49	-	58	81	43	23	8	64	49
42R	204	160	55	54	70	84	37	26	4	64	56
L	206	162	55	-	72	87	43	26	4	66	56
43R	198	142	51	51	-	-	44	28	5	64	51
L	200	143	52	52	62	84	44	24	3	63	53
44R	190	138	49	46	64	78	45	24	8	61	46
L	190	137	49	48	65	80	44	21	7	61	46
45R	188	152	47	45	59	77	43	28	10	66	49
L	190	153	47	46	56	79	46	26	7	67	48
46R	188	145	52	52	58	79	41	23	4	58	56
L	191	145	51	50	58	79	42	24	4	57	53
47R	206	152	45	48	71	84	45	26	8	68	52
L	205	153	47	48	71	84	48	26	8	68	52
48R	210	155	55	54	67	86	51	26	10	65	57
L	213	156	56	54	67	87	55	25	8	65	58
49R	187	139	49	45	54	74	39	23	4	55	50
L	187	139	49	47	57	74	38	19	0	55	48
50R	195	150	50	47	66	76	43	25	3	65	54
L	197	148	50	47	66	78	43	26	5	62	49

FEMALE INNOMINATE BONE

Serial Number and side	Maximum length	Breadth of ilium	Acetabulum		Pubic length	Ischial length	Gr. sciatic notch			Chilotic line	
			Vertical Diam.	Transverse Diam.			Gr. width	Gr. height	Length O-B	Sacral Part	Pelvic Part
1R	-	139	47	46	-	-	54	27	21	57	60
L	177	139	46	45	-	-	57	28	23	54	61
2R	183	140	47	46	67	72	51	29	18	57	59
L	181	140	47	46	65	74	51	28	13	58	57
3R	-	142	44	44	-	-	53	31	27	57	60
L	180	142	44	43	-	-	52	25	21	56	60
4R	174	126	44	45	61	74	49	29	18	55	53
L	176	129	45	45	60	74	50	27	16	54	55
5R	192	151	47	45	72	76	60	33	24	62	52
L	190	149	47	46	70	78	55	28	18	63	54
6R	177	147	46	45	-	-	51	26	16	57	59
L	178	149	45	-	-	-	52	27	19	56	64
7R	192	152	48	49	69	75	50	23	13	62	62
L	192	148	48	49	70	79	50	27	13	65	57
8R	179	141	48	48	71	77	51	23	18	55	64
L	180	140	49	49	73	77	49	24	20	55	61
9R	180	128	46	45	68	70	44	25	14	48	59
L	178	129	45	45	67	70	46	25	15	50	54
10R	165	128	42	-	63	64	49	22	15	55	50
L	165	129	42	-	63	64	49	22	16	55	50
11R	182	139	47	45	73	77	54	25	20	60	55
L	185	139	47	46	73	77	56	27	22	58	57
12R	192	148	50	47	77	81	49	33	14	65	56
L	194	149	50	48	78	80	51	34	19	65	56
13R	189	146	47	48	80	79	48	26	14	57	60
L	191	141	48	48	78	76	49	25	14	58	58

FEMALE INNOMINATE BONE

Serial number and side	Maximum length	Breadth of ilium	Acetabulum		Pubic length	Ischial length	Gr. sciatic notch			Chilotic line	
			Vertical Diam.	Transverse Diam.			Gr. width	Gr. height	Length O-B	Sacral Part	Pelvic Part
14R	183	131	46	46	74	74	47	22	10	53	64
L	183	-	47	47	75	74	50	21	14	-	-
15R	179	145	48	46	71	77	49	28	18	64	53
L	181	144	48	46	71	77	48	26	14	60	54
16R	189	144	47	47	79	77	53	22	15	58	57
L	190	147	48	46	-	-	44	25	12	60	59
17R	192	145	47	46	-	-	53	24	12	57	61
L	193	146	47	46	73	77	55	24	16	56	62
18R	185	147	46	45	69	75	54	30	21	56	61
L	181	143	45	45	68	74	48	27	16	51	62
19R	175	133	46	44	63	73	46	22	14	55	50
L	174	134	47	45	-	-	42	22	13	54	53
20R	174	139	41	41	64	70	47	26	14	49	60
L	176	137	42	40	64	70	48	21	11	49	57
21R	172	134	43	43	-	-	52	27	20	51	58
L	-	-	41	41	-	-	53	26	20	-	-
22R	184	147	46	46	67	76	49	26	17	59	61
L	183	150	46	46	67	76	52	26	16	57	61
23R	179	-	45	45	68	74	47	23	12	53	55
L	178	140	45	45	-	-	51	27	16	53	53
24R	175	138	46	44	61	74	51	24	18	60	54
L	178	141	47	45	61	73	47	24	16	57	55
25R	189	150	44	47	72	79	53	27	18	56	61
L	189	151	44	46	72	79	51	24	16	61	54
26R	182	146	48	-	-	-	48	22	13	48	64
L	180	145	47	-	-	-	47	24	14	50	63

Serial number and side	Maximum length	Breadth of ilium	Acetabulum		Pubic length	Ischial length	Gr. sciatic notch			Chilotic line	
			Vertical Diam.	Transverse Diam.			Gr. width	Gr. height	Length O-B	Sacral Part	Pelvic Part
27R	178	132	45	-	-	-	50	23	15	53	61
L	180	134	45	45	-	-	60	29	25	51	56
28R	167	-	46	45	62	74	46	25	15	47	55
L	167	-	46	45	64	73	47	26	14	47	52
29R	183	146	49	49	76	79	51	29	18	59	57
L	184	145	48	48	76	79	51	26	19	59	58
30R	178	136	45	44	73	68	55	29	20	53	55
L	178	140	48	46	73	69	54	29	20	57	50
31R	180	150	48	47	64	73	46	25	16	60	63
L	181	151	47	45	63	74	45	25	14	59	63
32R	190	145	48	49	72	79	45	26	12	62	57
L	195	147	49	50	68	77	45	27	12	61	58
33R	181	137	45	44	70	74	57	27	20	51	65
L	178	135	46	45	67	73	60	32	25	49	67
34R	186	147	47	46	72	73	45	26	12	68	49
L	186	146	46	46	72	74	46	27	9	63	49
35R	176	141	43	43	64	75	54	23	20	50	62
L	176	139	43	42	64	75	52	26	22	50	59
36R	178	134	46	47	-	-	50	24	16	53	58
L	179	137	47	46	-	-	58	22	18	54	59
37R	189	150	46	46	65	77	52	29	15	60	58
L	189	148	47	46	65	78	49	29	12	60	60
38R	179	139	48	47	64	73	49	25	15	58	57
L	180	138	48	47	64	73	52	26	16	59	56
39R	191	-	43	44	74	79	53	26	20	57	63
L	193	155	44	44	76	80	55	28	20	58	66

FEMALE INNOMINATE BONE

Serial number and side	Maximum length	Breadth of ilium	Acetabulum		Pubic length	Ischial length	Gr. sciatic notch			Chilotic line	
			Vertical Diam.	Transverse Diam.			Gr. width	Gr. height	Length O-B	Sacral Part	Pelvic Part
40R	193	161	48	48	75	80	55	30	19	67	58
L	194	160	49	49	76	83	56	30	18	64	63
41R	183	143	45	46	66	73	57	25	21	53	60
L	184	144	45	45	67	72	55	29	25	54	59
42R	184	148	46	45	-	-	52	25	17	60	57
L	186	148	44	44	64	73	52	25	20	59	61
43R	188	155	47	45	75	70	45	29	16	55	70
L	189	154	47	45	75	71	51	30	22	57	67
44R	181	146	44	46	-	-	50	26	19	63	54
L	185	145	44	-	-	-	54	26	19	59	56
45R	194	143	44	44	-	-	57	24	17	60	68
L	-	143	46	-	-	-	57	25	22	61	61
46R	180	132	46	45	66	73	52	24	19	54	60
L	179	131	46	-	-	-	54	24	19	53	63
47R	174	140	43	42	-	-	52	24	25	60	51
L	174	140	43	43	-	-	50	26	24	59	51
48R	165	136	41	43	67	69	49	29	22	55	54
L	170	138	42	43	69	70	47	26	21	57	56
49R	183	145	47	46	71	77	49	28	14	57	64
L	186	145	46	46	69	77	50	22	11	61	60
50R	179	133	47	-	-	-	50	25	20	57	57
L	179	134	46	-	-	-	50	25	20	-	-

APPENDIX C. MALE FEMUR

(linear measurements in mm.)

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans.cond. breadth	Angle of femoral neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
1R	432	428	82.8	83	117.4	79	41	131	67	130	10	16
L	432	428	79.3	82	112.5	79	42	132	69	126	10	28
2R	429	424	92.3	80	116.7	82	40	128	71	131	9	19
L	429	423	100.0	80	116.7	81	41	129	70	130	10	25
3R	445	444	75.9	79	112.5	80	41	131	67	131	5	25
L	447	445	75.9	81	108.0	80	42	132	66	128	7	28
4R	458	451	72.4	82	-	-	43	136	72	122	13	17
L	452	447	70.0	83	104.0	78	43	136	70	122	13	15
5R	455	450	75.9	82	107.7	84	45	142	71	128	10	21
L	457	452	75.9	83	112.0	85	45	141	72	128	10	29
6R	480	479	87.1	90	118.5	95	44	140	72	134	5	22
L	481	480	86.7	90	119.2	93	45	142	73	130	5	22
7R	440	437	88.0	76	121.7	80	41	129	66	135	8	17
L	438	435	80.8	76	113.0	77	41	131	65	133	7	18
8R	434	430	77.8	78	121.7	80	40	128	66	132	11	4
L	435	429	84.6	77	121.7	81	40	128	67	132	12	20
9R	427	420	87.5	72	114.3	71	40	127	69	134	11	26
L	430	423	80.0	73	109.1	72	40	126	69	133	11	35
10R	439	436	71.0	86	120.0	87	41	130	66	122	10	17
L	441	439	68.8	87	111.5	88	42	132	68	122	9	18
11R	447	439	75.0	77	104.3	76	44	139	65	135	12	25
L	447	444	70.0	82	100.0	78	44	141	69	128	8	36
12R	451	448	78.1	89	125.0	86	48	152	71	127	7	27
L	449	448	72.7	90	120.0	87	48	153	73	124	7	28
13R	470	467	82.1	81	130.4	84	42	132	70	128	8	8
L	473	469	82.1	82	130.4	84	42	132	69	125	9	17

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans. cond. breadth	Angle of femor neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
14R	435	429	75.0	78	104.2	78	41	134	66	132	11	20
L	433	429	78.6	80	92.0	76	41	132	66	129	10	29
15R	433	429	75.9	80	96.0	78	40	125	65	125	11	17
L	429	425	70.0	82	92.3	79	40	125	65	120	11	33
16R	420	416	77.8	76	113.6	73	41	128	67	131	10	16
L	421	417	69.0	78	113.6	73	41	129	68	129	10	26
17R	455	453	72.7	91	115.4	88	44	141	74	127	8	21
L	461	460	75.8	92	115.4	88	45	144	74	127	8	27
18R	452	449	82.8	85	107.7	84	46	147	73	130	8	23
L	457	452	82.8	85	108.0	83	46	146	73	130	10	34
19R	450	445	87.1	91	114.8	89	47	149	75	126	11	25
L	453	446	78.8	93	107.1	90	47	150	76	120	11	29
20R	489	486	80.6	87	103.7	86	44	140	68	131	8	14
L	482	480	78.1	89	111.1	89	45	141	68	130	6	30
21R	443	436	74.2	85	108.0	82	43	135	67	130	12	10
L	444	440	71.9	89	103.8	84	43	137	70	129	8	21
22R	470	468	87.1	93	114.3	96	45	141	77	124	8	17
L	468	465	81.8	95	106.9	95	46	144	81	123	9	24
23R	442	439	84.6	76	121.7	81	40	125	60	130	9	10
L	440	436	84.6	78	108.0	81	39	124	63	128	10	26
24R	429	426	82.8	84	116.7	82	41	130	65	129	8	33
L	426	423	82.8	85	120.0	85	42	131	66	126	9	32
25R	502	498	96.7	94	125.0	97	46	147	84	129	9	17
L	493	488	87.1	93	122.2	94	46	146	82	127	9	30
26R	405	405	72.4	79	84.6	75	41	131	66	130	5	18
L	408	407	72.4	80	92.3	76	40	128	68	130	7	10

MALE FEMUR

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans. cond breadth	Angle of femoral neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
27R	449	446	75.0	90	107.4	89	43	138	73	126	9	22
L	448	445	72.7	92	115.4	90	44	138	75	122	9	26
28R	439	436	81.5	78	117.4	79	41	131	69	135	8	19
L	439	434	81.5	78	117.4	79	41	131	69	135	10	27
29R	443	438	89.3	83	125.0	85	45	141	70	128	10	13
L	439	435	86.2	86	124.0	87	45	141	71	125	11	20
30R	443	441	80.8	77	112.5	80	41	130	64	134	6	18
L	448	447	77.8	76	128.6	78	41	129	64	132	5	29
31R	456	453	71.0	87	96.3	83	45	142	73	130	11	8
L	457	453	71.0	86	96.3	83	45	142	73	131	10	10
32R	443	441	83.3	85	116.0	85	43	137	72	124	6	25
L	444	443	100.0	85	132.0	90	43	137	72	127	6	-
33R	481	475	80.0	85	103.8	84	44	138	72	130	11	12
L	473	467	76.7	85	100.0	83	45	141	71	130	11	20
34R	427	423	82.1	80	108.3	79	43	133	70	131	10	15
L	430	426	82.1	81	104.0	79	43	135	70	130	10	17
35R	429	427	82.8	84	120.8	85	43	137	71	127	7	30
L	433	431	86.2	87	120.0	87	44	138	71	127	7	42
36R	432	428	65.5	75	104.3	73	41	130	65	129	9	18
L	426	423	62.1	77	100.0	73	42	132	66	122	9	24
37R	459	455	75.9	82	108.3	79	45	143	69	126	10	21
L	458	452	76.7	85	112.5	81	46	144	69	125	12	37
38R	456	453	92.9	86	130.4	87	43	136	72	133	9	3
L	459	456	88.9	83	130.4	84	43	136	72	130	9	17
39R	448	444	84.6	76	118.2	77	41	129	63	132	9	23
L	448	445	76.9	76	113.0	77	41	128	63	127	7	33

MALE FEMUR

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans. cond. breadth	Angle of femoral neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
40R	458	453	75.0	77	117.4	80	43	136	70	129	10	20
L	454	448	77.8	77	113.0	79	43	138	71	129	11	32
41R	445	443	73.3	81	92.3	79	43	135	67	126	7	18
L	444	441	72.4	78	100.0	76	43	135	65	125	9	37
42R	469	465	85.2	80	126.1	81	45	141	70	129	10	17
L	461	459	85.2	82	116.7	82	45	143	71	128	9	28
43R	458	457	75.0	91	111.1	89	43	137	71	120	7	20
L	463	460	70.6	93	107.4	91	44	139	72	125	9	21
44R	464	462	82.1	81	108.0	81	44	138	72	131	8	9
L	466	464	73.3	83	112.0	83	45	140	73	133	9	23
45R	413	411	71.4	76	91.3	70	42	132	71	122	9	17
L	407	405	69.0	79	91.7	72	42	134	70	117	11	30
46R	445	440	80.0	87	100.0	89	45	142	72	132	10	10
L	446	443	80.0	89	111.5	89	45	141	71	130	10	18
47R	494	494	77.4	91	127.6	105	50	156	82	130	3	15
L	498	496	80.0	91	134.6	97	50	158	82	130	6	25
48R	461	458	77.4	89	116.0	85	44	140	76	126	9	19
L	466	464	75.0	91	107.7	87	44	138	76	126	8	19
49R	426	424	88.0	74	122.7	77	40	126	68	125	6	22
L	425	422	77.8	77	113.0	76	39	124	66	127	8	33
50R	448	446	89.7	89	107.7	85	46	144	73	132	8	21
L	448	446	87.1	94	103.6	88	46	146	72	125	10	13
51R	430	425	67.9	76	100.0	72	40	128	66	128	10	31
L	433	429	69.0	77	104.3	74	40	128	66	125	11	26
52R	454	449	72.4	80	112.5	80	43	136	67	129	10	10
L	456	450	72.4	80	121.7	83	43	136	68	132	10	25

MALE FEMUR

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans. cond. breadth	Angle of femoral neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
53R	447	444	80.8	75	108.7	76	42	133	70	129	8	23
L	447	441	80.8	75	108.7	76	43	135	70	126	11	28
54R	463	458	73.3	83	100.0	79	45	142	74	130	9	43
L	464	460	71.0	85	100.0	82	45	142	72	127	9	34
55R	448	445	89.3	84	120.0	88	42	133	64	130	8	22
L	448	445	83.3	87	120.0	87	43	136	65	124	9	29
56R	473	468	79.3	84	112.0	85	43	139	68	124	10	15
R	470	465	77.4	87	103.7	87	43	138	68	118	11	23
57R	442	440	82.8	83	120.8	84	42	133	73	134	7	12
L	444	444	82.1	82	120.8	84	42	133	72	130	6	10
58R	428	425	81.5	80	121.7	81	41	130	72	128	8	20
L	427	422	75.0	78	122.7	79	41	132	71	127	9	31
59R	462	455	92.3	79	121.7	81	43	137	-	142	10	37
L	460	456	85.7	81	121.7	81	43	136	67	132	10	35
60R	446	442	83.3	87	107.4	88	40	129	74	117	9	26
L	449	445	83.3	87	119.2	90	41	130	74	121	9	29
61R	425	422	76.7	88	108.0	82	42	133	73	132	8	17
L	422	420	76.7	85	112.0	83	42	132	70	125	8	17
62R	441	437	78.6	82	104.0	81	43	135	71	125	9	23
L	438	433	70.0	85	104.0	82	44	139	71	125	10	36
63R	448	443	88.0	77	117.4	78	42	133	67	138	9	16
L	445	440	77.8	79	118.2	77	42	133	68	134	10	32
64R	427	424	78.6	79	104.2	78	42	130	71	127	9	10
L	431	429	75.9	80	112.5	80	42	130	-	128	9	18
65R	462	458	79.3	83	120.0	85	43	138	71	136	9	13
L	464	459	79.3	83	112.5	81	45	142	70	130	10	33

MALE FEMUR

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans. cond. breadth	Angle of femoral neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
66R	437	431	78.1	93	115.4	88	46	144	72	123	11	14
L	438	434	76.5	95	114.8	91	46	146	72	125	11	15
67R	433	429	73.3	82	112.0	82	42	131	65	123	11	21
L	440	435	78.6	81	112.5	81	42	133	64	121	11	34
68R	461	459	80.0	88	107.4	87	44	140	69	126	7	25
L	464	461	71.9	88	111.5	86	44	140	69	120	8	28
69R	439	435	82.1	81	126.1	83	41	128	69	121	10	15
L	436	434	73.3	83	116.7	83	42	129	70	120	8	20
70R	467	463	72.4	80	121.7	83	44	138	66	125	8	33
L	478	473	80.6	89	114.8	90	45	140	66	128	11	4
71R	449	445	77.4	86	100.0	82	45	142	72	129	11	20
L	451	447	75.0	88	96.3	84	46	144	71	126	9	30
72R	437	433	81.5	79	113.0	77	42	133	68	128	9	17
L	433	428	77.8	78	108.7	76	42	133	68	128	10	26
73R	471	466	78.6	80	95.8	75	43	135	69	129	11	17
L	471	467	73.3	83	95.8	76	42	133	68	126	10	34
74R	434	429	82.1	79	100.0	76	44	139	68	128	10	21
L	435	431	81.5	78	104.3	75	43	135	65	130	9	27
75R	434	433	88.5	80	117.4	79	43	139	74	125	6	18
L	434	434	88.9	82	121.7	81	43	139	74	123	5	17

FEMALE FEMUR

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans. cond. breadth	Angle of femoral neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
1R	462	456	84.0	77	121.7	80	38	120	66	131	10	16
L	464	459	84.0	78	118.2	76	39	121	66	127	10	37
2R	410	404	69.0	76	104.3	74	37	119	59	125	12	9
L	411	403	71.4	76	104.3	72	37	120	58	124	14	29
3R	435	427	88.5	81	130.4	84	39	125	62	131	13	16
L	431	427	92.0	79	126.1	83	39	125	63	125	10	26
4R	419	415	77.8	78	104.2	77	38	120	63	130	9	16
L	424	420	72.4	79	100.0	77	37	118	62	127	11	16
5R	391	387	76.9	73	91.3	69	39	122	59	129	10	21
L	394	391	80.8	74	91.3	69	39	123	60	129	10	23
6R	431	428	88.5	78	117.4	78	38	120	59	132	9	15
L	430	426	78.6	79	113.0	76	38	118	59	130	9	21
7R	437	433	75.0	78	104.2	76	39	123	60	124	11	16
L	437	434	69.0	78	108.7	75	39	124	61	124	10	22
8R	427	416	68.0	68	90.0	61	39	124	60	126	14	39
L	426	417	62.1	76	86.4	66	38	122	62	123	14	35
9R	416	413	84.6	77	118.2	76	40	124	63	132	10	14
L	418	414	77.8	76	108.7	75	39	122	62	130	9	26
10R	421	416	87.5	71	119.0	73	38	119	65	123	11	22
L	421	418	74.1	76	119.0	73	38	119	64	122	9	29
11R	392	387	75.0	68	105.0	65	37	118	61	132	10	27
L	391	383	75.0	68	104.8	66	37	118	61	132	12	30
12R	398	395	84.0	72	95.7	71	36	114	57	122	9	23
L	398	396	79.2	71	104.5	71	36	114	57	120	8	28
13R	433	427	85.2	80	108.3	79	38	122	62	131	11	16
L	435	432	78.6	80	108.3	79	39	123	64	127	9	17

FEMALE FEMUR

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans. cond. breadth	Angle of femoral neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
14R	453	450	96.2	85	120.8	83	39	123	65	138	9	16
L	449	446	92.6	85	112.5	82	39	123	65	134	8	21
15R	425	418	73.1	72	95.5	67	39	121	58	127	14	21
L	422	413	70.4	74	95.5	67	38	120	59	125	15	26
16R	426	420	74.1	76	118.2	78	38	121	62	134	11	26
L	425	420	71.4	75	118.2	75	39	122	62	130	9	39
17R	425	419	91.3	71	114.3	71	39	125	62	139	10	26
L	423	419	79.2	70	109.1	72	39	125	63	135	9	26
18R	437	434	77.8	77	113.6	74	42	130	66	129	10	26
L	436	433	84.6	78	118.2	76	42	130	65	127	9	30
19R	417	413	76.0	70	100.0	69	37	118	59	121	11	25
L	418	414	79.2	69	104.8	68	38	119	58	123	9	36
20R	411	408	75.0	78	95.8	73	39	124	61	123	10	16
L	412	408	74.1	77	104.3	74	38	122	62	121	11	25
21R	435	431	88.9	80	120.8	82	38	121	65	123	9	32
L	428	425	85.2	80	116.7	81	38	120	65	123	10	29
22R	411	404	77.8	77	96.0	75	38	120	58	123	13	13
L	407	403	77.8	77	92.0	74	38	120	58	120	11	36
23R	414	412	81.5	77	108.7	76	38	120	61	125	8	8
L	412	410	78.6	80	104.2	76	39	122	62	126	9	5
24R	399	394	73.9	64	90.5	63	36	113	54	133	9	43
L	394	390	69.6	64	95.0	62	35	110	54	132	9	50
25R	397	394	83.3	71	95.5	67	36	114	60	129	8	36
L	394	392	83.3	72	95.5	67	36	114	60	129	6	42
26R	458	455	95.8	77	118.2	76	37	118	63	124	8	34
L	461	457	88.5	79	113.0	77	37	119	64	123	10	35

FEMALE FEMUR

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans. cond. breadth	Angle of femoral neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
27R	429	422	78.3	66	90.5	63	38	121	-	134	13	-
L	432	424	73.9	65	95.0	63	38	121	63	135	12	44
28R	430	422	67.9	76	104.5	72	37	117	-	123	14	34
L	428	420	65.5	77	100.0	72	37	115	62	124	14	38
29R	408	404	76.0	70	109.5	70	38	120	63	132	10	2
L	403	401	72.0	69	100.0	69	38	121	63	132	8	8
30R	414	406	92.0	76	128.6	75	38	121	59	126	14	17
L	411	408	88.0	75	118.2	75	38	120	60	119	10	31
31R	444	440	71.4	77	104.3	73	39	124	65	125	10	29
L	444	436	75.9	80	104.3	73	39	123	63	126	14	26
32R	453	445	80.8	76	104.3	74	40	126	61	133	12	27
L	447	439	81.5	76	104.3	73	40	127	61	132	13	34
33R	450	447	81.5	78	104.3	75	39	123	64	131	8	23
L	453	452	81.5	77	100.0	76	39	124	61	132	7	17
34R	416	414	85.2	79	112.5	80	38	121	62	129	6	30
L	414	410	75.9	81	100.0	80	37	118	61	126	10	26
35R	460	459	84.0	74	104.5	71	39	124	62	131	5	21
L	470	470	77.8	77	-	-	40	125	63	124	4	11
36R	450	448	87.0	68	100.0	70	39	121	-	133	8	13
L	441	440	79.2	69	114.3	71	38	119	-	128	5	19
37R	448	444	80.8	76	122.7	78	40	126	66	130	9	27
L	447	444	74.1	75	117.4	78	40	126	66	126	8	20
38R	398	394	75.0	77	104.3	74	38	121	61	122	10	29
L	400	395	77.8	77	104.3	74	38	121	61	122	11	37
39R	430	428	83.3	72	100;0	72	40	126	64	126	8	21
L	426	424	76.0	72	100.0	72	40	127	64	123	8	21

FEMALE FEMUR

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans. cond. breadth	Angle of femoral neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
40R	457	452	88.9	79	108.3	77	41	130	65	134	10	14
L	466	462	82.1	80	108.7	75	40	129	65	130	10	31
41R	416	410	75.0	68	100.0	66	37	118	59	122	12	23
L	419	414	70.8	67	110.0	66	37	118	59	124	11	32
42R	467	463	76.9	74	109.1	73	39	123	65	130	8	26
L	469	462	84.0	75	113.6	73	39	123	67	132	11	11
43R	413	406	74.1	75	109.1	73	37	117	62	125	13	16
L	415	408	76.9	75	104.3	74	37	118	62	122	14	31
44R	427	426	70.4	74	95.8	73	36	113	56	119	6	23
L	422	422	76.9	74	95.8	73	36	114	56	119	5	24
45R	400	393	72.0	69	86.4	66	37	118	58	137	12	28
L	403	397	72.0	69	100.0	66	37	119	59	135	11	35
46R	443	438	91.7	74	117.4	78	38	122	63	132	10	28
L	443	440	88.0	75	121.7	79	39	121	63	130	9	29
47R	403	399	80.0	71	109.1	71	36	113	58	132	10	21
L	406	398	80.0	71	119.0	73	36	114	58	129	12	28
48R	414	411	67.9	74	87.5	72	39	123	63	128	10	11
L	412	411	67.9	75	91.7	73	39	123	65	126	9	17
49R	420	419	80.0	75	104.3	73	40	124	61	122	7	27
L	419	417	84.0	76	104.3	74	40	124	61	114	8	26
50R	406	402	69.2	71	95.2	67	38	119	60	121	12	19
L	405	401	65.4	72	90.9	68	38	119	59	118	11	21
51R	392	388	70.4	73	104.8	69	37	118	60	123	10	35
L	390	387	67.9	75	100.0	69	37	117	60	116	10	37
52R	420	416	73.1	72	114.3	72	37	116	61	136	10	23
L	420	416	76.9	73	109.1	72	38	119	61	129	12	26

FEMALE FEMUR

Serial number and side	Maximum length	Oblique length	Subtroch. region		Shaft at middle		Femoral head		Trans. cond. breadth	Angle of femoral neck	Angle of obliquity	Angle of torsion
			Platymeric index	Circ.	Pilastric index	Circ.	Vertical Diameter	Circ.				
53R	378	374	73.9	66	95.2	65	37	115	56	128	11	8
L	383	379	78.3	66	105.0	64	36	114	56	127	11	13
54R	429	424	82.6	68	120.0	70	39	123	62	131	10	26
L	429	422	87.0	69	131.6	70	38	119	62	126	12	26
55R	411	405	92.0	78	117.4	79	38	118	58	130	11	9
L	411	409	92.0	78	122.7	77	37	118	59	124	8	17