A CRITICAL ANALYSIS OF THE BANTU PELVIS, WITH SPECIAL REFERENCE TO THE FEMALE.

Thesis submitted for the Doctorate in Science
to the Department of Anatomy,
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- Professor -

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PART I

I INTRODUCTION

The student of pelvic morphology is compelled sooner or later to consider the two main functions of the girdle, those of weight-bearing and parturition. These functions inevitably guide his investigations. Comparatively little work has been done on the pelvic mechanics of erect posture. The evolution of man's erect posture, on the other hand, has been considered by Friedenthal (1910), Weidenreich (1913), Keith (1923), Morton (1926), Westenhöfer (1929), and Reynolds (1931). The last author's disappointing paper succeeds only in demonstrating the difficulty of establishing the principles underlying the orthopaedist's approach to the mechanics of man's posture.

Parturition, the second pelvic function, has throughout the ages stimulated scientific thought with greater force and much more constantly than has the weight-bearing function. The reason for this is that trauma of the vertebral column and lower limb girdle has always been much less frequent than aberrations during parturition: any parturient indeed may make

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some call on a full knowledge of labour mechanisms, and the mind of man has been occupied since the dawn of civilisation - and perhaps before - with the mysteries of childbirth problems.

In the first place it was the desire to become well acquainted with the bony passages as one factor in parturition that stimulated the present exercise. Since it is an accepted generalisation that a prominent cause of difficult labour in the Bantu lies in differences between the European and Bantu pelvis - a generalisation unsupported by any study of the bony pelvis -, it is essential at the outset in South Africa to lay down the foundations of such a study.

For the work on the Bantu* about 50 metrical and non-metrical values were analysed, all measurements chosen referring to the pelvic girdle rather than to separate component bones. So far from thinking that the analysis has been exhaustive, it is submitted that only 6 functions of the pelvic girdle - including area, indicial, angular, and linear values - are of essential importance to obstetrics (Heyns, 1944). Measurements

*"Bantu" is a linguistic name which, strictly speaking, should be replaced by the more appropriate physical term South African Negro.

of the pelvis might well be infinite, and scientific method must seek those that are essential to racial or sexual differentiation, to other anthropological purposes, or to obstetrics. The 6 pelvic functions are the predominant features to be considered in the analysis of any pelvis or group of pelves; and if a preliminary survey of a series is being made, these values should receive consideration first.

II HISTORICAL SURVEY

1. ANATOMICAL

(a) South Africa. The Bantu pelvis has not been studied on a collection of skeletal material comparable numerically with the present. Gillman (1929) and Shore (1930) published anatomical studies on the Bantu sacrum; Orford and Wells (1936) studied 100 living Bantu women on the basis of body habitus and of measurements obtained by clinical pelvimetry; and Orford (1934) described the Bush pelvis with a small series of Bantu pelves.

Last century Fritsch (1872) recorded some metrical data concerning Hottentots, 7 Kaffirs, and a few

Bushmen. Turner (1886, a & b) dealt with similar material in his papers on sacral and brim indices. Verneau (1875), and to a less extent other anatomists, also recorded measurements derived from pelves of Negro and related stocks found in South Africa.

The Boskop skull was discovered in 1913 and subsequent discovery of more complete skeletal material at the caves of Zitzikama (Fitz Simons, 1921; Dart, 1923) gave some information about the skeletal features other than the skull of this Boskop type. Thus arose new concepts concerning the physical composition of our living South African races. Gear (1925, 1926) gave the first description of the Boskop sacrum. Later Weiner (1934) in a symposium on the skeleton of the Bush race described 13 Bush sacra. Since the early nineteen-twenties there has developed a crystallisation of the view that the Boskop, Bush, and Bantu races are three generic groups as distinct in chronology as in physical type. Galloway (1937) has shown that all the South African Middle Stone Age skulls are within the normal range of variation of a single physical type.

Dart (1937) approaching the problem from a

historical point of view suggests that ten to twenty thousand years ago Africa was inhabited by the Boskop race. The Bush race migrated south, making contact with the Boskop people. Miscegenation gave rise to physical variation of features within both groups. This anthropological complexity was increased by contacts with people alien to Africa, for Mongoloid and even European skulls have been identified with a pre-Bantu cultural horizon. The Bantu arrived later and it is suggested that, "linguistically, the Southern Bantu can be subdivided into 3 main zones:-

1. Western, spreading north and south of the Okanvango River and including the Ambo, Herero, and Mbundu (as far north as Benguella on the Angola Coast);
2. South-Central, comprising the Shona tribes of Southern Rhodesia;
3. South-Eastern, situated principally in the Union of South Africa and Portuguese East Africa but also extending into Bechuanaland and the headwaters of the Zambesi. It includes:-
   (a) the Nguni peoples (such as the Xhosa, Zulu,

- and -

and Swazi) on the south-eastern sea-board, all of whose dialects are affected by Bush clicks;

(b) the Shangana-Tonga (Thonga) peoples of Portuguese East Africa, who have no clicks;

(c) the Sotho peoples, such as the Southern Sotho of Basutoland, Northern Sotho of the Transvaal, and Tzwana of Bechuanaland; and

(d) the Venda of North-Eastern Transvaal." (Dart, 1937).

While a great deal is known about skulls of South African physical types, living and fossil, little is known of the rest of the skeleton. The osteology of the Bush race was dealt with in a published summary of a symposium on the Bush skeleton (1934). The value of using the whole skeleton for racial diagnosis was shown in the material from Mapungubwe (Galloway, 1937); but although there is available in the collection of the Department of Anatomy, University of the Witwatersrand, a large collection of Bantu pelvic material, very little work has been done on it. Elsewhere in the world also few comprehensive studies on the osteology of the pelvic girdle have been made.

(b) Elsewhere. Verneau (1875) and Turner (1885-1886) studied the pelvis comparatively fully, Turner presenting no less than 35 separate data and devoting an entire monograph to the pelves of the H.M.S. Challenger skeletal material. The paper of Koganei and Osawa (1900) (not available in South Africa) is reported as an exhaustive study of the pelvis which might well serve as a guide (Wilder, 1920). Derry (1909, 1923) and Straus (1927-1928) studied specialised aspects of the innominate bones or the pelvic girdle as a whole. In Hooton's work (1930) on the skeletons of the Pecos Pueblo Indians, the pelvis was treated briefly; and Reynolds, writing a section on the pelvis in the same monograph for the purpose of assessing the data, confines himself almost entirely to a discussion on the mechanism of labour. Hill (1941) described 20 Veddah pelves and Pan (1929) 64 Hindu female pelves, studies which, though not exhaustive, are valuable. Ssoson-Jaroschewitz (1925) studied an extensive collection of Russian pelves. As these studies have followed usual procedures, they have not contributed anything to the method by which a series of pelves should be investigated. Specific aspects of

the pelvis have been explored, but workers have rarely presented a full range of metrical data. This statement does not apply to the sacrum which has been exhaustively studied by several anatomists, e.g. Radlauer (1908), Paterson (1896), Fischel (1906).

2. OBSTETRICAL

The majority of studies on the morphology of the girdle has been made by obstetricians. In the beginning, interest in this sphere was confined to measurements on the parturient or pregnant woman, so that in time small but useful collections of data were accumulated. It was on this foundation that later the physical anthropologist commenced building in a scientific manner. Before Vesalius (1543) no one is known to have described the anatomy of the pelvis accurately. It was he who demonstrated that it was impossible for the pelvic bones to separate adequately in dystocia due to contracted pelvis.

Belief in the Hippocratic theory of pelvic bone separation during labour resulted in disregard of the fixed measurements of the pelvis. Thus the rational

development of pelvimetry was retarded. The first known description of contracted pelvis was given only in 1572 by Arantius. It is true that Soranus of Ephesus, perhaps the greatest obstetrician of all time, in the second century A.D. observed a narrow pelvis to be a cause of dystocia, but he attributed the contraction to failure of the bones to separate during labour.

Van Deventer (1701) erected a milestone by being the first to introduce an illustrated description of pelvic osteology into a work on obstetrics, but it was Smellie (1752) who first gave definite pelvic measurements for normal and abnormal pelves. He also gave a tolerable description of the plane and axis of the pelvic brim. For many years subsequent to this clinicians strove to gain a maximum of measurements of the pelvis on their patients only. Thus, nearly a century ago Michaelis took measurements on 500 living women, and Litzmann on 200.

Martin (1866) measured 16 dried pelves and used 20 cadavera for comparison, and also gave brim measurements for pelves from different races. Zaayer (1866) measured 26 Javanese female pelves, and introduced the

pelvic brim index as a measure of brim shape. Skeletal study was carried out by Runge (1889) on 50 Russian female pelves, Rodriguez (1895) and Sanchez Gomez (1895) on Mexican pelves, Koganei and Osawa (1900) in Aino and Japanese, Garson (1881-1882) on 5 Australian and 13 Andamanese women, Emmons (1913) on 217 female pelves of American Indians, Thoms (1935) in America, and Caldwell and Moloy (1933) on 268 female pelves (American white and Negro stocks).

Recently radiographic studies on the living have taken the place of skeletal studies. Dry pelves take a considerable time to accumulate, whereas the living subject is available everywhere. Although X-ray pelvimetry can be very unreliable (see Appendix 1), contributions from living material will add considerably to knowledge of the pelvis and must remain the foundation of progress in the future. Caldwell et al. (1934, 1939), though providing no metrical data, have made such extensive radiographic pelvic studies on morphological lines, before and during parturition, that to-day they are considered the leading authorities on the influence of the bony pelvis on labour, and by inference the undisputed leaders in the wider field of pelvic

morphology. In England Nicholson (1938) and Ince and Young (1940) published very large series of pelvic measurements derived from X-ray studies of pregnant women, and Kenny (1944) investigated radiographically 1,000 pregnant women who had a "clinically suspect pelvis".

III SUMMARY

The pelvic girdle of the Bantu has received but scant attention. On the morphological side work has usually been done on the girdle either because of an interest in specific features such as the brim index, or because of the influence of the bony pelvis on parturition. Few exhaustive studies on the pelvis have been made, though the sacrum has been fully investigated by several anatomists.

Obstetricians were first in the field of pelvimetry, only living subjects being used for this purpose. The physical anthropologist carried the early work into the sphere of science; and since the time of Martin and Zaayer in 1866 the dried pelves of many races have been measured. Recent investigation has been based on radiography which offers greater possibilities than

does the slowly accumulated material of osteological collections. X-ray pelvimetry, although precarious, has in the past decade led to a better knowledge of the female pelvis.

PART II

MATERIAL AND METHODS

I INTRODUCTORY NOTE

For the present survey 100 male and 67 female pelves have formed the skeletal material, and 125 adult female patients were subjected to X-ray pelvimetry. These pelves were studied biometrically in the main, using quantitative values; and where morphological characters provided the material for analysis, the statistical method was applied as far as possible. The purpose of the investigation was to assess the Bantu pelvic girdle, with special reference to the female, and to determine its range of anatomical variation. Neither the innominate bone nor its 3 component elements were treated individually. Against criticism of this omission there must be advanced the reason that the present study does not claim to be comprehensive. A complete study would embrace (a) phylogenetic and ontogenetic aspects; (b) linear, indicial, angular, two-dimensional and perhaps three-dimensional considerations of the features of the sacrum, ilium, ischium, pubis, innominate

bone, and pelvic girdle as a whole - and the amplitude of the range of mensuration would be either infinite or merely arbitrary; (c) morphological studies; (d) pelvic orientation in varying postures; and finally, (e) the application of the findings to the pelvic functions of weight bearing and parturition. When the data have been collected there comes the responsible task of correlation, classification, and comparison of variables which in itself can be without end.

Of the above-mentioned branches of research the ontogenetic development of the human pelvis, for example, is virtually in its infancy; and there is no recorded evidence of the application of radiographic methods which alone can trace developmental changes that occur in given pelves from infancy to adolescence.

The present report contains (1) an analysis of such dimensions of the pelvic girdle and the sacrum as were thought from a practical obstetrical point of view to be of value, (2) a less adequate study of X-ray findings of the same kind, (3) a preliminary consideration of the foetal and infantile pelvis and

its sexual differences, and (4) an estimation of the weight and head measurements of the Bantu newborn, of which a knowledge is necessary for comparing female pelves of different racial groups. The last section is embodied in an appendix which also contains the experimental data on which the method of X-ray pelvimetry is based. The total data presented comprise some 17,000 determinations of which two-thirds belong to the pelvis and 7,000 of which were based on pelvic mensuration in some form. While the investigation is necessarily incomplete, it is being followed by further studies. Because of its greater urgency, ontogenetic development is being investigated on 100 Bantu foetal pelves and radiographs of infants and children. A long-term plan which is possible only with European material has been the collection of pelvigraphs of a series of children who will be X-rayed periodically at the ages of one year, 5 years, 8 years, 11 years, and 15 years. The latter series of films will give valuable evidence of the direction of growth of the pelvis, and should remove the necessity for speculation of the kind made by Breus and Kolisko (1904).

II MATERIAL

The adult skeletal material used was obtained from the Department of Anatomy, University of the Witwatersrand, where the disarticulated pelves are preserved. The male pelves, 50 Basuto and 50 Zulu, as well as the 67 female specimens were taken from dissected cadavera of known age, race, and sex.

Forty of the Basuto pelves were selected from the skeletal series of which the skulls were described by Galloway (1937) for the sake of comparison with his Mapungubwe material. Of the 50 Zulu skeletons used, Galloway has studied the skull in 31 cases. In the case of the female, 80 pelves were examined. Of these, 67 pelves were adult Bantu, 2 were Bantu aged 13 and 15 years respectively, and 11 were from individuals of mixed "coloured" Eurafrican race. The present study concerns the 67 adult Bantu pelves only, and the measurements refer to this group. (Totals of 64, 65 or 66, however, indicate an occasional impracticability of measurement owing to damage or gross malformation.) The races included in this group of 67 were: Basuto 24, Xosa 14, Zulu 11, Fingo 7, Swazi 2,

Barolong 2, Bechuana 2, Tembu 1, Pondo 1, ? Mochopi 1, and 2 unknown.

The women whose pelves were radiographed were all Bantu, but their specific race was not ascertained. Dart (1937) discussed the origin of the Bantu people, and it is conceded that "Bantu" is a generic term which is unsatisfactory anthropologically and ethnically. The word is here used to refer to those racial indigenous stocks in Southern Africa which are clearly differentiated from Boskop and Bush peoples, the latter including the Hottentot and the Strandloper (beachcomber.)

The foetal material was obtained at the Bridgman Memorial Maternity Hospital, and was known to be Bantu. Thirty foetal pelves were measured directly. An additional 20 foetūs were used to determine the number of sacral vertebrae in the Bantu foetus. The children X-rayed were aged 1 to 15 years, and were patients or visitors to the two Johannesburg hospitals for Non-Europeans.

III METHODS

1. General

Adult Pelvis. It was found that the bones could not be

- reliably -

reliably articulated with rubber bands. Where this was possible, the pelvis had insufficient stability to remain unchanged during handling. Plasticine and plaster of Paris soil the bones sufficiently to ruin them. Articulation was effected by "Metallic-X" which proved to be efficient for the purpose, and is easily removed either with a knife or a solvent like acetone. "Metallic-X" was applied to the sacro-iliac articular surfaces, the bones being carefully placed in wet sand until this adhesive hardened. Satisfactory articulation was judged by the following criteria:

(a) the most accurate coaptation possible for the sacro-iliac joint surfaces,

(b) symmetry of the whole pelvic brim,

(c) symmetry at the symphysis pubis and subpubic angle by viewing the joint from above and below, and

(d) special care when separation at the symphysis was greater than normal.

X-ray pelvimetry. Use of X-ray films for the measurement of pelvic diameters is unsatisfactory, and many views are required for a large range of dimensions. A paper (Heyns, 1945) is included as Appendix 1 to

show what method was used, the experimental work upon which the method was based, and the problems associated with a study of the living subject.

Foetal pelvis. Exhaustive experimentation demonstrated that there was no easy method of cleaning the foetal pelvis: the cartilage dries and shrinks rapidly, and even preservation in formalin results in some degree of distortion. Pelves were accordingly separated from the foetal trunk and lower extremities, cleaned with scissors, knife, and forceps, and measured without delay.

A further series of 20 foetūs was subjected to excision of the sacrum and a portion of the innominate bones. In 12 of these cases the vertebral column from immediately above the first lumbar vertebra was included with the sacrum. The object of this second foetal investigation was the determination of the normal number of sacral segments.

Other workers have not cleaned foetal pelves and measured them on the same day. For precision, however, this is desirable. Moreover, cleaning of this delicate structure is exacting, and demands 3 to 4

hours work before proficiency is gained. Laboratory assistants not aware of the care required in an investigation of this sort do not have the patience to carry out this type of work with thoroughness and skill; and it was found that cleaning of selected portions only was incompatible with accurate mensuration. The investigator of the foetal pelvis should personally handle the dissection throughout, arduous as the task may be.

2. Measurements.

Adult pelvis. The following measurements present no difficulty of assessment: the interspinous, intercristal, diagonal conjugate, antero-posterior of the cavity, height of the symphysis, external oblique, maximum height of the pelvis, interspinal distance, antero-posterior of the outlet (pubo-sacral diameter).

The following diameters are more difficult to standardize: transverse of brim, oblique of brim, depth of pelvic basin. The following measurements are often based on subjective impressions:

(a) Conjugata vera, which may be the anatomical or the obstetrical conjugate. The former is measured to

the anterior continuation of the ilio-pectineal line and is not always well defined; the latter is shorter and is measured to 'a point on the summit of the inwardly projecting eminence which lies a little below the upper end of the symphysis pubis' (Ince and Young, 1940).

(b) Width of sacro-sciatic notch (ischial spine to lateral edge of sacrum). This was measured to a point on the lateral edge of the sacrum, midway between the lowest two posterior sacral foramina.

(c) Transverse of outlet (inter-tuberal diameter). The tuberosities of the ischium are such large masses of bone that this measurement is frequently arbitrary, varying from observer to observer.

(d) Anterior sagittal diameter of outlet: posterior sagittal diameter of outlet. These depend for their length on the position of the intertuberal diameter already considered.

A large sacral promontory projecting far across the pelvic basin unjustifiably shortens the conjugata vera and lowers the pelvic index. Reliance on the basic value of this diameter, still persistent in obstetrics, can make a pelvis appear small, whereas

the area of the pelvic brim, discounting this enroachment of the promontory, may be larger than the estimate by as much as 10 sq.cm. Even if the conjugate is shortened sufficiently to obstruct passage of the foetal head, the transverse diameter of the brim may be absolutely increased and allow easy engagement of the head. The pelvic cavity below this plane would then, all things being equal, easily accommodate the head.

Some measurements are purely anatomical and are accurate for purposes of comparison (e.g. the interischial spine diameter), some are based on obstetrical considerations (e.g. the obstetrical conjugate and the transverse of the brim as seen radiographically), and some are valueless to both anatomist and obstetrician (conjugate diameters of the brim employing the promontory as one extremity).

X-ray pelvimetry. It is explained in Appendix 1 that the measurements possible were the following: conjugata vera, transverse of brim, interspinal, and intertuberous diameters, depth of the pelvic basin (antero-lateral and anterior), subpubic angle, and

symphyseal height. Areas of the pelvic brim, cavity, and outlet and the brim index were calculated from these data. No sacral measurements were taken.

Foetal pelvis. In order to measure diameters accurately, a travelling microscope was used. The vernier scale made it possible to read to an accuracy of 0.05 mm. For each measurement the small pelvis was oriented so as to bring the diameter into a horizontal plane. Red ink marks were made for guidance, and a pointer used to identify the mark to be viewed through the microscope. As a single observer effected all the measurements, it is believed that uniformity was obtained. This is of considerable importance because many of the diameters, e.g. the transverse of the brim, are indeterminate and would vary within small limits from observer to observer. In assessing sexual differences, however, the specimens of a particular series are comparable.

Three measurements were taken with a sliding compass without vernier attachment - the length of the sacrum and the diagonal conjugate, because the termini were not both visible through the microscope;

- and -

and the depth of the pelvic basin, because measurement with the compass was as precise as that with the travelling microscope. It must be pointed out that measurements with callipers or compass on the foetal pelvis are as unsatisfactory as those taken similarly on soft tissues. As far as can be judged from the literature, foetal diameters have been obtained only by this unsatisfactory method, and one which does not allow of reliable readings to 0.1 mm. Most observers have presented data showing tenths of a millimetre (Thomson, 1899; Kappers, 1938; Falk, 1908, etc.).

Infantile pelvis. With 2 exceptions, aged 13 and 15 years respectively, the postnatal material was not skeletal but derived from living children who were submitted to pelvic radiography.

In radiographs of the child's brim the y-shaped epiphysis is well seen when the brim is not parallel to the film, but after infancy the cartilaginous gap is not readily identified in horizontal brim shadows. This of course is due to over-lapping of the dense shadows of the ischium lying immediately below the

cartilaginous tissue. The most direct and convenient method of taking the pictures is that recommended in Appendix 1 , i.e. with horizontal brim. Measurements may then be corrected, and further inspection made of a brim which is undistorted. Unfortunately, it was found very difficult to induce subjects below the age of 5 years to sit in an attitude of semi-recumbency with moderate lumbar lordosis, which is the position required for the horizontal brim. At their best, juveniles are unsatisfactory subjects for X-ray work of this kind where precision is essential.

For these reasons recourse was had to Nicholson's stereometric method (1936) which gave satisfactory results. This thesis contains only a preliminary consideration of the relative growth of pubis, ilium, and sacrum at the level of the iliopectineal line during the age period 1 to 15 years. Therefore, further development of radiographic technique will not be discussed here. Accurate measurement of the length of these bones was made in a straight line, and the greatest transverse diameter

of the brim determined. The purpose of this was simple, viz. to find (a) whether growth occurs mainly in the pubis or in the ilium and (b) what is the effect of sacral development during childhood. Solution of the radiographic problem fully justifies this preliminary report, for this is the only method of approach to an important investigation which has universally been retarded owing to the impracticability of securing suitable skeletal material.

3. Analysis of Data.

It is quite clear that a mere studying of the facts will not give the truth. There is, however, the necessity to investigate the capacity of the Bantu pelvis, in order to discover what morphological relation it bears to the pelvis considered as average or normal, e.g. the European pelvis. "The thinker formulates his question from a given point of view determined by the context of his own experience. This context of experience includes those beliefs that are widely and firmly held by his contemporaries" (Stebbing, 1930). From the point of view of obstetrics the conclusion presents itself that there are no

available criteria for the Bantu pelvis on which any hypothesis could have been formulated by these contemporaries. If, for example, it is suspected that parturition in the Bantu varies considerably from that in the European, it would be an indispensable preliminary to an investigation into this matter to establish in a precise quantitative manner something of the range of anatomical variation of the female Bantu pelvis. A metrical survey of the pelvis would, in addition, afford the opportunity of assessing racial differences suspected on the basis of a similar "climate of opinion", as A.N. Whitehead has named it.

The method used was based mainly on measurement, both linear and two-dimensional. The data were treated statistically, as were non-metrical features such as the shape and size of the pubic arch. Classification of pelves based on the criteria laid down by Caldwell et al. (1933, 1934) was made. All results were compared with those of Europeans and the figures available for other races.

The biometrical processes used in the present investigation are essentially based on counting or

enumeration. "It cannot be over-emphasized that estimates from small samples are of little value in indicating the true value of the parameter which is estimated. Some estimates will be better than others, but no estimate is very reliable. In the present state of our knowledge this is particularly true of samples from universes which are suspected not to be normal.

"Nevertheless, circumstances sometimes drive us to base inferences, however tentatively, on scanty data. In such cases we can rarely, if ever, make any confident attempt at locating the value of a parameter within serviceably narrow limits. For this reason we are usually concerned in the theory of small samples, not with estimating the actual value of a parameter, but in ascertaining whether observed values can have arisen by sampling fluctuations from some value given in advance. For example, if a sample of 10 gives a correlation coefficient of +0.1, we shall inquire, not the value of the correlation in the parent universe, but, more generally, whether this value can have arisen from an uncorrelated universe, i.e. whether it is significant of correlation in the

parent" (Yule and Kendall, 1940).

It can be asserted that logicians now recognise that the foundation of the theory of induction is to be found in the theory of probability (Stebbing, 1930; Cohen and Nagel, 1934). Thus an attempt is made to obtain a fair sample of all possible instances of the class under consideration and to test the probability of the sample being representative of the instances of this class. In this manner, for example, a closer approach is possible to the truth as to whether a certain feature occurring in the Bantu is an essential racial character or, alternatively, that it occurs in the Bantu with a significantly different frequency from that found for other races.

If a study be initiated on the pelvic girdle of a particular racial group, the objective is elementary, if fundamental. The aim, in the first place, is not a general study of the pelvic girdle as an entity, but simply an analysis of the characters of this particular racial sample in order to contribute more to the sum-total of knowledge of the pelvis gained from all sources. A conception of different

aspects of the pelvis is best derived from the full aggregate of available knowledge, and it is obvious that the process of construction in that case is entirely divorced from the study of the particular racial sample which contributed to the whole. Certain generalised inferences may be made during analysis of the sample (e.g. a suggested morphological classification), but for such practice, the author may be arraigned, though by a few even acclaimed.

The first purpose in the use of the data obtained here is that of comparison with other results. For this reason the quantitative method seems to be the most convenient. Where attributes cannot be expressed quantitatively ab initio and depend on subjective analysis, counting of the data followed by analysis (e.g. presence or absence) will enable the statistical method to be used. If these observations are termed statistics of attributes, as opposed to statistics of variables where the magnitude of the variable character is at once determined, it can be seen that essential anatomical analysis, based on morphological features, need not be impaired. More

reliable conclusions are reached if the biometrical method is applied throughout the investigation.

Frequency distributions of variables have not been shown because in the Bantu skeletal material the series were too small. In order to claim significance for a departure from the curve of best fit, a low P value in the chi-square test must be demanded - and with the small racial series analysed such values are too improbable to justify the labour involved in curve fitting and calculations such as the chi-square test. Morant (1939) stresses the fact that a normal curve of distribution is almost invariably found for samples dealt with by the anthropologist. He refers to 3 examples provided by Felix van Luschan, and states that he knows of no other published distributions for any anthropometric character which show a clear departure from normality. It is unlikely, therefore, that Bantu samples would indicate either appreciable skewness or more than one mode for any of the variables or attributes here considered.

For present purposes, it may be said that the adult pelvis is in a static, well crystallised phase,

- and -

and that its characters should be stated in a conventional manner provided that such convention is progressive and efficient. The foetal pelvis is a dynamic object of which the characters are elusive and transient, thus making analysis - even on the ontogenetic side alone - more difficult. In the latter case ingenuity of the individual observer must be encouraged in order to remedy a serious lack of knowledge, whereas the study of the adult pelvis must follow well-trodden paths with, however, constant removal of the debris of false method and non-valid conclusion. If the anthropologist labours in the direction of becoming, in Plato's words, "the spectator of all time and of all existence", the data to be presented here can but aid him, and should not simulate any form of guidance.

To state summarily the value of the present collection of facts, the following are now available:

1. Data relating to the capacity and shape of the Bantu pelvis and sacrum which will make possible a comparative study in parturition, using a race which has lived under primitive conditions for

centuries.

2. Data which may throw light on racial diagnosis. A larger series of Bantu pelvic measurements and attributes is now available to the physical anthropologist who may be aided when he is considering skeletal material other than the skull, on which of course his chief reliance is placed.

3. It would be frivolous to disregard the possibility that the standard of living in the Bantu is in the process of being altered, or even considerably improved. There exists, then, the opportunity to assess the results of improved nutrition. For this purpose, it is urgent to observe the range of variation of the Bantu pelvic girdle before any possible changes set in: comparison, in a few generations, with the new findings will demonstrate the nature of the changes that may occur. Apart from any other considerations, therefore, it is imperative that the pelvic girdle, whose morphology is held to be sensitive to nutritional states, should be studied without further delay.

PART III
CLASSIFICATION

I INTRODUCTORY NOTE

Most systems of classification of the pelvis are obstetrical, and have an aetiological basis. There appears to be no classification by an anatomist. Anatomy in itself, as Bolk (1925) pointed out, has no creative power but is entrusted with the function of controlling, a control indeed which morphology cannot dispense with. Morphology is dependent on a consideration of function (physiology) in addition to anatomy - the latter observes, the former explains. The anatomist has pursued his line of thought concerning the pelvis into the more profound region of ontogeny to the exclusion of the simpler consideration of the influence of the bony pelvis on parturition. Therefore, classification of the pelvis has been left to the accoucheur. The latter has attempted quite reasonably to classify the girdle on a pathological basis, having as his first consideration the recognition of the types that cause dystocia. It has been more difficult to identify the morphological

characters of the pelvis that are most favourable to labour, i.e. to discover what is the ideal female pelvis.

II VARIOUS CLASSIFICATIONS

1. Van Deventer (1716) in the first classification of the female pelvis recognised 3 types: too large, too small, and too flat. Ingenuous as this grouping may appear, the analytical perspicacity displayed has not been significantly surpassed during the last two-and-one-half centuries. It is unlikely that there will ever be a simple and satisfactory classification of the pelvis, and the types of a given system will be useful for special purposes only. Pelves will, therefore, have to be grouped according to a prescribed purpose so that the basis may be, for example, obstetrical or anthropological.

2. Obstetrical classifications have been concerned with peculiarities - usually of a pathological nature - that give rise to dystocia: the morphology of the normal pelvis and its variations has been disregarded, except for a recognition of the small pelvis with average proportions (justo-minor or generally con-

tracted pelvis). Thus Litzmann's (1861), Kerr's (1923), Williams' (1936), and Zangemeister's (1927) classifications vary only slightly, and are based on deformities due to (a) faulty development, (b) disease of the pelvic bones, (c) disease of the vertebral column and (d) disease of the lower extremities. These classifications are of little interest to the anatomist.

3. It was not until 1933 that a more satisfactory classification on morphological lines was reported by Caldwell et al. Following von Stein's (1844) scheme of grouping pelves into round, longitudinal-elliptical, and transversely-elliptical, these workers recognised 4 parent types: 1) the gynecoid or average female type, 2) the android type with a strong male tendency, 3) the anthropoid type which is longitudinal-elliptical, resembles the brim shape found in anthropoid apes and present to a less extent in all mammals, and 4) the platypelloid or transversely-elliptical type. In addition to the parent types there are 8 groups with mixed characters, e.g. gynecoid with anthropoid tendency or android with gynecoid tendency (see Table 1).

- Caldwell et al. -

Caldwell et al. (1933, 1934) drew attention to the moderate frequency (about 12 percent) of the anthropoid type pelvis and described its labour mechanism. It is actually their great contribution to labour mechanisms which were studied radiographically in parturients (1934 b, 1935), that has made this team of workers celebrated. This fame has unfortunately spread to their classification which has received universal recognition. The classification is sufficiently complicated to be poorly understood by the majority of its would-be adherents, and its value has only rarely been discussed. In addition to the statement that a pelvis belongs to one of the 12 classes seen in Table 1, it is necessary to ascertain (1) whether the forepelvis is narrow, rounded etc. and (2) whether the pubic arch is wide, moderate, or narrow. Such a classification is too cumbersome, having only the merit of describing a pelvis, whereas the rationale of classifying an object is to reduce description by placing the object in a previously defined category. Because the Caldwell and Moloy system is accepted to-day, the 167 Bantu dry pelves have been classified accordingly (Table 1), and reference will be made to the

principles underlying the scheme.

To avoid a lengthy explanation, the authors' diagrams of the 12 pelvic types with a short description are given in Fig Cl . Classification is based entirely on the nature of the pelvic brim, and more particularly on that part of it lying posterior to the widest transverse diameter of the brim, this segment being only a little different from Derry's posterior segment of the pelvic chilotic line (1923) and Straus' (1927) lower iliac height. In the anthropoid type pelvis the distance of the transverse diameter from the sacrum is great, in the gynecoid type intermediate in length, and in the android type the diameter lies close to the sacrum. The anterior half of the brim is also characteristic for the different types, and may give rise to mixed types. This scheme of grouping is followed fairly faithfully by Turner's brim index, making the types mentioned respectively dolicho-, mesati-, and platypellic. There is indeed small merit in applying a new terminology to these pelvic inlets.

In addition to these morphological types there occur pathological types in regions where rickets is



Fig. 1.



Fig. 2.

Fig. 1.—*The true anthropoid type of pelvis (parent type).*
Note the long oval inlet. The anteroposterior diameter is long, the transverse is narrow. Study particularly the shape of the anterior segment (long and narrow) and posterior segment. In this pelvis the anthropoid influence predominates.

Fig. 2.—*The anthropoid type with gynecoid tendency (mixed type).*
The pelvis is wider and shorter than the true anthropoid and in general appearance is a long broad oval. The posterior segment is anthropoid, the anterior segment more gynecoid in form.



Fig. 3.



Fig. 4.

Fig. 3.—*The gynecoid type with anthropoid tendency (mixed type).*
The posterior segment is gynecoid, the transverse diameter being closer to the promontory. The long, oval appearance is caused by the long, narrowed fore pelvis.

Fig. 4.—*The gynecoid type with a narrow fore pelvis (mixed type).*
This pelvis is practically normal. The narrow fore pelvis is evidence of a weak anthropoid or male influence.



Fig. 5.



Fig. 6.

Fig. 5.—*The true gynecoid pelvis (parent type).*
In the developmental cycle this inlet is round and typically female in all portions. The female influence predominates.

Fig. 6.—*The gynecoid type with a flat tendency (mixed type).*
Note that the pelvis is wider and flatter, indicating a trend toward the true flat type.



Fig. 7.



Fig. 8.

Fig. 7.—*The flat (platypelloid) type (parent type).*

The wide transverse and short anteroposterior diameter are the salient characteristics.

Fig. 8.—*The android type with anthropoid tendency (mixed type).*

The posterior segment conforms to the male type. The long oval appearance is caused by the long narrow fore pelvis. This places it also in the anthropoid class.



Fig. 9.



Fig. 10.

Fig. 9.—*The android type with gynecoid tendency (mixed type).*

The flat masculine posterior segment is characteristic and defines the pelvic type. The fore pelvis is gynecoid, similar to the fore pelvis seen in Fig. 5.

Fig. 10.—*The true android type (parent type).*

Note the flat male posterior segment, the narrow anterior segment, the forward sacrum and converging side walls. This pelvis approaches very closely the shape of the average male.

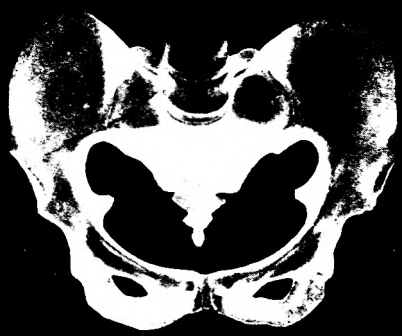


Fig. 11.



Fig. 12.

Fig. 11.—*The android type with flat tendency (mixed type).*

Although a male posterior pelvis is present, the general form is broad and flat.

Fig. 12.—*The asymmetrical type.*

The asymmetry is limited to the right side. The sacrosciatic notch is narrower on that side and the iliopectineal line is straighter.

common, and which may range from antero-posterior flattening to the complete distortion found in osteomalacia.

Comparatively rare pathological and developmental anomalies may cause asymmetry due to faulty posture (disease of spine or lower limbs), or the contraction seen in the Naegele and Robert pelvis in which there is faulty development of sacral alae.

III Caldwell and Moloy Classification of Bantu Pelves.

The classification in Table 1 of Bantu pelves is based on the standards laid down by Caldwell et al. (1933, 1934), whose paper (1934) presented a classification of 215 American white pelves, the figures relevant to which are here given in brackets after the Bantu figures.

It had been observed that the male pelvis exhibited several of the Caldwell and Moloy types, and an attempt was made to classify the male series according to the scheme for the female. It was surprising to find examples of nearly all the types, and even a male pelvic type which was hardly distinguishable from the essentially female gynecoid type. In Table 1 male figures are seen opposite gynecoid

and android divisions: this analysis is recorded for the purpose of comparison, for whilst similarity to these female types does exist in the male, it is not intended to extend the connotation of gynecoid and android to male pelvic types.

Table 1 Bantu Pelves (Caldwell and Moloy classification)

American white figures in parentheses

Classification	No. of pelves	Percentage incidence	100 Male
True anthropoid type	9 (25)	13.4 (11.6)	16
Anthropoid with gynecoid tendency	8 (14)	11.9 (6.5)	2
Gynecoid with anthropoid tendency	4 (10)	6.0 (4.6)	12
Gynecoid with narrow forepelves	8 (24)	11.9 (11.1)	7
True gynecoid type	19 (85)	28.4 (39.5)	15
Gynecoid with flat tendency	4 (7)	6.0 (3.3)	0
True flat (platypelloid) type	1 (2)	1.5 (0.9)	2
Android with anthropoid tendency	4 (8)	6.0 (3.7)	4
Android with gynecoid tendency	1 (11)	1.5 (5.1)	0
True android type	6 (25)	9.0 (11.6)	39
Android with flat tendency	2 (4)	3.0 (1.8)	2
Asymmetrical forms	1 (4)	1.5 (1.8)	1

With a few exceptions, the table shows a fairly close correspondence between the 3 sets of figures.

The Bantu sex differences qua incidence are seen (1) in the android parent type where the difference in favour of the male is 6.6 times its standard error; (2) in the gynecoid parent type with a difference in favour of the female of 2.33 times its standard error. The higher incidence of true anthropoid types in the male has no statistical significance. Thus in the male series the highest incidence was in the android group, and in the female a high incidence of the same order was found in the gynecoid group. The European female figures correspond in this respect with the Bantu. Apart from these 2 fundamental sex types, there is an appreciable correspondence between the females of the 2 races on one hand and the male Bantu on the other.

The true anthropoid type occurs in much the same proportion in both the Bantu and the American white series. But if this group is taken together with the pelves showing anthropoid tendencies, the Bantu female incidence is 37 percent (34 percent for the male), and the white 26 percent. The difference for the female is 1.5 times its standard error; and for

male and female Bantu combined the difference from the white material is 2.0 times its standard error: significance for this difference can only be established by analysing more Bantu pelves.

The true gynecoid type - the nearest approach to what is considered to be the ideal female pelvis - occurs in 28 percent only of female Bantu pelves as compared with 40 percent of whites. This might be regarded as possibly significant, were it not for the fact that the gynaecoid type with corresponding tendencies (e.g. anthropoid, flat, narrow forepelvis) occurs with much the same frequency in both female series.

While it was surprising that in the female the true android type actually had a lower incidence (9 : 12 percent) in the Bantu than in the white, the difference found is not significant. If all pelves exhibiting android tendencies are grouped together, the Bantu female percentage is found to be 20 as compared with 22 in the American series.

The female tendency to flatness occurring both in the gynecoid and in the android type shows in each case nearly twice the percentage in the Bantu series

as in the American. The gynecoid figure at 6.0 percent and the android at 3.0 percent are so low as to lack significance. If this tendency were established in a larger series, it might be suggested that the underlying cause is associated with some factor such as rickets which is so prominent during Bantu childhood.

The purely asymmetrical forms shown could not readily be subclassified. Where asymmetry occurred in pelves of other types, an alternative diagnosis was made.

IV Evolution of the Human Pelvis: Criticism of Caldwell and Moloy's view.

Caldwell et al (1934) have ventured beyond their classification in an attempt to explain the origin of the parent types. Fig C2 is reproduced to illustrate their ideas diagramatically, and in the printed paragraph beneath the figure it will be seen that the authors refer to their belief in an evolutionary factor which is responsible for producing the typically platypellic human forms ranging orthogenetically from extreme dolichopelly to an ultrahuman platypelloid human type. In the same paper they claim that this hypothesis is the most important

Again referring to Fig. 13, the android forms may be noted in the right section of the outer circle. The term "android" is used to designate the female pelvis possessing a masculine type of posterior segment. This may likewise occur in any pelvis within the developmental cycle just described. Hence, we find *android pelves with an anthropoid tendency, android pelves with a gynecoid tendency,* the true android type, and, below this type as the flat form is approached, the *android pelvis with a flat tendency* (Figs. 8 to 11).

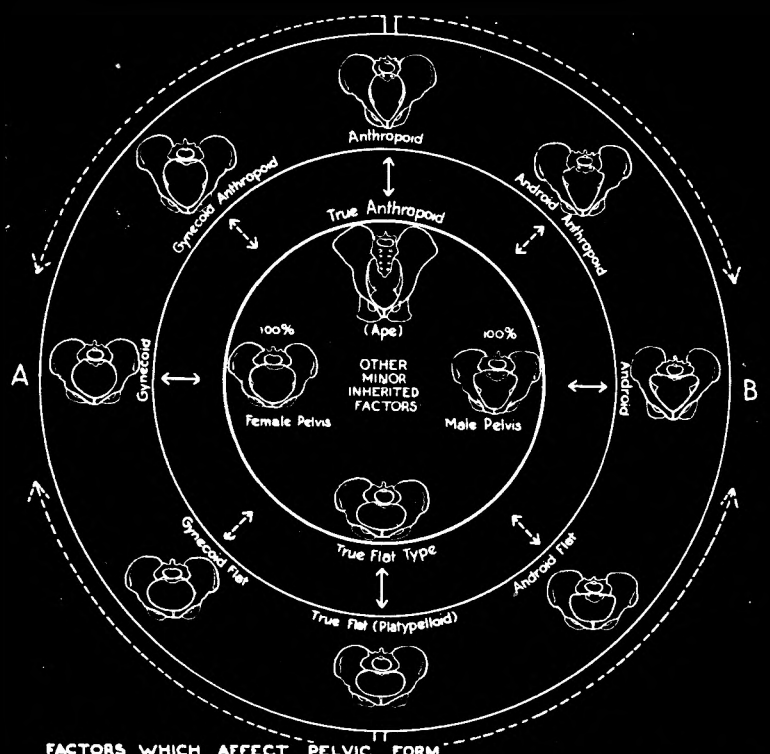


Fig. 13.—Diagrammatic illustration of the influences which affect the shape of the adult pelvis. The evolutionary factors are shown in the vertical series of the inner circle and the sexual or hormonal factors in the transverse series. The resulting living forms are illustrated in the outer circle.

Is it not possible that two great influences may be at work, one, the arrest in evolution from the ape form, the true anthropoid, to the perfect human form which is characteristically flat, and the other, a sexual or hormonal factor which may determine certain masculine characters in the female form?

If this is true, two distinct but radically different trends in pelvic shape result: evolutionary and sexual (hormonal). The evolutionary cycle has been described above. In Fig. 13 the evolutionary factor is

contribution of their work.

The Caldwell and Moloy view is that orthogenesis begins in lower mammals where the pelvic inlet is always longest in the antero-posterior axis (brim index over 100), and ends with platypelly found in man (brim index under 100). The authors assert that the occurrence of anthropoid type pelves (10 to 20 percent) is due to an arrest of evolution (1934). These assertions will now be examined.

If the recapitulation theory is being invoked for the argument concerning the arrest of evolution, there is a danger that evolution, or this process of "arrest in evolution", might be by-passing the foetus in respect to the pelvis. If the Caldwell and Moloy hypothesis is to mean anything, the picture before one is a high incidence of primitive "anthropoid type" pelves in the foetus and embryo; a more human (possibly flattish) pelvis later during ontogeny; and at the end of ontogeny some more highly developed pelvis which is well removed from the ape (or lower mammalian) pelvis morphologically. Our authors choose to believe that this last, fully evolved, pelvis is their platypelloid type, i.e. a pelvis with an

average brim index below 80. This presumption is based on very poor evidence, for not only have Caldwell and Moloy (1934) reported an incidence of only 2.0 percent for this type, but the Bantu incidence does not rise above this figure, nor does the English (Ince and Young, 1940; Kenny, 1944). Moreover, Caldwell and Moloy have made no reference to any personal experience with foetal pelves, nor has any reliable foetal pelvic work been reported by any writer in English. Kappers' monograph (1938) is the only available study of this kind which can be considered authoritative.

An ontogenetic survey of the Bantu pelvic brim demonstrates the following facts.

(1) Seventeen of 100 foetus had an index over 100 (or 100 and over).

(2) In 39 children aged 1 to 15 years, 15.4 percent have indices over 100 and are of well marked anthropoid type. But 35.9 percent (14 pelves) have an index of 100 or more.

(3) For adult indices of 100 or over, there were 17 of 100 male dry pelves, 12.0 percent of 67 female dry pelves, 17 of 100 female X-rayed subjects, and 20.0 percent of another series of 25 X-rayed women. The

dry pelves exhibited the Caldwell and Moloy anthropoid type in 13.4 percent of females and 16.0 percent of males, both figures being very close to those given above (12 and 17 respectively).

Concerning the foetal brims mentioned under (1) above, the index reached 110 on only 2 occasions, and the brims never resembled the pronounced "anthropoid type" seen in the adult: they certainly do not approach the relative proportions of the ape brim. These high-index foetal brims are in fact only round, or "more round" than the average brim; and 33 percent of all the foetal brims were dolichopellic (index over 95).

The infant and child pelvis moves further in the direction of "roundness" than the foetal with a percentage difference which is 2.23 times its standard error. Now for the first time do outspoken "anthropoid types" appear - but the outstanding observation concerning the infant brim is the trend from flatness to roundness.

In the adult there occurs on the average a flatter pelvis than in the child. The "anthropoid type" incidence is still equal to that in the foetus, though

the "anthropoid" appearance reaches greater emphasis in the specimens so characterised. Something happens at pubertal age to arrest the development of round or ultra-dolichopellic brims, but the basis of this is not evolution. The cause may be some combination of factors concerned with sex hormones, the influence of nutrition on metabolism, and physical forces based on weight-bearing and progression.

There is no question here of running with the Lamarckian hare and hunting with the Weismann hounds. The possibility under consideration is whether orthogenesis is being exhibited in the case of the pelvis, for on this matter Caldwell and Moloy speak of an arrest in evolution. A point is, therefore, reached at which it appears that many dolichopellic forms, slight and exaggerated, should occur; but coincident in time there emerges the sex factor, and the adolescent phase is associated with only occasional development of the sort of pelvic brim which is found throughout the mammalian class. In the anthropoids, on account of their greater facial angle, the foetal head is held in flexion during labour and thus re-

quires adequate width further forward in the pelvis than is necessary in, say, ungulates.

It is a point of no mean importance that Kenny's (1944) paper has established finally the belief that the anthropoid type pelvis in women is associated with a minimum of dystocia, complicated labour being much rarer than with the "gynecoid" pelvis. If labour in mammals be considered, it is not unreasonable to conclude that difficult labour may jeopardise the continuation of the species. Hence only pelves favourable to easy expulsion of the foetus would evolve. In the anthropoid apes greater and rounder heads have developed, and the problem becomes more acute. Observations in Homo sapiens have demonstrated that the flatter the pelvis, the more difficult does parturition become. Antero-posterior shortening in morphological types is very rare, but common in diseases causing softening of bone. Evidence is accumulating that human types of superior physical status possess on the average round brims, while showing a high incidence of "anthropoid" types. There is mathematical certainty in the fact that, with a given perimeter such as is

represented by the brim, a circle encloses the greatest area: as the circumference becomes compressed and alters shape, so there is a loss of area.

So far, then, from supposing that evolution strives for platypelly, the evidence is in favour of dolichopelly being the highest and most efficient attainment. Bolk (1925-1926), in his hypothesis on retardation and foetalisation, has shown that morphologically the apes have advanced much further than man along the road of evolution. His idea was that human anatomical features are all tainted with foetal characteristics; and what represents only a transitional stage in apes, has in man become the consummation of ontogeny. All human races have not made equal progress on the developmental road, and Bolk mentions such examples as the Mongolian physiognomy which is a foetalisation effect absent in white races, and the persistence of a metopic suture which is much more frequent in white than in black races. Bolk emphasizes the necessity for embryonic potentialities in human tissues such as epiphyses which continue to grow over a very long period: phylogene-

tic maturity could only be reached very late, while retardation during ontogeny is inhibiting this evolutionary progress all the time. This inhibition is often essential for man (vide the late obliteration of cranial sutures).

In the pelvis the same process with side-effects occurs. During ontogeny (5th to 10th years), attempts at evolving the dolichopellic ancestral pelvis are seen. These attempts appear to be suppressed at puberty; but a certain number of girdles, nevertheless, break the bonds of the foetalising influence and become "anthropoid". The majority, however, now resemble the foetus more closely than they did during infancy.

Although the factors which, in groups such as those studied by Thoms (1939), make possible a pelvic development beyond the foetal stage are unknown, the available evidence contradicts the Caldwell et al. belief that the ultra-dolichopellic pelvis represents an arrest in an evolutionary movement which has platypelly as its purpose. There is no evidence for this ill-conceived viewpoint; and it is submitted that in one sense the reverse is true, viz. that the ape

pelvis has developed further than man's which is foetal in character, though the latter shows a tendency to reach towards more efficient dolichopelly. If the foetus exhibited many well developed "anthropoid" forms, and if during adolescence these forms diminished in number and essential characters leaving only a few "evolutionary arrests", Caldwell and Moloy would have gained their point. Unfortunately, the facts are inconsistent with their thesis.

Commentary.

The view of Caldwell et al. (1934) that the platypelloid pelvis is the end-point of evolution in man, while dolichopelly (resembling the apes) demonstrates an arrest in evolution, has been refuted. Although only Bantu data were used for this argument, it must be stated that the figures of other observers provide equal support. Thus Kappers (1938) had only 4.0 percent of foetūs with brim index over 100, and Turquet's series (1884) of 70 infantile pelves showed a brim index of 100 or more in 28.5 percent. Preservation of these juvenile specimens has the effect of raising the index, with the result that the

childhood period of ontogeny has always been credited with a very high dolichopellic incidence. Evidence gained from fresh pelves, however, shows that this observation is sound, and the Bantu X-ray results support it strongly.

The view advanced here is that the evolutionary purpose in man is to produce the "anthropoid type" pelvis. In accordance with Bolk's hypothesis, the retardation of the factors leading to pelvic maturity is sufficiently effective to leave the stamp of foetalisation on the majority of adult pelves: a minority only excel, become phylogenetically more highly evolved, and are more efficient as ultra-dolichopellic pelves. The latter have relatively larger inlets, presumably because ilium and pubis grow more, in order to provide the long inlet which would have possessed a smaller area had it been round because of the earlier cessation of growth.

To classify pelves until more is known about their evolution is futile. Further ontogenetic studies must be directed to X-ray investigation of many pelves during puberty and adolescence in an attempt to determine the factors responsible for development or

arrest of the fully evolved human pelvis. Some knowledge of other primate foetal pelves is also necessary. (Bolk in 1926 published a paper on the comparative anatomy of a gorilla and a chimpanzee foetus, but this study is not available in South Africa.) The brim index is a promising basis for classification, but it may be necessary to consider other features of which the most significant appears at present to be the pubic arch. Turner's index is, therefore, still the most important determination as a basis for classification. A further observation is found in the fact that a pelvis may be small, average, or large in size; and for parturition this character of absolute size is an essential feature. Pathological anomalies must be considered in a category which bears no relation whatever to morphology. When the ontogenetic investigation now in progress in the Department of Obstetrics has been pursued further, and the relative capacity of dolichopellic girdles has been determined accurately, a scientific classification will be evolved.

PART IV

THE PELVIC GIRDLE AS A WHOLE

A. Certain External Measurements of the Pelvic Girdle

The measurements considered here are the intercristal, interspinal, and external oblique diameters; the maximum height of the pelvis, the depth of the pelvic basin, the height of the symphysis pubis, the intertuberal diameter, and the width of the sacro-sciatic notch in the line of the sacro-spinous ligament. The external conjugate could not be measured, though reference to it is made.

In the table for each of these diameters the last column shows values on which the significance of differences is based. If the difference between the means for the two male series is less than 2.0 times its standard error, the series are grouped and the mean and other values for the combined male pelves (100) is shown. A calculation to determine whether the difference between the female series (67) and the combined male series (100) is significant is then made, and also shown in the last column mentioned above.

While for the purpose of the present work only a difference which is 4 times its standard error can be

- said -

said to be certainly significant, a value of 3 times has been taken to show significance, one of 2.5 to 3 times a probable, and one of 2.0 to 2.5 times a possible significance. Measurements for the Bush pelvis are those given by Orford (1934), and the European figures those of Verneau (1875) except where otherwise stated. In the following tables the mean ± the standard error of the mean is shown, not as in a previous paper on the Bantu female (Heyns, 1944) the mean ± twice the standard error of the mean.

1. Intercristal diameter.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error	
67 Female	23.80 ± 0.17	1.4	20.9 - 26.5		
50 Basuto	24.00 ± 0.24	1.67	20.1 - 26.8	1.7	2.1
50 Zulu	24.57 ± 0.24	1.69	21.6 - 27.8		
100 Male	24.29 ± 0.16	1.63	20.1 - 27.8		

In the male series the Zulu values were a little higher than the Basuto, but otherwise there was no difference of note. The difference between the combined male and the female series is possibly significant, and this tendency for the male figure to be higher is recognised elsewhere.

- Thus -

Thus the Bush and European female diameters were respectively 19.0 cm. and 26.6 cm., the corresponding male figures being 20.2 cm. and 27.9 cm. The largest intercristal diameters in both Bantu sexes were actually 0.1 mm. less than those for the respective European means.

It had been thought that the greater dimension in males might be due to more massive iliac crests, but Verneau (1875) measured the distances in control series between the medial aspects of the crests. The proportion in favour of the male was 23.1 to 22.2.

2. Interspinal diameter.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
67 Female	20.86 ± 0.19	1.60	17.0 - 23.8	
50 Basuto	21.49 ± 0.24	1.68	17.3 - 25.0	1.1 / 3.17
50 Zulu	21.87 ± 0.25	1.77	18.6 - 25.7	
100 Male	21.68 ± 0.17	1.74	17.3 - 25.7	

The Zulu measurements here, as with the intercristal diameter, showed a tendency to be higher. The difference between male and female means was significant. Means for females were Bush 17.0 cm., and European 22.2 cm. Whilst the smallest Bantu female measurement here was equal to

the average Bush diameter, 2 Bantu pelves, aged 13 and 15 years, not included in the series, measured less than 17.0 cm.

The other male figures were Bush 17.6 cm., European 23.1 cm. The European female mean is considerably higher than that of the Bantu male, and the Bantu female in turn shows an even greater preponderance over the Bush male. This diameter shows a pronounced tendency to be greater in the male.

3. Interspinal/intercristal index.

Series	Mean	S.D.	Range	Significance: Diff. of means Stand. error
67 Female	87.70 ± 0.45	3.72	76.0 - 93.9	
50 Basuto	89.74 ± 0.52	3.70	80.0 - 97.4	0.76 / 3.03
50 Zulu	89.16 ± 0.55	3.92	79.0 - 100.8	
100 Male	89.52 ± 0.38	3.85	79.0 - 100.8	

Here the male index is the greater and the difference between the sexes is significant.

4. External oblique diameter.

The measurement is made from the posterior superior iliac spine of one side to the anterior superior spine of the other side. The diameter is bilateral, and the correspondence between the two sides follows fairly closely

the correspondence between lengths of the oblique diameters of the pelvic brim. In some pelves, however, equal external oblique diameters occurred in the presence of a variation of ½ - 1 cm. in the oblique brim diameters, and vice versa. Both sets of diameters are measurements of the ilium alone, but may be influenced by the sacrum.

4. External oblique diameter.

	Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error	
Left	67 Female	18.88 ± 0.11	0.88	16.2 - 20.6		
	50 Basuto	18.74 ± 0.14	0.97	16.9 - 21.1	2.1	1.6
	50 Zulu	19.18 ± 0.15	1.09	16.9 - 22.5		
Right	67 Female	18.93 ± 0.11	0.89	16.3 - 20.8		
	50 Basuto	18.67 ± 0.15	1.04	16.5 - 20.8	2+	
	50 Zulu	19.18 ± 0.14	0.98	17.2 - 21.6		

For both left and right means the Basuto male is less than the female which lies between the two male groups. The mean of the left female diameter is 0.5 mm. shorter than the right. Asymmetry at the brim was a striking feature of the present material, and a shortening of the left oblique was emphasized. The mean of the right oblique diameter is

1.4 mm. greater than the left. On the contrary, the Basuto male left diameter is the greater by 0.7 mm., with a left oblique of the brim greater than the right by 0.7 mm. The Zulu male left oblique of the brim is 0.8 mm. greater than the right, corresponding with the Basuto, though in the Zulu the two external obliques are equal. While there is no significant difference between the means of the two sides in these series, the preponderance of left over right in the male and the reverse in the female may be due to chance. But this trend persists in other dimensions, such as the area of the auricular surface, and must not be entirely disregarded.

5. Maximum height.

	Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error	
Left	67 Female	19.08 ± 0.11	0.92	17.3 - 21.6		
	50 Basuto	19.68 ± 0.16	1.14	16.9 - 22.3	0.55	4.2
	50 Zulu	19.80 ± 0.15	1.03	17.3 - 22.5		
	100 Male	19.74 ± 0.11	1.09	16.9 - 22.5		
Right	67 Female	18.99 ± 0.11	0.88	17.0 - 20.9		
	50 Basuto	19.75 ± 0.16	1.14	17.1 - 22.5	0.07	5.4
	50 Zulu	19.91 ± 0.14	1.01	17.3 - 22.8		
	100 Male	19.83 ± 0.11	1.08	17.1 - 22.8		

The differences between individual right and left sides were found to show no significance whatever for all four groups: female, Basuto and Zulu male, and the combined 100 males. The differences were all less than 1 times their standard errors. However, the sex differences for maximum height showed the following:

Female and Zulu male (left): 3.9 X standard error.

Female and 100 combined male (left): 4.2 X standard error.

Female and 100 combined male (right): 5.4 X standard error.

Therefore, the smaller diameter for the female was a significant finding, and on both sides the Zulu dimension was greater than that of the Basuto.

In both male groups the left was less than the right maximum height.

In the female, however, left maximum height was greater than right.

It will be seen below that the depth of the lesser pelvis is the reverse of the maximum pelvic height for the two sides.

In both male groups left depth was greater than

right depth.

In the female left depth was less than right.

No cause for this disparity can be suggested. The common point for the two measurements is the tuberosity of the ischium, the second point being in one case on the crest of the ilium and in the other on the superior ramus of the pubis. It is obvious that during growth the ilium may be influenced by factors different from those affecting the pubis, but no explanation of their nature can be offered.

The Bush and European figures for the female were respectively 16.8 cm. and 19.7 cm., and for the male 17.4 cm., and 22.0 cm.

6. The height-breadth index. (maximum height / intercristal diameter)

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
66 Female	80.47 ± 0.47	3.82	73.3 - 88.7	
50 Basuto	82.44 ± 0.62	4.40	74.3 - 97.8	0.86 / 1.92
50 Zulu	80.86 ± 0.60	4.22	74.8 - 89.6	
100 Male	81.70 ± 0.44	4.36	74.3 - 97.8	

The other female figures were Bush 89.4 and European 74.0; and the corresponding figures for the male were

88.2 and 79.0. The tabulated figures show that the sex difference is probably not significant, and suggest that the female pelvis in this respect has the same proportions as the male, but is smaller. In view of the insignificant sex difference for the intercristal means, a discrepancy here is apparent. But this is explained by the fact that for this particular index, the mean maximum height for each pelvis is employed: it will be recalled that in the male the right side was greater and in the female the left. Herein is found the reason for the highly significant sex differences for the two sides, these being respectively 4.2 and 5.4 times the standard error for left and right sides.

7. The depth of the pelvic basin - "from the ilio-pectineal line in the region of the ilio-pectineal crest, to the lowest point of the sciatic tuber of the same side" (Wilder, 1920) - is an important obstetric pelvic measurement, and has been used in Table 4 . In the present series the superior point was anterior to the ilio-pectineal eminence, and where possible, at right angles to this part of the ilio-pectineal

- line: -

line: the line from the tuberosity of the ischium always runs in relation to the postero-lateral border of the obturator foramen and approximately is a tangent to the anterior portion of the acetabulum. In the X-ray measurement of this diameter the line was drawn as a tangent to the acetabulum. Several workers, including Verneau, measured from the ilio-pectineal eminence. Care has, therefore, to be exercised in making comparisons with figures where the measurement is not defined.

The sex difference has a pronounced significance and it is seen that

In the male left depth of pelvic basin is greater than right.

In the female left depth of pelvic basin is less than right.

	Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
Left	67 Female	8.75 ± 0.06	0.51	7.9 - 10.9	
	50 Basuto	9.26 ± 0.07	0.49	7.9 - 10.2	1.5 / 6.7
	50 Zulu	9.37 ± 0.08	0.58	7.7 - 10.5	
	50 Male	9.31 ± 0.05	0.55	7.7 - 10.5	
Right	67 Female	8.77 ± 0.07	0.56	7.9 - 11.1	
	50 Basuto	9.20 ± 0.07	0.50	7.9 - 10.1	1.5 / 5.75
	50 Zulu	9.35 ± 0.08	0.58	7.7 - 10.5	
	100 Male	9.27 ± 0.05	0.55	7.7 - 10.5	

In the female, where the basin depth was 9.0 cm. or more, the pubic arch tended to be narrow, and there was a slight tendency to heaviness of the bones: 36 percent of the entire series had a depth measurement of 9.0 cm. or more, as had 9 out of 13 android pelves as against 27 percent of the other types. This measurement is greater in the male than in the female, and the finding that a narrow pubic arch and increased weight of the bones tends in the male direction with increase in the depth of the pelvis emphasizes the obstetrical significance of this measurement. The Bantu female measurement of 8.8 cm. was remarkable, since in 50 American white female pelves Caldwell and Moloy (1933) found the average pelvic basin depth to be 9.0 cm., and in 53 American white male pelves 10.1 cm. The Bantu female average is thus lower than that for the white woman.

Verneau's (1875) means, which must be greater as pointed out above, were 9.3 cm. for the female, and 10.7 cm. for the male.

8. The length of symphysis pubis was measured in the articulated pelvis to correspond as closely as possible with the limits of the roughened contact areas

- between -

between the two bones.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
66 Female	3.45 ± 0.04	0.30	2.7 - 4.5	
50 Basuto	3.57 ± 0.04	0.30	2.8 - 4.4	0.35 / 2.6
50 Zulu	3.59 ± 0.04	0.27	3.0 - 4.1	
100 Male	3.58 ± 0.03	0.28	2.8 - 4.4	

The sex difference in the means is small but, nevertheless, probably significant. The European averages were 3.9 cm. for the female and 4.3 cm. for the male (Verneau). Most authors show a difference of about 4.0 mm. in the sex means, and some (Litzmann, 1861) show high values because their symphysis measurements include the subpubic ligaments. It has been found that symphyseal height measured in the living subject is large, no doubt owing to this last named fact, and in two European cases of dystocia was well over 6.0 cm.

This measurement is not only extremely important obstetrically, but shows profound changes during ontogenetic development - a point which is elaborated in the foetal section of this thesis.

- In -

In his extensive investigations into age changes in the pubic symphysis, Todd (1920-1921) pointed out that the vertical diameter of the symphysis could not be measured accurately until the age of 27 to 30 years, and that even at 35 there might still be doubt. Todd's aim was the assessment of age of a skeleton by observation of the symphysis pubis in which he was able to show regular age variations. 10 phases were described, the last of which had an age factor of 50 years and over. Todd's significant findings were not applied to the Bantu material because only a very extensive experience with these symphyses would justify such analysis.

9. The intertuberal diameter.

The diameter used was the inner intertuberal breadth measured from the most medial points on the lower surfaces of the ischial tuberosities.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
67 Female	10.20 ± 0.16	1.30	6.6 - 13.2	
50 Basuto	8.37 ± 0.15	1.03	6.6 - 10.3	2.2 / 10.7
50 Zulu	7.89 ± 0.16	1.15	5.5 - 10.2	
100 Male	8.13 ± 0.11	1.12	5.5 - 10.3	

In view of the fact that the difference between the

male means was 2.2 times the standard error of the difference, it may not be justifiable to group the two male series. There is little reason for regarding the difference as significant and attempting to explain the smaller Zulu diameter, when the Zulu pelvis tends to give greater measurements for other diameters. The sex difference, however, is extremely significant. The greatest male measurements are seen only to approach the female mean, as in Verneau's (1875) female mean of 13.6 cm. with a range of 12.0-15.5 cm. and corresponding male mean of 12.2 cm. Verneau's termini, rarely used, lie on "le milieu de l'espace, compris entre la terminaison de la levre profonde de l'ischion et l'epine sciatique" (Kappers, 1938).

However the diameter be defined, the points are mostly chosen arbitrarily, and it is fortunate that this diameter is losing caste in obstetrical considerations, and giving way to more important features connected with the outlet (e.g. interspinal diameter, size of the pubic arch, area of the plane of least pelvic dimensions). While the intertuberal diameter is commonly stated to be 4 inches in the normal pelvis, the

Bantu female measurement is on the average a fraction of a millimetre above this. The smallest female diameter found in the series was 6.6 cm., or 2 ⅝ inches. In Ince and Young's series (1940) of 474 London women, radiography gave a mean of 10.9 ± 0.03 cm., standard deviation 0.7 cm., C.V. 6.4 percent, and a range of 8.6 - 13.3 cm. In the London series the diameter is 7 mm. greater than in the Bantu, yet the mean value for the Bantu female shows that this part of the outlet is adequate.

Thoms (1935) refers to "records" of 1,000 women "presenting what I assumed to be normal external pelvic measurements", and an average of 9.5 cm. for the intertuberal diameter. This figure becomes improbable when the London and the Bantu series are critically considered. Thoms' measurements were apparently taken by different observers, and the unusually large posterior sagittal diameter (averaging 7.5 cm.) implies a taking of the transverse measurement too far forward. For statistical purposes clinical measurement of the intertuberal diameter is useless.

10. The width of the sacro-sciatic notch was measured from the tip of the ischial spine to a point on the lateral edge of the sacrum midway between the lowest 2 posterior sacral foramina.

	Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
Left	65 Female	4.92 ± 0.11	0.88	2.8 - 6.9	
	50 Basuto	3.75 ± 0.07	0.51	2.5 - 5.0	1.0 / 10.1
	50 Zulu	3.64 ± 0.08	0.55	2.5 - 4.5	
	100 Male	3.69 ± 0.05	0.53	2.5 - 5.0	
Right	65 Female	4.94 ± 0.10	0.82	3.0 - 7.0	
	50 Basuto	3.75 ± 0.07	0.49	2.3 - 4.8	
	50 Zulu	3.65 ± 0.08	0.56	2.1 - 4.7	

The respective notch diameters on right and left sides are identical when the male groups are considered. This is due to chance: the sides frequently differ in individual pelves on account of variations in the ischial spines in a given specimen, and the fact that the articulation of the pelvic bones is not always perfectly symmetrical.

The sex difference is pronounced, a fact generally recognised. No other estimation of the size of the sacro-

sciatic notch was made, though in the foetus three separate measurements were used in an attempt to give metric values for this variable feature of the pelvis.

11. The external conjugate was not measured because articulation of the lumbo-sacral joint is difficult and apt to be inaccurate, and because this diameter does not appear to be of value. Ince's (1940) formula has, however, been used to arrive at some values for the external conjugate, thus - C.V. in mm. = 0.36 X external conjugate in mm. + 47.47, and the standard error is 9.0 mm. Taking the mean value of C.V. (conjugata vera) in the female Bantu, viz. 107.6 mm., the external conjugate by calculation is 167.0 mm. or 6.58 inches: even adding the 9.0 mm. of the standard error, this diameter in the Bantu remains below 7 inches. Clinically an impression is gained that the Bantu external conjugate averages about 7 inches; but in a large proportion of cases it is certainly less. In obstetric practice, a contracted pelvis is suspected when the measurement is below 7 inches, e.g. by authorities like Thoms (1935).

- But -

But in the Bantu at any rate this suspicion has no valid foundation.

Perin (1945) has published clinical pelvimetric findings on 2,033 indigenes from Kimvula, Belgian Congo. The measurements are much smaller than those of the present series, though the external conjugate averages 17.5 cm. Perin believes that these natives are a degenerating race, and no female had a height of more than 1 m. 50 cm. The neonatal cephalic measurements show the head to be only slightly smaller than that of the Bantu, the biparietal and suboccipito-bregmatic diameters both being just under 9.0 cm. In these small people, then, the external conjugate still averages 17.5 cm.

In Thoms' series the conjugate averaged 7½ inches, and in Ince's series over 8 inches.

Ince's formula is inaccurate for small conjugata vera values. His smallest true conjugate of 87 mm. would give an external conjugate 4 1/3 inches (110 mm.), and the commonly accepted figure of 4 inches of the standard true conjugate would make the external conju-

gate 150 mm. or almost 6 inches. A superficial examination of the prepubertal pelvis shows that an adult pelvis with external conjugate as low as 5 inches is almost inconceivable. Measurement of the osteomalacic pelvis shows how difficult it is to get any external conjugate figure much below 7 inches, and how obstetrically valueless this diameter is.

The above argument is necessary because no figures are available to calculate the co-efficient of correlation for true and external conjugate. The co-efficient is almost certain to be too low to justify the derivation of the true from the external conjugate by biometricians dealing with the living subject.

B. The Pelvic Brim and Cavity

The figures in Table 2A call for comment: these should afford the most reliable data, being from the skeleton directly, whereas the X-ray measurements are from living subjects. Caldwell and Moloy's (1933) figures were puzzling, and compelled certain calculations, after which their Table 2 became intelligible. Their figure of 109 mm. for the conjugata vera in American whites seemed very low, an impression strengthened by the higher corresponding figure (110.9 mm.) for Negro stock. Their male averages of 101 and 98 mm. also seemed relatively high.

These unusual figures became understandable when it was realized (from their Table 1) that, of 147 white and 121 Negro female pelves available, only 73 white and 90 Negro were measured. Further, the respective numbers of gynecoid, android, and anthropoid types of pelvis for the white series were 26, 25, and 19; whereas their percentage incidence for the whole series of 147 pelves was 41, 32, and 23. Similar considerations affect the figures for the Negro pelves. Thus, of a series of 268 female pelves, only 163 were actually measured: hence the figures from this series

must, unfortunately, be accepted with reserve.

Pan (1929) studied 64 female pelves from Hindu cadavera, measuring but three diameters each of inlet, cavity, and outlet: all pelves exhibiting any deformity were excluded from his investigation. However, Table 2 shows that these pelves are extremely small: the brim area by calculation averages approximately 94.4 sq.cm., as compared with a Bantu average of 101.2 sq.cm., and with English averages of 121.0 and 126.8 sq.cm. The average birth weight of 100 Hindu babies was only 5 lb. 6¼ oz., against a Bantu mean of 6¾ lb. (Heyns and Hersch): the Hindu head measurements were all less than the accepted averages.

Table 2B shows a fairly close correspondence of measurements obtained by X-ray pelvimetry, but the formula used for the London series is not available; Thoms' antero-posterior view method does not outline the whole of the sacral promontory, whilst his lateral view method, though more accurate, must sometimes give rise to errors in determining the end-point at the symphysis pubis. Nicholson's stereometric technique is accurate to the nearest millimetre, and this pre-

Table 2

Comparison of average diameters of the pelvic brim, the antero-posterior of the cavity, and the diagonal conjugate.

A. Direct measurement on the skeleton

Diameter	Bantu	Bush (Orford)	White American (C.& M.)	Negro American (C.& M.)	Hindu (Pan)	White Male (C.& M.)	Negro Male (C.& M.)
Conjugata vera, mm.	107.6	113.0	109.0	110.9	101.0	101.0	98.0
Transverse, mm.	119.6	107.0	135.1	125.1	119.0	130.0	116.0
Oblique, mm.	121.3	113.0	--	--	115.5	--	--
Diagonal conjugate, mm.	122.6	129.0	--	--	--	--	--
Antero-posterior cavity, mm.	117.5	--	--	--	101.0	--	--
Brim index %	90.4	105.2	--	--	84.9	--	--
No. of pelves	67	4	73	90	64	43	52

B. X-ray measurement of living subject

Diameter	London English (I.& Y.)	Rural English (N.)	Clinic Women (Thoms)	Student Nurses (Thoms)
No. of pelves	509	350	132	104
Conjugata vera, mm.	118.3	116.4	114.4	121.5
Transverse, mm.	130.6	132.3	125.4	121.9
Brim index, %	90.8	88.3	91.2	99.7

cision can be relied on where shadows are clearly defined.

12. Conjugata vera.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
66 Female	10.76 ± 0.10	0.80	9.1 - 12.6	
50 Basuto	10.39 ± 0.15	1.09	8.1 - 12.8	0.54 / 3.0
50 Zulu	10.28 ± 0.14	1.00	7.9 - 12.7	
100 Male	10.33 ± 0.11	1.06	7.9 - 12.8	

These figures show an unimpressive sex difference: the range for the female lies completely within that for the male, the difference in means is only 3 times its standard error, and the male conjugate is above 4 inches which is the length usually given for the standard female pelvis.

The conjugata vera in the Bantu female of 107.6 mm. (4¼ inches) may be compared with that in English women of 116 - 118 mm. (between 4½ and 4⅔ inches). Ince and Young (1940) discussed this diameter fully, and suggested that teaching that the standard length is 4 or 4¼ inches may be a legacy from Smellie's "Treatise on Midwifery" in which the length is given as 4¼ inches. There has always been a strong, though unsubstantiated, opinion in South Africa that the Bantu pelvis is much smaller than that of the

European. If one accepts European conjugata vera averages of about 4 2/3 inches, the smaller Bantu corresponding diameter is of interest. Urban Bantu removed from the tribal mode of life are subjected to a low standard of living and nutrition, whilst those living in the native territories may have to withstand occasional periods of great privation. It is possible that with an improvement of nutrition the female Bantu pelvis may alter considerably both in form and dimensions.

13. Transverse diameter of brim.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means Stand. error
67 Female	11.96 ± 0.10	0.80	9.8 - 13.8	
50 Basuto	11.22 ± 0.12	0.83	9.5 - 13.3	0.77 / 5.65
50 Zulu	11.34 ± 0.10	0.73	9.9 - 12.7	
100 Male	11.26 ± 0.08	0.80	9.5 - 13.3	

The sex difference here is very significant statistically, and is more pronounced than the sex difference for the conjugata vera.

Table 2 shows that the American Negro male conjugate (Caldwell and Moloy, 1933) is 0.53 cm. lower than the Bantu male, but that the Negro transverse diameter is 0.34 cm.

- greater -

greater. The Negro male pelvis is, therefore, smaller at the brim than is the Bantu.

The female Bantu had a brim transverse mean more than 1 cm. less than that of English women or of Caldwell and Moloy's American white material (13.51 cm.), and was even less than their figure (13.0 cm.) for the male American whites. Thoms' clinic women approached it more closely with a measurement of 12.54 cm., and his series of women of superior physique (12.19 cm.) gave an average of only 0.23 cm. more. This last comparison may be accounted for by the fact, emerging from the experiments described in the appendix, that no known X-ray technique can show the outline of the pelvic brim: the skiagram will only show the shadow of a lower level of the pelvic ring. But in different series, if the X-ray measurements alone are compared, English hospital women appear to have a wider brim than the corresponding American class, and American women of superior physique possess an even narrower pelvic brim.

13a. <u>The pelvic brim index</u>.

So many figures have been published on this important pelvic index, and as in Turner's paper (1886) so many races providing only a few specimens have had

their respective indices put on record, that it is of value to have available Bantu figures derived from a reasonable series. For Europeans alone, Martin (1928) and Turner (1886) collected figures for both sexes from seven authors, three of whom found a higher figure for the female, and four a lower figure for the female.

13a. The pelvic brim index. In the English literature this is known as the index of Turner (1886) who himself, however, explains how Zaayer (1866) came to be the first to use this valuable numerical expression.

Series	Mean	S.D.	Range	Significance: Diff. of means Stand. error
65 Female	90.35 ± 1.02	8.20	69.6 - 104.4	
50 Basuto	92.80 ± 1.34	9.47	70.2 - 117.0	1.17) 0.88
50 Zulu	91.08 ± 1.17	8.24	75.5 - 110.0	
100 Male	91.56 ± 0.91	9.11	70.2 - 117.0	

It can now be said that the Bantu male has an index comparable with that of the female, and that there is no significant difference whatsoever between the sexes; that the index is over 90, and that it is, therefore, mesatipellic in Turner's (1886) sense.

The female Bush pelvis gave a brim index of 105.2, the 4 pelves studied having an index of 99, 112.6, 97.3, and 112 respectively. The male Bush pelvis has the high brim

index of 97.7 ranging in 9 pelves between 88.6 and 105.5 (Orford, 1934). Slome (1929) found the average index for 2 female Bush pelves to be 99.7 and for 5 male pelves 89.2. When Turner wrote in 1886, 8 female Bush pelves and 5 male had been measured by different authors. The females showed an average index of 89.0 which suggests that the true mean is lower than Orford's high figure of 105.2; and the males an index of 99.5. The male indices ranged from 93 in Fritsch's (1872) specimen to 109 in Turner's. Thus the total of 19 male pelves give a dolichopellic index, or one over 95. The females appear to have a lower index. The male pelvis does not necessarily show a slightly higher index than the female: the index is probably variable, and a lower index in the male is the expected tendency.

14. Antero-posterior diameter of pelvic cavity.

The sex difference here is much more pronounced than in the case of the conjugata vera, being 9.3 times its standard error, whereas the differentiation based on the true conjugate was found to be of the order of 3.0 times the standard error. The male conjugata vera was only 1.5 mm. less than this corresponding cavity measurement, whereas these two diameters

in the female showed a difference of 10.0 mm. If a significant sex difference could be shown for the curvature index of the sacrum, that explanation would be adequate. But this is not the case, the male curvature index for 100 specimens being 92.46 which is 0.59 greater than the female, a difference which is not significant (0.95 times standard error).

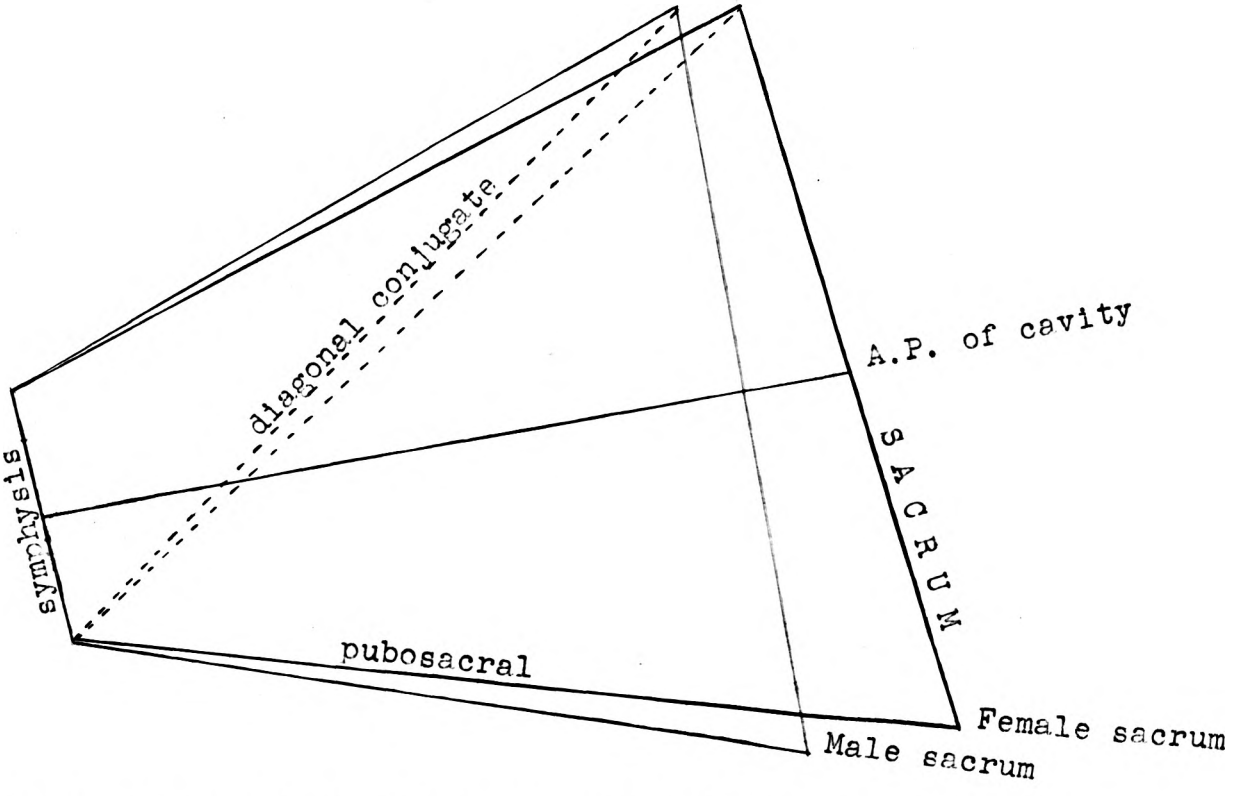
14. Antero-posterior diameter of the pelvic cavity. The measurement was made from the junction of vertebrae S2 and S3 posteriorly to the mid-posterior aspect of the symphysis pubis.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
67 Female	11.75 ± 0.10	0.80	10.0 - 13.5	
50 Basuto	10.57 ± 0.14	0.99	8.7 - 13.0	0.6 / 9.3
50 Zulu	10.44 ± 0.13	0.92	7.7 - 12.5	
100 Male	10.48 ± 0.10	0.98	7.7 - 13.0	

If the pubo-sacral diameter is considered, it is found that the mean diameter for 100 Bantu males is 10.05 cm., and for 66 Bantu females 11.65 cm. The difference of 1.60 cm. here is 12.9 times its standard error. The diagram (Fig. P1) illustrates to what extent the male sacrum relative to that in the female is inclined forward. For both male and female means the length of the symphysis is stan-

Fig. P1

Construction of a diagram to investigate the cause of the marked sexual difference in the antero-posterior diameter of the cavity, when the sex difference for the true conjugate was much less pronounced. A common symphyseal length is drawn, and the male and female diameters shown are proportional to the relative mean values.



dardized at the female mean value of 3.45 cm. The male mean measurements are reduced according to the proportion 3.45/3.58 and the positions of true conjugate and sacrum found. It is seen that the male sacrum shows greater forward inclination than the female, the difference in the angle between sacrum and conjugate being 10°. Further, in the diagram a perpendicular bisecting the symphysis has been

- drawn -

drawn to the lines representing the **sacra.** This perpendicular must be very close to the mean antero-posterior of the cavity. Measurement shows that this diagrammatic diameter, corrected, in the case of the male is 91.2 percent of the true diameter, and in the female it forms 91.7 percent of the true diameter. Because the curvature index in both sexes shows no significant difference, it is submitted that the greater forward inclination of the male sacrum is the major cause of the sex difference being greater for cavity than for brim antero-posterior diameters; and that this is not due, to any significant extent, to a possibly different site of maximum curvature of the sacrum in the two sexes.

15. The diagonal conjugate in 66 Bantu female pelves showed a variable relationship to the true conjugate, dependent on the height and slope of the symphysis. The mean length was 12.26 ± 0.10 cm., or 1.5 cm. more on the average than the true conjugate. The difference between these conjugates was as low as 0.5 cm. in one example, and as high as 2.8 cm. in another.

The arithmetical means for the two male groups

Fig. P 2

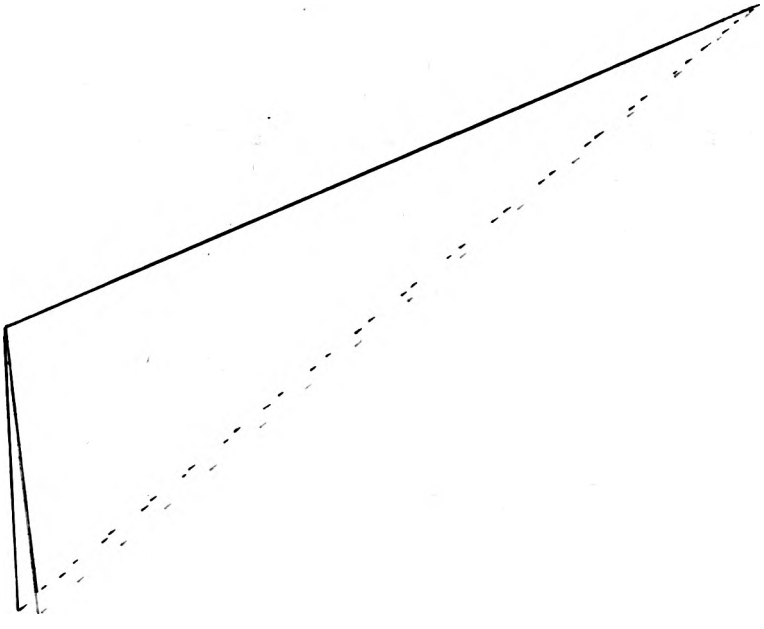
A common conjugata vera is drawn and the relative mean value of symphyseal height and diagonal conjugate shown for female Bantu, and male Basuto and Zulu.

(Female 57.5°
(
(Basuto 54.0°
(
(Zulu 56.0°

Female - - - - -

Basuto male - - - - -

Zulu male - - - - -



of 50 were: Basuto 12.12 cm., Zulu 11.86 cm. For the Bantu the ratio true conjugate : diagonal conjugate was female 0.88, Basuto male 0.86, Zulu male 0.87.

Fig. P2 shows the relation of true conjugate to symphyseal height and diagonal conjugate in the Bantu female, the male Basuto, and the male Zulu. The conjugata vera has been used as a constant, and the other diameters have their relative values.

In lower mammals the length of the symphysis tends to be relatively great, thus giving a diagonal conjugate which may be twice the length of the true conjugate. Schumann (1915) gives the following values for the ratio of true conjugate to diagonal conjugate: lioness 1 : 2 (C.V. 11 cm., D.C. 22 cm.); macaque 7 : 10; gorilla 18 : 22; man 110 : 128.

16. <u>The oblique diameter of the brim</u> may be greater or less than the transverse. The sex difference in the length of this diameter is highly significant. A second feature, which is not statistically significant, is the difference in all three groups of pelves

between the diameters of right and left sides. In the female the left oblique diameter is the shorter, and in the male the right diameters are shorter in both Basuto and Zulu races. It was shown above that the external oblique diameters correspond in the three groups with this asymmetry of the pelvic brim.

	Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error	
Left	67 Female	12.13 ± 0.08	0.70	10.2 - 13.5		
	50 Basuto	11.51 ± 0.11	0.81	9.8 - 13.4	0.65	5.2
	50 Zulu	11.60 ± 0.09	0.65	10.2 - 13.3		
	100 Male	11.56 ± 0.07	0.74	9.8 - 13.4		
Right	67 Female	12.27 ± 0.08	0.70	10.3 - 13.7		
	50 Basuto	11.44 ± 0.12	0.83	9.7 - 13.3	0.55	7.2
	50 Zulu	11.52 ± 0.09	0.65	9.7 - 12.8		
	100 Male	11.48 ± 0.07	0.75	9.7 - 13.3		

The difference between right and left oblique diameters is greatest in the female, but is only 1.23 times its standard error. While antenatal experience of the Bantu pelvis raised anticipation of a high incidence of asymmetry at the pelvic brim, the frequency with which

asymmetry was found compelled consideration of the warping which is liable to occur in macerated skeletal material. The effects of maceration and drying on the skull and femur were studied by Todd (1923) and Ingalls (1927) respectively. Caldwell and Moloy (1933) stated that in a personal communication Todd claimed that "shrinkage with distortion of inlet measurements is particularly marked in the pelvis". Where minor degrees of pelvic brim irregularity can be palpated clinically, it is usually the left side of the brim that is contracted: the generous curve at, and anterior to, the sacro-iliac joint shows a tendency to be straightened. This is the case in so many Bantu women showing minor degrees of pelvic disproportion that one hesitates to place reliance on these findings. In the skeletal material it is almost invariably the left side which displays a contracture, as is shown by the fact that the right oblique diameter of the brim exceeds the left almost without exception, the means of these dimensions actually differing by 1.4 mm.

The asymmetry indicated below is based on the difference between the two oblique diameters of the brim:

Diff. of 1.0cm. or more - 2 pelves (3.0% of total)
" " 0.6-0.9cm. (inclusive) - 9 " (13.4% " ")
" " 0.3-0.5cm. (") - 15 " (22.4% " ")

Twenty-six (or 38.8 percent) pelves showed a difference of 0.3 cm. or more in the lengths of the oblique diameters of a given brim; 16 (or 23.9 percent) showed this difference to be not less than 0.4 cm; and 11 (or 16.4 percent) gave a difference of more than 0.4 cm. In the notes on individual pelves "asymmetry" was recorded where on inspection the brim showed this character. Measurement revealed that this note was made in every case where the difference between oblique diameters was above 0.5 cm., but that it was not made in 5 of the cases where the difference lay between 0.3 and 0.5 cm. It appears, then, that a difference above 0.5 cm. is readily appreciable on inspection because it causes an obvious distortion of the pelvic brim.

It cannot be accepted that this distortion occurred wholly during maceration, if only for the reason that the "mixed race" pelves showed much greater asymmetry. Out of 11 pelves in this group, the ob-

lique diameter differences in 5 were respectively 1.8, 0.9, 0.9, 0.7, and 0.5 cm. If warping of the bone occurred during drying, why should this have been more marked in the case of the non-Bantu coloureds, or on the opposite side as in the case of Bantu males? The age of the subjects throws no light on the problem.

17. Area of the inlet.

It remains to consider the size or area of the plane of the pelvic brim. The assessment of pelvic capacity at this level on the basis of the conjugata vera was criticized above, and even 2 axes of the brim or its circumference will not readily indicate the extent of this plane.

Series	Mean (sq.cm.)	S.D.(sq.cm.)	Range(sq.cm)	Significance Diff.of means / Stand. error
51 Female	113.38 ± 1.31	9.29	94.0 - 135.8	
50 Basuto	100.50 ± 1.98	14.00	74.3 - 140.2	
50 Zulu	98.20 ± 1.72	12.13	70.4 - 126.0	0.88 / 7.5
100 Male	99.35 ± 1.32	13.16	70.4 - 140.2	

The female Bantu brim is about 14 sq.cm. greater than the male which has an average of just about 100 sq.cm. It was found that this difference was definitely significant (7.5 times its standard error); but it must be observed that the female range lies entirely inside that of the male. The areas considered above are accurate for indi-

vidual pelves, because dioptographic tracings of the brim were made and the areas determined with a planimeter. For the sake of comparison, however, the calculated area of the inlet must be considered.

Nicholson (1938) suggested that the shape of the brim closely resembles an ellipse of which the axes are the conjugate and greatest transverse diameters. A study by dioptograph and planimeter of 60 selected pelves showed that a modified Nicholson's formula is correct to within 5 percent of the area, but that the unchanged formula is liable to an error greater than 5 percent (see Appendix 1). The true area will always exceed the calculated mainly because of the projecting promontory; but the calculated area may approach the true area closely where the brim is beak-shaped or where a converging or angular fore-pelvis exists. In the 51 female pelves shown above, with a mean planimeter area of 113.38sq.cm., the mean area by calculation was 104.30 sq.cm. The computed mean of the true area for the whole female series of 66 pelves is a little over 115.09 sq.cm.

The area of the inlet by calculation in the 66 female Bantu pelves ranged between 74.75 and 126.8sq.cm.,

with a mean of 101.23 ± 1.25 sq.cm., and a standard deviation of 10.17 sq.cm.; and it is these figures that must be compared with Ince and Young's (1940) mean of 126.8 sq.cm., and with Nicholson's (1938) mean of 121.0 sq.cm. It is on this basis that Ince and Young's mean is exactly equal to the largest area of the Bantu range. In this respect a comparison between Bantu and English pelvic capacity assumes significance, whereas the difference between the linear values is not impressive. Even Pan's Hindu pelves give a conception of their size only when the formula is applied to their mean brim diameters and an approximate mean brim area of 94.4 sq.cm. is obtained. Pan (1929) and Ince and Young (1940) both used the longer anatomical conjugata vera, and it is, therefore, striking that the mean Hindu area (94.4) is less than the smallest area (95.0) of Ince's range.

18. The transverse diameter of the plane of the cavity lies in the same plane as, and is the greatest diameter perpendicular to, the antero-posterior diameter of the cavity described above.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff.of means / Stand. error
50 Basuto	10.78 ± 0.10	0.72	9.3 - 12.1	1.97
50 Zulu	11.04 ± 0.08	0.60	9.6 - 12.1	
100 Male	10.91 ± 0.07	0.67	9.3 - 12.1	

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This diameter was not measured in the original series of 67 female pelves (Heyns, 1944), and since that time most of the specimens have been disarticulated; but a calculation for the area of the pelvic cavity had been made by replacing the cavity transverse diameter by that of the brim.

In 100 Bantu male pelves the difference between the transverse diameters of cavity and brim was 0.35 cm. which is 3.36 times its standard error. Thus in the Bantu male the brim transverse is significantly greater than the corresponding cavity diameter.

19. The area of the plane of the cavity.

Series	Mean (sq.cm)	S.D.(sq.cm)	Range(sq.cm)	Significance Diff.of means / Stand. error
50 Basuto	88.96 ± 1.83	12.91	66.7 - 113.0	)
				) 0.5
50 Zulu	90.16 ± 1.63	11.52	58.8 - 113.2	)
100 Male	89.56 ± 1.22	12.24	58.8 - 113.2	

It is rare for the Bantu male to have a greater cavity transverse than brim transverse, but this occurs more frequently in the female where funnelling of the pelvis is uncommon. In view of this fact and because the more circular shape of the cavity in all pelves should give re-

liable results with the formula used for the brim, an approximate calculation of the area of the cavity plane can be made from the antero-posterior diameter of the cavity and the transverse diameter of the brim. This was done (Heyns, 1944), and in 67 female Bantu pelves the range of cavity area was from 85.2 to 135.2 sq.cm., with a mean of 111.78 ± 1.39 sq.cm., and a standard deviation of 11.4 sq.cm. Nearly half of the cavity areas were just about 10.0 sq.cm. more than the brim area, this being the difference of the means. In this respect there is a greater sex difference in the cavity areas than in the brim areas.

C. Measurements Affecting the Outlet

The intertuberal diameter and the symphyseal height have been discussed: it remains to consider the plane of least pelvic dimensions, the posterior sagittal diameter of the outlet (showing to what extent the lower sacrum encroaches on pelvic space), and the anterior sagittal diameter (indicating the height of the pubic arch, and a dimension of the anterior portion of the outlet).

The plane of least pelvic dimensions is probably more important obstetrically than the lower plane containing the intertuberal diameter; the most convenient diameters to measure are the inter-ischio-spinal and the pubosacral, the latter being the distance between the anterior aspect of the sacral tip and the lower border of the symphysis pubis. The four points concerned lie very nearly in the same plane in the majority of pelves.

20. The inter-ischio-spinal diameter.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
66 Female	9.70 ± 0.13	1.00	6.5 - 12.4	
50 Basuto	8.08 ± 0.09	0.63	6.4 - 9.3	0.4 / 11.15
50 Zulu	8.02 ± 0.11	0.79	6.2 - 9.7	
100 Male	8.05 ± 0.07	0.72	6.2 - 9.7	

The sex difference is highly significant.

In the rural English series of 250 women (Nicholson, 1938) the mean was 10.54 cm., and in 376 London women (Ince and Young, 1940) it was 9.95 ± 0.037 cm. A large number of Ince's cases did not show ischial spines radiographically and had to be omitted for this measurement: many of the larger outlets were excluded, which may ac-

count for Ince's mean being 6 mm. less than Nicholson's. The Bantu female inter-ischio-spinal diameter is, therefore, about ½ cm. below the mean in English women; it is, nevertheless, of ample length, i.e. approximately 4 inches, which may be considered to be roughly the European mean.

21. The pubo-sacral diameter.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
66 Female	11.65 ± 0.10	0.80	10.0 - 13.5	
50 Basuto	10.11 ± 0.09	0.65	8.3 - 11.2	12.9
50 Zulu	9.99 ± 0.11	0.80	8.3 - 11.7	0.9
100 Male	10.05 ± 0.07	0.73	8.3 - 11.7	

As in the transverse diameter (inter-ischio-spinal) of the plane of least pelvic dimensions, the antero-posterior axis also shows a highly significant greater female length. As pointed out above, the sex difference of 1.60 cm. is due mainly to the greater forward inclination of the lower end of the sacrum in the male. The sex difference in the mean brim sagittal diameter is only 0.43 cm. Therefore about ¾ of the sex difference in the pubo-sacral

diameter is derived from the forward sacral position in the male (the sacral curvature in the sexes being similar).

The rural English series had a much larger diameter (13.01 cm.), and the London women a mean (11.97 cm.) only slightly greater than the Bantu female. Lateral view X-ray measurement of the pubosacral diameter is unreliable, as failing to determine accurately the anterior point of this diameter (see Appendix 1).

The female Bantu pubosacral diameter is 4 3/5 inches. There exists a great tendency towards some contraction of the Bantu outlet, and even an occasional gross contraction, rare in the European pelvis, wherein the expected average diameter is not much less than 5 inches. Nicholson's measurement in this respect appears acceptable.

22. The area of the outlet (plane of least pelvic dimensions) may be calculated from the ellipse formula, with inter-ischio-spinal and pubosacral diameters as axes. Tracings of the outline of this plane

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showed that in most instances its shape approaches an ellipse more closely than does the brim; unfortunately, the interspinal is often much shorter than the greatest transverse diameter of the ellipse, and this leads to a reduction of area which may be as great as 20 percent in pelves with exaggerated male characters. The error is greatly dependent on a pronounced intrapelvic projection of the ischial spines. In the average "normal" female pelvis, however, this error is so small that a fair estimation of the area is obtained by the calculation suggested: in a few outlets the calculated area will be appreciably less than the true area.

Series	Mean(sq.cm.)	S.D.(sq.cm)	Range(sq.cm)	Significance: Diff. of means / Stand. error
65 Female	88.80 ± 1.52	12.30	58.1 - 116.9	
50 Basuto	64.08 ± 1.07	7.54	44.5 - 79.0	0.98 / 14.55
50 Zulu	62.46 ± 1.25	8.82	43.8 - 88.4	
100 Male	63.27 ± 0.82	8.24	43.8 - 88.4	

The sex difference in the outlet area is highly significant, and is greater than that found for the pelvic brim area.

Nicholson's (1938) rural English series, which it was suggested gave a figure closer to the true pubosacral than Ince and Young's (1940) series, had a mean outlet area of 106.7 sq.cm. with a standard deviation of 11.9 sq.cm. Ince's mean was 93.7 sq.cm. It is obvious that, with standard deviations of the same order, the Bantu female outlet is considerably smaller than the English. Of these English outlets 20 percent had an area larger than the biggest Bantu outlet, and only 7 percent of the English fell below the Bantu mean area. Comparing the European and Bantu pelvic dimensions for the female generally, the most impressive differences were those in the areas of brim and outlet (plane of least pelvic diameter).

The anterior and posterior sagittal diameters of the outlet were measured in the female series only.

23. The anterior sagittal diameter of the outlet showed a mean of 7.03 $\pm$ 0.08 cm. with a range of 5.6 - 8.5 cm. Thoms' (1935) figures from 1,000 women gave an average of 5.0 cm. for this diameter, and 10.5 cm. for the antero-posterior measurement of the

outlet: as suggested, these dimensions appear to err on the low side.

24. <u>The posterior sagittal diameter</u> of the outlet in 66 Bantu pelves ranged between 3.5 and 8.4 cm. with a mean of 5.99 $\pm$ 0.13 cm. Eden and Holland (1937) give this diameter as 4 inches and unwarrantably predict difficult delivery if this length is reduced. In view of Nicholson's and Ince's findings of a pubosacral diameter of about 5 inches, it is obvious that this sagittal diameter cannot be 4 inches. Williams (1931) showed figures which led Thoms (1935) to suggest that if the sum of the intertuberal diameter and the posterior sagittal of the outlet did not amount to 15.0 cm., difficulty in delivery should be anticipated. It is obvious that, however narrow the outlet, the foetal head can negotiate it provided the sacrum is placed sufficiently far back. In the 66 pelves the mean sum of these 2 diameters was 16.2 cm., the range being 11.9 - 19.9 cm.; 15 (23 percent) of these values were below 15.0 cm.

The outlet area may reasonably be compared with

this value, because neither takes into account the size of the subpubic angle, and both attempt to estimate the dimensions of the plane of the outlet. The outlet area is likely to be the more precise measurement in this respect. Taking the area of the maximal cross-section of the well-flexed foetal head to be 70.0 sq.cm., then an outlet area below 80.0sq.cm. may be considered to be critical. The figures in Table 3 are some comparisons between the outlet area and William's critical value of 15.0 cm. as gained from the Bantu pelves.

Four outlets had an area of over 80.0 sq.cm. but intertuberal and posterior sagittal under 15.0 cm. With the latter value over 15.0 cm., 6 outlets were under 80.0 sq.cm. The figures in Table 3 also serve to illustrate the disparity between these values. It is suggested, therefore, that Thoms' rule is untenable; and that, even if true for some cases, it is liable to mislead the obstetrician particularly where indicative of a bad prognosis.

These facts are more accurately brought out in the graph (Fig.P3). In 20 pelves dioptographic

FIG. P3.

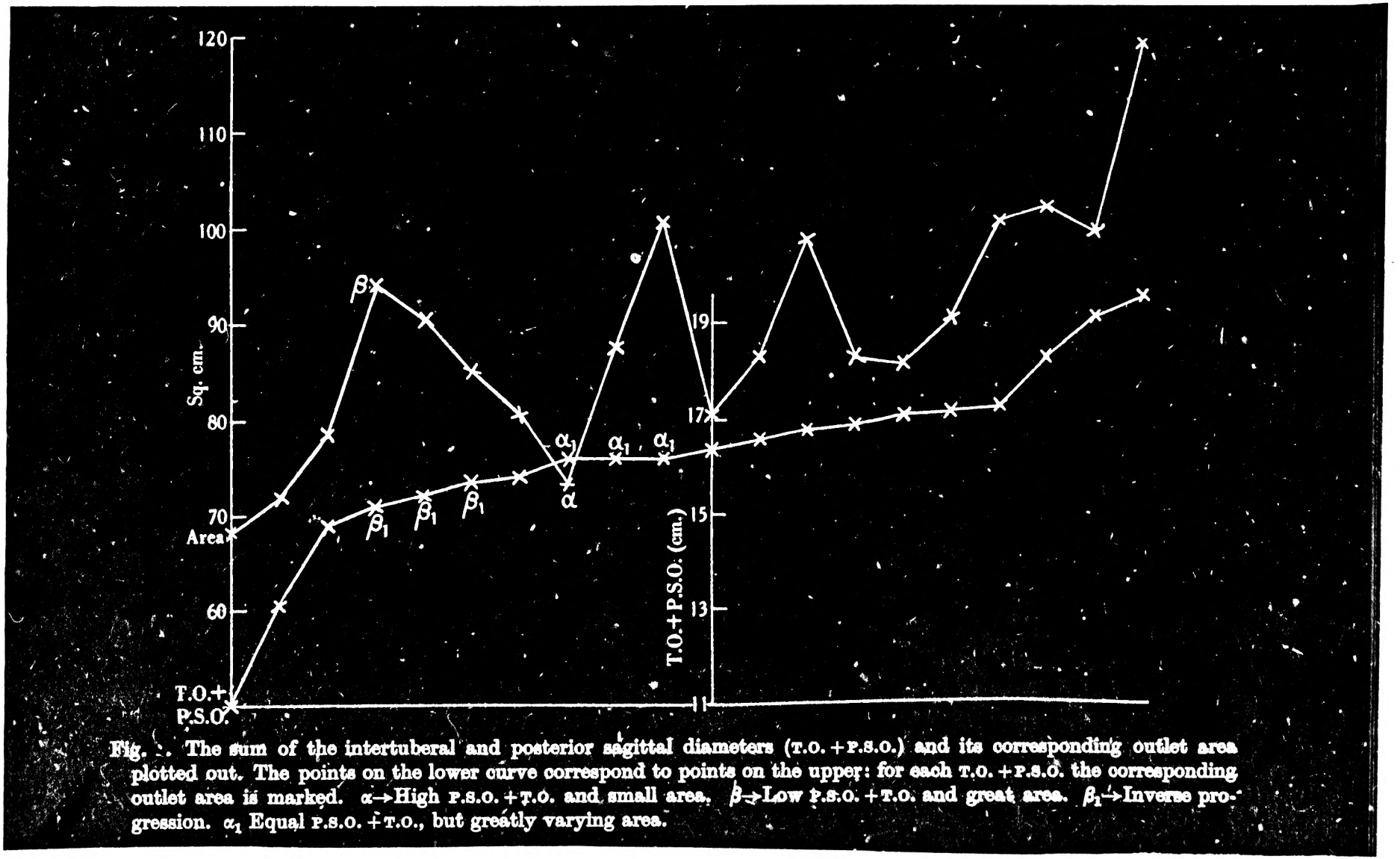


Fig. . The sum of the intertuberal and posterior sagittal diameters (T.O. + P.S.O.) and its corresponding outlet area plotted out. The points on the lower curve correspond to points on the upper: for each T.O. + P.S.O. the corresponding outlet area is marked. $\alpha \rightarrow$ High P.S.O. + T.O. and small area. $\beta \rightarrow$ Low P.S.O. + T.O. and great area. $\beta_1 \rightarrow$ Inverse progression. α_1 Equal P.S.O. + T.O., but greatly varying area.

tracings were made of the outlet and the areas thereof were measured with a planimeter: these areas are, therefore, accurate. The transverse and posterior sagittal diameters were also measured on the bones, and are likewise precise. The graphs show that these two values are by no means strictly proportional.

Table 3

Identification number of pelvis	Transverse of outlet+ posterior sagittal of outlet(cm.)	Area (sq.cm.)	Planimeter area of diopto-graphic tracing (sq.cm.)
A849; 886	13.5	102.8	Not done
A281; 371	13.1	66.0	72.0
A397	15.2	98.4	94.1
A458; 527	16.2	80.0	73.2
A 85; 224	16.7	75.4	Not done

The area marked α is low (73.0 sq.cm.) and the Williams value 16.2 cm. The area at β is high (94.0 sq.cm.) and the corresponding value 15.2 cm. The Williams values at $\beta 1$, $\beta 1$, and $\beta 1$ ascend, while there is a steep descent in the corresponding areas; and at α_1, α_1, and α_1 occur 3 equal values with area ascending from 73 through 87 to 100 sq.cm. While the

3 values below 15.0 cm. are from pelves with areas below 80.0 sq.cm., the 3 marked β1 are only just over 15.0 cm. but have adequate areas which average about 90.0 sq.cm.

That no reliable correlation obtains between the outlet area and the intertuberal diameter is illustrated by the fact that in 2 pelves where the latter diameter was 8.8 and 9.0 cm. respectively, the corresponding outlet areas were 66 and 92 sq.cm. The great reliance placed clinically on this 'transverse' of the outlet cannot be supported. Williams (1931) appreciated the distance of the sacrum from this diameter as an essential in obstetric prognosis. His figures showing the length of the posterior sagittal diameter required for a given transverse diameter deal with a range of the latter which is extremely low, and some of the posterior sagittal figures are extraordinarily high, even improbable. These Williams values are better replaced by considerations of area at the plane of least pelvic dimensions. Clinically, however, the form of the pubic arch must also be

- known, -

known, for with a well-curved arch the prognosis is better even if intertuberal alone, or intertuberal + posterior sagittal, are small, whilst with dangerously small areas a head may still pass if the pubic arch be moderately wide and well curved. At the outlet the important obstetric factors are two, viz. the area of the outlet, and the pubic arch. These features should receive adequate attention in any description of a pelvis.

D. Results of X-ray Measurements

100 primigravidae were X-rayed in the second half of pregnancy by the method outlined in Appendix 1 and 25 non-pregnant women (8 nulliparous) were dealt with by Nicholson's stereometric method (1936). The results were as follows:

1. The true conjugate with range 8.2 - 12.5 cm. had a mean of 10.59 ± 0.08 cm. and S.D. 0.81 cm. This mean showed no significant difference from the corresponding figure of 10.76 cm. for the female skeletal material.

The series of 25 gave a mean value of 11.01 cm.

2. The transverse of the brim, ranging between 9.15 and 13.0 cm., had a mean of 11.34 ± 0.08 and S.D. 0.78 cm. The mean for the skeletal material was 11.96 cm. thus giving a difference which is 4.8 times its standard error. It is one of the important conclusions stated in Appendix 1 that the iliopectineal line cannot be demonstrated in X-ray films except on the rarest occasions and that, therefore, the greatest transverse diameter of the brim cannot be measured

radiographically, whatever method or position be adopted. The radiographic brim is represented by shadows of bone which lies deep to the brim. The result of this is a reduction in the length of the transverse diameter.

The mean for the second series of 25 was 12.07 cm.

3. Pelvic brim index.

The application of this index in X-ray pelvimetry is discussed in Appendix 1 . Because the X-ray brim, as just pointed out, lies within the pelvic cavity, it is "cavity" measurements that are taken. It was shown, however, that the index calculated from antero-posterior and transverse diameters must lie very close to Turner's index. For 100 women this index ranged between 79.7 and 121.2, the mean being 93.6 $\pm$ 0.72 and S.D. 7.2. The number (i.e. percentage) of indices 100 or over was 17, which corresponds closely with the figures for the skeletal material of both sexes.

Series 2 (25 pelves) gave a mean of 91.27.

4. The area of the pelvic inlet was 99.33 $\pm$ 1.21 sq.cm.,

S.D. 12.09 sq.cm., and range 66.6 - 127.6 sq.cm. The corresponding female area for the skeletal material averaged 101.23 sq.cm., the difference between these means being not significant.

Mean of series 2: 113.04 sq.cm. for 25 subjects.

5. The area of the cavity plane ranged from 60.0 - 121.9 sq.cm., had a mean of 93.75 ± 1.26 sq.cm. and S.D. of 12.58 sq.cm.

Mean of series 2: 104.82 sq.cm. for 25 subjects.

6. The inter-ischio-spinal diameter for 100 X-rays ranged between 7.45 and 12.58 cm., and had a mean of 10.47 ± 0.09 cm. and S.D. 0.93 cm. This diameter in 66 dry female pelves averaged 9.70 cm., the difference from the X-ray material being nearly 5 times its standard error and, therefore, highly significant. It may be accepted that this diameter allows of precise measurement by the X-ray technique used here, and the reason for the difference is probably accounted for by the nature of the material of which the 2 series are composed. Thus the X-ray pelvimetry was practised

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on pregnant women in whose range the lowest values of the skeletal material did not occur. In several of the dry pelves spontaneous birth would have been impossible, and it is further probable that some of those subjects may never have conceived. It is well known that very small pelves are found more frequently at sterility and hormone clinics than at the antenatal clinic. The X-rayed women, therefore, have shown themselves possessed of sufficient development to become pregnant, whereas this quality was not necessarily present in the subjects from whom the dry material was derived.

Mean of series 2: 10.03 cm. for 24 subjects.

7. The <u>pubosacral diameter</u> was measured directly on the patient with callipers. There is no method by which this diameter can be measured radiographically with precision that is greater than that possible in clinical pelvimetry. Only 65 women were measured, the reason being that pelvimetry in the X-ray department was undesirable and in some cases the patient did not attend subsequently at the clinic.

In 65 subjects with a range of 9.1 - 15.7 cm.

the mean was 12.20 ± 0.17 and the S.D. 1.33 cm. The mean diameter for the dry pelves was 11.65 cm., and the difference is nearly 3 times its standard error.

Mean of series 2: 12.90 cm. for 21 X-ray observations.

8. The area of the outlet calculated from the last 2 measurements 6 and 7 gave a mean of 100.12 ± 1.88 sq.cm., S.D. 15.12 sq.cm., and range 64.5 - 131.0 sq.cm. The difference from the value for the skeletal material (88.8 sq.cm.) was 4.7 times its standard error.

Mean of series 2: 101.95 sq.cm. for 20 subjects.

It will be observed that inlet and outlet areas lay within 1.0 sq.cm. of each other. This finding is disconcerting as to technique, but a possible reason for the small difference is the depth at which the brim shadow shows on the film. Even with the correction suggested in Appendix 1 the anatomical brim dimensions may not be equalled. The brim, as demarcated by the iliopectineal lines, frequently lies high on a sloping shelf well above the true boundary of the pelvis minor. This plane is, therefore, of no importance in obstetrics and is indeed as arbitrary as

the one presented by the X-ray beam. Living material is more readily available for study than skeletal, and there can be no reason why these "radiographic pelvic inlets" and their modifications should not be accepted provided their true nature is fully understood. They have this virtue that they demonstrate the narrowest pelvic plane which is the important one in childbirth, and sound X-ray pelvimetry may even make these rare osteological studies obsolete or unimportant.

9. In 87 cases ranging between 8.5 and 14.0 cm., the intertuberal diameter averaged 11.47 ± 0.12 cm. with S.D. 1.15 cm. The difference between the means in the living and skeletal material is 6 times its standard error; but this unsatisfactory diameter may not be measured by the same observer on the same parts of the massive ischial tuberosities on different days. It is believed that by the Chassard and Lapine radiographic method advocated greater uniformity is possible than by direct measurement of this diameter on dry pelves.

Mean of series 2: 10.76 cm. for 21 observations.

10. In 87 cases the height of the symphysis had a mean of 3.27 ± 0.04 cm., range 2.5 - 4.2 cm., and S.D. 0.40 cm. The skeletal mean of 3.45 cm., although close to the above mean, is significantly different (more than 3 times the standard error). A criticism of the X-ray symphysis is that its upper border is not always well defined and often fuses with lumbar vertebral shadows.

Mean of series 2: 2.96 cm. for 19 observations.

11 and 12. Two measurements were taken of the depth of the pelvic basin: one from midpoint of intertuberal diameter to top of symphysis (11), and the other from tuberosity of ischium to iliopectineal line along a line tangential to the anterior curve of the acetabulum.

The greater depth (11) in 87 cases gave the following values: mean 10.25 ± 0.07 cm., S.D. 0.66 cm., and range 8.5 - 12.0 cm. The true lateral depth (12) for 87 cases gave a mean of 8.77 ± 0.06 cm., S.D. 0.58 cm., and range 7.6 - 10.2 cm. The latter mean corresponds closely with that for the 67 dry female pelves which gave values of 8.75 and 8.77 cm. for

left and right sides respectively.

Mean of series 2: no.11 - 9.87 cm.; no.12 - 7.57.

13. Of all measurements of the female pelvis, the determination of the subpubic angle in degrees is the most fanciful. The method of assessing the "angle" is given in Appendix 1 , and in 87 observations the mean was 95.95 ± 1.30 degrees, S.D. 12.09 degrees, and range 64 - 139 degrees.

Summary.

Results are presented of X-ray pelvimetry practised on 125 adult Bantu women of various tribes. No males were studied radiographically. A small number of diameters only is shown, because many different views would be required for the range of pelvic measurements usually considered. The error possible in X-ray pelvimetry must be carefully studied, and a discussion of this problem based on experimental results is contained in Appendix 1 .

It was planned to radiograph a second 100 women according to Nicholson's technique (1936). This plan was abandoned, when 25 adult subjects had been thus

X-rayed, in favour of radiographic study of development in the infantile and juvenile pelvis. In the last category 40 subjects have been investigated up to the present, and the results are reported elsewhere in this work.

Nicholson's method (1936) has been found extremely cumbersome and time consuming as compared with the simple method advocated in Appendix 1 . His stereometric method is ingenious and theoretically sound, and won an award for the author. But Nicholson deserves censure for his indifferent description of the technique and its implications. In anticipation of the present work, a considerable number of experiments had to be performed with the markers laid into the Potter-Bucky diaphragm. As Nicholson dealt only with pregnant women, his exposure times were long; and it is possible that even he was unaware of the length and intensity of the shadows caused by the markers during exposures of the order of one second.

The radiologists consulted could not predict what results might be obtained; and a series of experiments was necessary to determine not only the effect

of time on the moving marker, but also the accuracy of the method in practice. Two important conclusions follow from experience with the stereometric method: (1) that, unless the technique be more fully reported, workers will have to experiment before gaining precision; and (2) when the previous objection has been dealt with, observers will conclude that the accuracy of the method in practice is not sufficient to justify the time required in preparing the films and measuring the tracings made from them.

The stereometric technique made it possible, on account of the shift involved, to observe the anterior limb of the Y-shaped acetabular epiphysis; and this was found to be the only approach to an ontogenetic study of the pelvic brim. By means of this method the distance between 2 points can be found even if the line joining them is oblique to the film: moreover, the tracings will show whether the line is oblique or parallel. The conclusion that Nicholson's stereometric method is of great value to the investigator, therefore, remains.

Note on further results of experiments in X-ray pelvimetry.

In addition to the experiments in X-ray pelvimetry

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discussed in Appendix 1, 20 dry Bantu female pelves were radiographed with the brim horizontal. The purpose of this was to find the accuracy of the modifications suggested for measuring the lengths of the inter-ischio-spinal diameter and the transverse of the brim, the area of the brim, and the brim index. The true measurements of these diameters and the planimeter area of the brims were known from precise measurement on the dried pelvis.

1. The greatest error for the interspinal diameter was -2.4 mm. in one case, the majority of errors being under 1.0 mm., and a few 1.0 to 2.0 mm. It was suggested in the appendix that the error would rarely be more than 1.0 mm. The mean error was 0.0995 cm: in 1 there was no error, in 5 there was a plus error, and in 14 a minus error.

2. For the brim transverse diameter, it was found in the 20 specimens that the average error was -0.589cm. It was pointed out in the appendix that the true brim transverse was never shown on the X-ray film, and that the outline of the brim on the film always represented a level of the pelvis near the cavity plane. It was suggested that the X-ray transverse diameter was about

7.5 mm. shorter than the brim transverse.

3. The modified true conjugate suggested showed a mean increase for 20 pelves of exactly 1.0 cm. over the actual true conjugate. Against this there is a loss of 0.589 cm. for the transverse as explained in 2.

4. Area of brim. On the average (20 pelves) the calculated X-ray brim area was 6.39 sq.cm. less than the true planimeter area. For these pelves the mean planimeter area was 112.655 sq.cm. Therefore, the mean percentage error of the calculated X-ray brim area is -5.67

5. Area of cavity. Here the X-ray area was less than the area calculated from bone measurements in half the cases, and more in half. The minus errors showed a greater total area. The mean error of -1.5 sq.cm. is much smaller than the error for the brim.

6. Brim index. It will be observed that the brim index is in truth a "cavity" index. The conjugate diameter is on the average 10 mm. more than it should be, and the transverse 6 mm. less. Therefore the index obtained must be a little higher than Turner's index. This suggests that a higher index will be found than

was in fact the case. Thus in 65 dry pelves the index was 90.4 ± 2.0 with a range of 69.6 - 104.4. In 100 pregnant women the mean index was 93.6 ± 0.72 with range 79.7 - 121.2.

E. Miscellaneous

I THE PUBIC ARCH

Series	Mean(deg.)	S.D.(deg.)	Range (deg.)	Sig. Diff means / Stand. error
50 Basuto Male	56.36 ± 1.20	8.48	34 - 74	)
50 Zulu Male	58.40 ± 1.18	8.37	38 - 76	) 1.2
100 Male(total)	57.38 ± 0.85	8.48	34 - 76	)

Despite attempts in the female to estimate the subpubic angle in degrees, it must be realized that the shape of the arch is rounded, not angular, and that it is only the narrow arch with straight rami that lends itself to such estimation. Thus it is reasonable to measure the male subpubic angle in degrees, and by comparing readings taken on different days it was concluded that an accuracy up to 1.0 degree was attainable.

A well-curved arch (sometimes of a marked Norman arch appearance) with eversion of the antero-inferior edges of the rami is the female tendency and the obstetric ideal. In such, only the portion of the arch near to the symphysis pubis is of importance obstetrically: this portion is rounded, with part

Table 4. Bantu pelves: subpubic angle

Pelvic type	Width: Narrow	Width: Moderate	Width: Wide	Norman arch	Well-curved	Straight	Depth of pelvic basin 9cm. or over	Thickness of bones: Heavy	Thickness of bones: Average to light
13 android	11	2	0	0	6	7	9	10	3
17 anthropoid	5	11	1	1	11	5	5	8	9
35 gynecoid	8	21	6	7	23	5	9	8	27
65 Totals	24	34	7	8	40	17	23	26	39
Width of subpubic angle									
25 narrow				2	14	9	13	13	12
34 moderate				8	22	4	8	13	21
8 wide				1	5	2	3	1	7
67 Totals				11	41	15	24	27	40

The numerical difference is due to one pelvis being platypelloid and to one being asymmetrical.

Table 5. Depth of pelvis compared with thickness of bones

Depth of pelvic basin	Thickness: Heavy	Thickness: Light	Thickness: Average
24 9 cm. or over	13	3	8
43 under 9 cm.	14	7	22
67 Totals	27	10	30

of it lying outside the angle enclosed by the lower aspect of the symphysis and the rami in the region of the ischial tuberosities. Hence the pubic arch must be assessed subjectively, and here again Caldwell and Moloy's classification, embracing narrow, moderate and wide forms, has been followed.

Table 4 shows that the android pelvis in Bantu material tends to have a narrow subpubic angle which is 'straight' to 'curved', that its pelvic basin tends to be deeper than the average, and that the vast majority of the bones are heavy. The Bantu gynecoid pelvis has almost opposite characters; and the pubic arch of the Bantu anthropoid pelvis is intermediate between these 2 types.

For the entire Bantu series of pelves the narrow pubic arch occurs in 37 percent, but in 85 percent of the android type: this is significant, the difference being about 5 times its standard error. The straight form of the arch was found in 54 percent of the android type, and in 26 percent of the whole series: this difference is a small fraction less than twice its standard error, and cannot be re-

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garded as significant, but if the straight arch percentage in the android pelves be compared with that of all other pelves in the series, the difference is more than twice its standard error. Considering these 2 features together, the table shows a relatively high incidence of straight forms associated with a narrow arch. The difference between the narrow and all wider arches is twice its standard error, which is significant. The android pelvis tends greatly to heaviness and a deep pelvic basin. For both of these features the difference between the android and all the other types is more than 3 times its standard error, and this is significant.

The second part of Table 4 shows that a narrow arch was associated with a heavy bone in 52 percent of pelves, whilst one example only of a wide arch was associated with a heavy bone (12½ percent). The difference is significant. A narrow arch may also be expected to occur when the pelvic basin is deeper than normal, for 52 percent of narrow arches were so associated, as against 26 percent of the other arches. Here the difference is more than twice its standard error, and is significant.

An apparent correlation between the depth of the pelvic basin and the thickness of the bones is shown in Table 5 . More than half (54 percent) the pelves with a deep basin are heavy, but only 32.6 percent of pelves with a basin depth below 9 cm. This difference is 1.8 times its standard error, and is unlikely to be significant.

Although no statistical comparison of the pubic arch in the 2 sexes is possible, little is lost, for this attribute of the pelvis is probably the most characteristic for either sex. The above findings for the android type female arch show a near approach of the android pelvis to the pelvis of the male.

II SPLAY OF THE SIDE WALLS

Following Caldwell et al (1934) the splay of the side walls of the pelvis was determined. Three degrees of wall disposition were recognised, viz. convergent, straight, and divergent, the slope of the pelvic lateral walls being judged from the ilio-pectineal line above to the ischial tuberosities below. In the female, straight or convergent walls were seen in 81 percent of android pelves, and if this character be compared with its lower incidence in the

gynecoid type of pelvis, the difference is 1.5 times its standard error. It is possible that if a greater number of specimens were examined, this difference might prove to be significant. Caldwell et al (1934) state that there is a high correlation between the splay of the side walls and the width of the pubic arch. In the Bantu series a narrow pubic arch was found in 85 percent of android type pelves, a figure which differed significantly from those giving the incidence in the gynecoid and anthropoid types.

In the Bantu male 41 Zulu and 40 Basuto, i.e. 81 percent of males, had convergent pelvic side walls. Nine Zulu and 10 Basuto (19 percent of males) had straight walls: there were no examples of divergence. In the case of the straight sides, the observer gains the impression of looking into a well rather than the pronounced funnel of the typical male pelvis minor.

III THE ISCHIAL SPINES.

Ischial spines were classified as anthropoid, average, or sharp (Caldwell et al., 1934). The anthropoid spine approaches the gorilla spine, of which the apex is poorly defined, and the base broad and flat.

In the 67 female Bantu pelves, 12 (18 percent)

of spines were anthropoid, 13 (19 percent) were sharp, and 42 (63 percent) were average. In the anthropoid pelves 41 percent of spines were of the anthropoid variety, the difference between this and the percentage in the other 2 types being more than twice its standard error. Thus, an anthropoid spine is likely to belong to an anthropoid type pelvis, and unlikely to belong to another pelvic type. Caldwell et al. found, contrary to present experience with the Bantu pelvis, that the android group shows the greatest number of sharp spines. Table 6 gives the distribution of the different types of ischial spine among the three parent types.

Table. 6. Female Bantu Pelves: distribution of ischial spines

	Varieties of spine		
	Anthropoid	Average	Sharp
35 gynecoid	4	22	9
14 android	1	11	2
17 anthropoid	7	8	2

An additional variety of ischial spine was observed in the male, here termed the papillary. Its

appearance was characteristic, and it had the highest incidence.

Table 7 Males.

Variety of ischial spine	Zulu	Basuto	Total male percentage
Papillary	20	22	42
Anthropoid	10	13	23
Sharp	10	10	20
Average	10	5	15

Nothing statistically significant was found in the distribution of ischial spines over the Caldwell and Moloy types of pelvis in the male. As in the female, the sharp spine which can be readily distinguished occurred typically in the gynecoid group. A classification of ischial spines is unsatisfactory, and different observers are bound to disagree in their diagnosis of an appreciable percentage of examples.

Summary to Part IV.

Intra-racial sex comparisons showed statistically significant differences for the following:

1. Male variable greater in

Interspinal diameter
Interspinal/intertuberal index
Maximum pelvic height (left and right sides)
Depth of pelvic basin (left and right sides)
Symphyseal height.

2. Female variable greater in

Intertuberal diameter
Width of sacro-sciatic notch
Conjugata vera
Transverse of brim
Antero-posterior of pelvic cavity
Oblique of brim
Area of inlet plane
Area of cavity plane
Area of outlet plane
Inter-ischil-spinal diameter
Pubosacral diameter.

Pubosacral diameter: mean sex difference = 16.0 mm.
Conjugata vera : " " " = 4.3 mm.

The relative shortness of the male pubosacral diameter has been shown to be due to forward sacral inclination.

The pelvic differences between Bantu and European females were most emphatic when the areas of brim and outlet were used as a criterion.

While the average male brim area was 14 sq.cm. less than the female, the greatest brim areas were male (140). The female range lay completely within the male range. The greatest calculated Bantu female area (126.8 sq.cm.) was equal to the mean area for London women (Ince and Young, 1940).

In both sexes over 80 percent of pelves had convergent side walls. A higher percentage of pelves

had straight side walls in the male than in the female. In the case of the straight sides the observer gains the impression of looking into a well rather than into the pronounced funnel of the typical male pelvis minor.

In the two male skeletal series the Zulu measurements were greater than the Basuto in all dimensions except the transverse diameter of the brim, which was greater in the Basuto.

The following asymmetries have been persistent, though the differences on left and right sides are not statistically significant. Nevertheless, these well defined manifestations cannot be disregarded. In the female the following was found:

Auricular surface area) L > R
Preauricular sulcus)

Oblique diameter of brim) R > L
External oblique diameter)

Maximum pelvic height) L > R
Depth of pelvic basin) R > L

In the male the exact opposite occurred for each of the above dimensions.

It seems, then, that the left limb is better developed and more active inthe female, but that the

right limb predominates in the male. A curious finding is the fact that the pelvic basin is deeper on the side where the maximum height is greater, and this obtained throughout the analysis of the two sexes.

1. The female pubic arch cannot be measured in degrees. 2. A narrow pubic arch occurs characteristically in the android type female pelvis. 3. The android pelvis is associated with heavy bones and a deep pelvic basin. 4. A narrow arch is associated with heavy bones. 5. The narrow arch occurs when the pelvic basin is deeper than normal. Williams' and Thoms' dictum basing outlet size on the sum of the intertuberal diameter and the posterior sagittal diameter of the outlet bas been shown to be invalid.

In the female an anthropoid ischial spine is likely to belong to an anthropoid type pelvis, and unlikely to belong to another pelvic type. In the male a new variety of spine was described, and was named "papillary".

The Bantu pelvic brim in both sexes is mesatipellic, indices below 82.0 being comparatively rare.

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Authors of last century, e.g. Turner and Verneau, found average indices below 80.

In both Bantu sexes the greatest intercristal diameter found was less than the European mean. The smallest Bantu diameters are greater than the Bush mean value.

Radiographic measurements of the pelvis were taken by two methods. On 100 antenatal primigravidae the method discussed in Appendixlwas used, and to a series of 25 non-pregnant women Nicholson's technique (1936) was applied.

PART V

THE SACRUM

The convention used in the arrangement of the following tables follows that of the dimensions of the pelvic girdle. The linear measurements and indices pertaining to the sacrum are after Radlauer (1908) who published the most comprehensive study of the sacrum that is known to us.

(1) DIMENSIONS OF THE SACRUM

1. Anterior straight breadth.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand.	error
66 Female	10.66 ± 0.08	0.64	9.0 - 12.7		
50 Basuto	10.40 ± 0.10	0.71	8.8 - 11.9		
				0.52	2.12
50 Zulu	10.47 ± 0.09	0.63	8.9 - 11.7		
100 Male	10.44 ± 0.07	0.68	8.8 - 11.9		

In the Bantu the female sacrum is wider than the male, but the difference is not sufficient to make it definitely significant. According to the standards set out elsewhere for this work, the difference can only be said to be possibly significant.

When the 50 male Zulu sacra are compared with the female series, the difference is 1.6 times its standard error; and for this no significance can be claimed. The Basuto male series shows a factor of 2.03 times the standard error

for its difference from the female sacra.

2. Midventral straight length.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means Stand. error
66 Female	9.97 ± 0.13	1.07	7.6 - 12.8	
50 Basuto	10.32 ± 0.16	1.11	7.8 - 13.0	0.28 / 2.18
50 Zulu	10.38 ± 0.14	1.02	7.5 - 12.5	
100 Male	10.35 ± 0.11	1.10	7.5 - 13.0	

The Bantu female sacrum is shorter than the male, but the significance of the difference is of the same order as was found for the sacral breadth which, however, was greater in the female. It is possibly true that the female sacrum is shorter but wider than the male, but the figures presented do not substantiate this. Therefore it is safer to conclude that in the Bantu there is a tendency for the female sacrum to be short and broad as compared with that of the male. The female range is seen to lie entirely within that for the male.

3. The sacral index for the male was significantly lower than that for the female. In the European the male index is 102.9 (Radlauer, 1908); and Ince and Young's (1940) series of 489 pregnant London women gave a mean of 108.9,

the range being 82 - 141. The Bantu sacral index corresponds, therefore, extremely closely with that of the European. Radlauer (1908) gives the following values for the female of certain races: Negroes 103.16(18), Andamanese 103.4(35), Australians 110.0(13), Japanese 107.1(36), Europeans 112.4(43). The Bantu female sacral index, being above 106, may be termed platyhieric, the male being subplatyhieric (100- 106).

3. The sacral index (Anterior straight breadth/midventral straight length X 100).

Series	Mean	S.D.	Range	Significance: Diff. of means / Stand.	error
67 Female	107.9 ± 1.35	10.90	82.0 - 146.2		
50 Basuto	101.8 ± 1.51	10.68	78.6 - 130.9	0.4	3.37
50 Zulu	102.6 ± 1.43	10.12	86.7 - 129.9		
100 Male	102.2 ± 1.04	10.41	78.6 - 130.9		

Turner (1886) and Radlauer (1908) considered that they had established an undoubted sex differentiation based on sacral index mean values; but to reach this conclusion their argument was based on the component lengths of their index finding which, as here, showed that the female sacrum was broader and shorter than the male. However, no statistical proof was attempted, and indeed no valid con-

clusion reached.

4. The midventral curved length of the sacrum was obtained by using a half-inch wide strip of tinfoil, which was smoothed out by running over it a conveniently shaped wooden block held between the fingers. The tin-foil was then carefully applied to the anterior surface of the sacrum, marked, and ironed out again. Measurement was then made.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
66 Female	10.85 ± 0.15	1.22	8.5 - 13.8	
50 Basuto	11.13 ± 0.17	1.17	8.4 - 14.0	0.53 / 1.8
50 Zulu	11.26 ± 0.18	1.28	7.7 - 13.8	
100 Male	11.20 ± 0.12	1.23	7.7 - 14.0	

The female sacrum is shorter than the male, and the curved length is accordingly shorter; but not significantly so. The curvature index allows comparison of curvature more readily.

5. The Curvature index

The very slight difference in curvature, with the female more curved, is not significant statistically. Radlauer (1908) gives the following percentage values for

this index: Simian apes 98.7, Negroes 92.4, American Indians 91.6, Asiatics 89.7, Australians and Oceanians 93.1, Europeans 86.5. As sex is unspecified, these figures presumably include both males and females. Simian apes, therefore, have a straight sacrum, the Negro figure corresponds with the present Bantu figure, and Europeans have a comparatively well defined sacral curve. In his section on conclusions Radlauer points out the racial difference in this respect between Negro and European, emphasizing the pronounced sacral curvature in the latter. The mean values for the Bantu female curvature index in the 3 parent types of Caldwell and Moloy were as follows: gynecoid 91.8 (range 83.6 - 99.0), anthropoid 91.7 (range 83.8 - 100.0), and android 92.0 (range 86.0 - 96.9). These figures were all close to the average for the series, viz. 91.87. The sacral index analysed similarly gave gynecoid 109.0 (range 88.7 - 128.4), anthropoid 108.0 (range 82.0 - 126.3), and android 105.8 (range 84.8 - 121.2): the mean for the series was 107.9.

The female sacral index for the android type of pelvis only is subplatyhieric, and further analysis of this

type shows that its sacrum is the widest and longest (10.8/10.3 cm.), the corresponding gynecoid type measurements being 10.7/9.9 cm., and the anthropoid 10.5/9.8 cm. Obstetrically, then, the android pelvis embodies unfavourable features in almost every respect except that its anterior straight breadth of the sacrum is the greatest, and thus at least contributes towards a greater transverse diameter of the brim.

5. The curvature index (straight length/curved length).

Series	Mean	S.D.	Range	Significance: Diff. of means Stand. error
67 Female	91.87 ± 0.44	3.59	83.6 - 100.0	
50 Basuto	92.76 ± 0.66	4.69	81.4 - 100.0	0.69 / 0.95
50 Zulu	92.16 ± 0.57	4.00	80.5 - 98.1	
100 Male	92.46 ± 0.44	4.37	80.5 - 100.0	

The male Bantu sacra examined in terms of Caldwell and Moloy's classes show trends similar to those in the female as set out below, but nothing of unquestionable significance was found.

The Basuto and Zulu racial differences for the sacral index seen in (a) the gynecoid type, and (b) the anthropoid type (Table 8 A) may have arisen by chance:

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owing to the low numbers involved no significance was found statistically.

Table 8

A. Analysis of Male Sacrum according to Parent Types.

	Sacral Index		Curvature Index	
	Basuto	Zulu	Basuto	Zulu
Android	102.97	103.70	93.48	92.80
Anthropoid	102.90	97.24	89.67	89.40
Gynecoid	97.2	105.33	92.66	91.61

B. Basuto and Zulu Males Combined (100 sacra).

	Sacral Index	Curvature Index
True Android	103.30	93.14
Android + other tendencies	103.20	93.00
True Anthropoid	100.44	89.58
Anthropoid + other tendencies	100.50	90.00
True Gynecoid	100.99	92.17
Gynecoid + other tendencies	101.10	92.40

A close agreement is seen in Table 8 B between the figures for parent types and those of the corresponding parent type with mixed attributes. In all Bantu groups,

even including the females, the anthropoid type sacrum was more curved than in the other types, and this was a feature observed during handling of the material. Statistically, nothing of significance can be claimed for this finding.

On the average the male Bantu sacrum was subplatyhieric, though platyhieric examples did occur. The female sacral index was characteristically platyhieric with the android type becoming subplatyhieric and approaching the male "android", itself the type with the highest male index. The other types of male pelvis again had lower values than this essentially male type (android), and were very nearly dolichohieric.

No other measurement concerning sacral curvature was made. The position of the maximum height line (Radlauer, 1908) in the Bantu sexes was assessed by inspection only. In a very great majority of the specimens studied the maximum height of sacral curvature was approximately at the junction of sacral vertebrae 2 and 3. In the male the point of maximum height was lower than the junction of S2 and S3 more

frequently than in the female, owing to a sharp forward curve of the terminal end of the sacrum in some specimens; but this feature was also present in some female sacra and cannot be claimed as uniformly characteristic of the male sacrum. If this curvature of the lower end of the sacrum be due to weight bearing - with possible softening of the bone as an accessory factor -, it would be difficult to account for a sex difference in view of the fact that these factors are common to male and female.

Table 9 (Radlauer, 1908)

Sacral level	Percentage incidence of point of maximum curvature.	
	Paterson.	Radlauer.
1-2	0.4	--
2	3.0	14.8
2-3	1.8	1.1
3	83.1	68.0
3-4	1.4	--
4	8.5	16.1
4-5	0.4	--
5	1.4	--

No age, or race, or sex differentiation is stated in this table or in Radlauer's text.

Paterson (1893) gives the 3rd sacral vertebra as the position of greatest curvature. Table 9 shows the percentage incidence of this point at different sacral levels. It may be added that in anthropoids the greatest curvature is very close to the promontory.

6. Lumbo-sacral joint (Articular surface of 1st sacral vertebra).

a. Antero-posterior diameter of articular surface of S1.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error
50 Female	2.91 ± 0.05	0.34	2.3 - 3.6	
50 Basuto	3.10 ± 0.04	0.27	2.3 - 3.8	1.86 / 4.4
50 Zulu	3.21 ± 0.05	0.32	2.0 - 3.8	
100 Male	3.16 ± 0.03	0.30	2.0 - 3.8	

The male diameter is significantly greater than the female, the mean difference being 0.25 cm. The female range, however, lies entirely within the male range.

b. Transverse diameter of articular surface of S1.

The male mean for this diameter is 0.3 cm. greater than the female, and the difference is significant.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff.of means / Stand. error	
50 Female	4.74 ± 0.08	0.54	3.4 - 5.6		
50 Basuto	5.04 ± 0.05	0.38	4.2 - 5.9	0	3.44
50 Zulu	5.04 ± 0.08	0.59	3.7 - 6.4		
100 Male	5.04 ± 0.04	0.44	3.7 - 6.4		

c. Sacral base index.(Antero-posterior of articular surface of S1/Transverse of articular surface of S1).

Series	Mean	S.D.	Range	Significance: Diff.of means / Stand. error	
50 Female	62.12 ± 0.84	5.92	50.0 - 76.3		
50 Basuto	61.44 ± 0.67	4.74	50.0 - 71.7	2.33	1.45
50 Zulu	63.72 ± 0.71	5.04	51.7 - 75.6		

The difference between the mean indices of the two male series was as high as 2.33 times its standard error, and in view of the possible significance of this difference there is some danger in grouping the two male series. The female mean lies between the two male means, and shows a greater difference, without significance, from the Zulu male.

The three Bantu ranges all include the averages of Radlauer's racial groups varying from 54.1 in the inhabitants of the Ural Mountains to 66.4 in Burmese.

7. The sacral auricular surface.

a. Length of auricular surface.

The greatest length was measured.

	Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff. of means / Stand. error.	
Left	50 Female	5.64 ± 0.08	0.59	4.5 - 7.0		
	46 Basuto	5.86 ± 0.08	0.56	4.5 - 6.8	1.34	2.92
	50 Zulu	6.02 ± 0.09	0.61	4.2 - 7.2		
	96 Male	5.94 ± 0.06	0.59	4.2 - 7.2		
Right	50 Female	5.60 0.09	0.63	4.1 - 6.9		
	46 Basuto	5.88 0.08	0.52	4.6 - 6.7	1.07	3.3
	50 Zulu	6.01 0.09	0.65	4.2 - 7.2		
	96 Male	5.95 0.06	0.59	4.2 - 7.2		

The female length is significantly smaller than the male on both sides. In comparing the right auricular surface length with the left, there is a minimal difference of no significance in all the Bantu groups studied. For Radlauer's material the mean and range were:
Left: 6.19 (4.1 - 8.1)cm.; Right: 6.2 (4.1 - 7.8)cm.
The greatest length encountered (8.5 cm.) was found in a

- gorilla -

gorilla sacrum.

b. Index: $\frac{\text{Length auricular surface}}{\text{Midventral curved length of sacrum.}}$

This index shows the relative length of the auricular surface when compared with the sacral length.

	Series	Mean	S.D.	Range	Significance: Diff. of means / Stand. error	
Left	49 Female	52.10 ± 0.86	6.09	41.1 - 73.0		
	46 Basuto	52.74 ± 0.80	5.40	41.3 - 65.6	0.7	1.8
	50 Zulu	53.68 ± 0.95	6.74	43.6 - 77.9		
	96 Male	53.25 ± 0.63	6.15	41.3 - 77.9		
Right	49 Female	51.79 ± 0.76	5.37	41.1 - 66.3		
	46 Basuto	52.26 ± 0.75	5.11	39.3 - 67.8	1.16	1.1
	50 Zulu	53.38 ± 0.89	6.29	42.8 - 72.7		
	96 Male	52.85 ± 0.60	5.86	39.3 - 72.7		

No significant differences were found for the sexes or between the male groups, but the left side consistently showed a higher index for all the groups studied. The length of the auricular surface was less in the female with statistical significance, and the midventral curved length of the sacrum was less in the female with

a sex difference only 1.8 times its standard error. The index, nevertheless, shows that on the average the auricular surface is just over half the curved length of the sacrum, and this holds for males and females.

Radlauer's values for this index were:

Lower apes	85.5	
Anthropoids	70.4	
Australians and Oceanians	54.8	Highest individual index of human series was 75.6
Negro	52.3	
European	52.1	
Asiatics	51.9	
Americans	48.4	

Thus, while lower apes and anthropoids have a relatively long auricular surface (with, however, a lower average number of sacral vertebrae than in human races), shortening occurs in the racial groups shown, with Asiatics and Americans having a relatively shorter joint surface than Europeans.

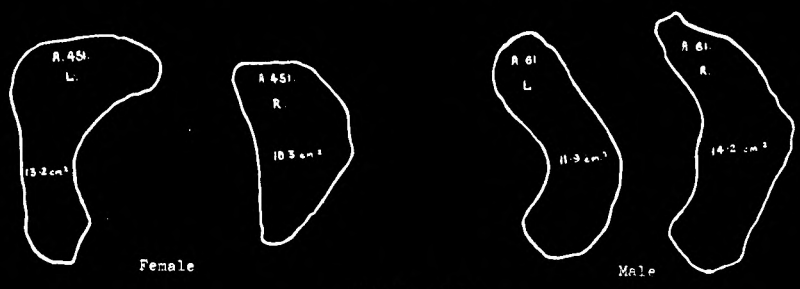
c. Width of auricular surface.

The measurements found in the Bantu were so much

FIG. 51

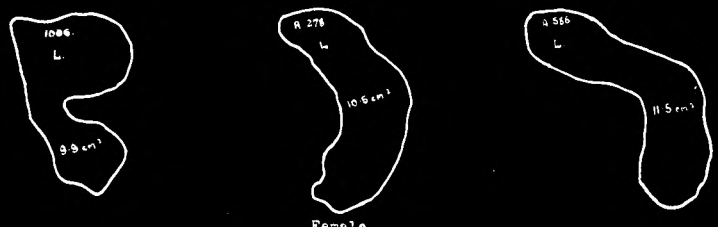
VARIETIES OF SACRAL AURICULAR SURFACE

Approximately half-size. Actual area indicated.

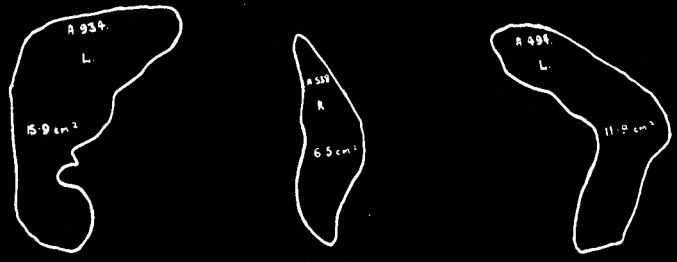


Female Male

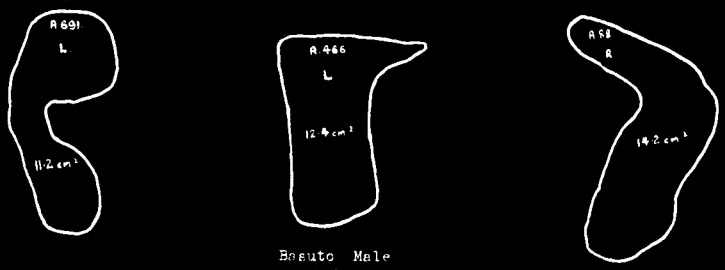
UNEQUAL AREAS



Female



Zulu Male



Bosuto Male

VARIOUS SHAPES OF AURICULAR SURFACE

greater than those given by Radlauer (1908) that it was apparent that the method of mensuration must have differed from that used by this worker. He states clearly that the greatest width is the one to be measured, and this was done in the Bantu specimens. The shape of the auricular surface varies from a sigmoid structure to one with limbs at an angle which sometimes decreases to 90 degrees. In all cases the measurement taken on the Bantu sacrum was the greatest width and this was most often the length of the superior horizontal limb. Owing to the poor standardisation of this measurement, it was considered that the dimensions of the joint surface could be better expressed by its length, the index giving its length relative to that of the sacrum, and the area of the auricular surface as measured on a dioptographic tracing by the planimeter.

The male measurements of the width and the width/length index will be recorded here to illustrate the divergence from Radlauer's figures.

Owing to the possible significance of the difference between the Basuto and Zulu series, it was

considered inadvisable to group the two sets of figures.

Series	Mean (cm.)	S.D.(cm.)	Range (cm.)	Significance: Diff.of means / Stand. error
Males only				
Left (46 Basuto	3.07 ± 0.10	0.66	1.7 - 4.4)	
Left (50 Zulu	3.34 ± 0.09	0.67	2.0 - 5.3)	1.99
Right (46 Basuto	3.03 ± 0.11	0.74	1.8 - 4.8)	
Right (50 Zulu	3.33 ± 0.08	0.60	2.0 - 4.8)	2.18

The auricular surface index of width/length for the Basuto series alone was:

Series	Mean	S.D.	Range	Significance: Diff.of means / Stand. error
46 Basuto (left)	52.72 ± 1.64	11.13	27.2 - 68.3)	
46 Basuto (right)	54.35 ± 1.61	10.91	30.5 - 75.0)	0.71

Radlauer's averages for the breadth were 2.51 cm. for the left auricular surface, and 2.63 cm. for the right. The greatest measurements for this diameter were 3.5 cm. (left) in a Tyrolean sacrum, and 3.4 cm. (right) in a Burmese specimen. The smallest measurement - 1.7 cm. left and right - was found in a Burmese sacrum. For

anthropoids a maximum breadth of 2.3 cm. was found in a gorilla.

It might accordingly be expected that Radlauer's breadth/length index was lower than that for the Bantu. The following figures confirm this.

	Left	Right
Negro	40.1	40.4
Asiatics	38.8	40.9
Europeans	41.6	42.0

The Basuto male percentage index is 12 to 14 higher than Radlauer's Negro figure. There can be little doubt of some disparity between the diameter used for the Bantu and Radlauer's, in spite of the fact that in his conclusions concerning race differences he states that in the Negro the auricular surface is usually broader than in the European.

8. Area of Auricular surface. (by planimeter)

In the male groups the right articular surface was greater than the left, the reverse being true for the female. Statistically, however, these differences are far from being significant. When the

- larger -

larger male right side is compared with the smaller female right side, a figure approaching a significant difference is found.

	Series	Mean(sq.cm.)	S.D.(sq.cm)	Range(sq.cm)	Significance: Diff. of means / Stand. error	
Left	50 Female	10.72 ± 0.23	1.62	7.8 - 13.3		
	46 Basuto	10.94 ± 0.29	1.95	7.0 - 15.3	1.3	1.6
	50 Zulu	11.46 ± 0.29	2.08	8.2 - 18.2		
	96 Male	11.21 ± 0.20	2.04	7.0 - 18.2		
Right	50 Female	10.68 ± 0.25	1.77	7.5 - 14.3		
	46 Basuto	11.24 ± 0.32	2.20	6.6 - 15.5	0.78	2.38
	50 Zulu	11.60 ± 0.33	2.32	7.9 - 17.3		
	96 Male	11.43 ± 0.19	1.87	6.6 - 17.3		

Of the male Basuto sacra 15 (32.6 percent) had the left auricular surface greater, 29 (63 percent) had the right side greater, and 2 were equal. It is thus significant for the male Basuto more often to have a greater right auricular surface, the difference being 3 times its standard error. The Zulu male had 24 each for a right and a left sided preponderance, and 2 were of equal area; and in the 50 female specimens, 26 had greater areas on

the left, 22 greater areas on the right, and 2 were of equal area. The female difference in favour of a greater left-sided area is not significant, and the male tendency (combined series) for a right-sided predominance is greater with a difference which is twice its standard error.

Schultz (1930) points out that the gorilla has an articular surface of the same size as in man, though this ape is double man's weight. Similarly in the chimpanzee, weighing about the same as man, the joint has an area only half that of man. This is due to the fact that in man the sacrum has to support a relatively greater direct weight.

(2) NUMERICAL CONSTITUTION.

Series	4-piece sacrum	5-piece sacrum	6-piece sacrum
66 Female	1 (1.5%)	44 (66.7%)	21 (31.8%)
50 Basuto	0	36 (72.0%)	14 (28.0%)
50 Zulu	1 (2%)	41 (82.0%)	8 (16.0%)

Statistical analysis of the above figures shows no significant sex or race difference in any respect.

Further analysis in the case of the female sacrum only.

Of the sacra examined 1 had the 24th vertebra fused with the 1st sacral, 4 had the 30th vertebra fused with

- the -

the 5th sacral, and 4 had the 31st vertebra fused with the 6th sacral.

Among the 6-piece sacra 15 showed 'sacralization' of the 30th vertebra; 4 of these exhibited 'lumbarization' of the 25th vertebra of transitional form, 2 contained a 30th vertebra of transitional characters, and 4 contained 6 vertebrae plus the fused 31st vertebra. The last 4 specimens and the 4 5-piece sacra with fusion of the 30th vertebra were classified as cases of possible pathological synostosis, though it is possible that some of these 8 sacra may have been examples of developmental fusion of the 30th or 31st vertebra, in which case the incidence of this sacral variation would be higher than 31.8 percent. Shore (1930) included 6 such sacra in his '6-piece' group: if these be rejected, the difference between his predominantly male series and the present female series of Bantu subjects would be significant.

Sacrum A849; 886, to which the 24th vertebra was fused, had 5 segments: the 24th vertebra projected forward about an inch beyond the anterior surface of

the body of S1; it did not enter into the sacro-iliac articulation, which on the left side showed a developmental synostosis. The age of this Zulu subject was 96 years. Specimen A531 (aged 45), not included in this series because of 'mixed' race, resembled specimen A849; 886 very closely except for the sacro-iliac fusion in the latter.

If the gynecoid, android, and anthropoid types of pelvis are analysed, the distribution of the number of vertebrae shows nothing significant. The 6-piece sacrum was found most frequently in the gynecoid type (13 out of 35 observations), and only one of these showed an anthropoid tendency. In the anthropoid type a 5-piece sacrum seemed to be the rule.

Comment on 6- and 4-piece sacra.

In the small Bantu series 10 pelves with 6-piece sacra had narrow pubic arches, and 11 others a moderate or wide arch. With 6-piece sacra Caldwell and Moloy (1933) found in a series of 241 pelves approximately twice as many narrow arches as moderate

or wide ones. In the Bantu series there was no significant evidence of any contraction of the outlet in 6-piece sacra, for the 21 outlets concerned gave a mean area of 88.9 sq.cm. as against 88.8 sq.cm. for the whole series, and ranged in area from 62.9 - 109.0 sq.cm. Only 6 of the 21 outlets had an area below 80.0 sq.cm. In the Bantu pelvis, therefore, a 6-piece sacrum is no indication of a contracted outlet.

Caldwell and Moloy (1933) found that 28.2 percent of 131 female American white pelves had 6-piece sacra. (The Bantu figure was 31.8 percent). These observers found a 6-piece sacrum in 18.1 percent of 110 Negro female pelves. Their corresponding figures for 50 white males and 49 Negro males were respectively 38.0 and 12.5 percent. The difference in the incidence for males and females - taking white and Negro stocks separately - is not significant. Whether the 6-piece sacrum occurs more frequently in females than in males is not known, and against such possibility is Caldwell and Moloy's figure of 38 percent for white males against 28.2 percent for white

- females. -

females. But in their series there were 37 female pelves with long sacrum to 19 male pelves, and it may be chance that the male percentage exceeds the female.

Shore (1930) studied the vertebral column in 82 Bantu skeletons, including 17 females. Out of 81 sacra 17 (21 percent) contained 6 vertebrae, and 64 contained 5 vertebrae: no 4-piece sacrum was found. Shore, therefore, found a lower incidence of 6-piece sacra and no 4-piece sacra in his predominantly male collection.

(3) SHAPE OF LOWER END OF SACRUM.

Following the Caldwell, Moloy, and D'Esopo scheme, the terminal sacrum has been considered as either blunt, or average (where rounded), or as dagger-shaped.

Series	Average	Blunt	Dagger
66 Female	29	26	11
50 Basuto male	21	16	13
50 Zulu male	35	13	2
Male & female(percent)	51.2	33.2	15.7

The sex differences arising out of the above figures are not significant.

In the female, most dagger-shaped tips (7) were found in gynecoid pelves, 2 in android pelves, and the 2 most typical anthropoid pelves had dagger tips. In the male, the Basuto series showed 3 dagger tips amongst the 9 anthropoid pelves, the android and gynecoid percentage distribution being similar (15 and 13 respectively). The male incidence of the dagger-shaped tip is higher in the Basuto than in the Zulu, showing a significant difference of more than 3 times its standard error.

Radlauer's findings appear not to be comparable with the above figures. Like Paterson (1893) he considered the "inferior lateral angle of the sacrum" to be "well marked, obtuse, or badly marked". If for these terms one substitutes dagger, average, and blunt respectively, the following attempt at comparison is available.

Series	Dagger %	Average %	Blunt %
17 Lower apes	65	-	35
11 Anthropoids	57	36	7
11 Burmese	33	67	-
? European	74	19	7
90 Bayern	77	17	6
41 Swiss	78	18	4
30 Tyrolean	65	25	10

The blunt terminal end strongly suggests the sacrum with angle absent. An incidence of this variety of sacrum amounting to 33.2 percent in the Bantu must then be compared with the low percentages noted above, lower apes alone giving a comparable figure. Of 11 Burmese sacra 67 percent had an "obtuse" angle which in some cases may have resembled the blunt variety of Caldwell and Moloy's grouping; and viewed in this light, it is possible to place 30 percent of Radlauer's Negro sacra in the blunt class, a figure which corresponds with 33.2 percent of the corresponding class in the Bantu. No other basis for comparison can be perceived.

(4) THE NUMBER OF SACRAL VERTEBRAE IN DIRECT RELATION TO THE SACRAL AURICULAR SURFACE.

This was determined in 50 Bantu female, 50 Basuto male, and 50 Zulu male sacra.

When the auricular surface extended on to the lateral projection from a vertebral body (costal elements) forming the inferior one-third of an anterior sacral foramen, it was described as being in relation

to this vertebra: this is shown in Table 10 by the number of the vertebra when the coincidence is complete, and by the vertebral number followed by a minus sign when the auricular surface coincides incompletely.

Table 10

Sacral Vertebrae in Relation to the Sacral Auricular Surface.

Vertebral bodies in relation to auricular surface.		Female Bantu. 50 sacra. No.	Basuto male. 50 sacra. No.	Zulu male. 50 sacra. No.
1, 2.	(2)	13	10	5
1, 2, 3-.	(2+)	15	7	12
1-, 2, 3.	(2+)	7	3	2
1, 2, 3.	(3)	14	28	25
1-, 2, 3, 4-.	(3)	0	0	3
1, 2, 3, 4-.	(3+)	0	1	3
1-, 2, 3, 4.	(3+)	1	1	0

From Table 10 it is seen that the female auricular surface extends over less than 3 complete vertebrae in 70 percent of cases. The total male sacra had 53 percent of auricular surfaces in relation to 3 complete vertebrae, the

female corresponding figure being 28 percent: this sex difference is significant, being more than 3 times its standard error.

The Bantu figures of the combined sexes are seen in Table 11 with Radlauer's figures. If Radlauer's percentages are compared with those of the Bantu female, a close correspondence is observed. The variation from the total Bantu figures might be considered thus: 75.4 percent of Bantu sacra show auricular surfaces with either 3 complete or more than 2 vertebrae contributing to its formation, and that the corresponding figure for Radlauer's sacra is 83.6 percent. This difference is small and is not significant statistically; and in view of the fact that Radlauer does not define precisely his groups shown in Table 11, no importance can be attached to the individual discrepancies seen between Bantu and Radlauer sacra in the 1, 2, 3-, the 1-, 2, 3, and the 1, 2, 3 classes.

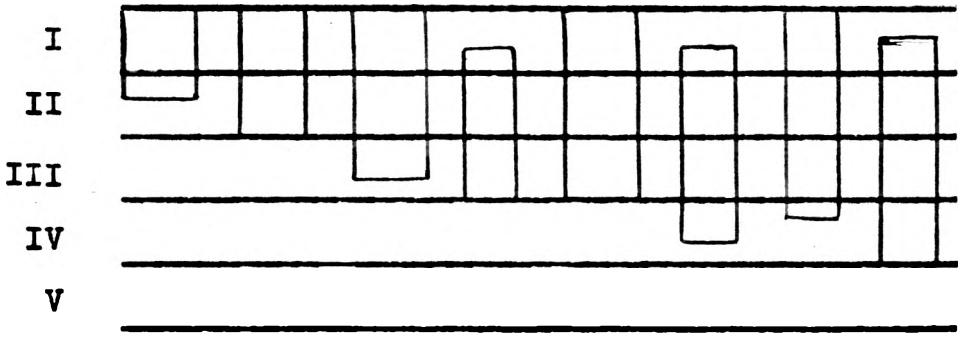
It will be noted that Radlauer shows a few sacra of which less than 2 vertebrae participated in the sacro-iliac joint. Two vertebrae only were in-

volved in 18.7 percent of Bantu sacra, but only 14.5 percent of Radlauer's material; and in this respect the female Bantu showed a higher incidence than the male, though the sex difference is not significant.

Table 11

Facies auricularis coinciding with number of sacral vertebrae. The figures are percentage values, those above being Bantu and those below being Radlauer's.

Bantu	0	18.7	22.7	8.0	44.7	2.0	3.7	1.3
Radlauer	0.6	14.5	60.0	0	23.6	0.3	1.0	0



(5) SACRAL NOTCH.

The incidence of the sacral notch was noted because of Paterson's (1893) statement: "The sacral notch may be regarded as a racial character in the Andamanese (57.6 percent), and the Negro (69.2 percent), as among

- the -

the anthropoid apes (62.7 percent)." The Bantu figures are based on 100 male and 71 female sacra, and the sacral notch was found present in 40 percent. This corresponds with the European figure and does not bear out Paterson's statement quoted above. Radlauer (1908) questions Paterson's statement concerning racial differentiation and shows the following percentage incidence.

	Paterson	Radlauer
Europeans	30.2	44.0
Negro and Bush	62.5	34.5
Asiatics	28.6	70.6

It is now necessary to define the sacral notch. "The form assumed by the 2nd and 3rd sacral vertebrae affects, in a marked manner, the whole of the sacro-iliac articulation. The 2nd sacral vertebra is generally narrower from side to side than either the 1st or 3rd. This, consequently, in some cases, causes the appearance of a hollow or notch about the middle of the articular surface, followed by a projection or lip on the succeeding vertebra" (Paterson,

1893). For the Bantu material the site of the "hollow or notch" was taken at its lowest level, i.e. where the succeeding vertebra widened out.

Table 12 presents the findings in the three Bantu groups.

* Radlauer's percentages are based on a total of sacra containing a sacral notch, and are accordingly greater than the Bantu figures.

Table 12

Sacral notch and its level in 71 females and 100 male Bantu sacra: Percentage incidence.

	Absent	At S2	At S3	At S4	At S2-3	At S3-4
71 Female	59	19.8	9.9	0	9.9	1.4
50 Basuto	68	6	18	2	4	2
50 Zulu	54	4	26	0	16	0
Total 171	60	11.1	17.0	0.6	10.0	1.2
Radlauer	0*	3.4	68.7	4.0	10.2	12.2

It is noted that both in Radlauer's and the Bantu sacra, just over 70 percent have the level of the notch at S2 and S3 as grouped in Table 12.

(6) PREAURICULAR SULCUS.

It has often been stated that the preauricular sulcus is a female characteristic. In 3 Bantu series of 50 pelves each (viz. 50 female, 50 Basuto male, and 50 Zulu male) no preauricular sulcus was present in

24 percent of females
22 percent of Basuto males
and 26 percent of Zulu males

If separate inominate bones are considered the position is as follows:

In 100 female ossa coxae the sulcus is absent in 28.

In 100 male Basuto ossa coxae the sulcus is absent in 32.

In 100 male Zulu ossa coxae the sulcus is absent in 28.

Zaayer (1866) first described this sulcus, but according to Derry (1909) neither Zaayer nor Pipin Löhr (1894) realised that its presence tended to signify the female sex.

The figures published by Zaayer and Löhr show, in both instances, a sex difference which is not significant statistically. Observation based on uncertain criteria results in a disagreement between

observers about presence or absence of such an anatomical feature. While there is no doubt that the sulcus may be completely absent, it has been claimed that the female sulcus is pronounced, that it is wide and deep as compared with the negligible groove of the male (Derry, 1909). For these reasons, points ranging from 0 - 3 were awarded in the Bantu material to all sulci, 0 signifying that the feature was absent and 3 that it was most conspicuous. Depth of the groove was considered before width, and an attempt made to subject all the material to a uniform, even though subjective, analysis. The results are seen in Table 13 .

Table 13

Preauricular sulcus: The sulci were awarded points according to whether their definition was, for example, poor (0) or pronounced (3).

Degree of definition of preauricular sulcus.	Female Bantu No.	Basuto Male No.	Zulu Male No.
0 points	12	11	13
1 "	12	18	19
2 "	8	5	10
3 "	6	3	2
Asymmetrical	12	13	6

- Where -

Where the sulcus on one side was more pronounced than the other, the following analysis was possible. Concerning the asymmetrical examples in Table 13 , in all of the 6 Zulu male pelves the right side showed a better marked sulcus; in the 13 Basuto male specimens the right side preponderated in 9 and the left in 4; in the 12 female pelves the left side was greater in 8 and the right was greater in 4. This difference between male and female is more than 2.5 times its standard error, which means that, statistically, it is probably correct to say that in the female the preauricular sulcus is better marked on the left side and in the male better on the right - that this is true where the asymmetry is obvious, but that in most pelves the sides are equal as judged by unaided inspection. If the sulcus is the origin of the anterior sacroiliac ligaments, it becomes important to recall that dimensions of the auricular surface in the Bantu showed a tendency for the female left side and the male right side to preponderate. Statistical significance for these differences could, however, not be

- deduced -

deduced from the figures obtained from the present material.

According to the grading of sulci preauriculares used above, if all the points gained by the individual ossa coxae comprising the present 150 Bantu pelvic girdles are determined, the sulci present in the three groups are of the following degree: female 130 points, Basuto male 93 points, Zulu male 106 points. On this basis the female sulcus is 30 percent more pronounced than that of the male in Bantu innominate bones. Sulci that were particularly well defined (3 points) occurred in 4 percent in the Zulu series, 6 percent in Basuto males, and 12 percent in the female series. These facts, therefore, force the conclusion that in the Bantu the preauricular sulcus is not of value for purposes of sex differentiation, but that the average female sulcus was more pronounced in the material studied.

The above section has been included in a consideration of the sacrum, because the preauricular sulcus is directly related to the anterior sacro-

iliac ligaments, and because Verneau (1875) has described an analogous sulcus on the sacrum - one which must not be confused with the groove on the innominate bone.

(7) INCLINATION OF SACRUM

On viewing pelves from the lateral aspect it is obvious that the female sacrum is inclined more posteriorly than the male. At the lower end of the sacrum this inclination can be measured approximately by considering the pubosacral diameter. This diameter in the Bantu male had a mean equal to the lowest Bantu female measurement (10.0 cm.). Only 3 out of 65 female pelves gave the measurement below 10.5 cm. On the other hand only 14 percent of the male pelves had a measurement above 10.5 cm., the specimens being 5 Basuto and 9 Zulu.

Judged by lateral inspection, most of the male sacra were set forward in the pelvis, thus giving what Caldwell et al (1934) named a convergent bore. A small proportion exhibited a straight bore, but there were no examples of divergence.

- In -

In the female the tendency for the "android" sacrum was to be forward rather than average or backward: 54 percent of these sacra were inclined forward as against 17 percent for the whole series, a point of significance. Table 14 presents a further analysis of the Bantu female sacrum.

Inclination of Sacrum. Table 14

Pelvic type	Average No.	Backward No.	Forward No.
34 gynecoid	26	5	3
13 android	5	1	7
17 anthropoid	13	3	1
64 Totals	44	9	11

Summary.

Significant sexual differences occur in the sacral index for which the female has the higher figure; and in 4 other variables which exhibit a male predominance, viz. the antero-posterior and transverse diameters of the lumbo-sacral joint, the length of the auricular surface (left and right sides), and ~~only~~ the area of the auricular surface (right side

- only -

only).

No racial characters were discovered in Bantu sacra. Paterson's (1893) statement that the sacral notch is racially characteristic in Andamanese and Negroes is not borne out by the Bantu. Radlauer (1908) also denies Paterson's findings.

In both sexes the length of the auricular surface is just over half the curved length of the sacrum (52 to 53 percent).

A 6-piece sacrum occurred in 31.8 percent of female, and 22.0 percent of male sacra. In the female a 6-piece sacrum is no indication of a contracted outlet.

There was a significant sex difference in the number of vertebrae participating in the formation of the auricular surface. In 70 percent of females the joint extended over less than 3 vertebrae. In the male 3 vertebrae were included in the joint in 53 percent of examples, the corresponding female figure being 28 percent. No auricular surfaces involving less than 2 vertebrae were found in the Bantu.

The sacral notch in over 70 percent of examples was found at the level of the 2nd and 3rd sacral vertebrae.

No preauricular sulcus was found present in

24 percent of 50 females
22 percent of 50 Basuto males
26 percent of 50 Zulu males.

Absence or presence of the sulcus in the Bantu is of no value for sexual differentiation.

Judged by lateral inspection, most of the male sacra were set forward in the pelvis. Female pelves showed this forward inclination in 17 percent of the series, but in the android type alone the corresponding figure was 54 percent.

PART VI

THE FOETAL PELVIS

As a result of the publications of Fehling (1877) and Thomson (1899), there entered into the English literature on the subject the assertion that sex differences in the pelvis were recognisable in foetal pelves at the third or fourth month of intra-uterine life. Even such authorities as Caldwell and Moloy (1933), Thoms (1935), and Whitridge Williams (1931) repeated the statement, de Lee (1938) subsequently modifying his expression of the assertion. Amongst British authors Johnstone (1937), Vaughan (1937), and Eden & Holland (1937) are amongst those who have propagated this belief.

During the course of the present work the ontogenetic development of the pelvis was given consideration, and grave doubts entertained concerning sexual differentiation during early foetal life. When it was resolved to test the validity of Fehling's and Thomson's conclusions, there was a full sensibility that the investigation was in many respects irrelevant to the original problem. While it is arbitrary to include in a study some aspects of a problem and not others, it was admitted above that the present study of the Bantu

pelvis was in no way comprehensive. When work on the foetal pelvis had sufficiently progressed to confirm the doubts concerning sex differentiation, Kappers' (1938) outstanding monograph came to hand. Huxley (1906) wrote appropriately: "Each such answer to the great question, invariably asserted by the followers of its propounder, if not by himself, to be complete and final, remains in high authority and esteem, it may be for one century, or it may be for twenty: but, as invariably, Time proves each reply to have been a mere approximation to the truth - tolerable chiefly on account of the ignorance of those by whom it was accepted, and wholly intolerable when tested by the larger knowledge of their successors."

While experimenting to find a convenient method of preparing foetal pelves for measurement and other observation, it became clear that the specimens had to be studied before any drying and resultant distortion could take place. The specimens are cartilaginous for the most part, and drying causes considerable shrinkage. The dermestid beetle has been used successfully in clearing small skeletons of all

soft tissue, and a method of this kind was considered. It was soon obvious that neither insects nor bacteria, nor even solvents which were tried extensively, could fail to influence the shape of a specimen considerably. It was concluded that pelves had to be cleared by dissection immediately after excision from the trunk, and that preservation in formalin was contra-indicated (see Scammon and Calkins, 1929). Measurement had, therefore, to be effected on the day of preparation of the specimen.

In repeating the work of earlier observers, measurement had to be precise. The travelling microscope with a vernier scale reading to 0.05 mm. was selected. It was concluded that, with careful cleaning of pelves and measurement in this manner, results obtained would be reliable. In the case of indeterminate diameters, the figures would still be comparable because all observations were made by the same individual.

Of the better known studies on the foetal pelvis, each exhibited some unsatisfactory details of technique. It was concluded that there should be no limit to the pains taken in accumulating data. Kappers

(1938) made dioptographic tracings of his specimens, thereby gaining linear and angular measurements. Such a method offers the greatest promise, for magnifications are made available. But it is improbable that a dioptograph could be constructed to give enough accuracy for use on small specimens. Such technique was rejected on the ground that it was desirable to collect a few precise data rather than a mass of values of which some might be misleading. Projection by other means was considered, but no satisfactory technique could be elaborated. While it was found that, for present purposes, the method adopted was suitable, it should be possible to devise an optical arrangement which would give results superior to those found for the Bantu foetus.

Analysis of foetal data.

In contrast with the static adult pelvis the foetal pelvis is changing with time, and valid comparison between individual pelves is difficult to establish. In spite of the assertions made by Fehling (1876) and Thomson (1899) that the influence of sex in the pelvis can be seen from the third to fourth

month of foetal life, sex differentiation has eluded the attempts at proof of all workers known to us. Thomson's conclusions (1899) are based on observations on 8 foetal pelves of which the measurements are treated in a manner which is not valid; Fehling (1876) was unable to give statistical support to his conclusions; and even Kappers (1938) employed a method of analysis which is not acceptable. The last observer, for example, grouped foetūs with a crown-rump length differing by not more than 0.5 cm. from one another. He would then find, say, 13 groups in which the mean diameter was greater in the female in 9 and greater in the male in 4. Kappers expressed it thus:

$$♀\ 9\ x\ \rangle\ ♂$$
$$♀\ 4\ x\ \langle\ ♂$$

Kappers (1938) states that Breisky in 1865 reduced his foetal measurements to a percentage of the breadth of the sacrum. This appears more satisfactory than the methods mentioned above, though sacral breadth is too variable to afford a stable basis for such treatment of data.

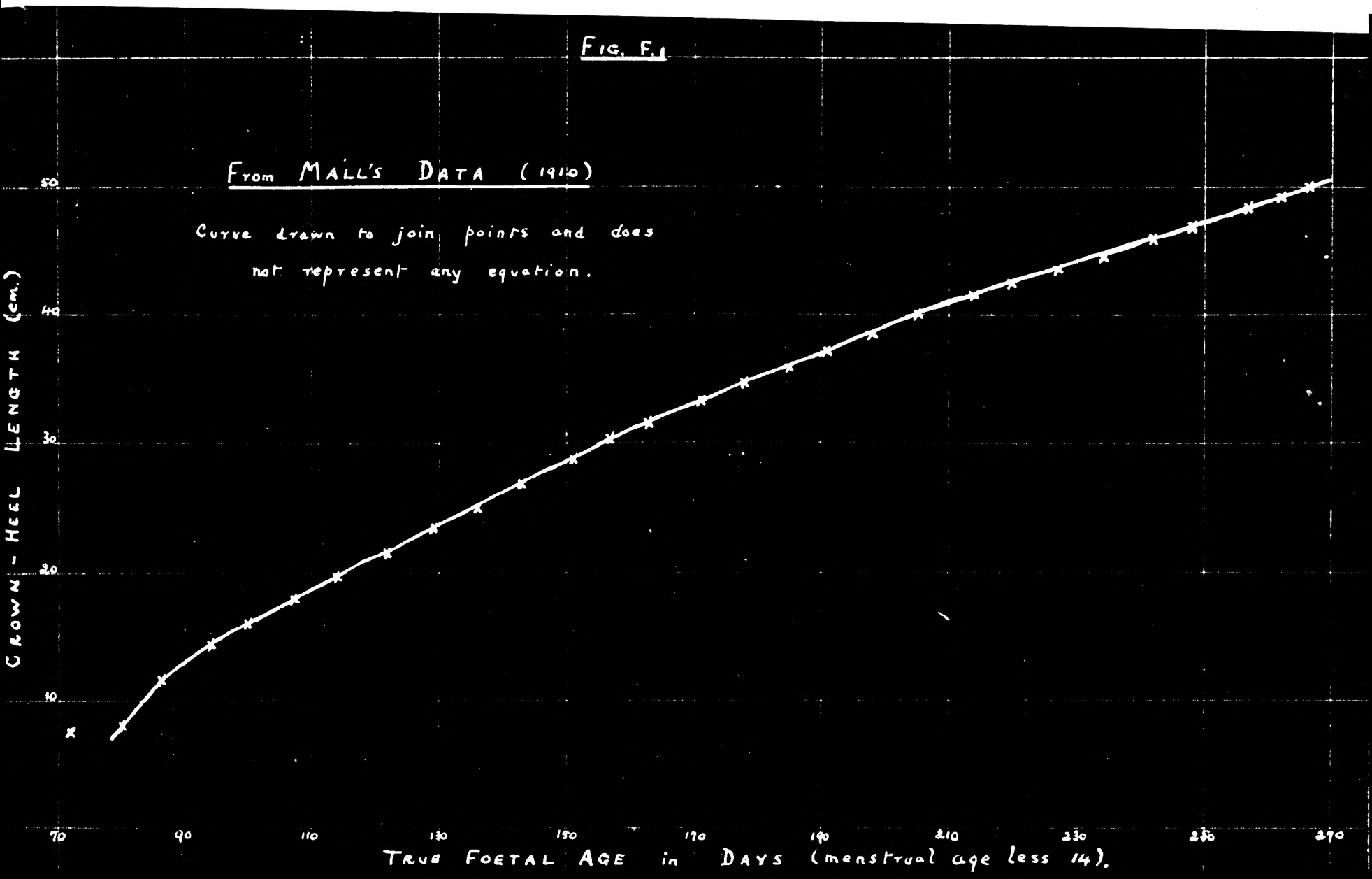
During work on the present foetal material, the height of the symphysis pubis appeared to be relatively

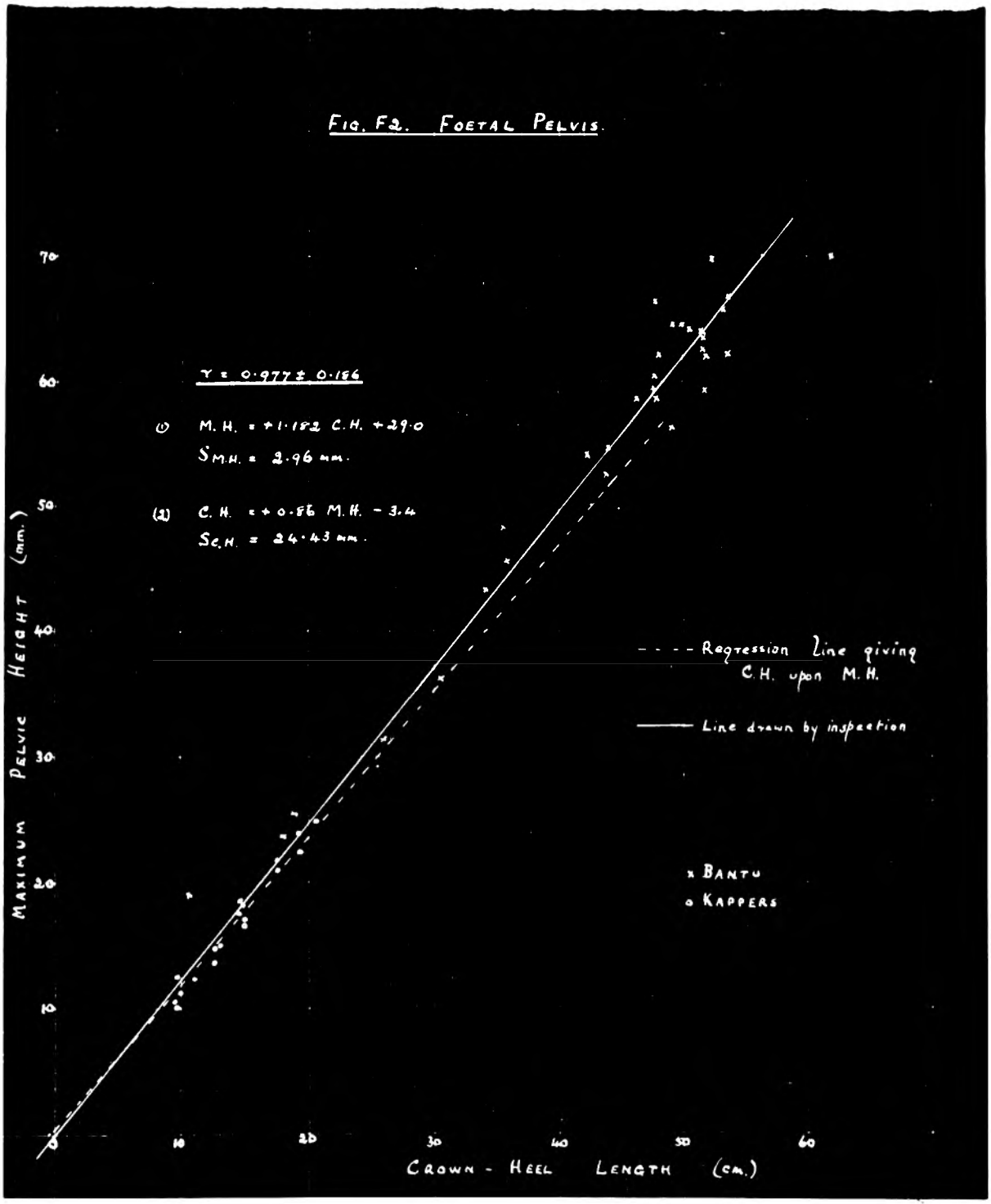
so stable that it presented a possible standard on the basis of which all the data might be made comparable. Of the foetal measurements taken, the only other diameter to compete with it was the maximum height of the pelvis. This possibility will now be considered.

As an example of the type of comparison of pelves that may be required, the determination of sex differences may be taken. Superficially considered, it would be suggested that a male and a female pelvis of exactly the same age might be compared for sex differences. To this end, various attempts have been made by observers to find an equation which will give foetal age on the basis of foetal length.

The age of a foetus can never be known precisely, because the time of conception must always be unknown. The best that can be done is to make use of the menstrual age; and although it is believed that ovulation almost invariably occurs at mid-cycle, cases are known where fertilisation could only have taken place late in the menstrual cycle. Ovulation and fertilisation in the human female cannot be separated by more than a space of some hours. Therefore, curves constructed on the age-length relationship are not absolutely accurate. The available evidence shows

FIG. F.1


From MALL'S DATA (1910)
Curve drawn to join points and does not represent any equation.
CROWN - HEEL LENGTH (cm.)
50
40
30
20
10
70
90
110
130
150
170
190
210
230
250
270
TRUE FOETAL AGE in DAYS (menstrual age less 14).


FIG. F2. FOETAL PELVIS.
Y = 0·977 ± 0·186
(1) M.H. = +1·182 C.H. +29·0
SM.H. = 2·96 mm.
(2) C.H. = +0·86 M.H. − 3·4
Sc.H. = 24·43 mm.
Regression Line giving C.H. upon M.H.
Line drawn by inspection
x BANTU
o KAFFERS
MAXIMUM PELVIC HEIGHT (mm.)
CROWN - HEEL LENGTH (cm.)
70
60
50
40
30
20
10
10
20
30
40
50
60

that the relationship is almost a rectilinear one, and that, approximately, the length of the foetus is proportional to its age. Now, from the 4th month onwards, the crown-heel length of the foetus increases about 1.0 cm. in 5 days, and the maximum pelvic height increases 1.24 mm. in this time. Individual growth varies not only by being more rapid throughout the whole gestation period in some foetūs, but over short periods growth may possibly increase or decrease relative to the average rate. Clinical experience with foetūs of known age gives this impression, and in the present material there are striking differences in the size of several comparable pelves irrespective of their sex. While the absolute value of an age basis is questioned, a graph showing the age - crown-heel relationship is shown (Fig. F1).

The graphs shown in Figs. F3 to 11 have been made with maximum height as the x axis and crown-heel length and all the pelvic diameters considered in the Bantu study as the y axis. The straight lines have been drawn by inspection, and nearly all pass through the origin: the exceptions are the conjugata vera and pubosacral diameters, and the width of the sacro-

- sciatic -

sciatic notch which all cut the x axis slightly to the right of the origin. It is submitted, therefore, that some such pelvic diameter as the maximum height is a more accurate and stable standard for comparison of foetal development. It is better than crown-heel or crown-rump lengths because it can be more precisely measured - it is rigid, well defined, and in the present material it does not vary after death (as crown-heel and crown-rump must always do).

If crown-heel length were not so variable after death, one would be prepared to accord it an equal value with maximum height as the basis on which all measurements can be reduced to a comparable standard. But the measurement of the total length of the foetus after death must vary with a multitude of factors, and is quite unsuitable as a basis for precise comparison. If the argument in favour of the maximum height is accepted, dimensions from a worker giving crown-rump length as his basic length may be analysed and compared with dimensions from one giving crown-heel length as his basic length (cf. Kappers and Bantu figures in the scatter diagrams mentioned above).

It is obvious that use of the maximum height as basis must be supported by calculation of the regression equation of maximum height against each of the diameters studied. This was done in the first place to test the reliability of symphyseal height as the basis. It was found that there was a considerable intercept on the y axis; and as the regression line did not pass through the origin, symphyseal height did not bear a rectilinear relationship to crown-heel length or crown-rump length for the whole range of intra-uterine life. These calculations concerning symphyseal height were made on Kappers' 26 males and 27 females relative to crown-rump length, and on 12 male and 12 female Bantu relative to both crown-rump and crown-heel lengths. The results were as follows:

x, measured in mm., is height of symphysis (H.S.).

y, measured in cm., is crown-rump (C.R.) or crown-heel (C.H.) length.

$S_y = \sigma_y \sqrt{1-r^2}$

Series	H.S. and C.R. length (Kappers)	
26 males	y=2.0639x + 2.7289	Sy=1.5152 cm.
27 females	y=2.1710x + 1.9179	Sy=1.2248 cm.
53 males & females	y=2.1148x + 2.3455	Sy=1.233 cm.

Series	H.S. and C.R. length (Bantu)	
12 males	y=2.2754x + 0.3354	Sy=2.2282 cm.
12 females	y=2.2789x + 1.7472	Sy=3.6297 cm.
24 males & females	y=2.2240x + 1.6112	Sy=3.0821 cm.

Series	H.S. and C.H. length (Bantu)	
12 males	y=3.4769x + 0.5482	Sy=3.5930 cm.
12 females	y=3.2981x + 3.9398	Sy=5.2072 cm.
24 males & females	y=3.3397x + 2.8798	Sy=4.5283 cm.

These equations estimate y for x, when x lies within a range of 2.2 and 16.0 mm. It was decided then to test maximum height as the basis instead of symphyseal height, and the graphs in Figs. F3 to F11 were constructed. When maximum height is plotted against crown-heel length, the line drawn by inspection passes through the origin, and similarly all the other lines shown

- except -

except those for the true conjugate, the pubosacral diameter, and the width of the sacro-sciatic notch. For two reasons, regression equations have not been derived to substantiate the graphic method: (1) these equations will be found when the further study of foetal pelves, now proceeding, provides 100 specimens, and it has been thought profitless to duplicate the heavy task by making calculations for the preliminary series of 30; and (2) the lines shown in the graphs obviously lie very close to the ones of best fit, and possible variation has been found to have a negligible effect on the reduction of pelvic dimensions to a common standard.

The value of the above assertions may be better assessed by the figures showing the association between maximum height (M.H.) and crown-heel length (C.H.) in the 30 Bantu foetūs. The sexes were taken together.

$$r(\text{M.H. and C.H.}) = 0.977 \pm 0.186$$
$$= 5.25 \text{ X Standard error.}$$

The following equations were found for a range of M.H. between 19.3 and 69.8 mm., and for C.H. between 151.0 mm. and 536.0 mm.

(1) $M.H. = +1.182\ C.H. + 29.0$

$SM.H. = 6\,M.H.\ \sqrt{1 - r^2}$

$= 2.96$ mm.

(2) $C.H. = +0.86\ M.H. - 3.4$

$SC.H. = 6\,C.H.\ \sqrt{1 - r^2}$

$= 2.44$ cm.

Variables other than symphyseal height and maximum height have not been tested in this manner, because maximum height and symphyseal height are the only diameters in the present study, which are sufficiently free from morphological influences and those due directly to stress at articulations. Biologically, the advantage of symphyseal height is that it is composed of a single unit, the pubis; whereas maximum height owes its length to pubis, ischium, and ilium. Both can be perfectly measured with the travelling microscope. But temporary arrest or stimulation of growth at the symphysis, if such does occur, would have a pronounced effect on percentage calculation based on symphyseal height, whereas a similar aberration at any one place in the pelvis would affect maximum height relatively less. Finally, the graphs show that maximum height is

superior for the purpose set out; and it is believed that even age as a basis is less reliable and useful.

RESULTS.

The figures obtained for the foetal pelves are shown in Appendix 5 . The top figure in each compartment is that found by conversion of dimensions to a standard maximum pelvic height of 50.0 mm. The "standardised mean" referred to below is based on these top figures; the "average" is the arithmetical mean of all the specimens of each sex, and is shown because both the mean crown-heel (C.H.) length and the mean maximum height (M.H.) are comparable for the 2 sexed groups. Thus:

Series	C.H. length	C.R. length	M.H.	H.S.
12 male	44.18cm.	28.90cm.	54.56mm.	12.54mm.
18 female	42.90cm.	28.38cm.	54.04mm.	11.33mm.

With the exception of symphyseal height (H.S.) which has been found to show a significant sex difference in the foetus, these measurements are only slightly

- greater -

greater in the male. The average age of the male group must be very close to that of the female, because in these dimensions the male is bigger than the female. This method of averages has not been used to arrive at important conclusions: the "average" is shown to present results different from those based on the graphic method (maximum height as standard). Even if these "averages" were accepted as valid, significance in their differences cannot be calculated because the foetūs are of variable age, and have grown more in some cases than others.

For the "standardised" data, standard deviations and standard errors were calculated in order to discover whether there was any significance in sexual differences.

1. Intercristal diameter.

"Standardised mean" Male 58.1 mm.
Female 57.7 mm.

Difference = less than 0.5 X its standard error.

"Average" Male 63.6 mm.
Female 62.3 mm.

- The -

The sexual difference is, therefore, not significant; nor could any ontogenetic variations be derived from the figures. Kappers (1938) came to the conclusion that there was a tendency to sexual differentiation, when his material was grouped with that of Fehling (1877) and Falk (1908) into 46 groups not varying by more than 0.5 cm. in crown-rump length. In this manner 58.7 percent of the male groups gave an intercristal diameter greater than the female.

Kappers' data were reduced to a standard maximum height of 50 mm. by the method used for the Bantu diameters. For 26 males and 27 females the difference of 1.18 mm. was less than 1.4 times its standard error.

"Standardised mean" (Kappers)	Male	58.52 mm.
	Female	57.34 mm.

It must be concluded, therefore, that the smaller diameter for the female may have arisen by chance, and that significant sexual differentiation based on pelvic width has not been established by Kappers.

2. Interspinal diameter.

The standard error of the difference was of the same order as for the intercristal diameter, and the

difference for the interspinal is less than for the intercristal. Thus the difference here is even less significant than in the case of the intercristal diameter.

Interspinal diameter.

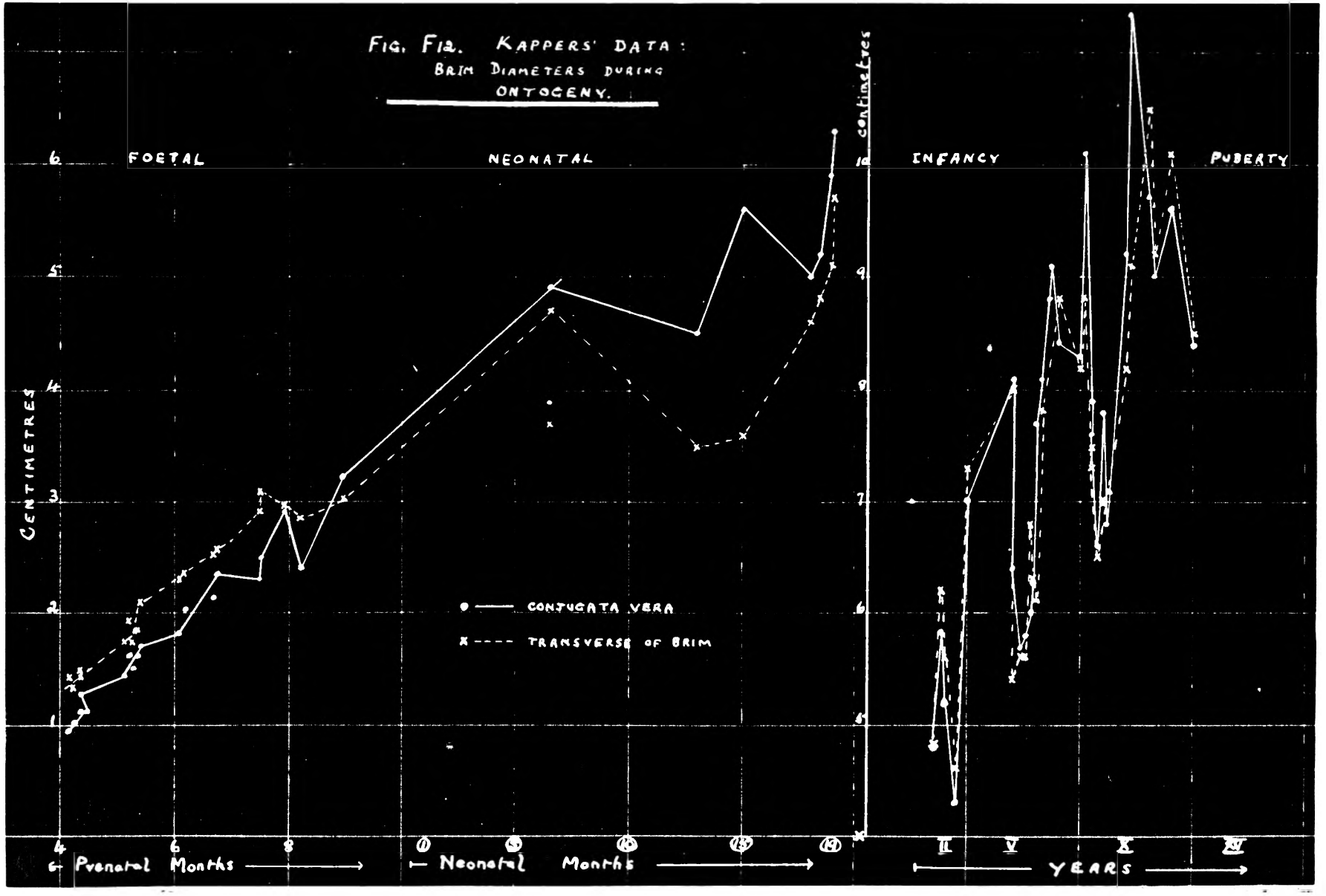
"Standardised mean"	Male	54.72 mm.
	Female	54.44 mm.
"Average"	Male	59.6 mm.
	Female	58.3 mm.

In the adult Bantu too, intercristal and interspinal diameters were greater in the male with a clear significance for the latter. (3.17 times standard error). The corresponding factor for the intercristal diameter was 2.1.

3. Conjugata vera.

"Standardised mean"	Male	25.56 mm.
	Female	25.76 mm.
"Average"	Male	28.2 mm.
	Female	27.8 mm.

Both "means" correspond closely in the sexes, but


FIG. FI2. KAPPERS' DATA:
BRIM DIAMETERS DURING ONTOGENY.
FOETAL
NEONATAL
INFANCY
PUBERTY
CENTIMETRES
centimetres
CONJUGATA VERA
TRANSVERSE OF BRIM
Prenatal Months
Neonatal Months
YEARS

in one the female is greater and in the other the male. The difference is far from being significant, as it is about ½ of its standard error. In the adult the female diameter is greater (3.0 times standard error).

4. Transverse of brim.

"Standardised mean" Male 27.69 mm.
Female 27.37 mm.

Difference = 0.32 ± 0.673
= 0.49 X its standard error.

"Average" Male 30.5 mm.
Female 29.4 mm.

The greater male finding may be due to chance.

The graph in Fig.F12 shows the relationship of brim conjugate to brim transverse as demonstrated by Kappers' figures. The transverse was the greater almost without exception. The correlation between transverse of brim and maximum height was calculated from Kappers' female figures - r = +0.9191 ± 0.196; and for transverse of brim and crown-rump length r = 0.9845 ± 0.196. It must be noted that in the

adult male the brim is characteristically narrow, the difference in transverse of brim values here being 5.65 times the standard error.

5. Interischial spine diameter.

"Standardised mean" Male 18.47 mm.
Female 20.13 mm.

Difference = 1.66 ± 0.61 mm.
= 2.72 X standard error.

"Average" Male 20.4 mm.
Female 21.8 mm.

Kappers' conclusion corresponds with the Bantu finding that the interischial spine diameter shows a significant sex difference. At the end of ontogeny, the higher value for the female diameter is significant with an impressive difference which is 11.15 times its standard error.

6. Pubosacral diameter.

While the Bantu shows a clear sex differentiation, Kappers concludes that there is only a tendency in this direction. Falk's data, grouped by Kappers, agree more closely with those for the Bantu: out of 18 groups there was a female preponderance in 13. In

- the -

the Bantu adult, the significance for the pubo-sacral diameter (12.9 times standard error) showed sex differentiation which was even greater than for interischial spine diameter.

Pubosacral diameter.

"Standardised mean" Male 22.63 mm.
Female 24.11 mm.

Difference = 1.48 ± 0.602 mm.
= 2.49 x standard error.

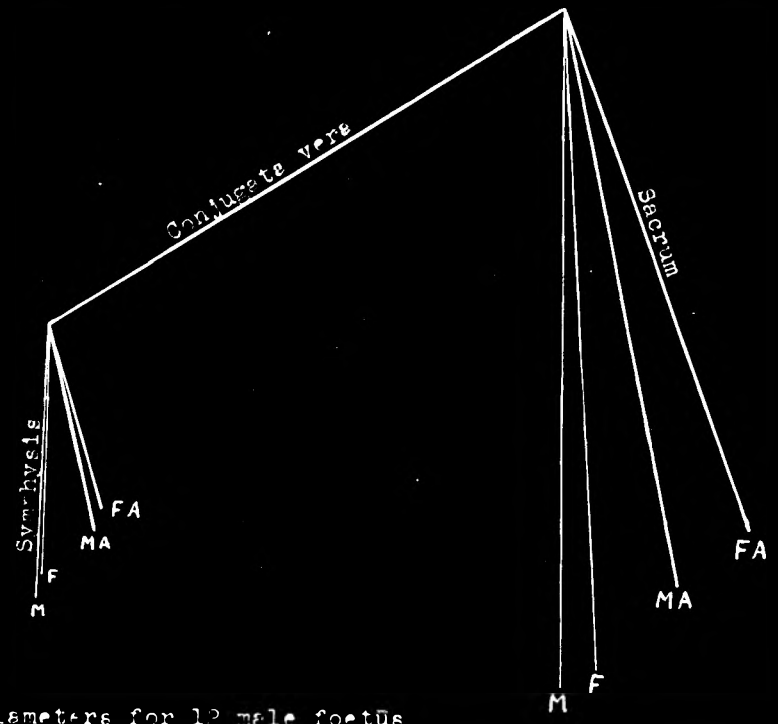
"Average" Male 25.0 mm.
Female 26.3 mm.

Kappers makes no mention of how the lower end of the sacrum was determined in his material. His decision in connection with the number of foetal sacral segments must have been arbitrary, and this would have influenced his measurement of the pubo-sacral diameter.

Fig.F13 shows the inclination of the body of the os pubis to the brim plane and its relation to the sacrum. A common true conjugate of 10.0 cm. is drawn, and pubis and sacrum for different pelves are

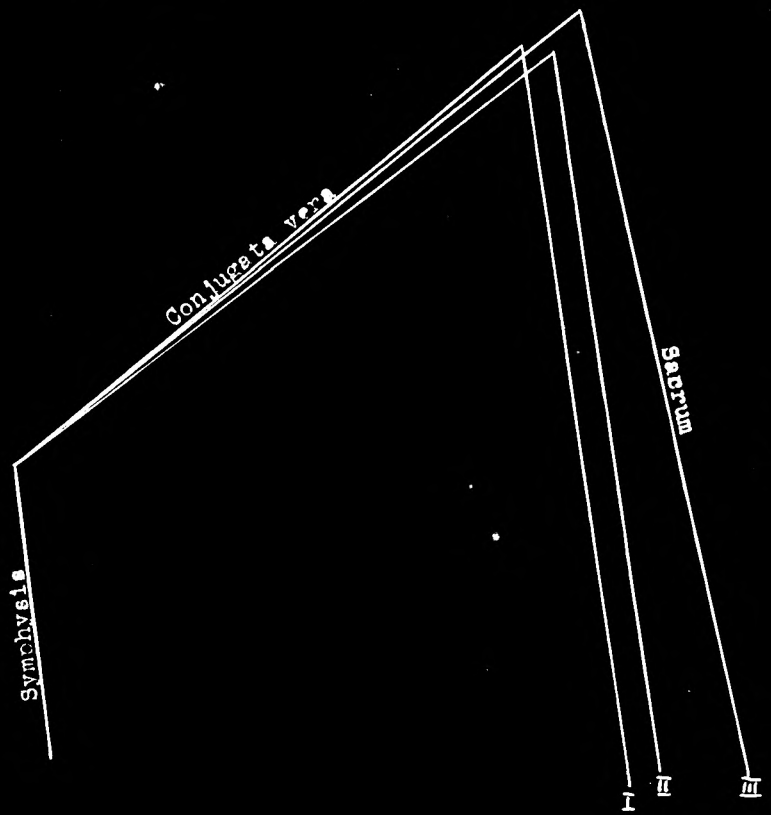
- attached -

FIG. F 13



M = Mean diameters for 12 male foetūs
F = " " " 18 female "
MA = " " " 50 male Basuto
FA = " " " 67 female Bantu

FIG. F 14



I = 5 specimens of mixed sex for the foetal age period 3½ to 6 months.

II = 7 male foetal pelves at term.

III = 7 female foetal pelves at term.

attached on the basis of the lengths of the corresponding diagonal conjugate and pubosacral diameter. Similar figures analysing ontogenetic development through several intra-uterine stages showed no consistent trends. The reason for this may depend on the small number of specimens, or variation in the features under consideration may not occur with regularity during their intra-uterine evolution. Because symphyseal height is more constant relative to pelvic size than true conjugate, a set of figures was based on a common symphyseal height of 5.0 cm. The results were very similar to those obtained when true conjugate was the common denominator. From the 5th to 9th lunar months the angle between symphyseal height and true conjugate was much greater in the female than the male. In the male at the 4th month symphyseal height was maximal, but in the female minimal. As there were only 3 specimens of this period, this result is unreliable. Fig. F14 is based on 5 specimens of mixed sex for the age period 3½ to 6 months, and 7 male and 7 female pelves at term.

Of the more pronounced differences, the following may be mentioned. On a common true conjugate the body of the pubis lies further forward in the foetus than in the adult, the male in both cases the more anterior and of greater length. This greater male length is probably significant in the adult, and certainly significant in the foetus. The inclination of the sacrum to the conjugate corresponds inversely to that of symphyseal height, with the adult female lying dispropoftionately most posterior. As a result of these inclinations, the mean pubosacral diameter is least in the male foetus, being followed in order of magnitude by the female foetus, the male adult, and the female adult.

7. Diagonal conjugate.

"Standard mean" Male 33.71 mm.
Female 33.08 mm.

Difference = 0.63 ± 0.629 mm.
= 1.0 X standard error.

"Average" Male 36.8 mm.
Female 35.7 mm.

- The -

The diagonal conjugate had to be measured with callipers because both termini could not be viewed adequately through the microscope when the pelvis was correctly orientated. The only reason for measuring this diameter was the fact that it was required for drawing figures as illustrated in Figs. 13 and 14.

8. Area of pelvic brim.

"Standard mean"	Male	555.3 sq.mm.
	Female	550.0 sq.mm.

Difference = 0.76 X standard error.

"Average"	Male	735.3 sq.mm.
	Female	683.2 sq.mm.

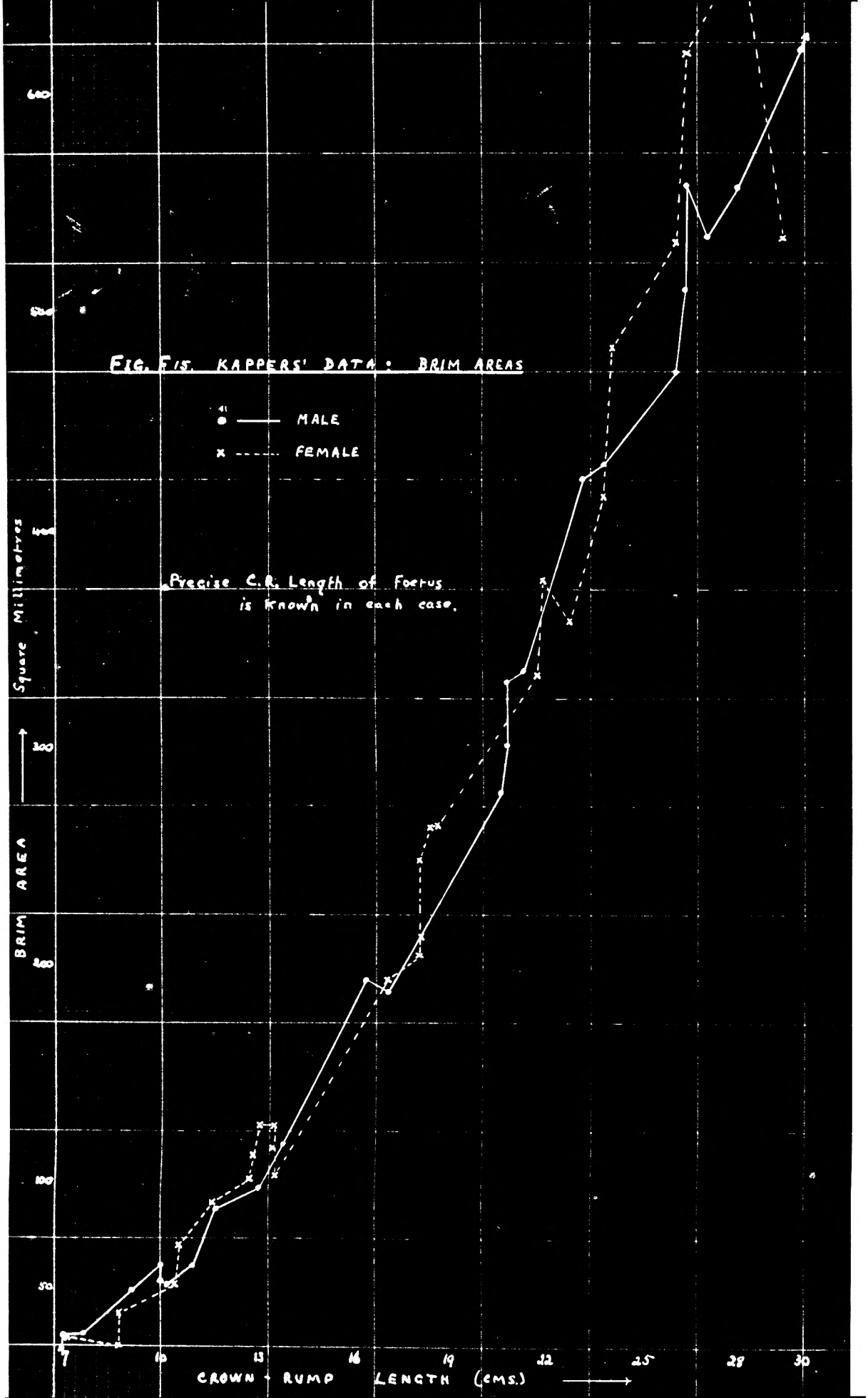
In the adult material, tracings were made of the brim, and the area was determined with a planimeter. This was not done here, because there was no available pantograph to give reliable tracings of such small areas. The ellipse formula used in the case of adult pelves was applied to the two axes, true conjugate and transverse of brim. After calculation of the areas, reduction to a standard maximum height of 50 mm. required squaring of the maximum height factor: in

dealing with an area, reduction could not be effected by multiplying by the simple factor. This reduced product is equal to the area obtained from calculation based on the reduced true conjugate and transverse brim as axes.

It is possible to say, then, that the brim has approximately the same size in the sexes. The Bantu figures actually show a larger male **area**, but the difference is so insignificant that it may easily have occurred by chance.

There appears to be no sex difference when different foetal ages are considered. The two smallest "standardised" male areas (under 500 sq.mm.) belonged to a 3½ months and 7 months foetus respectively, but a 5 months foetus had an area of 540 sq.mm. In the female, the two smallest areas belonged to a foetus of 7 months (450 sq.mm.) and one of 6 months (458 sq.mm.). All the female areas over 600 sq.mm. belonged to premature specimens, the largest area occurring in the smallest foetus of the female series.

Equal "standardised" areas (450) were found in a male foetus 35.9 cm. long and a female 35.6 cm. long. Comparison of individual specimens is of small value,


FIG. F15. KAPPERS' DATA: BRIM AREAS
MALE
FEMALE
Precise C.R. Length of Foetus is known in each case.
BRIM AREA
Square Millimetres
100
200
600
CROWN - RUMP LENGTH (CMS.)
7
10
13
16
19
22
25
28
30

because the variability that occurs makes it possible to illustrate almost any pelvic correlation. There can be little question that the statistical method must be used to reach valid conclusions. In the adult the female brim area was significantly greater than the male (7.5 times standard error).

9. Outlet area.

"Standardised mean" Male 328.8 sq.mm.
Female 383.7 sq.mm.

Difference = 54.9 ± 12.38 sq.mm.
= 4.43 X standard error.

"Average" Male 434.4 sq.mm.
Female 482.4 sq.mm.

The outlet area, calculated from pubosacral and interischial spine diameters as axes, shows a definite sexual differentiation. In the adult the female area was greater than the male with a difference 14.55 times its standard error.

In the female adult $\frac{\text{area of outlet}}{\text{area of inlet}} = 0.78$

In the male adult $\frac{\text{area of outlet}}{\text{area of inlet}} = 0.64$

Therefore, funnelling of the true pelvis is more

- pronounced -

pronounced in the male.

In the female foetus $\frac{\text{area of outlet}}{\text{area of inlet}} = 0.70$

In the male foetus $\frac{\text{area of outlet}}{\text{area of inlet}} = 0.59$

Therefore, funnelling is more pronounced in the male.

It appears from these figures that funnelling, based on the proportion of outlet and inlet areas, decreases with age between foetal and adult stages in both sexes. The male/female ratio for funnelling varies between foetus and adult as 843 does to 821, i.e. the sex variation is less marked in the foetus.

10. Maximum height of pelvis.

"Average" Male 54.56 mm.
Female 54.04 mm.

Because the maximum height was employed as the standard dimension on the basis of which all other measurements were reduced, a "standardised mean" was not calculated. This could not be found against symphyseal height which itself showed a significant sex difference in the foetus. Reference to Fig.F2 will show that both in the Bantu and Kappers' material the straight line plotted for maximum height upon crown-heel length

- passes -

passes through the origin. The coefficient of correlation, in Kappers' females, for maximum height and crown-rump length was 0.9893 ± 0.196.

Figs.F3 to F11 show scatter diagrams of values of foetal measurements for values of maximum height.

Kappers, Fehling, and Falk found no evidence of any foetal sex differentiation whatsoever, but Kappers' figures for the adult correspond with those for the Bantu in showing a pronounced sexual differentiation.

11. Height of symphysis.

"Standardised mean" Male 11.58 mm.
Female 10.56 mm.

Difference = 1.02 ± 0.301 mm.
= 3.39 X standard error.

"Average" Male 12.54 mm.
Female 11.33 mm.

In the foetus sexual differentiation of the length of the symphysis is better emphasized than in the adult (1.3 ± 0.5 mm.). The foetal measurement included the subpubic ligaments, whereas the adult skeletal material had been cleared of all soft tissue.

Kappers is willing to grant only a tendency towards

- significant -

significant sexual difference. He finds no difference in his material, Fehling finds a considerable difference, but Falk's foetūs and neonati show an overwhelming proportion of greater male dimensions. Falk states that after the 3rd month the symphysis is greater in males without any exceptions. This sweeping statement would be difficult to substantiate. The Bantu material contained an occasional female symphyseal height which was greater than in some males at the same stage of development. It is submitted that a foetal pelvis could not be sexed from a knowledge of its symphyseal height and its age.

12. Depth of pelvic basin.

"Standardised mean"	Male	21.53 mm.
	Female	21.43 mm.

The difference is only a small fraction of its standard error.

"Average"	Male	23.66 mm.
	Female	23.21 mm.

Kappers measured what he termed the true height of the pelvic basin, the termini being the ischial tuberosity and the junction of iliopectineal line and

- sacro-iliac -

sacro-iliac articulation. The Bantu foetal measurement was that used for the adult, viz. the greatest distance between ischial tuberosity and iliopectineal line anterior to the iliopectineal eminence. Kappers regrets that no material of other observers was available for comparison. However, this dimension is not correctly termed the true height, for the pelvic basin is shallowest anteriorly, deeper laterally, and deepest posteriorly.

Kappers' lateral "height" corresponds with the depth measurement used here. Neither in his material nor in the Bantu is there any significant difference between the sexes. But for his "true height" Kappers finds a significant sex difference, inverted as compared with the adult, for the foetal diameter is greater in the female. In order to test this conclusion for the foetus, Kappers' figures were treated by the method used for the Bantu. Thus standard deviations could be found, and the difference between the mean "true heights" for the sexes was 0.85 ± 0.425mm. Thus the difference is 2.00 times its standard error. This difference for a greater female dimension may have arisen by chance and, when it is considered how

precarious measurement of this diameter must be, caution is necessary in accepting a possible significance.

In the Bantu adult, there was a highly significant sex difference for the "lateral height" employed, the deeper pelvis of the male being a widely recognised sex character. It must be recalled that in the Bantu skeletal material there was asymmetry in this respect: in the male the left depth was the greater, and in the female the right depth was the greater.

13. Intertuberal diameter

"Standardised mean" Male 18.42 mm.
Female 19.87 mm.

Difference = 1.45 ± 0.662
= 2.19 X standard error.

"Average" Male 20.0 mm.
Female 21.4 mm.

The sex difference found here is taken to be significant, and this view is based on experience with the foetal pelvis. On statistical grounds alone, a difference of 2.19 times its standard error does not

give the confidence gained during measurement of sexed pelves.

In the adult Bantu the sex difference for this diameter was extremely significant. Kappers concludes that at the end of ontogeny sexual differentiation has been reached, a tendency in this direction having commenced during the second half of the prenatal period. This tendency he considers to be so strong that it is possible to speak of a sexual differentiation even during prenatal life. The Bantu figures have been carefully analysed for a possible difference between the first and second halves of the gestation period. The means correspond extraordinarily closely, and there is positive evidence that the same degree of sexual differentiation exists in the earlier as in the later foetal period. Apart from this, the conclusions drawn about the Bantu are in complete accord with Kappers' broader view.

SACRUM AND SACRO-SCIATIC NOTCH.

The transverse diameter of the foetal brim showed no significant sex difference, and it is now seen that sacral breadth is similar in the sexes. There is no evidence, in the Bantu at any rate, of a foreshadowing,

during intra-uterine life, of sexual influence in the important brim of the pelvis minor. A significant difference for the breadth of the sacrum cannot be expected in the Bantu foetus when in the adult the difference is of doubtful significance. The figures of Kappers, Fehling, and Falk show no difference between the sexes for the total gestation period, nor (as in the Bantu) is any particular arrangement on a monthly basis to be perceived.

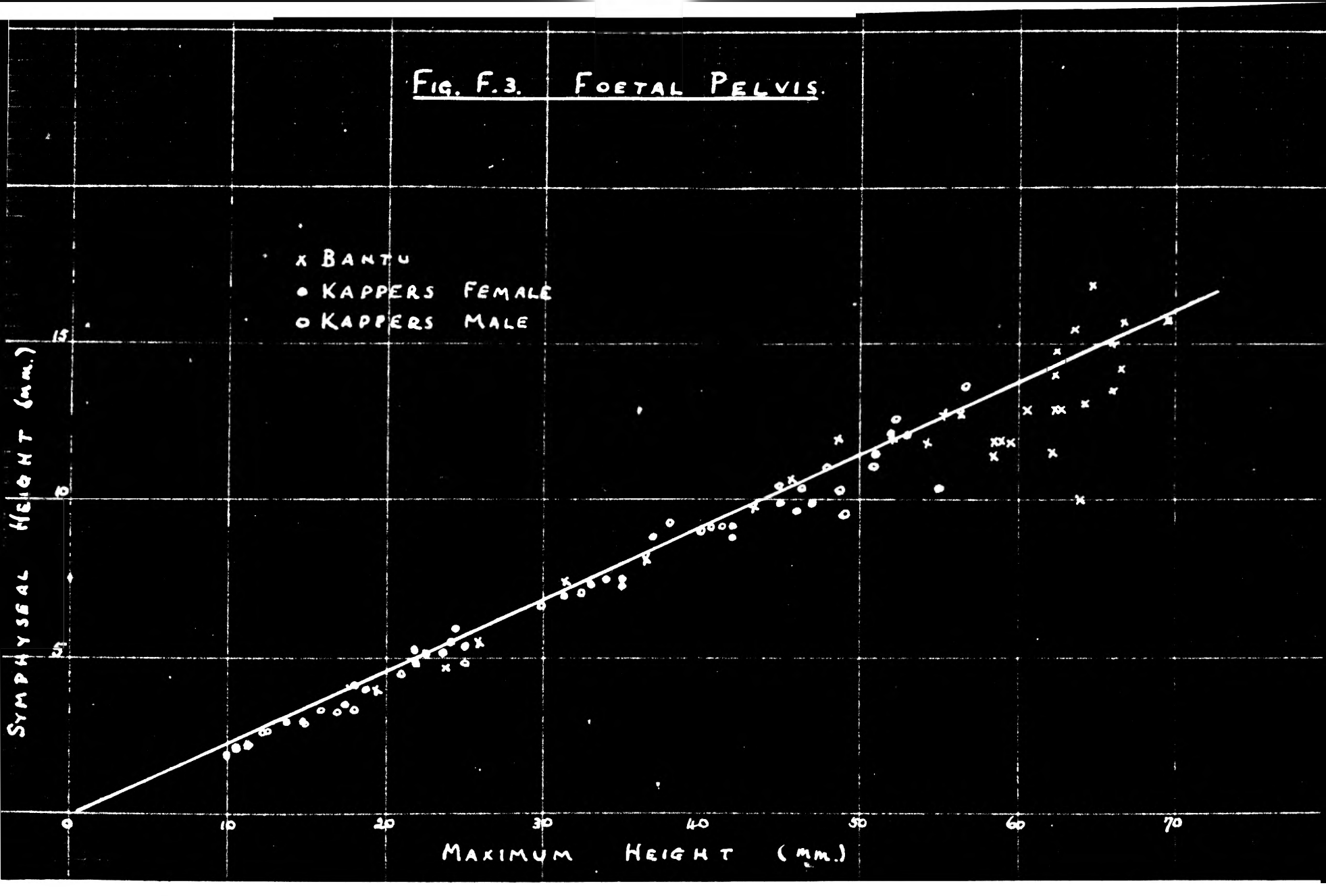
14. Breadth of sacrum.

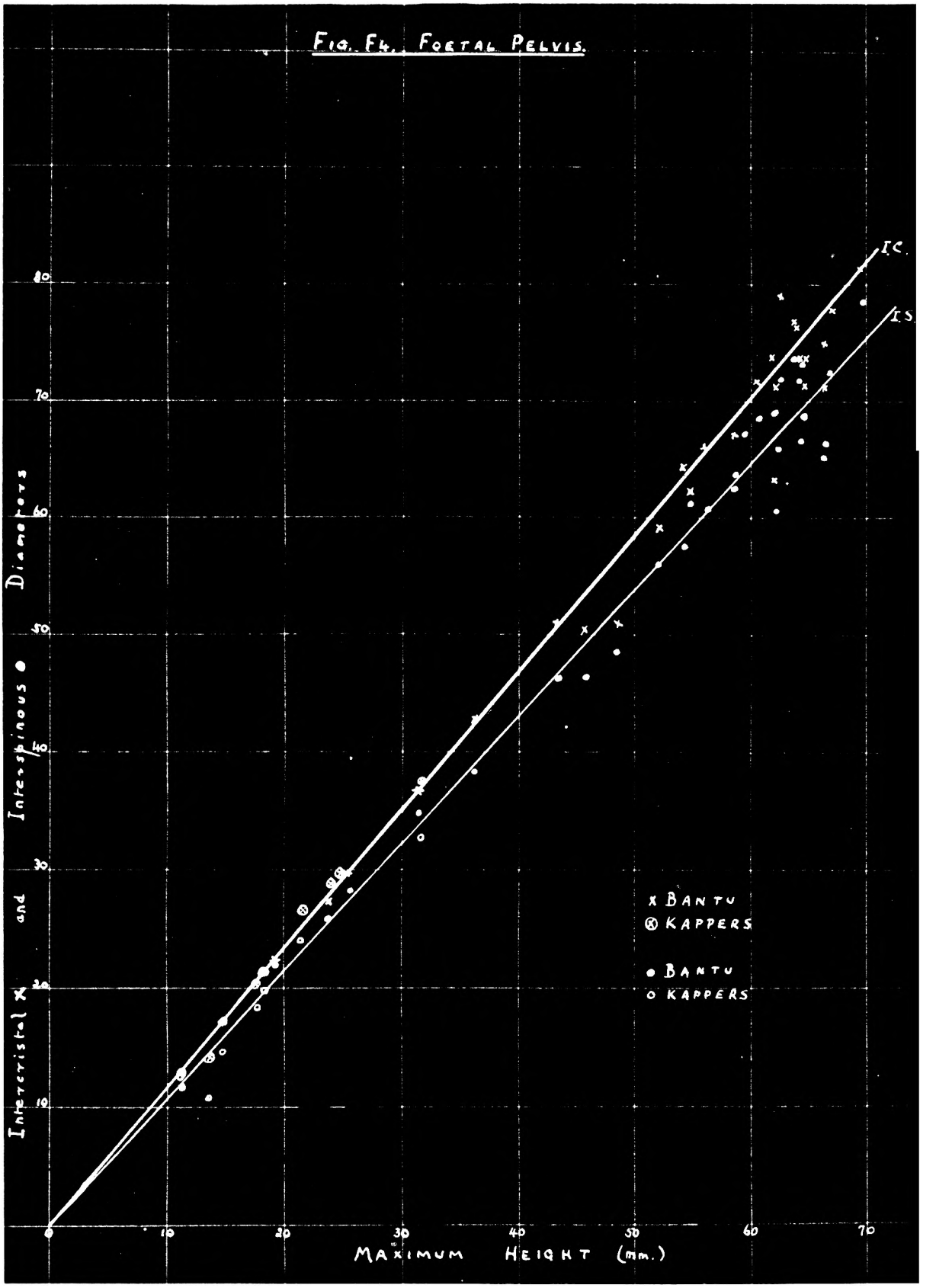
"Standardised mean"	Male	27.88 mm.
	Female	27.54 mm.

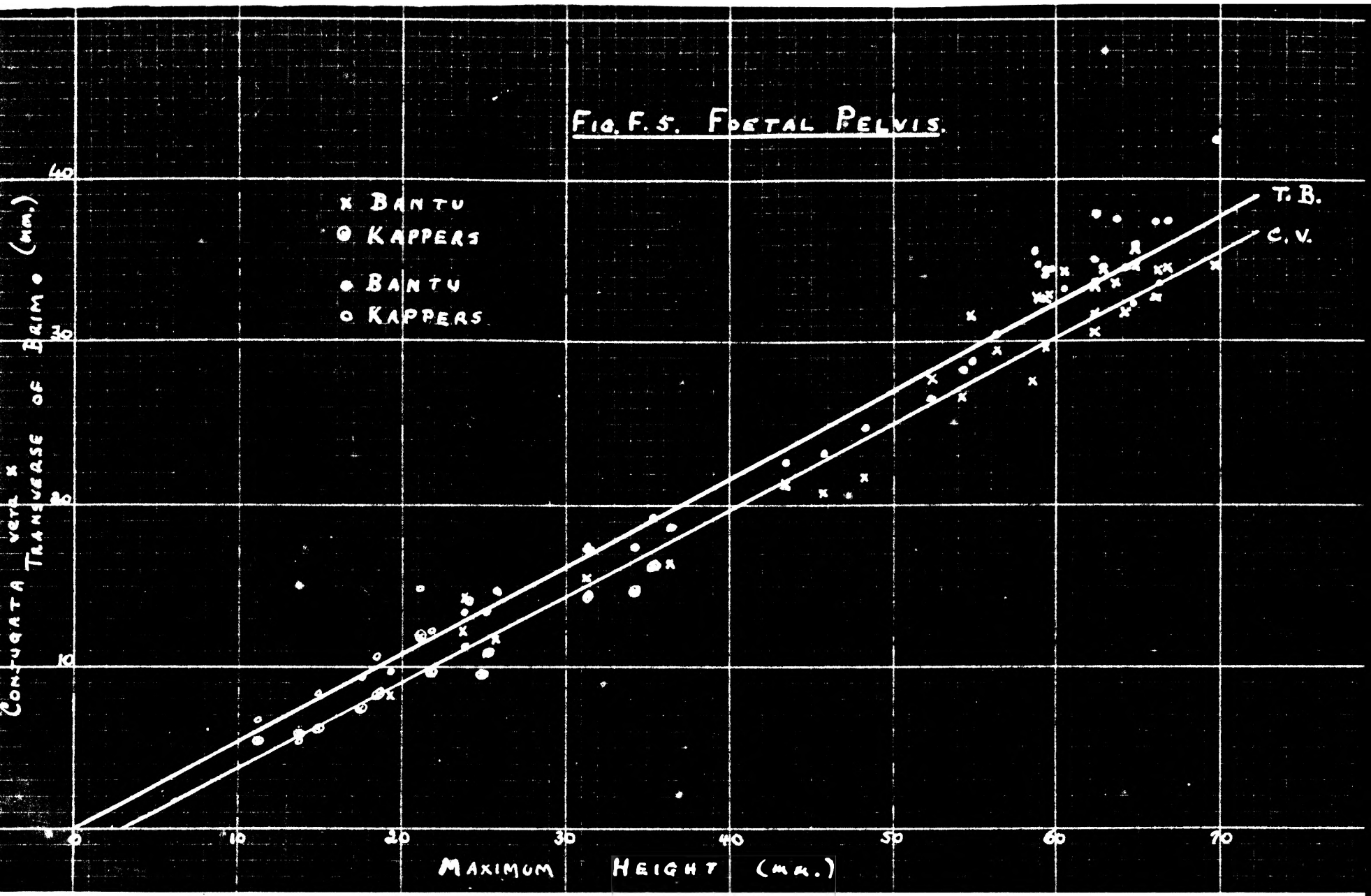
The difference (0.34 mm.) is a small fraction of its standard error.

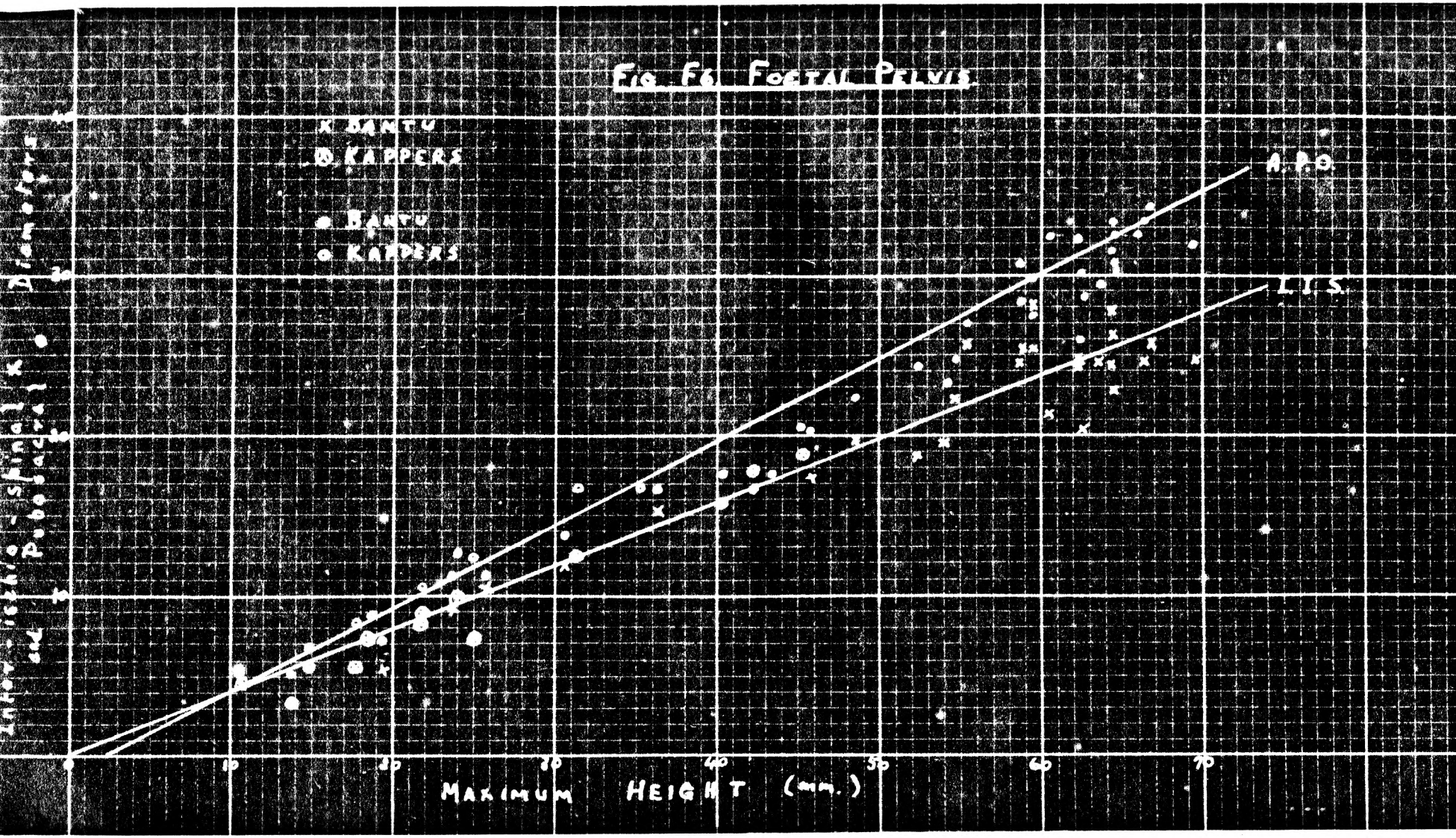
"Average"	Male	30.4 mm.
	Female	29.9 mm.

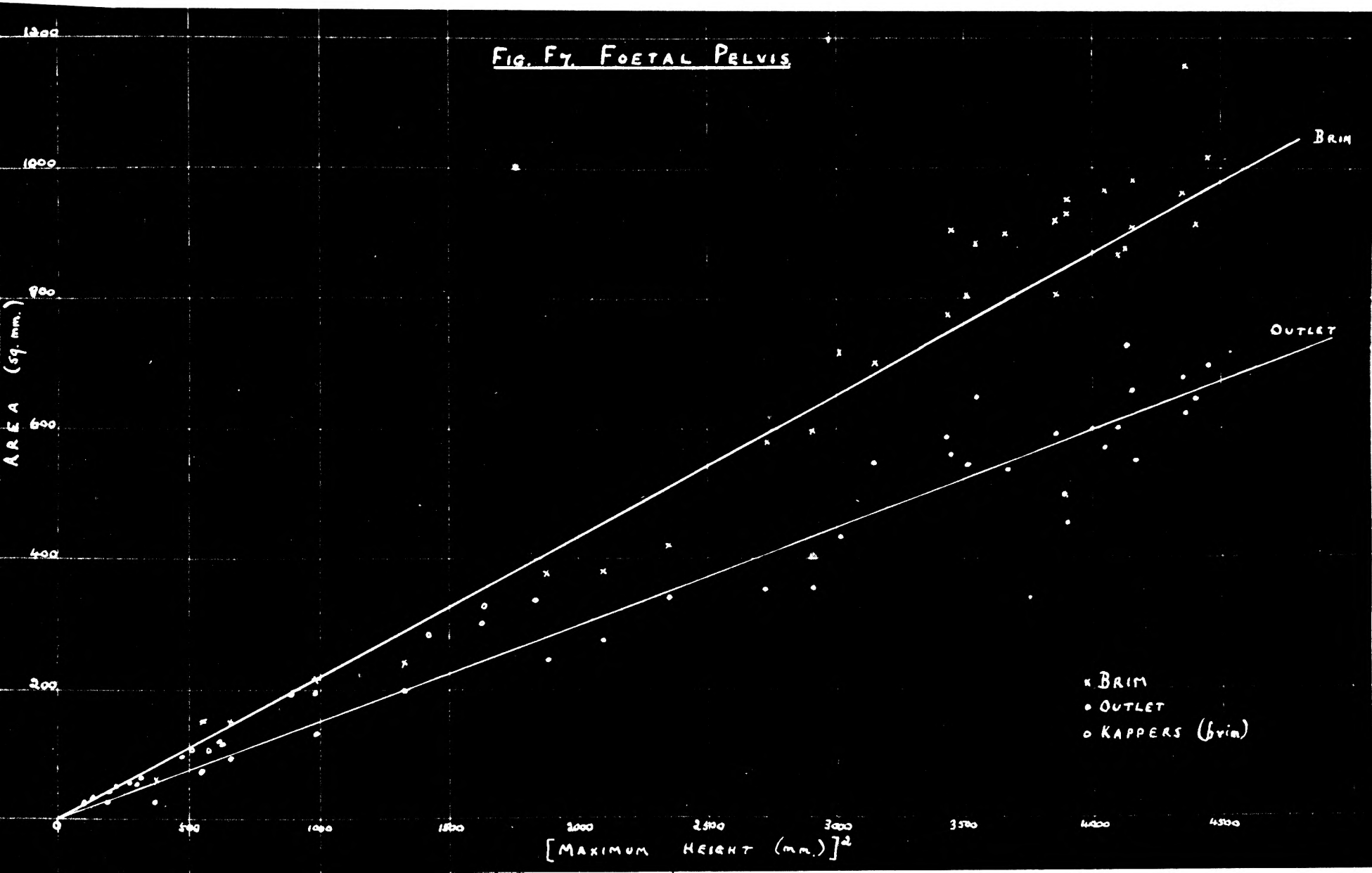
Fehling's grouped figures show the male sacrum to be slightly broader than the female, as in the Bantu. Kappers' and Falk's figures indicate a larger female measurement. But Fehling exceeds the bounds of justification when he attempts to show that the

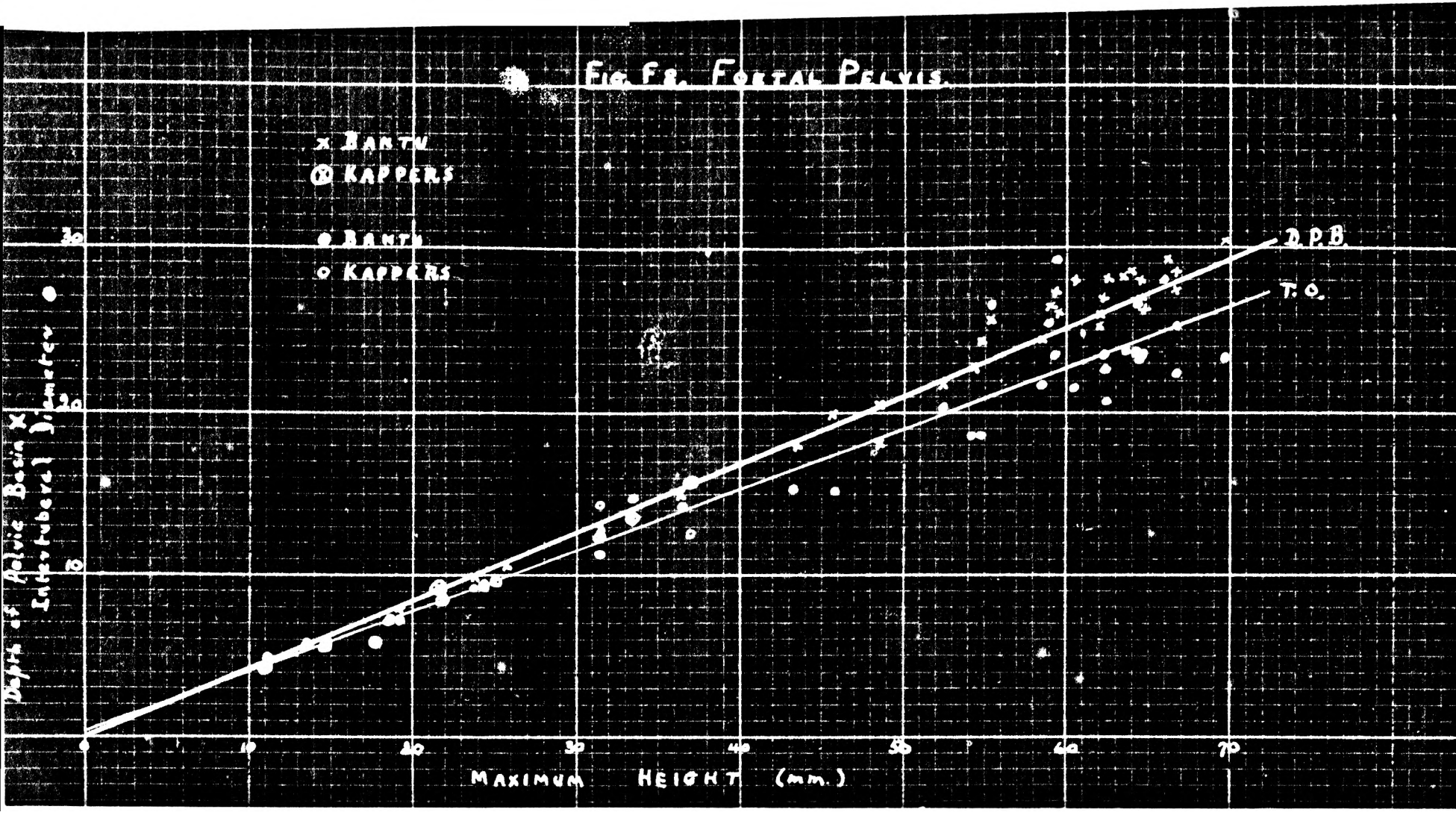

FIG. F.3. FOETAL PELVIS.
x BANTU
• KAPPERS FEMALE
o KAPPERS MALE
SYMPHYSEAL HEIGHT (mm.)
15
10
5
0
10
20
30
40
50
60
70
MAXIMUM HEIGHT (mm.)

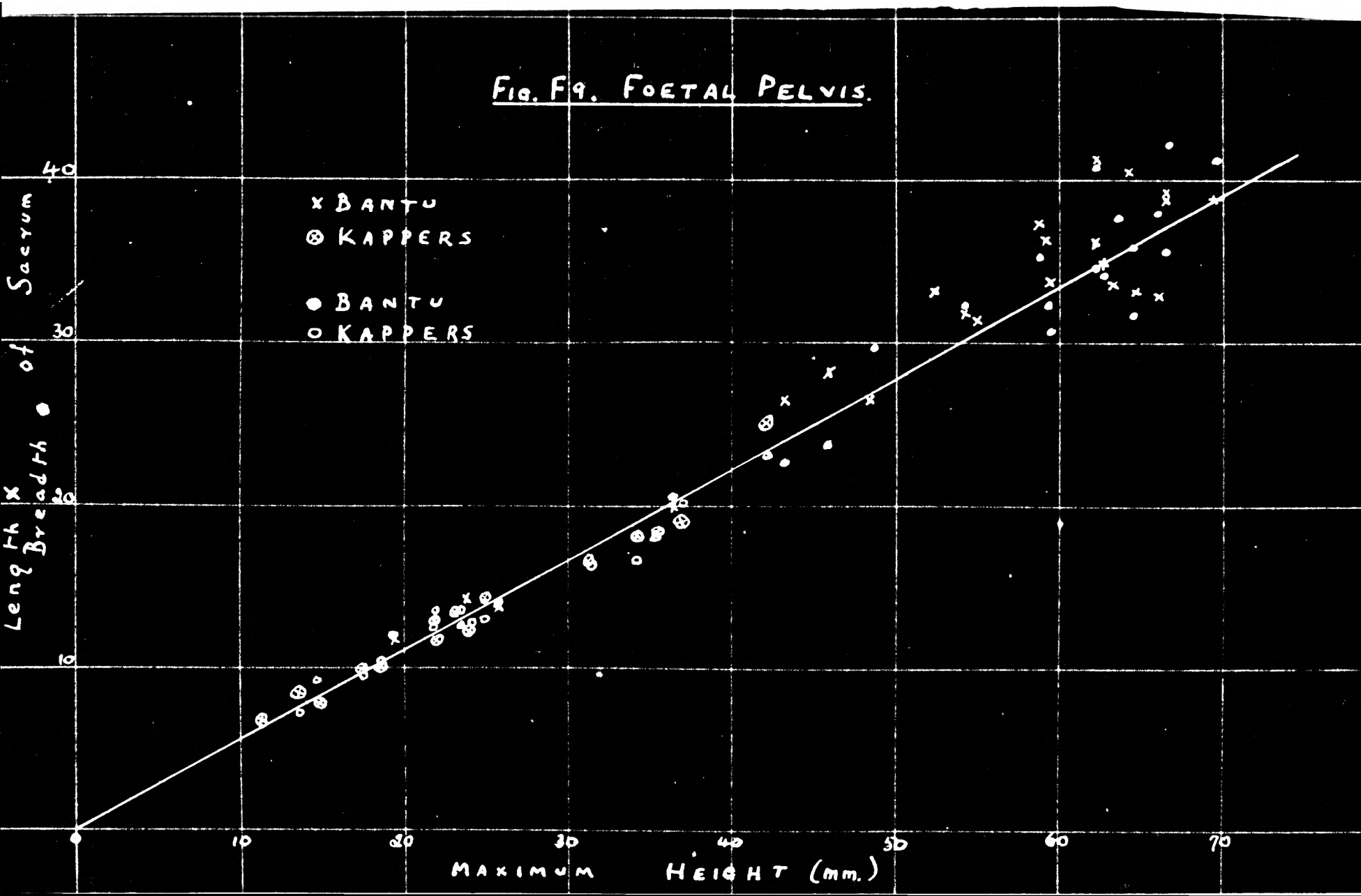

FIG. F4. FOETAL PELVIS.
I.C.
I.S.
Intercristal ✕ and Interspinous ● Diameters
MAXIMUM HEIGHT (mm.)
10
20
30
40
50
60
70
80
✕ BANTU
⊗ KAPPERS
● BANTU
○ KAPPERS


FIG. F. 5. FOETAL PELVIS.
× BANTU
○ KAPPERS
● BANTU
○ KAPPERS
T. B.
C. V.
CONJUGATA VER. & TRANSVERSE OF BRIM. (MM.)
MAXIMUM HEIGHT (MM.)
0
10
20
30
40
50
60
70
10
20
30
40


FIG F6 FOETAL PELVIS
BANTU
KAPPERS
BANTU
KAPPERS
A.P.D.
L.T.S.
Antero-posterior Diameter of Pelvic Brim
MAXIMUM HEIGHT (mm.)


FIG. F7. FOETAL PELVIS
BRIM
OUTLET
AREA (sq. mm.)
1200
1000
800
600
400
200
0
500
1000
1500
2000
2500
3000
3500
4000
4500
[MAXIMUM HEIGHT (mm.)]²
× BRIM
• OUTLET
o KAPPERS (Brim)


FIG. F8. FOETAL PELVIS.
x BANTU
⊗ KAPPERS
● BANTU
○ KAPPERS
D.P.B.
T.O.
Depth of Pelvic Basin X Intertuberal Diameter
10
20
30
0
10
20
30
40
50
60
70
MAXIMUM HEIGHT (mm.)


FIG. F9. FOETAL PELVIS.
× BANTU
⊗ KAPPERS
● BANTU
○ KAPPERS
Length × Breadth of Sacrum
40
30
20
10
10
20
30
40
50
60
70
MAXIMUM HEIGHT (mm.)

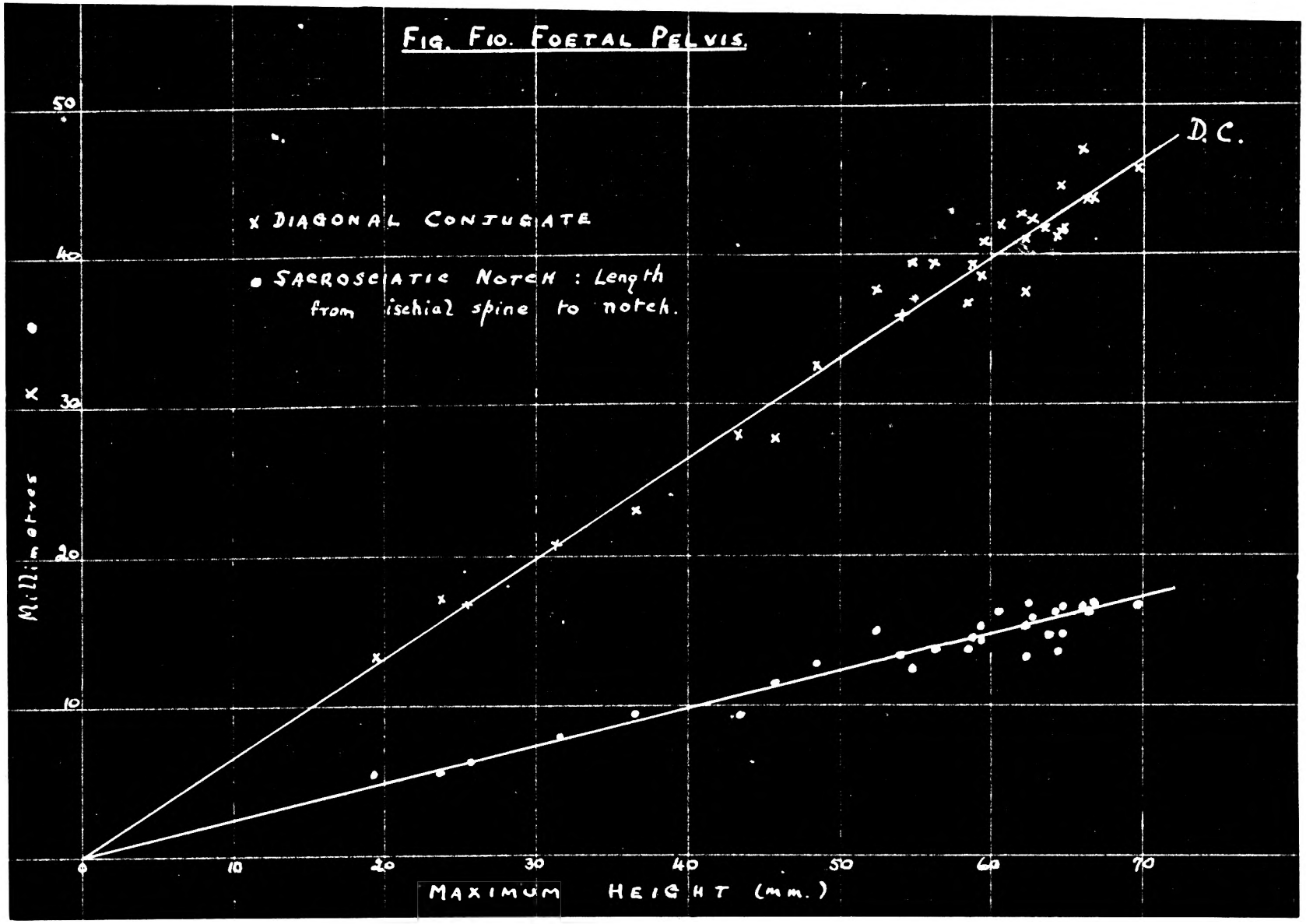

FIG. F10. FOETAL PELVIS.
D.C.
x DIAGONAL CONJUGATE
• SACROSCIATIC NOTCH : Length from ischial spine to notch.
50
40
30
20
10
Millimetres
0
10
20
30
40
50
60
70
MAXIMUM HEIGHT (mm.)

Fig. 11. Foetal Pelvis.

male breadth is significantly the greater. This view he bases on figures taken from certain half-monthly periods, even though the numbers are very small. Thus in the 4th month he compares 2 males with 2 females, and in the whole of the 10th month 3 males and 1 female. He remarks that there is no sex difference in the 7th month.

In neonatal specimens Falk found the male dimension slightly larger, but asserts that this is due to one unusually broad sacrum. He protests against Fehling's conclusions concerning a sex differentiation during prenatal life, and Kappers supports Falk's objection.

15. Length of sacrum.

"Standardised mean"	Male	28.95 mm.
	Female	28,46 mm.

The difference (0.49mm.) is approximately half its standard error.

"Average"	Male	31.3 mm.
	Female	30.7 mm.

Elsewhere the length of the foetal sacrum to be measured is discussed at some length. For convenience

of comparison, foetal sacra were considered to contain 5 segments. It was found that in the Bantu the foetal norm was a 6-piece sacrum. Nowhere in the available literature was there any mention of the manner in which the terminal end of the foetal sacrum was determined. Kappers, although he has made a profound study of the relevant literature, fails to refer to this point on a single occasion.

Both Kappers and Fehling found a longer sacrum in the female in the majority of their groups, the latter having 11 out of 15 groups with a female preponderance. Falk, however, has only 5 female groups out of 17 with longer sacra. From the data of Falk and Fehling on neonatal pelves, 4 combinations demonstrated greater sacral length twice in favour of the male, once on the side of the female, and equality once. The averages of Litzmann (1861) are slightly higher for the female.

For the adult, the Bantu male has a longer sacrum with a difference from the female which is only possibly significant. The Bantu data in this respect fail entirely to support a belief in sexual differentiation before birth, nor is much support gained

from the findings of the observers referred to above.

The sacro-sciatic notch is a morphological feature which is widely employed in sexing pelves. The term sacrosciatic is used because the notch here considered is the greater sciatic notch plus a portion of the sacrum. If accurate tracings could be made, analysis of the notch would have been based on this method. The standard of accuracy aimed at was better served, however, by taking linear measurements. Firstly, the least width of the notch between ischial spine tip and lateral aspect of sacrum was determined, then the greatest width of the notch parallel to the last diameter; and lastly, the distance from the ischial spine to the uppermost curve of the notch, the cross-wire of the travelling microscope making a tangent with this curve. All 3 measurements were made with the travelling microscope.

16. Least width of sacro-sciatic notch.

Although the female dimension is greater than the male, statistical analysis of the data shows that this result may have been reached by chance. The width of the notches in general showed great variation, the female exhibiting smaller notches than the male in

several instances. No trend could be perceived in the material, i.e. no well defined and persistent change of the form or size of the notch during growth from the end of the 3rd month to the 10th.

. Least width of sacro-sciatic notch.

"Standardised mean" Male 7.44 mm.
Female 8.15 mm.

Difference = 0.71 ± 0.529 mm.
= 1.34 X standard error.

"Average" Male 8.0 mm.
Female 8.9 mm.

17. Greatest width of sacro-sciatic notch.

"Standardised mean" Male 8.61 mm.
Female 9.01 mm.

Difference = 0.40 ± 0.316 mm.
= 1.27 X standard error.

"Average" Male 9.5 mm.
Female 9.8 mm.

In a few instances this width was less than the least width, because the latter was taken at the level of

- the -

the ischial spine and the former higher up. The "greatest width" was greater when the sides of the notch were concave, and less when the sides were convex.

There is no reliable difference between the sexes, and this diameter follows No.16 in a fairly regular manner.

18. Length of spine to superior curve of notch.

"Standardised mean"	Male	12.53 mm.
	Female	12.21 mm.

The difference of 0.32 mm. is a little less than its standard error.

"Average"	Male	13.5 mm.
	Female	13.2 mm.

While these 3 measurements of the notch have exhibited no significant sexual differentiation, the data point to the male notch being narrower than the female, but longer.

Having failed to obtain tracings of these notches, it was thought reasonable to calculate the areas. The notch was considered as an ellipse and the axes used

were the greatest width (No.17) and the length of the notch (No.18).

19. Calculated area of notch.

"Standardised mean" Male 84.63 sq.mm.
Female 86.81 sq.mm.

Difference = 2.18 ± 3.76 sq.mm.
= 0.579 X standard error.

It would be very satisfactory if the lack of sexual differentiation for the notch area shown above could be relied upon. The weakness here is postulating an ellipsoidal shape for the notch. Analysis of the 30 notches showed that in 5 male and 4 female pelves the shape closely resembled an ellipse - the narrower the notch, the more ellipsoid it seemed to be; but that in 5 males and 9 females the shape was that of the rounded end of a cigar, i.e. cylindrical but bluntly rounded off above; 2 males and 5 females were intermediate between these 2 categories. Therefore, about half the males and half the females had sacro-sciatic notches that were ellipsoidal or nearly so, the other half in both sexes were not ellipsoidal, but cigar-shaped. In the latter half the ellipse formula would

give an area less than the true area. The Bantu figures show that the male is more likely to exhibit an ellipsoidal notch than the female, but only slightly more frequently. Let it be supposed, therefore, that on the average the female notch has lost 5 percent of its area by calculation, but that the correct area has been ascribed to the male. The mean difference between the notch areas in the 2 sexes will then be 1.72 times its standard error which is still not significant.

An attempt was made to check the above suggestions for a formula by which the area of the notch can be calculated. Dioptographic tracings were found to be too inaccurate for this purpose, and magnification by means of projection on a screen was tried. In order to project an image of the notch, the pelvis had to be bisected in the sagittal plane. This section had no influence on the size of the notch when a pelvis preserved in 0.5 percent formalin was used. There were, however, objections to the procedure, and they are as follows:

1) Comparison of measurements taken on fresh foetal pelves and ones preserved in very dilute formalin

showed that there was considerable contraction and distortion of the girdle in the latter, and these effects were present in the sacro-sciatic notch as well. Therefore, direct determination of areas would give only the changed size of the notch, not the original.

2) A formula for the notch area might obviously be derived by the use of this preserved material, in the projection method. This would, however, necessitate the cutting up of 20 or 30 pelves. As the specimens are required for further study, this mutilation had to be postponed. As the larger investigation on 100 foetal pelves progresses, an attempt will be made to derive a useful and accurate formula for calculating the notch area from linear measurements.

With the reservation that the present report on the foetal pelvis is in a preliminary stage, it is submitted that the sacro-sciatic notch does not show any sexual differentiation during the prenatal phase.

INDICES.

The indices do not require modification on the

basis of maximum pelvic height, as in the case of linear and two-dimensional values, because they provide a ratio which does not depend on absolute size. Even if numerator and denominator of an index were independently multiplied by the maximum height factor, the ratio would remain unchanged. The arithmetic mean of the indices was found where no growth differences could be perceived.

20. Sacro-sciatic notch index (greatest width ÷ length).

Mean	Male	69.13	Range	48.6 - 80.8
	Female	73.75		62.7 - 83.7

Difference = 4.62 ± 3.23

= 1.43 X standard error.

The female notch, therefore, exhibits the greater width, though the difference has not been shown to be significant. This index is of value because the length of the male notch is slightly greater, and this must add something to its area. In comparing with the female which has greater area and greater width, this greater length in the male must receive consideration.

To summarize the data concerning the notch, no

significant sexual differences were found. The female notch is the wider, as shown by the two measurements and the notch index, and its area is slightly greater. The male notch is the longer. No trend was observed during development of the notch, except that the smallest male had a notch index of 48.6. The other younger specimens of both sexes showed no special deviation from the mean notch index: the female indices were all over 60; one male was 48.6, another 58.0, and the rest over 60.

21. Interspinous/intercristal index.

Mean	Male	93.20	Range	82.8 - 99.8
	Female	93.40		88.9 - 99.6

The difference of 0.20 was very far from being significant. Careful analysis of the foetal data in respect of ontogeny failed to show any trend. At the end of ontogeny, however, the Bantu index becomes smaller, i.e. below 90 in both sexes. This implies greater curvature of the iliac crest, or less flaring out anteriorly. The adult female index was the smaller with a significant difference 3.03 times its standard

- error -

error.

22. Height-breadth index: $\frac{\text{Maximum pelvic height}}{\text{Intercristal diameter}}$

Mean	Male	86.13	Range	78.9 - 90.7
	Female	86.86		79.6 - 98.0

The difference of 0.73 was less than its standard error. A very close correspondence between the male and female indices is seen, the smaller pelves showing no greater deviation from the mean than the older.

The index in the Bantu has not been found above 98.0 which means that pelvic breadth was always greater than height. In a male Basuto adult there was an index of 97.8, in a female foetus a corresponding figure of 98.0. Kappers' highest figure was 98.3 for a female foetus. In the adult the male index was higher than the female, but with a difference only 1.92 times its standard error.

Kappers did not find any sex difference for the index during the prenatal period. The relatively greater breadth of the adult, illustrated by the decrease in the index in Bantu and European, is stated by Kappers to develop after the age of 2 years, to

remain constant for very long thereafter until at puberty, in its early rather than late phase, the breadth increases further.

23. Pelvic brim index.

Mean	Male	92.43	Range	81.6 - 110.2
	Female	94.23		77.6 - 111.2

The sex difference (1.80) is only a fraction of its standard error.

Amongst the 12 male pelves 2 indices were over 100, and of 18 female indices 4 were over 100. The above means are very close to those for the adult in whom there was no significance whatever in the sex difference. Male and female in the Bantu adult had an incidence respectively of 17 and of 12 percent for indices of 100 or over, the corresponding figure for 30 foetus being 20 percent. This greater frequency of the "anthropoid" pelvis in the foetus is not significant, the difference being less than its standard error.

If the round or dolichopellic brim is indicated when the index is over 95 percent, then 13 or 43.3

percent of Bantu foetal pelves conformed to this class. Fehling's figure of 12.3 percent (130 foetūs) compares with the Bantu figure of 20 percent for indices of 100 or more. In Turquet's series (1884) of 70 infantile pelves, the index was 100 or over in 28.5 percent. Kappers actually had only 2 foetal indices above 100 in 27 females, and none in 26 males. The significant difference from the Bantu data is probably accounted for if one considers the individual variation that may enter into measurement of brim conjugate and transverse, particularly in the foetus. This important index is discussed more fully elsewhere.

24. Index sexualis of Sergi: $\frac{\text{transverse of brim}}{\text{intercristal.}}$

Mean	Male	47.63	Range	43.4 - 52.1
	Female	47.30		43.6 - 53.2

The difference of 0.33 has a standard error of more than 1.0.

In the adult this index is a characteristic sex feature. The mean for the Bantu adult male was 46.34 ± 0.23, a figure which is very close to that for the foetus. With the significantly higher female

Bantu index at 50.33 ± 0.38, it appears that the male transverse and intercristal grow pari passu throughout ontogenetic development, whereas the female brim transverse increases relative to the intercristal diameter between the foetal and adult stages.

The foetal data from the material of Kappers, Fehling, and Falk show no sexual differentiation for this index. Kappers reports the averages for 53 foetūs as follows:

Male	48.4 (43.6 - 51.6)
Female	48.4 (39.4 - 45.2)

Falk states that in his groups - monthly between 3 and 6 months inclusive, thereafter 5 cm. crown-heel length divisions from 35 to 50 cm. - the female mean is invariably greater than the male. He points out that this result corresponds with that of Arcangelis who obtained a female mean of 48.0 and a male mean of 47.9 for the index sexualis. Falk's methods call for consideration. It was pointed out to what extent increase in the length of diameters could be expected in the course of a month; and concerning 5 cm. crown-heel intervals, the grading is as coarse

as the monthly grouping, and accuracy in measuring total lengths of the foetus is seriously impaired by post-mortem changes in soft tissue. In addition to this, Falk's courage in believing that a 0.208 percent difference between means is significant cannot be shared to-day. What is Falk's mean sex difference worth?

Figures from different observers for this index agree so admirably, that a standard error of the sex mean difference might be postulated to correspond to that of the Bantu foetus, i.e. a standard error of at least 1.0. A significant difference would on this basis have to be of the order of 3.0 as compared with Falk's and Arcangelis' difference of 0.1 which is, therefore, one-thirtieth of the magnitude required. These points are noted, because investigation of the ontogeny of the pelvis is stultified by many weaknesses of this kind.

Kappers has collected the sexual indices of 55 infantile and juvenile pelves, finding a mean of 46.1 and a range of 41.6 to 53.3. This figure is only slightly lower than the corresponding value for the foetus. Sergi's means for the adult index are similar

- to -

to those for the Bantu adult, the former being 46.5 for the male and 50.8 for the female (Kappers, 1938). The male adult and child in general are, therefore, seen to have the same indices. The female alone exhibits an increased index, but this appears to occur only after puberty.

25. Index of height of pelvis minor and maximum pelvic height.

Mean	Male	43.06	Range	40.4 - 45.2
	Female	42.78		40.7 - 46.2

Difference = 0.28 ± 0.6

In this remarkably constant index there is no sexual differentiation, nor any perceptible trend during the prenatal phase of development. As in the foetus, the Bantu adult male had a higher index, 47.18 ± 0.32, with a sex difference of only 0.70 ± 0.419. As this difference is 1.67 times its standard error, no sexual differentiation is exhibited.

From the mean indices it is seen that in both sexes the adult is about 4 percent higher than the foetus. Examination of the ranges of indices shows

- that -

that only in the foetus was a figure below 41 found - an adult index below 43 (the foetal mean index) was exceptional -, but that 46.2 was the highest foetal index: in the adult, indices above 50 occurred in 7 percent, and above the foetal maximum of 46.2 stood 67 percent of adult pelves.

The evidence suggests that sex influence during development of this aspect of the pelvis is negligible. The higher adult index, however, does mean that the depth of the pelvis minor increases out of proportion to maximum pelvic height, this disproportion being even more pronounced when lesser pelvic height is compared with the height of the false pelvis taken separately. In this respect, therefore, pubis and ischium have outgrown the ilium.

26. Sacral index: $\frac{\text{anterior straight breadth}}{\text{midventral straight length}}$.

Mean	Male	96.82	Range	80.1 - 115.1
	Female	96.68		85.5 - 112.2

The standard error of the difference is many times the difference, and there is no significance whatever. The sacra of the early months show the same haphazard

- variability -

variability as do the later specimens. Kappers concludes that there is a tendency to sexual differentiation, after enlisting the support of Falk's and Fehling's data which do not change his percentage incidence of greater male values, but merely add the weight of numbers. For Kappers' own 53 pelves this conclusion of his was tested statistically, as was done with his depth of pelvic basin and intercristal data for which he claimed an unexpected significance. For Kappers' sacral indices the sex difference was found to be 2.27, a difference of approximately 1.45 times its standard error and, therefore, of no statistical significance. This high mean index difference of Kappers as compared with that of the Bantu foetus may be due to the fact that the Bantu sacra were measured as having 5 vertebrae, whereas Kappers did not deny measuring 6-piece sacra. Whatever the reason, Kappers' indices cannot be accepted for comparison, because he does not discuss the problem of determining the lower end of the sacrum.

In the Bantu adult there was certain significance in the sacral index difference between the sexes.

This, according to Radlauer's data (1908), is true for the European sacrum too. All the adult figures reported by Radlauer were over 100. It appears, therefore, that on the average the dolichohieric sacrum is found only in the foetus, and perhaps in the infant up to 3 years (Kappers gives a mean of 94 for 9 such sacra); but that after the age of 3 the index exceeds 100 (Kappers' 31 sacra had a mean of 101), and in the adult the sacrum is either subplatyhieric or platyhieric (102.9 to 112.4 in different series).

Whether the increase in relative sacral breadth during infancy is due to an absolute increase, or due indirectly to sacral curvature diminishing the straight length, has not been conclusively determined.

THE PUBIC ARCH.

The pubic arch was not measured in degrees in the foetus. It was found possible to measure the subpubic angle in degrees only in the male: the rounded arch of the female did not permit mensuration which could be of value for purposes of comparison. The foetal pubic arch was accordingly assessed subjectively as

being narrow, moderate, or wide; rounded or angular; and whether showing eversion of the ischio-pubic rami or not. The results obtained are simply presented in Table 15 .

Table 15 . Foetal Pubic Arch

12 males and 18 females.

	Male	Female	Sex difference.
Narrow	11	10	2.53 X standard error
Moderate	1	6	2.57 X standard error
Wide	0	2	
Rounded	3	10	1.80 X standard error
Angular	9	8	1.79 X standard error
Eversion: Present	3	12	2.50 X standard error
Eversion: Absent	9	6	2.52 X standard error

In addition the pubic arches were classified as being typically male or female, or intermediate between these categories. The female arch was based

- on -

on the characteristic adult features, i.e. the wide, rounded arch with eversion of the free edges of the ischio-pubic rami.

Ten out of 12 males (83.3 percent) were classified as typically male, the remaining 2 males being of intermediate type. Of 18 females 6 (33.3 percent) were typically female, 5 (27.8 percent) were of intermediate and 7 (38.9 percent) of typically male type. A special feature of these pelves was the exaggerated maleness of some female pubic arches. Indeed, the 7 female pelves of which the arches were classified under the typically male group were indistinguishable in this respect.from the males of that group. Only 6 arches in all looked truly female, for the intermediate group tended in the male direction while having one or two marked female features.

The fact that 83.3 percent of male arches appeared as typically male when only 33.3 percent of female arches look typically female is significant. This difference in favour of maleness - i.e. of the male appearing male and the female appearing female - is 3.2 times its standard error. From the Bantu analysis it emerges that a female pelvis has a pubic

arch which is just as likely to look male as female: almost an equal percentage of female arches will have a form intermediate between these two classes.

Referring to Table 15 it is seen that there is statistical significance for the following morphological features:-

A male pelvis can be expected to have a narrow arch.

A narrow arch is more likely to belong to a male than to a female.

A moderate (wide) arch is more likely to belong to a female than to a male.

That eversion of the rami is characteristic for the female, and absence of eversion a male character, is shown not to be due to chance: this sex tendency can be expected to recur.

While male arches were often angular and seldom rounded, and while the reverse obtained in the female, no significance for this difference in behaviour was established.

In comparing foetal and adult Bantu female arches, there are no significant differences in the incidence of narrow, wide, or straight arches in these 2 groups at the beginning and end of ontogeny. For the male-like characters of narrowness and straightness, the foetal incidence was higher; but for the female character of a moderate or wide arch, the adult incidence was higher. In all 3 instances the difference was 1,4 times

its standard error, which shows that the preponderance of foetal incidence over adult or vice versa may have occurred by chance.

This analysis is based on the separate characters of the pubic arch. If the arch be taken as a unit, it is seen readily that the adult female arch is essentially female in appearance even when leaning towards the male. Table 15 shows that a narrow arch may still have a Norman arch appearance with eversion of the rami, or even that a wide arch could have straight rami. If subjective experience with the material of this investigation may be referred to, it must be stated that only very rarely would it be possible to confuse the sex of an adult pubic arch: in no case in the 167 pelves studied did the pubic arch fail to show some of the expected sex characteristics. In several pelves, however, the pubic arch was the only feature by which the bones could be sexed.

This distinct sexual dimorphism was not experienced with foetal pubic arches. In the female foetus the different features of the arch tend in the male direction with the same regularity as the adult, but in the foetus the female arch as a unit can be more

completely male than in the adult. Analysis showed that an arch belonging to a female foetus could be indistinguishable from the average male arch, and this, as pointed out above, never occurred in the Bantu adult. It is difficult to proceed further with a comparison of male tendencies in the foetal and adult arch, because there is no basis of comparison beyond what has been used above, e.g. it is found that the arch of the android type adult pelvis cannot be compared with the male-like arch of some female foetus. In the android type with its better developed arch there are mixed sex characters, but in the corresponding foetus no sexual dimorphism is discernible.

Pelvis of the Infant and Child

Results.

Table 16 shows the radiographic results obtained from living subjects of both sexes for the age period 1 to 15 years.

The pubic length was measured in a straight line from the symphysis to the anterior edge of the Y-shaped cartilage on the iliopectineal line. The gap

TABLE 16. Measurements in centimetres in children aged 1 to 15 years.

21 Females. 18 Males.

	Name and age (yrs)		Length of ilium	Length of pubis	Index: Ilium / pubis	Width of sacrum		Transverse of brim		Index: Sacrum / brim trans.	+0-ind. brim	Width of cartilage
	Emmanual	($1\frac{1}{2}$)	2.2	2.6	84.5	5.2		5.8		89.7	-	0.5
1	Mary	($1\frac{1}{2}$)	2.4	2.7	88.8	5.2		6.6		78.8	-	0.4
	Sidney	($1\frac{3}{4}$)	1.9	2.35	80.7	4.0		4.9		81.6	-	0.45
2	Daniel	(2-3)	2.6	3.1	83.8	4.8		5.9		81.3	0	+
3	Lizzie	(2-3)	2.4	2.8	85.7	4.8		5.3		90.5	-	0.4
	Sam		2.95	3.55	83.0	4.55		6.3		72.2	0	+
	Mpambaloni		3.05	3.4	89.7	5.7	5.08	7.0	6.6	81.4	-	0.5
4	Samual		2.35	3.7	63.5	5.0		6.4		78.2	-	0.4
	Esmay		3.0	3.2	93.7	5.1		6.3		80.9	+	0.2
	Isaac		3.0	3.7	81.1	5.8	6.0	6.8	7.2	85.3	-	0.4
	Elsworth		4.05	3.7	109.3	6.2		7.6		81.6	0	0.6
5	Eunice		2.9	3.4	85.2	5.8		6.3		92.0	+	0.275
	Emily		2.8	3.0	93.2	4.9	5.1	6.6	6.3	74.3	+-	0.35
	Bertha		2.9	3.0	96.6	4.6		6.1		75.3	+	0.4
	Martha		2.65	3.4	77.8	5.3		6.5		81.5	-	0.45
6	Sadie		2.9	3.5	82.7	5.9		7.1		83.1	-	0.4

	Arthur	3.9	3.6	108.2	6.1	7.7	79.2	-.	0.3
7	Bobsie	3.9	4.0	97.5	5.95	8.1	73.4	-.	0.4
	Leslie	2.95	4.4	67.0	6.5	7.6	85.5	0	+
8	Wilhemina	3.4	4.7	72.3	6.5) 7.0	7.7) 8.05	84.4	0	+
8	Maria	3.45	4.6	74.8	7.5)	8.4)	89.2	-.	0.35
	Elliot	3.9	4.6	84.8	6.7	8.45	79.3	-.	0.35
9	Dorothy	5.2	4.3	121.0	6.3) 6.35	8.2) 8.35	76.8	-.	0.4
9	Mina	4.55	4.35	104.6	6.4)	8.5)	75.2	+	0.45
	Jeremiah	4.4	3.9	112.8	6.2	8.0	77.4	0	0.25
10	Elizabeth	4.5	5.5	81.8	8.4	10.0	84.0	-. big girl	+
	Joseph	3.6	4.5	80.0	8.1	8.7	93.1	-.	0.5
11	Gladys	3.9	5.0	78.0	8.6	9.45	90.(	-.	0.4
	Zulu Boy	3.15	4.6	68.4	7.0	8.4	83.3	-.	0.3
12	Lydia	4.6	5.4	85.0	7.65(?)	9.0	85.0	0	+
	Simon	4.1	5.3	77.3	7.7	9.2	83.7	-.	+
	Beauty	5.6)	5.8)	96.6	8.1)	10.35)	78.2	+	0.4
13	Euphina	4.8) 4.9	4.55)	105.5	8.0) 8.2	10.2) 9.9	78.5	-.	0.4
	Sisie	4.5)	5.3) 5.1	84.8	8.4)	10.0)	84.0	-.	x
	A769	4.8)	4.7)	102.1	8.1)	9.0)	90.0	-.	0.1

14	Sloe	5.3	4.85	109.3	8.0	10.0	80.0	0	0.3
	Octavia	5.0	5.5	90.9	9.1	10.9	83.5	-.	x
15	A154 288 F.	5.0	4.8	104.1	8.0	8.6	93.0	-.	0.1
	Samual	5.0	5.2	96.1	8.05	9.5	84.8	+	0.46

of cartilage as seen on the film was not included in these measurements. The ilium was then measured from the posterior edge of the cartilage to the sacro-iliac joint at its junction with the iliopectineal line. An index was adduced to give the proportion of the iliac distance to the pubic. The width of the sacrum was taken between the two posterior points of the iliac length measurement, and the brim transverse diameter was the greatest transverse diameter. A second index giving the ratio of sacral width to brim transverse was calculated.

Ilium/pubis index.

In the great majority of subjects the index was under 100. The range was 63.5 - 121.0. This means that the ilium was longer than the pubis in a few cases only. A scatter diagram plotting index against age showed that no curve or straight line could be fitted to the points. The highest indicial values occurred in the second quinquennial period, but also the lowest. The rate of growth of (a) pubis and (b) ilium appear to be similar: (b) was found greater than (a) only at 7 and 9 years of age, when average values were plotted.

Width of sacrum/transverse of brim index.

The scatter diagram showed an irregular distribution with a small range of 72.2 - 93.1. Brim width remained proportional to sacral width with consistency.

Lengths of pubis and ilium.

The distribution for both lengths was represented graphically by a straight line with a fair degree of accuracy. Ilium length was almost invariably less than pubic.

Transverse of brim.

The points plotted in a graph based on age lay very close to a straight line. There was no sexual difference.

Width of sacrum.

The plotted points, up to the age of 10 years, lay close to a straight line, but from 10 to 15 years of age there was a wider scatter.

Conclusions.

No sexual differences could be derived from an

analysis of the results obtained radiographically. The brim index was not calculated precisely. The "+" sign indicated that the true conjugate was the greater axis, "O" that the axes were equal, and "-" that the transverse was the greater axis. It was stated in Part III that dolichopelly was significantly more frequent between birth and puberty than during the foetal period. Of 39 juvenile pelves 6 had an index over 100, 8 had an index of 100, and 25 were below 100.

There is no evidence in the Bantu to show whether growth occurs mainly in the pubis or in the ilium during the development of the brim. The sacrum is not responsible at any age period during ontogeny for variations in the shape of the brim.

It is now necessary to embark on a radiographic investigation of a large series of pelves in subjects aged 14 to 20 years, and a second series aged 7 to 10 years. The adolescent pelvis has never been studied fully, and it is at this stage that true sexual differences will be best seen.

Summary.

It has been commonly believed, and repeated by many writers, that sex differences are recognisable in

the pelvis as early as the 3rd ar 4th month of intra-uterine life. The investigation of Bantu foetal pelves has refuted this statement completely.

Pelves were cleaned with instruments and measured on the same day, i.e. before any shrinkage or distortion could take place. No other worker is known to have done this, preserved specimens having been studied previously.

The foetal pelvis is growing continuously, and comparison between any 2 pelves is difficult. A mathematical method has been evolved to make comparisons possible. The maximum height of the pelvis has been shown to bear a relationship to foetal crown-heel length - and indirectly to age (Mall, 1907 - 18) - which is represented by a straight line. Thus all dimensions have been reduced on the basis of a common maximum height, and comparison may be made in a manner similar to that for the static adult pelvis. No other known method of equal validity is available.

Significant sexual differences were found for only 4 foetal pelvic dimensions:

1. Inter-ischio-spinal diameter
2. Pubosacral diameter
3. Area of plane of least pelvic diameters (outlet)
4. Symphyseal height
5. ? Intertuberal diameter.

Sexing of an individual pelvis is not possible from any or all of these 5 measurements. Neither the index nor the area of the brim show perceptible differences in the sexes.

The sacro-sciatic notch is characteristic of sex in the adult pelvis; in the foetus neither linear measurements nor the area of the notch show sexual divergence.

Concerning the most striking sexual characteristic of the pelvis, viz. the pubic arch, the neutral type in the foetus is the male-like arch: 38.9 percent of female arches were typically male, and only 33.3 percent typically female. Eighty three percent of male arches were typically male. The adult female arch probably develops ontogenetically as a secondary sex character imposed upon the neutral or fundamental male arch.

None of the indices studied in the foetal pelvis differed in the two sexes sufficiently to be utilisable for the purpose of displaying sexual differences, nor did they show any trend in the direction of development during the different stages of ontogeny right up to full term.

The Bantu foetal sacrum consists normally of 6 vertebrae (19 - ?20 - out of 20 examples). It seems probable that this is also true for other races, though no worker in this field has reached such a conclusion. The Bantu adult incidence of 6-piece sacra is 22 to 31.8 percent.

Thirty-nine pelves of Bantu children aged 1 to 15 years were studied radiographically. During this stage of ontogeny dolichopellic brims occur more frequently than in the foetus with a difference that is statistically significant. Thus the brim during childhood is rounder than is the case in the foetus, and more "anthropoid" types are found then.

No evidence was found to show that during childhood the ilium grows more at the brim than the pubis, or vice versa; or that dolichopelly is determined by more rapid iliac growth and changes in the tempo of sacral development.

PART VII

GENERAL DISCUSSION

A. SEXUAL DIFFERENCES IN THE PELVIS

Hooton (1930) in his monograph on the Pecos Indian declares: "but every anthropologist, unless he deceives himself, must recognise that many of his decisions as to sex are questionable." This represents the average view concerning sexual differentiation. While Hooton considers the pelvis more suitable than any other portion of the skeleton for the purpose of sexing, he points out that in archaeological material the pelvis is the least well preserved of all skeletal parts. "Moreover, the orthodox pelvic criteria are not infallible." While these views are acceptable, exception is taken to the opinion expressed by Hooton - and one held rather widely by anthropologists - that in primitive peoples pelvic sex differences are often less pronounced than among Europeans.

The evidence for this belief is quite unknown to us, and it would be gratifying to know even on what hypotheses this fancy is based. There is strong evidence to show that a distinct sexual dimorphism is seen in the pelvis only at puberty. The male pelvis

- up -

up to this time is almost indistinguishable from the female and, moreover, closely resembles the adult male pelvis. Female pelvic characteristics present at the end of ontogeny may, therefore, be regarded as secondary sex characters. Development of the essential differences between the sexes must be based on active endocrine principles. These complicated factors may act in various ways, but the hormonal balance would tend to have an influence in favour of either maleness or femaleness. It is not clear whether in both sexes the hormonal influence has a positive effect in producing the characteristic sexual appearances; whether the childhood pelvis is indifferent and becomes positively female in appearance when the requisite feminising hormone is present; and lastly, to what extent the morphology of the male pelvis is shaped by masculinizing hormones, i.e. whether or not these hormones contribute further to the development of the adult male pelvis from its earlier, indifferent, male-like character.

Hooton's thesis of diminished sexual differentiation in primitive races must accordingly depend on

weaker sex reactions in these peolpes, whether the lack be manifested in females or in males, or in both. The reverse of this would have been anticipated; and experience with the Bantu pelvis is in opposition to the suggestion advocated by Hooton.

Variables exhibiting significant sexual differences in the adult Bantu pelvis.

1. Sacral index (straight breadth/straight length). F >

2. Diameters of lumbo-sacral joint surfaces. M >

3. Length of auricular surface (sacrum) - left and right joints. M >

4. Area of right auricular surface. M > . On the right side there is a marked tendency for the male auricular surface to be greater than the left, the reverse holding in the female. The result is that there is not a significant sex difference for the left side.

5. The following diameters and index of the girdle are significantly greater in the male:

1) interspinal diameter
2) maximum pelvic height (both sides)
3) depth of pelvic basin (both sides)
4) symphyseal height
5) interspinal/intercristal index.

6. In the female the measurements that exceed the male with a significant sex difference are:

1) intertuberal diameter
2) width of sacro-sciatic notch
3) conjugata vera
4) transverse of brim
5) oblique of brim
6) antero-posterior diameter of pelvic cavity plane
7) area of inlet plane
8) area of cavity plane
9) area of outlet plane
10) inter-ischio-spinal diameter
11) pubosacral diameter.

NOT SIGNIFICANT.

Absence or presence of a preauricular sulcus was proved to be of no value in the Bantu for sexing pelves. The available evidence for other races lacks statistical significance for the claim that the sulcus is a female attribute.

Two characteristic pelvic sex features are the pubic arch and the greater sciatic notch.

The female pubic arch is wider than that of the male, and is less angular. But a very reliable attribute of the arch for purposes of differentiation is the fact that the male exhibits perfectly straight rami with no eversion of the medial borders. In the female there is invariably some suggestion of outer curvature of the rami: this appearance is sometimes caused by eversion of the medial borders of the rami, a character which has not been found absent in the Bantu female. In analysing

the Bantu dry pelves as an exercise, a few male specimens were found more difficult to sex than any of the "android" females. The only anatomical feature on the basis of which the true sex could be determined was the pubic arch which was characteristically male. In the "android" female specimens the pubic arch was even more characteristically female. It was concluded that the arch offered the best guide to the sex of a pelvis.

In the foetus the neutral type of pubic arch is male-like. Thus 38.9 percent of female arches were typically male, and only 33.3 percent typically female. Of the male arches 83.0 percent were typically male. The fully formed female arch develops, possibly throughout the period of ontogeny, as a secondary sex character imposed upon the neutral or fundamental male arch.

For the Bantu adult female the following observations have been made:-

1. A narrow pubic arch occurs characteristically in the android type pelvis;

2. the android type pelvis is associated with heavy bones and a deep pelvic basin;

3. a narrow pubic arch is associated with heavy bones;

4. a narrow arch tends to occur when the pelvic basin

is deeper than normal.

The width of the greater sciatic notch was found to be of less value in determining the sex of a pelvis. In an appreciable proportion of cases female notches are indistinguishable from male both in width and in depth. If the posterior portion of the notch is produced along the lateral border of the intact sacrum to form a "sacro-sciatic" notch, the width of this notch contributes no more to sexual differentiation than the notch belonging to the innominate bone alone. This observation holds in spite of the fact that on the average the male sacrum is inclined considerably further forward than the female.

Hooton (1930) calculated valuable coefficients of correlation for these attributes.

1. Narrow greater sciatic notch against poor preauricular sulcus (male) - alternatively, broad notch and deep sulcus (female).

Male: $r = +0.604$
Female: $r = +0.362$

There were 144 female specimens. It appears, then, that the male characteristics may be expected to be more consistently present than the female, i.e. the female

shows greater variability.

2. Subpubic angle against greater sciatic notch.

Both narrow - Male: r = +0.488
Both wide - Female: r = +0.310

Here again the male characters show greater consistency in their association.

The most impressive sex differences in the European as well as in the Bantu are seen in the areas of both brim and outlet. It has been shown that the small male antero-posterior diameter of the outlet (pubosacral) is accounted for by the greater forward inclination of the sacrum from above down. Thus the mean sex difference for the pubosacral diameter is 16.0 mm., whereas the corresponding difference for the conjugata vera is only 4.3 mm. In the sexing of an individual pelvis, however, it is recommended that attention be paid mainly to the pubic arch.

Note on the greater sciatic notch.

A high degree of association between the iliac portion of the iliopectineal line and the width of the greater sciatic notch is difficult to establish. It has been thought that the length of this iliac portion of the iliopectineal line tends to be proportional to

the width of the notch. The following measurements in the adult Bantu have been made on 50 female and 40 male Zulu pelves.

a) The length contributed by both ilium and pubis to the iliopectineal line was measured in a straight line, i.e. as chords and not arcs of a circle. An index showing the ratio of ilium length to pubis length was then calculated.

Ilium/pubis index in female Bantu: 100.92.
Ilium/pubis index in male Bantu: 103.30.

	Females	Males
Index under 100	18	11
Index 100	6	3
Index over 100	26	26

(b) In the females 7 pelves had a brim index of 100 or more. Of these 7 pelves 4 had the ilium/pubis index over 100, and 3 had this index under 100. The average ilium/pubis index was 97.7, which is lower than this index for the total of 50 females.

The indications are, therefore, that (1) a high Turner brim index is not due entirely to greater length of ilium than pubis in the region under consideration; and (2) that great width of the sciatic notch is not

dependent on either the length of the iliac portion of the iliopectineal line or on the Turner brim index. i. In the female the width of the ilium from the anterior superior spine to the region of the posterior iliac spines is relatively greater than in the male. This allows greater length of the superior limb of the greater sciatic notch. ii. Further, in the female this limb tends to form an angle with the lower limb which is closer to 90 degrees than is the case in the male. In the male the upper limb tends to curve acutely downward. iii. That portion of the notch which approximates the ischial spines depends chiefly on development of the ischium. Massive spines will reduce the size of the notch, as will pronounced development of the total ischium. The anterior limb of the notch will be affected, apart from this, by the manner in which growth causes the ischium to be set forward in the pelvis towards the symphysis pubis or backward towards the sacrum.

If a prepubertal pelvis be examined in which there is separation of the bones meeting at the Y-shaped epiphysis of the acetabulum, it will be observed how

ischial growth may have the effect of pushing this component of the innominate bone relatively forward. The result would be a widening of the sciatic notch anteriorly.

These three observations provide an alternative explanation to the impression that it is the ilio-pectineal line that determines the shape and size of the greater sciatic notch. Examination of the notch frequently gives an impression of narrowness because the superior limb is short (male), or of width because the sides of a slightly greater angle than that in the male are produced along the greater length of the superior limb of the female.

B. The Adult Female Pelvis in General

Opportunity has been taken of analysing a series of female Bantu pelves and an attempt made to depict the morphological form of this pelvis.

The conjugata vera in the Bantu female pelvis proved to be 107.6 mm. or 4¼ in.: the mean value for this diameter in English women is between 4½ and 4¾ in., not 4 in. as frequently stated. In view of the importance usually attached to this conjugate, it is necessary to consider whether any relation obtains between it and the area of the brim, which is the dimension of most value at this level of the pelvis. The brim area can be derived from two axes, one of which is the conjugata vera and the other the transverse diameter. If these two diameters can vary independently of each other, there could be a chance correlation only between the conjugate and the area. Nicholson (1938) found in 350 cases that the correlation coefficient between the two diameters was 0.043, a low value and one that might occur by chance if there were no relation between the diameters. Ince and Young (1940) in 492 cases found this value to be 0.172, which is statistically significant.

The majority of pelvic brims have a tendency to roundness. As these are large or small, so the two diameters increase or decrease together. About 12 percent of pelves are of the anthropoid type, however, wherein the conjugate undergoes an absolute increase in length while the transverse is shorter, the decrease being relative, though sometimes absolute: consequently, the pelvis is narrowed. The reverse of this form is the flattened brim seen in the android and the rickety types of pelvis, wherein the shortened conjugate is accompanied by a correspondingly lengthened transverse diameter. The area cannot, therefore, be expected to vary in direct proportion to the conjugate diameter. Statistically some degree of correlation appears because of the large proportion of round brims in the series, and because at either end thereof there occur but few examples of pronounced difference between the two diameters.

Examples taken from this series, in each of which the brim area has been obtained accurately by means of the planimeter, further illustrate the unreliability of the conjugate as a basis for inlet size (Table 17). With a diameter of 10 - 11 cm., 2 brims had areas below

100 sq.cm., 10 were 100 - 110 sq.cm., and 1 was over 120 sq.cm. Further examples of this lack of correlation between area and conjugate could be given. It follows that a knowledge of the conjugate diameter, though often a fair index of brim area, may grossly mislead the observer; it is submitted that this dimension is of value only in conjunction with the transverse diameter in estimating an index or an area.

Table 17

Identification number of pelvis	Conjugata vera (cm.)	Area of brim (sq.cm.)
A730; 721	9.9	119.4
A777; 774	9.9	101.5
A784; 790	9.9	94.0
A431	10.0	92.8
A646	10.0	105.7
A703	10.0	107.8
A451; 541	10.0	112.6
A648; 703	10.0	116.2

The Bantu brim and outlet areas illustrate well the smaller general dimensions of this pelvis as compared with the European. Equally important is the Bantu brim index of 90.4 ± 2.0, which compares well with European indices of 88.3 (Nicholson, 1938), 90.8 (Ince and Young, 1940), and over 90 (Thoms, 1939). In the Bush race the index is probably near 100. There is

no good foundation for the prevalent belief that the platypellic brim of index 80 to 85 is characteristic for the female.

The obstetric importance of the pubic arch can scarcely be overstated, the arch being second in importance to no other part of the pelvis.

The different ways of drawing the straight lines of the subpubic angle are arbitrary, and pubic arches of manifestly different build and obstetric significance may be represented by the same figure in degrees. A subpubic angle above 90 degrees is commonly regarded as normal and favourable to labour, and one below 90 degrees as contracted: angles exceeding 90 degrees must be rare. When the arch is well curved, with everted edges, its true significance is lost when the lines for the angle are drawn as chords of a circle inside the curve. A very simple improvement was suggested by Dr. Bleksley of the Applied Mathematics Department of this University. From the point at which the inferior pubic ramus on each side reaches the symphysis pubis, two tangents are drawn to the arch in a postero-lateral direction on either side. The angle between these two lines would give more information

about the size in various arches, and an accompanying statement of the intertuberal diameter would complete this information. In the case of a straight form of arch the tangents would tend to coincide with the rami, and in a well-curved arch they would approach a straight line representing 180 degrees. This procedure is recommended as being more conveniently applicable than an involved mathematical formula or index. Because of the fallibility of the current convention, description of the pubic arch has herein been based upon a subjective analysis into narrow, moderate, and wide, with a form that might be straight, well-curved, or of Norman arch appearance.

In the Bantu series 37.0 percent of arches were narrow, compared with 16.0 percent in Caldwell's (1934) American white series: in other arch features the two series correspond fairly closely. In the pelvic types of the Bantu series, significant differences were found to indicate that the android type tended to have a narrow arch, to be heavy, and to have a deep pelvic basin. The series was not large enough to establish the association of the android type with a straight form of arch. For the narrow arch there was

no tendency towards a straight form.

In 40 percent of the Bantu series the bones were heavy, and in some cases remarkably massive, because of syphilitic sclerosis, or, more rarely, of osteitis deformans.

Regarding the pelvis as a whole, Nicholson's (1938) suggestion is approved of reducing the total of obstetrically valuable pelvic functions to four, viz. pelvic index, brim area, area outlet, subpubic angle. To these four functions it is proposed to add two, viz. depth of pelvic basin, and symphyseal height. Furnished with such data, both anatomist and obstetrician possess a complete survey of the average pelvis. The area and the index of the brim constitute a sounder basis for classification than the morphological one of Caldwell and Moloy, and the other factors mentioned complete the survey of a pelvis more precisely than does the analysis of the forepelvis adopted by those authors.

The brim area may be determined with a planimeter, or sufficiently accurately by calculation. The area of the outlet (plane of least diameters) is calculated from the interspinal and pubosacral diameters. Both radiological and direct measurement can be used in assessing

these values. The subpubic angle to be of value must be drawn according to a proposed new method, the angle suggested lying between tangents to, not chords of, the pubic arch. A knowledge of the depth of the pelvic basin completes the picture for the pubic arch. Finally, the height of the symphysis pubis contributes information about the width of the osseous component of the girdle anteriorly. Nicholson (1938) found the correlation coefficients for some of these functions to be as follows:

Pelvic index and area of brim	+0.432,
Area of brim and area of outlet	+0.446,
Area of outlet and subpubic angle	+0.250

C. THE PELVIC BRIM INDEX

The pelvic brim index is a simple expression of brim shape, and is one of the six basic functions of the pelvis stressed earlier (Heyns, 1944). Numerous theories concerning morphogenesis are based largely on this index. It is important to consider whether a flattened or rounded brim is to be expected under average living conditions, and what is the evidence for the belief that the European trend is in the direction of the round brim with index near to 100 (Thoms, 1939; Ince and Young, 1940).

A low index found for a living racial group was the figure (84.9) calculated from Pan's averages (1929) for Hindu females. Only 16 of the 100 male Bantu pelves had an index below 82. An index of 80 or 81 as an average for white races is extremely unlikely: Nicholson (1938) found a mean of 88.3 for the brim index in 350 rural English women, and Ince and Young (1940) a mean index of 90.8 in 509 London women. An approximate figure (calculated from the average of the two diameters) for Thoms' 132 clinic women (1939) was 91.2, and for his 104 nulliparous students 99.7. In a later series of 600 white women Thoms (1939) found 60.6 percent of the series with what he defined as the dolichopellic

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and mesatipellic type of brim: he does not employ Turner's formula, but his classes would have indices of over 92.5. The great majority of Thoms' subjects had an index of over 90.0, and a minority were platypellic. Ince and Young (1940) found that, using the anatomical (as opposed to the obstetrical) conjugata vera, 30.3 percent only of 509 women were platypellic, i.e. had an index below 90. In the light of this evidence, and from findings in the Bantu (90.4) - and even in the dolichopellic Bush race - the prevailing belief that the platypellic type of brim is characteristic for the female is not well founded.

The earlier authors, however, found strikingly low indices. Thus Turner (1886) and Verneau (1875) amongst others found average indices below 80. In many cases small series of under 20 specimens were reported on, and Verneau himself studied biometrically only 35 females and 63 males amongst European pelves. It is difficult to account for these low indices, even if different measurements were employed for conjugate and transverse diameters which, in the majority of cases, have termini that are well marked on the bones.

Ontogeny and phylogeny.

The foetal brim index in all the series considered, except that of Kappers (1938), was over 100 just as frequently as the adult. There was very little sex difference except in Fehling's series (1876). In the post-natal years the brim becomes round and even dolichopellic (see Fig.F12). Before the 10th year, in fact, it is exceptional for the transverse diameter to exceed the sagittal. In the infantile pelves up to the 7th year, as Kappers (1938) points out, shrinkage with distortion is most marked: the effect of this is to increase the conjugate and decrease the transverse diameter. But in formalin-preserved and fresh specimens the preponderance of conjugate over transverse is still pronounced, and even after the 10th year this ratio holds. In spite of the arguments surrounding this question, therefore, the index is in all probability higher during childhood than during the foetal period.

Hennig (1880) measured 5 female pelves aged 6 months to 8 years of which the inlets were round, and made a remark about the 8 years-old pelvis that it was round while in situ in the fresh cadaver. A

female pelvis aged 10 years was dolichopellic, and Hennig states that the index is higher in children than in neonatals.

Merkel (1903) observed an increase in the conjugate during infancy, and Veit (1883) found in 50 neonatal pelves that the ratio of conjugate to transverse was as 1 is to 1.093. Jürgens (1891) and Kehrer (1873) observed the increase of the conjugate in infants, the series of the former totalling 43. Ssoson-Jaroschewitz (1925) studied an enormous collection of skeletal material. Of 150 adults over the age of 25, 13.3 percent had an index of over 100; of 108 pelves of all ages up to 25 years, 39.1 percent had indices over 100. The Bantu females of the present series had 13.4 percent of anthropoid pelves (Caldwell and Moloy Classification, 1933) in which the brim index is usually over 100; and of the 100 males 16 were anthropoid. This corresponds well with the Russian findings of Ssoson-Jarowschewitz (1925) and even with the 215 Americans (11.6 percent) classified by Caldwell and Moloy (1934). It is submitted that 12 percent of the pelves of a given population can be expected to be anthropoid, and Kappers'

criticism (1938) of the Russian results is not well substantiated. The fact that emerges from the Russian material, however, is that childhood shows more high indices than the adult stage.

Of Fehling's (1876) 130 foetūs available for this analysis, 12.3 percent had an index of 100 or more. Veit's (1883) 27 neonatal pelves contained 3 with an index above 100.

Breus and Kolisko (1904) state that the transverse diameter becomes less than the antero-posterior from 8 to 11 years. "It should be observed," says Kappers (1938), "that this surely cannot be regarded as unusual, when even before the 8th year a similar ratio is found". Breus and Kolisko suggest that from 8 to 11 years sacral growth is arrested with the accompaniment of a more rapid tempo in ilium growth. After this age-period, growth of the sacral breadth gains momentum and exceeds that of the ilium.

But these authors measured very small numbers of infantile pelves, and of these only a small proportion were young ones.

In Turquet's series (1884) of 70 infantile pelves, the sagittal was equal to or greater than the transverse

in 28.5 percent. He mentions as a cause of this finding tuberculosis and syphilis, diseases to which these infants succumbed.

Kappers' figures (1938) show a decline in the brim index from the 10th year of life. He also concludes that no clearly defined sexual differentiation is discernible. Summarising the position, Kappers states that his material - but not Fehling's (1876) and Falk's (1908) - shows a "weakly pronounced" tendency towards a rise in the brim index at the end of the foetal period. The level now is similar to that of the adult. Fehling and Falk find a rather higher level, as is the case with the neonatal pelves of Veit (1883) and Litzmann (1861). During infancy, as shown by several authors, the index rises; but at the age of 10 years the index falls again. Thus it may be said (1) that the foetal pelvis is platypellic with, towards the end of intrauterine life, occasional examples of mesati- and dolichopelly; (2) that during infancy and childhood up to the age of 13 years the brim is mesatipellic: while dolichopelly is normal and common, platypelly is now rare; and (3) that after 13 years and during the adult stage the pelvis is platypellic. At no period can any sexual

sexual differentiation be based on the pelvic brim index.

A phylogenetic survey shows (Schumann, 1915) that at the gorilla stage the contour of the pelvic inlet is oval, the antero-posterior diameter still being greater than the transverse, though the proportion is much more nearly equal than in any lower species. In the kangaroo the pelvic brim has the shape of a narrow triangle. The triangular form becomes progressively widened as the scale is ascended until, the sides becoming more and more concave, the brim becomes ovoid in the ungulates. In all quadrupeds the antero-posterior is greater than the transverse diameter. The infantile pelvis, then, more nearly approximates the quadruped type, and is not dissimilar to that of the highest apes.

In the lower mammalian orders, from the monotremata to the quadrumana, there is extension of the head on the trunk during parturition (Schumann, 1915); but in anthropoid apes and man the facial angle rises above 45 degrees, and flexion of the head during birth becomes the ideal.

Commentary.

In his stimulating paper Derry (1923) bases some conclusions on his pelvic **chilotic** line which corresponds with that portion of the ilio-pectineal line extending from its anterior extremity on the ilium to the sacro-iliac joint. It was found that females of the VIth to XIIth Dynasties possessed pelves with the greatest antero-posterior diameter. English hip-bones from Whitechapel indicated smaller pelves in this respect than even the Predynastic and Kerma (Nubian) innominate bones studied. The English material was thought to be less typically female than is the case in Egyptian women generally, and even less so when compared with the women of the VIth to XIIth Dynasties. Because the Predynastic and Kerma female material was less differentiated from the male than was the case with the corresponding higher English and Old Empire groups, Derry sees confirmation of the view that there is less sex differentiation in primitive than in higher races. Kenny's findings (1944) show how correct was Derry's conclusion that a large antero-posterior diameter is of greater importance for an easy labour than a large transverse. This is seen illustrated in South Africa when Bantu

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and European labours are critically compared (Heyns & Shippel), and in Britain when the incidence of dystocia in the rickety women of Glasgow is compared with that in cities further south where the pelvis is more round and less flat (Mac Lennan, 1944).

The radiographical evidence on brim shape brought forward by Thoms (1939) is most impressive, but it is not stated whether the antero-posterior conjugate measurement is confirmed on the more precise lateral view film: in the antero-posterior view the whole promontory is not seen, a fact responsible for an enlarged diameter and consequently for a higher brim index. That Thoms' series of women of superior physical and economic status should relatively show an index of 99.7 compared with 91.2 for the clinic women is suggestive of a trend. Jarcho (1933) states that the round or dolichopellic type of pelvis is found in the aborigines of America, Australia, and the East Indies. Several observers agree with Stoney (1930) and Vaughan (1937), that platypellic pelves are less the result of racial influence than of the conditions of life in modern

civilization. Two interesting racial groups are the Veddahs of Ceylon and the Indians of Pecos Pueblo. While the former gave an index (Hill, 1941) of 91.9 (13 males) and 91.2 (7 females), the corresponding Indian figure was below 74.0 in all female groups (Hooton, 1930). The Pecos Indians subsisted chiefly on maize, and there is evidence that the health of the inhabitants declined during the closing periods of the settlement. Nevertheless, the female brim index was 70.5 in the two earliest periods, and the male remained approximately the same throughout (mean 76.1). These pelves were extremely wide, both at the brim and the iliac crest, as compared with the Bantu, and the brim calculated mean area of 95.5 sq.cm. compares with the corresponding female Bantu figure of 101.2 sq.cm. The Pecos area is similar to Pan's (1929) for the female Hindu (94.4 sq.cm.), yet the latter has a brim transverse of the same order as the Bantu female. The Pecos superior strait is, therefore, much flatter than that of the Hindu which in turn is considerably flatter than that in the 20th Century Bantu, English, or American white female. The Veddahs show an index equal to that of the last three groups.

This Ceylon race availed itself of a range of food which is almost unequalled, an exception being the absence of milk. Hill (1941) states that water was the only drink known to these people. As milk is the only important source of calcium, it is difficult to understand how in the Veddah rickets is avoided during childhood, and consequently a flat pelvis. In many hundreds of human pelves studied, the non-rickety platypelloid pelvis of Caldwell and Moloy occurs in only 1 - 2 percent (Caldwell and Moloy, 1933; Heyns, 1944; Kenny, 1944 etc.) There is no doubt that development of the pelvic brim during childhood and adolescence must be studied with greater precision before the factors influencing pelvic shape will emerge. The alternative view that the morphology of the brim is due to racial factors is as unsatisfactory as postulating nutritional causes in all those cases which do not exhibit frank rachitic pathology.

Finally, the influence of sacral breadth on the brim index must be considered. The Veddah sacral index was dolicho-hieric in the male and only 100.7 in the female. Such a narrow sacrum is unusual, but has the effect of decreasing the brim transverse diameter and accordingly raising the brim index. Con-

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versely, the female Pecos sacral index was very high at 114.3 - male index 111.2 - and the sacral breadth was 114.34 mm. in 47 females and 115.89 mm. in 66 males, as against a figure of 106.6 mm. in the Bantu female. It is evident that the sacrum must be partly responsible for the low Pecos brim index. It is submitted, therefore, that the sacral breadth should always be shown with the brim index.

D. COMMENT ON 4- AND 6-PIECE SACRA

Even if it is considered of no great importance what the numerical vertebral constitution of the human sacrum may be, because of its instability both on the phylogenetic and ontogenetic side, it may be of value to assess the available knowledge in order to reach definite conclusions on the status of the sacrum in this respect. A prominent feature of this question is the pronounced variability presented by different authors of the incidence of the 6-piece sacrum. As the incidence of the 6-piece sacrum lies most commonly between 10 and 30 percent, and the 4-piece sacrum probably occurs in under 2 percent of any large series wherever taken, attention need be directed only to the deviation of the former from the 5-piece sacrum. Moreover, it is submitted, on evidence provided by our foetal studies, that the sacrum at first consists of 6 vertebrae.

Table 22 presents the incidence of 4-, 5-, and 6-piece sacra based on the findings of several authors. Beyond the Bantu, American Negro, and White races, no analysis was made either because the numbers found for other races were too small, or lack of the literature

prevented a careful scrutiny of the author's methods. Thus Paterson (1896) is commonly quoted (Radlauer, 1908; Keith, 1903; Schultz, 1930) as having found 34 or 35 percent of 6-piece sacra. Now Paterson's Table III shows a series of 265 sacra examined: the 35.46 percent for "6-piece" sacra is the sum of the following:

5 sacral + Coc. 1 fused	12.07 percent
asymmetrical 5/6 sacral	6.79 "
6 sacral	15.47 "
6 sacral + Coc. 1 fused	1.13 "

For the purpose of Table 22 Paterson was credited with only the last 2 groups, those in which there was a sacrum with 6 complete vertebrae. There is an obvious lack of agreement amongst workers as to what constitutes a 6-piece sacrum; and when the foetal sacrum becomes the focal point of this looseness in definition, it becomes imperative to strive after uniformity.

In the study of the Bantu material the conclusion was reached that only a sacrum with 5 complete anterior sacral foramina would be considered to have 6 vertebrae. Shore's definition (1930) will not suffice, for he included 6th vertebrae in sacra where he discussed the

possibility of pathological synostosis of the last piece: this amounts to giving sacral status to 1st coccygeal (30th) vertebrae which merely give the appearance of being developmentally fused with the sacrum. It is submitted that such a 30th vertebra should at least exhibit sufficient development to simulate average 5th sacral (29th) vertebrae. Such development would entail a size of transverse processes and caudal elements sufficient to complete the 5th sacral foramen.

There can be no question of a 1st coccygeal vertebra being sacralised by virtue of its being merely united with the sacrum in such a manner as to obliterate the normally mobile sacro-coccygeal joint. The distinction between developmental and pathological synostosis does not enter into the problem of what might be termed true sacralisation. On the practical side the number of sacral vertebrae present is important during parturition, and difficulty increases in proportion to the length of the sacrum whether it be composed of vertebrae showing sacral characters morphologically or of coccygeal vertebrae which are merely fused with it. Purely

anatomical considerations, however, must be based on the number of sacral vertebrae which have some morphological claim to be sacral in character.

After having come to these conclusions a search was made for some authoritative guidance on this matter, but either indifference or failure to recognise the facts has led to a disregard of the criteria that must determine whether a vertebra be 5th sacral or 1st coccygeal. Schultz (1930) seems to have been the only investigator who has defined the sacrum from this point of view and his definition agrees with the present suggestion that both the bodies and the lateral masses must be fused, the result being that the lowest anterior sacral foramen must be complete (on each side). Adolphi (1912) says indirectly that coccygeal vertebrae are those which do not participate in the formation of the pars lateralis.

In the twenty-second edition of Gray's Anatomy there is depicted (fig.259) a normal 5-piece sacrum which certainly has the 6th vertebra missing - an inference which is possible because of the half-completed 5th foramina shown. A similar error was made with the Bantu material, e.g. amongst the females

6 4-piece sacra were found giving the unique frequency of 9 percent. In the Basuto male no 4-piece sacrum was found, but in the Zulu male it was seen during preliminary sorting that about 8 percent of sacra had only 4 segments. Closer inspection led to suspicion and the skeleton boxes were searched for missing lower portions of these sacra and such "5-piece specimens" as the one seen in Gray's Anatomy. For the majority of the sacra under suspicion the terminal vertebrae were discovered amongst the other skeletal elements: it is easy during maceration to lose so small a flake of bone, and even after the third decade of life these vertebrae separate readily from the sacrum.

When a 6-piece sacrum is complete, there can be no confusion in determining the number of its vertebrae. Unless in some skeletal collections the 6th vertebra had frequently become separated from the sacrum - an improbable event - it is difficult to explain why the incidence of 6-piece specimens should be as low as Le Double's (6.1 percent). Of the authors included by Le Double (1912) the following found an extremely low incidence of 6-piece sacra:

Bianchi	1 out of 130
Steinbach	2 out of 133
Staderini	2 out of 100
Topinard	12 out of 350

These findings can only be accepted with reluctance, though the data showing a high frequency are more readily criticised because of the possibility of counting ankylosed coccygeal vertebrae as sacral. Table 22 shows that the 6-piece sacrum has a percentage incidence of 24.3 in the Bantu, 13.7 in the American Negro, and 21.4 in white stocks. An additional 1809 sacra from different races gave a 6-piece incidence of only 8.8 percent. If Le Double's groups - i.e. excluding Paterson's (1896) and Bardeen's (1904) - are subtracted from the grand total of over 3,000 sacra, it is seen from the table that 1942 sacra had 6 segments 353 times or 18.2 percent. It must be conceded at once that there is no justification on statistical grounds for grouping the figures for different series, because the differences between several of the series are significant. In spite of this the tendency for 6-piece sacra to occur about 20 times out of 100 seems to be strongly marked, and the grouping of Table 22 , even if unjustifiable, can

only have the effect of reducing the incidence percentage - presumably below that of the universe.

In the case of several of the observers mentioned, data were analysed with sufficient care to deserve absolute reliance on their accuracy. In spite of this there are differences for the 6-piece sacrum that are highly significant. Even though the Le Double groups may be suspect, significant differences in others are suggestive of underlying causes which may not be discovered readily.

Adolphi (1912) discusses at some length the findings of Fischel (1906) whose paper has not been available for consultation. Fischel examined 524 sacra, and found a 6-piece sacrum in 2.0 percent of men and 1.4 percent of women. In pointing out that his own Russian and Lithuanian material showed the incidence for this variety of sacrum to be about 11 times as high as in the Czech material of Fischel, Adolphi concludes that the profound difference could not be due to chance. He considers that the reason can be found only in the anthropological variability of the material in which he admits that there is a lack of anthropological uniformity. It seems idle to suggest that the

variable incidence could be due to racial influences, because low incidence is found in several series from white stocks and Negroes, and even the Zulu male incidence was low as compared with the two other Bantu series, though the figures for the Bantu were too small to show statistical significance for the difference.

According to Schultz, Frets (1909) showed by means of animal breeding that numerical variations of vertebrae are hereditary. Decades before this Darwin (1905), in his consideration of the breeding of pigeons, made observations on skeletal variation in the numerous breeds derived originally from the rock-pigeon. While the rock-pigeon had 12 sacral vertebrae, a fairly constant variation occurred in the different breeds. Thus Pouters had sacra of 13 to 14 vertebrae, Runts and Carriers 12, and Tumblers 11, 12, or 13 vertebrae. The caudal vertebrae in these breeds were 7 in number, except in Pouters where 8 or 9 occurred. The question arises, then, whether in Man such numerical variation might be hereditary: the longer sacrum might in some communities be derived from an occasional individual

whose absence in others might account for a very high incidence of the normal 5-piece sacrum in the latter.

Cartilaginous lateral mass.

During preparation of the foetal pelves for measurement, it was discovered that the determination of the number of sacral segments demanded so much dissection that the labour involved did not seem justified, if indeed it was even then possible to gain a precise estimate of the number of vertebrae present. It was accordingly decided to deal with all foetal sacra as 5-piece bones. Careful cleaning of the lower end of the sacrum in a few specimens, however, showed in each case that 6 vertebrae were fused together, a finding which led to the suspicion that in the foetal sacrum the cartilaginous lateral mass extended distally in such a manner as to complete the 5th anterior sacral foramen.

In order to study the limits of the lateral mass of the foetal sacrum, foetūs were used for this purpose alone, because removal of the ischiopubic portions of the girdle gave better access to the sacrum. As these specimens were not used in the study of the

pelvis, the total number of foetūs dealt with was 50, i.e. 20 for the sacral problem and 30 for the pelvic.

The sacrum was removed with so much of the ilia as to determine with accuracy the site of the alae of the 1st sacral vertebra and the sacro-iliac joint. After the first 8 dissections it was decided to count the lumbar vertebrae, and 12 foetūs were added to this series. Cleaning the sacrum with scissors, knife, and forceps was done at the time of removal from the body. Special attention was paid to the cleaning of the anterior foramina, the 5th foramen was located, and the nature of its lateral wall determined. Cartilage was readily recognised and in 9 cases confirmed histologically. No attempt was made to study the foramen distal to the 5th.

Of the 20 foetūs 1 was a 16 weeks gestation, 3 had a crown-heel length of 35-40 cm., 12 40-45 cm., 2 45-50 cm., and 2 were 50-52 cm.

Macroscopical cartilage, of which the structure was confirmed histologically in 9 cases, was found present in the lateral wall of the 5th anterior sacral foramen in 19 out of 20 cases. In the excep-

tional case - one with 6 lumbar vertebrae - cartilage could not be stated to be unequivocally present, though this was probably the case. Statistically the significance of this foetal difference from the adult is such that it must be accepted that in the Bantu foetus the sacrum consists of 6 vertebrae.

In 12 foetūs 10 had 5 lumbar vertebrae, 1 had 6 lumbar vertebrae, and 1 5-6 lumbar vertebrae with a rib on one side only. It was in the foetus with 6 lumbar vertebrae that a 6th sacral vertebra could not be established with certainty; but if this case had 25 presacral vertebrae the 5th sacral foramen would be comparable with the 6th in the other columns - and study of these small "6th foramina" would be very difficult.

The 6-piece sacrum found consistently in the Bantu foetūs apparently did not occur in European embryos and foetūs. Bardeen (1904) found a sacrum with 6 vertebrae once in 30 embryos (4 lumbar vertebrae twice and 6 lumbar once); Rosenberg (1876) once in 9 embryos (4 lumbar 3 times and 13 thoracic 4 times); Paterson (1893) 5 times in 30 foetūs (6 lumbar 8 times and 4 lumbar not at all); Steinbach (1889)

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found only one variation in 25 foetus, viz. 6 lumbar vertebrae once, and in 50 infants up to the age of 12 months there were only 3 6-piece sacra - sacralisation of coccygeal vertebrae twice and of lumbar once. To these names there must be added those of Kappers (1938), Fehling (1876), Thomson (1899), Falk (1908) and others who have done ontogenetic studies on pelvis and sacrum. For the first group mentioned the figures show that the 5-piece sacrum is the normal, whereas the second group of workers does not even discuss how the lower end of the sacrum is determined nor the number of sacral segments in the foetus. In contrast to this, it has been found in the Bantu foetus that the normal sacrum contains 6 vertebrae and that, while variations must be expected to occur, this numerical constitution is probably very constant during the foetal or cartilaginous phase. Paterson (1893) quotes Topinard (1877) as leaning to the view that the normal sacrum contains 6 segments, and that he regards as defective a sacrum possessing only 5 vertebrae.

It is obvious that during ossification of the pars lateralis sacri the cartilage constituting the lateral wall of the 5th foramen does not ossify in a great

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majority of cases. Is it possible for ossifiable cartilage either to disappear or to be converted into fibrous tissue? Bardeen (1910) states: "Not all the cartilage of the embryonic skeleton becomes replaced by bones. Some of the embryonic cartilages become reduced to fibrous tissue, as in the case of the stylohyoid ligament; some give origin to the cartilages of the definitive skeleton, such as the costal cartilages and parts of the nasal capsule; some merely disappear."

It may be presumed that in 20 to 30 percent of cases the cartilage under discussion ossifies, while in the remainder it becomes the lateral sacro-coccygeal ligament. It is recognised (Keibel and Mall, 1910) that in the embryo there are usually 7 coccygeal vertebrae, sometimes 8, this stage being reached in embryos from 8 to 16 cm. in length. In the adult the coccygeal vertebrae commonly number 4 or 5, only rarely 6. If coccygeal vertebrae are lost during development, then some elements of the sacrum may similarly disappear. If some mechanism such as Rosenberg's theory (1876) of a proximal pelvic shift is

involved, an explanation of these phenomena becomes possible. But the point at issue is simply a question of the possibility of a portion of the sacral cartilage not becoming ossified, and thus supporting the finding for the Bantu that the foetus has a 6-piece and the adult a 5-piece sacrum.

Phylogenetic relationships between different primates.

In connection with variations in the lower part of the vertebral column a brief consideration of the thoracic and lumbar regions becomes necessary. Tables 18 to 23 give the findings for man and the phylogenetic relationships between different primates. Reference to the primates, except where otherwise stated, is based on the careful work of Schultz (1930), whose valuable paper deals with considerable series of primates.

Cervical vertebrae exhibit a pronounced constancy in regard to their number. Schultz's material did not present a single case with a deviation from the normal number of 7. In the literature only two instances were found in which 8 cervical vertebrae occurred in apes. A reduction in number has not been reported, except for

man.

TABLE 18

Thoracic Vertebrae.

Author	Race	Total of Cases	No. of thoracic vertebrae				
			11	11½	12	12½	13
Trotter 1929	Negro	97	5		90		2
Schultz 1930	Negro	64	3		57		4
Total of Negroes	.....	161	8		147		6
Nishi 1928	Japanese	148			148		
Fischel 1906	White	524	2		499		23
Trotter 1929	White	92	5		84		3
Frey 1929	White	150	9	1	137	1	2
Total of Whites	.....	766	16	1	720	1	28
Total of all races		1,075	24	1	1,015	1	34

Table 18 analyses the number of thoracic vertebrae in different human races, and it is seen that in 94.4 percent of vertebral columns the standard number of 12 occurs. Table 19 similarly gives the number of lumbar vertebrae for man. 5 vertebrae occur in 91.8 percent of cases, 6 in only 4.8 percent. The average number of lumbar vertebrae for the different human races as well as for the total is 5.0. Table 21

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shows percentages and averages for different primates concerning lumbar vertebrae, and Table 20 the corresponding figures relating to thoracolumbar vertebrae. The latter may vary from 15 in catarrhines to 24 in prosimians (Schultz, 1930).

TABLE 19

Lumbar Vertebrae.

Author	Race	Total of Cases	No. of lumbar vertebrae			
			4	4½	5	6
Trotter 1929	Negro	97	8		80	9
Schultz 1930	Negro	63	4		58	1
Total of Negroes	.....	160	12		138	10
Nishi 1928	Japanese	148	4		135	9
Fischel 1906	White	524	12		502	10
Trotter 1929	White	92	3		77	12
Frey 1929	White	150	3	1	135	11
Total of Whites	.....	766	18	1	714	33
Total of all races		1,074	34	1	987	52

It is seen that 5 lumbar vertebrae form the rule for gibbons and man, whereas the average number has become reduced in the orang-outang, chimpanzee, and gorilla. In

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regard to the number of lumbar vertebrae, and also of the thoracic vertebrae, man is more stable than all the other higher primates. In the genus Gorilla minus-variations are frequent and plus-variations rare, thus demonstrating an evolutionary change in the direction of a reduction of the lumbar vertebrae from 4 to 3. Man and Pithecus are the most stable forms, adhering to the typical number of thoracolumbar vertebrae in over 90 percent of individuals, whereas Cebus, Symphalangus, and Gorilla with a corresponding figure of less than 60 percent are the least stable. In all the unstable higher primates variations amounting to a reduction in thoracolumbar vertebrae are much more common than those showing an increase. Man's greater stability, on the other hand, is associated with plus-variations more often than with minus-variations. The difference in the case of man is comparatively small. This supports the claim that in man the evolutionary process has come to a standstill.

The numerical variation of sacral vertebrae among the lower primates ranges between 2 and 4, among the Hylobatidae between 3 and 6, and among the highest

primates between 4 and 7. Thus, with the general advance of primate evolution more and more vertebrae tend to participate in the formation of the sacrum. The extremes of the above ranges are rare, and Table 23 shows that this progressive sacralisation is more pronounced in the case of Pan and Gorilla than in man. In the Bantu the percentage incidence of the plus-variation is greater than in the other racial series (24.3); and if the available data concerning European foetal sacra are confirmed, the Bantu sacrum must be considered to be more variable than that of the European, and accordingly to exhibit an evolutionary trend in this respect which is less removed from the other primates than is the European. In comparing Table 20 with Table 23 it is found that the number of sacral vertebrae is much more constant than that of the thoracolumbar ones in the lower primates, but a great deal more variable in all the higher primates, including man.

Broom (1930) states that in therapsids and mammals it is difficult to decide how many true sacral vertebrae there are, as the proximal caudal vertebrae have

independent costal elements not unlike those of the sacrals. Usually a number of these caudal vertebrae are fused with the true sacrals. Broom suggests that in man there are only 2 true sacrals, and that the other 3 or 4 vertebrae are really caudals which have fused with the true sacrals. In some mammals a very much larger number of caudals than the latter is united in the sacrum.

TABLE 20

"Percentage distribution of variations and averages of the number of thoracicolumbar vertebrae in primates". After Schultz, 1930.

Primate	Total of Cases	No. of thoracicolumbar vertebrae							Average
		15	16	17	18	19	20	21	
Cebus	38				2.6	47.4	47.4	2.6	19.5
Alouatta	25				12.0	68.0	20.0		19.1
Ateles	22			13.6	86.4				17.9
Pithecus	53				7.5	92.5			18.9
Hylobates	63			17.5	76.2	6.3			17.9
Homo(Negroes)*	347		4.0	90.5	5.5				17.0
Homo(Japanese)	148		2.7	91.2	6.1				17.0
Homo(Whites)*	3097		2.8	92.2	4.9				17.0
Homo sapiens	3592		3.0	92.0	5.0				17.0
Pan	63	1.6	19.0	74.6	4.8				16.8
Gorilla(gorilla and beringei)	86	1.2	39.5	58.1	1.2				16.6
Pongo Pygmaeus	83	14.5	75.9	9.6					16.0

* Willis (1923) included.

- TABLE 21 -

Table 21

"Percentage distribution of variations and averages of the number of lumbar vertebrae in primates". After Schultz, 1930.

Primate	Total of Cases	Number of lumbar vertebrae							Average
		3	3½	4	4½	5	6	7	
Cebus	37			2.7		35.1	56.8	5.4	5.6
Alouatta	24					91.7	8.3		5.1
Ateles	20			100.0					4.0
Pithecus	50						16.0	84.0	6.8
Hylobates	57			8.8		86.0	5.2		5.0
Pongo Pygmaeus	79	5.1	5.1	78.5	2.5	8.8			4.0
Pan	55	16.4	3.6	74.5		5.5			3.9
Gorilla (gorilla and beringei)	82	40.3		58.5		1.2			3.6
Homo (Negroes)	160			7.5		86.3	6.2		5.0
Homo (Japanese)	148			2.7		91.2	6.1		5.0
Homo (Whites)	766			2.3	0.1	93.3	4.3		5.0
Homo sapiens	1,074			3.2	0.1	91.8	4.8		5.0

TABLE 22

Number of sacral vertebrae in human races.

Author	Race	No. of observations	No. of sacral vertebrae 4	5	6	Percentage of 6-piece sacra.
Shore 1930	Bantu	81	0	64	17	21.0
Heyns	Bantu	166	2	121	43	25.9
Total of Bantu		247	2	185	60	24.3
Trotter 1929	Negro	97		90	7	
Schultz 1930	Negro	58		48	10	
Caldwell & Moloy 1933	Negro	159		133	26	
Total of Negroes		314		271	43	13.7
Bardeen 1904	White	53	1	48	4	
Adolphi 1912	White	289	2	225	62	
Frey 1929	White	150	1	117	32	
Trotter 1929	White	92		82	10	
Caldwell & Moloy 1933	White	181		125	56	
Total of Whites		765	4	597	164	21.4
Paterson 1896	Various races	265	3	218	44	16.6
Radlauer 1908	Various races	351	10	299	42	12.0
Le Double 1912	Various races (including foetus)	1,193	11	1,109	73	6.1
Total of various races		1,809	24	1,626	159	8.8
TOTAL OF ALL RACES		3,135	30	2,679	426	13.6
Subtracting Le Double's groups		1,193	11	1,109	73	
		1,942	19	1,570	353	18.2

Table 23.

Percentage distribution of variations and averages of the number of sacral vertebrae in primates.

Primate	Total of Cases	Number of sacral vertebrae						
		2	3	4	5	6	7	Average
Cebus	37	2.7	97.3					3.0
Alouatta	24		91.7	8.3				3.1
Ateles	20		95.0	5.0				3.1
Pithecus	50		100.0					3.0
Hylobates	54			59.3	40.7			4.4
Pongo Pygmaeus	88			11.4	68.4	20.2		5.1
Homo (Negroes)	314				86.3	13.7		5.14
Homo (Whites)	765			0.5	78.0	21.4		5.20
Homo (Bantu)	247			0.8	74.9	24.3		5.24
Homo (diff.races)	1,809			1.3	89.9	8.8		5.08
Homo sapiens	3,135			1.0	85.3	13.6		5.12
Pan	42			4.8	47.6	47.6		5.4
Gorilla (gorilla and Beringei	61				47.5	50.9	1.6	5.5

Summary.

A 6-piece sacrum has been defined as showing sufficient development of the transverse processes and caudal elements of sacral vertebrae 5 and 6 to complete the 5th sacral foramen. There can be no question of a 1st coccygeal vertebra being sacralised by virtue of its being merely united with the sacrum in such a manner as to obliterate the normally mobile sacro-coccygeal joint.

Of 3,135 sacra of various human races, 13.6 percent had 6 segments. If Le Double's (1912) groups with a very low incidence are omitted, then 1,942 sacra were 6-piece in 18.2 percent of those observations. In some moderately large series the 6-piece sacrum occurred in under 4.0 percent, and there is no obvious explanation of this variability except to postulate an analogy with certain animals in which similar numerical variations of vertebrae are hereditary.

In the Bantu foetus 20 consecutive sacra had 6 segments. One was doubtful, and may have had 5 vertebrae. The statistical significance of this finding was calculated thus: let the incidence of 6-piece sacra in the Bantu adult be the highest found, i.e. the 30 percent of the female. Then the probability that this series of 20 sacra

had occurred with 6 segments by chance is 1 in $1/(0.3)^{20}$, or 1 in 28,710 million different series of 20 consecutive sacra each. If 19 out of 20 sacra had 6 vertebrae each, the difference from the adult is 10.57 times its standard error, which also means that the probability of such a sequence occurring by chance is of the order of several thousand million to 1 against.

What does this probability amount to in time? To apply the chance factor reasonably, imagine it to refer to all modern races of men, not to the Bantu only. The chances are, then, that this series of 20 consecutive 6-piece sacra could have occurred by chance only once in all births of the species Homo sapiens since the dawn of the Pleistocene period. The alternative is to accept that, though the adult incidence for 6-piece sacra is only 30 percent, the incidence in the foetus is different and approaches 100 percent. It will of course not be disputed that this is in fact the case for the Bantu foetus.

E. ROSENBERG'S THEORY

Reference must be made to the theory and writings of Emil Rosenberg on the development of the vertebral column of man. Between 1875 when his first paper appeared, and 1925 when, as ascertained by consultation of the "Index Medicus", he wrote his last report on the same subject in reply to Stieve (1923), Rosenberg published 9 articles comprising over 300 pages and 1 monograph.

The original publication deals with 13 embryos of which 9 form the basis of Rosenberg's theory of a proximal shift of the pelvic girdle along the vertebral column during ontogeny. Subsequent writings were not supported by further observation of embryonic skeletons. In 1899 the author published a defence against criticism of his theory, in 1920 there was a further discussion of the significance of his findings, and in 1922 there appeared a reply to an attack on his work by Stieve who continued the quarrel in 1923, to be answered finally by Rosenberg in 1925.

Rosenberg's concept (1875) was that the last

lumbar vertebra of the embryo subsequently became sacralised, and that one or more embryonic sacral vertebrae became coccygeal. In this manner the appendicular skeletal attachment advanced proximally along the vertebral column during ontogeny. This shift of the pelvis was believed to be similar to a corresponding change which can be traced in the phylogeny of man. Rosenberg ascribed variation in the adult to a failure during ontogeny to effect the changes mentioned, or to the possibility of these changes proceeding further than they do on the average.

In 56 percent of Rosenberg's embryos there are 24 presacral vertebrae; and by applying his hypothesis, it would be anticipated that a very high percentage of columns with 23 presacral vertebrae would occur in the adult. Table 20 shows that of 3592 human columns 3.0 percent had 23 presacral vertebrae, the race variation ranging from 2.7 - 4.0 percent. On the contrary, the "plus-variation" of 25 presacral vertebrae for this large series averaged 5.0 percent, with a racial range of 4.9 - 6.1 percent. It is seen, therefore, that "plus-variations" in man occur with greater frequency than "minus-variations" with a

difference that is significant, but that it is the frequent occurrence of "minus-variations" that follows as a corollary to Rosenberg's hypothesis.

Rosenberg's low embryonic incidence of 24 presacral vertebrae (56 percent) compares with a corresponding Bantu foetal incidence of 83.3 percent in the 12 examples studied for this purpose. It is noteworthy that this difference is not significant and that, therefore, the strikingly high incidence of Rosenberg's "abnormal" presacral regions may have arisen by chance. Is this not a reasonable explanation why Rosenberg's embryonic presacral region should have shown a "plus-variation" more frequently than was the experience of other observers? Similarly, the "plus-variation" of the 12 Bantu foetūs is high at 16.6 percent when compared with the corresponding variation of 5.0 percent for the large adult series of 3592. Yet the difference involved is about equal to its standard error and is, accordingly, not significant. Dealing with a small number of observations such as represented by the present Bantu and Rosenberg's material, the play of chance in random sampling makes it possible for an incidence as high

as 44.0 percent to be obtained when the corresponding incidence for the universe is near to 5.0 percent, the truth of this statement being dependent of course on uniformity in the causal factors on which the variable depends.

It is deplorable that Rosenberg and Stieve should have entered into such undignified bickering. It is obvious that they were unaware of the possibility in the European - as is in fact the case in the Bantu - that the 30th vertebra might be sacral during foetal life. If Rosenberg's views concerning the pelvic girdle are correct, then their scope ends with embryonic life, i.e. 2 or 3 months after fertilisation of the ovum. If it is possible during early development to make the accurate observations which are a sine qua non for Rosenberg's theory, it must be pointed out that several other observers failed to confirm Rosenberg's findings (Bardeen, 1904; Fischel, 1906; Stieve, 1921 and 1923).

There can be no doubt that too great prominence has been given to Rosenberg's work. The older papers entered into full discussions on his theory, more

- recently -

recently Rosenberg has been misinterpreted, and some writers have even misspelt his name. The hypothesis was of interest for a time, but it has served its usefulness and should be abandoned, until new and fundamental evidence may seek to resuscitate it.

PART VIII

GENERAL SUMMARY

I Outline of Material and Methods.

The Bantu pelvis girdle as a whole has been studied on 100 male and 67 female dry pelves, and 125 adult female patients who were subjected to X-ray pelvimetry. These pelves were analysed biometrically for the greater part. A preliminary report has been given on the ontogeny of the pelvis: 30 foetal and 39 infant pelves were used (the latter being treated radiographically).

The weight of the Bantu newborn was assessed in some 2,000 cases, and the head measurements in 500 babies.

The method of X-ray pelvimetry used is discussed fully in an appendix. Experiment was required to establish the accuracy of the available methods.

The adult pelvis, after careful articulation, was measured in the usual way. Dioptographic tracings were made of the brim and auricular surface and the areas determined with a planimeter. The foetal pelvis was cleaned with instruments and measured with a travelling microscope without delay. X-ray pelvimetry of the

infant pelvis was difficult at first, but the fundamental observations were satisfactorily made by Nicholson's (1936) technique.

Foetal pelvic measurements were made comparable in the following manner. All measurements were reduced or increased on the basis of a common maximum height of 50 mm. which was arbitrarily chosen. Maximum height was shown to bear a relationship to crown-heel length - and indirectly to age - which is represented by a straight line.

II General Conclusions.

1. The Bantu foetus has a sacrum composed of 6 vertebrae. In 20 to 30 percent of cases the cartilage of the lateral mass ossifies, and in the remainder it becomes the lateral sacro-coccygeal ligament.

2. Sexual differentiation in the foetal pelvis is almost entirely absent. Only a few dimensions and other features show significant sexual differences, but individual foetal pelves can only rarely be sexed on the available criteria. As far as can be judged at present, these conclusions apply to the child's pelvis with equal force.

3. When the Caldwell and Moloy classification was

applied to the Bantu skeletal material, the incidence of the different female types was similar to that found for the American white stock. A striking result was the fact that male pelves were distributed over the whole range of female types, one male pelvic type being hardly distinguishable from the essentially female gynecoid type.

4. The anthropoid type pelvis with brim index over 100 occurred in 13 to 17 percent of Bantu pelves. The incidence in the foetus was similar, but the age period 1 to 15 years showed significantly more of these pelves and more round specimens. It is suggested that during ontogeny the girdle tends to develop in the direction of dolichopelly, as it does in other primates. But retardation of this evolutionary movement occurs, and at puberty in particular there is difficulty in breaking the bonds of foetalisation by which man appears to be tied. While about 12 percent of pelves break through and develop the efficient anthropoid type pelvis, the majority remain mesatipellic as in the foetus. Thus man has developed less highly than other primates in respect of the pelvis.

5. Rosenberg's theory of a proximal shift during ontogeny of the pelvic girdle along the vertebral col-

umn has been refuted on statistical grounds.

6. The mean Bantu birth-weight in over 2,000 cases was found to be 6¾ lb. Where a university clinic was organised for pregnant women, the birth weight rose to 7¼ lb.

The evidence provided by the analysis of baby head measurements shows that the Bantu newborn has a head as large as that of the European.

Therefore, the Bantu baby is in both these respects comparable in size with the European.

7. The Bantu female pelvis is only slightly smaller than that of English women. The difference is only clearly seen when the areas of inlet and outlet are considered.

By the method of analysis employed, no reliable racial characters were discovered in the Bantu sacrum or pelvis.

8. The adult, like the foetus, shows sexual differentiation most emphatically in the region of the outlet and pubic arch. The latter represents the most reliable criterion available for the sexing of a pelvis.

It has been shown that the major cause of the sexual difference inthe antero-posterior diameter of the outlet is a greater forward inclination of the sacrum

in the male, not greater sacral curvature.

There are six essential functions of the pelvis which furnish both anatomist and obstetrician with a complete survey of the average pelvis. These are the areas of brim and outlet, the pelvic brim index, symphyseal height, capacity of the pubic arch, and depth of the pelvic basin.

9. The preauricular sulcus was present in the female Bantu only sightly more frequently than in the male. There is no statistical significance in this difference, nor in any other differences that have been found published. It is, therefore, of no value in sexing skeletal material.

10. Asymmetry of certain diameters has persisted, though statistical significance could not be established. The sacro-iliac joint surfaces, the pelvic brim, and the height of the pelvis show sufficient asymmetry to suggest that in the female the left limb is better developed and more active: in the male the reverse holds, with equal consistency.

11. It is submitted that the Caldwell and Moloy classification should be abandoned because it serves no purpose. A pelvis is grouped with equal value on the basis of the Turner brim index. With the help of Nicholson's stereometric technique (1936), it is now

possible to study accurately the growth of the pelvis during childhood. When more ontogenetic facts have been acquired, a rational classification can be developed. On the basis of our present knowledge the pelvis does not lend itself to a classification of any value.

12. Experiments in X-ray pelvimetry have assessed the possible error arising in determining certain variables. i. Modifications have been suggested in calculating the areas of brim and cavity. ii. An anatomical constant concerning the ischial spines has been discovered, and the distance between them can be found with an error of only 1.0 percent. iii. The pubosacral and transverse of brim diameters can never be measured on any film with a degree of accuracy that is of value. The reason for this is overlapping of shadows at the termini of these diameters, thus making identification impossible.

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APPENDIX 3.

The Size of the Bantu Head at Birth

The Bantu female pelvis has been compared with that of the Bantu male. In comparing the female pelvis girdle of different racial groups, it is of value to know the relative size of the foetus for the respective races. For this reason an analysis of the gross birth-weight in over 2,000 cases is presented (Appendix 2); but it is obvious that birth-weight would vary with good or poor nutrition during intra-uterine life, probably in the main owing to the quantity of subcutaneous fat laid down in the foetus. While the mean Bantu weight was about 6¾ lb., the mean in a smaller series receiving good antenatal care was 7¼ lb., a near approach to the average for any prosperous European community. It is, therefore, of importance to assess the size of the head in the Bantu newborn, for this is the biggest part of the foetus to pass through the birth canal. The correlation table (Table 24) demonstrates that in the newborn there is not a very high degree of relationship between weight and the area of a cross-section in the plane of the

occipito-frontal and biparietal diameters of the skull.

Measurement was carried out on 500 heads of which two-thirds were Natal Zulu, one-fifth Basuto, and the rest Xhosa, Swazi, and Mpondo. Males and females were taken at random, and no separate analysis is shown for the sexes.

The birth-weight was observed in all cases, and on the day of birth the following head diameters were measured: the occipito-frontal, biparietal, suboccipito-bregmatic, and mentovertical. Areas were calculated to represent a cross-section of the greatest part, as it traverses the pelvis, of a) the well-flexed head (biparietal and suboccipito-bregmatic as axes), and b) the deflexed head (biparietal and occipito-frontal as axes). The correlation coefficient and regression equation for weight and area (b) were found.

The measurements considered are those of the vault of the cranium, because the latter forms the major portion of the skull. In the full term foetus the face, mandible, and temporal bones are small, the

size of the head depending on the 4 large squamous bones, viz. the 2 parietal, the frontal, and the occipital.

Mean birth-weight. For 500 babies ranging in weight between 60 ounces (3 lb. 12 oz.) and 178 ounces (11 lb. 2 oz.), the mean weight was 112.13 ± 0.71 ounces, standard deviation 15.83 ounces, and coefficient of variation 14.1 percent. This weight averaged approximately ¼ lb. more than that of the larger series presented in Appendix 2 . Only 7 weights were under 5 lb., their occipito-frontal-biparietal plane areas varying between 65 and 80 sq.cm.; 5 corresponding areas of heavier babies were below 65 sq.cm.

Occipito-frontal diameter. The mean length of this diameter was 11.30 ± 0.03 cm., range 9.75 - 13.5 cm., standard deviation 0.64 cm., and coefficient of variation 5.67 percent. Moulding during parturition may increase or decrease this diameter, usually with a corresponding inverse change in both suboccipito-bregmatic and biparietal diameters.

- Scammon -

Scammon and Calkins (1929) give a list of authors who have published average values for this diameter. Unfortunately Scammon and Calkins measured from glabella to inion, whereas the Bantu diameter was the greatest distance between occipital and frontal bones. The latter is the measurement of practical value, and one which can be taken accurately in all cases; moreover, Williams (1936) and De Lee (1938) recommended these termini for the diameter. As the last mentioned authorities are found in the Scammon and Calkins list of 25 other authors, it may be assumed that some of the authors measured the diameter in the manner used for the Bantu. In 12 of the 25 series the mean was less than that for the Bantu, and in 1 equal to the Bantu mean. De Lee (1938) who states that his figure is based on a large number of measurements showed an average of 11.0 cm., Williams (1923) a corresponding mean of 11.75 cm.

The mean occipito-frontal diameter in the Bantu may, therefore, be claimed to correspond with that found for Europeans.

Suboccipito-bregmatic diameter. With a range for this diameter of 7.25 - 12.0 cm., the mean was 9.68 ± 0.03 cm., standard deviation 0.63 cm., and coefficient of variation 6.50 percent.

Scammon and Calkins (1929) give a list of 17 observers publishing averages for this diameter, and of these 8 found figures lower than the Bantu mean of 9.68 cm.

Biparietal diameter. This is the greatest width of the head between the parietal eminences. The figures for the biparietal diameter were as follows: mean 9.22 ± 0.02 cm., standard deviation 0.53 cm., coefficient of variation 5.74 percent, and range 7.5 - 10.75 cm.

Scammon and Calkins (1929) cite 47 series from 38 authors who published means for the biparietal diameter: in 15 series the means are smaller than that for the Bantu. Both De Lee (1938) and Williams (1923) show a mean of 9.25 cm. as compared with 9.22 cm. for the Bantu mean biparietal diameter.

If the area of a cross-section of the head with biparietal and occipito-frontal as axes is calculated

from the means of these diameters, it is found that the Bantu area is greater than that for Scammon and Calkins (1929) and De Lee (1938), but slightly less than that for Williams (1923).

Mentovertical diameter. For 475 heads with a range for this diameter of 11.0 - 15.5 cm., the mean was 13.27 ± 0.03 cm., standard deviation 0.74 cm., and coefficient of variation 5.48 percent. The measurement was made from the point of the chin to the most distant point on the vertex (parietal bone). Scammon and Calkins define the posterior point of this diameter as the external occipital protuberance, as in the case of their occipito-frontal diameter. From the table of authors presented by Scammon and Calkins, comparison with the Bantu mean for the mentovertical diameter shows that in 15 series out of 34 the mean diameters were less than that of the Bantu. The Bantu figure lay midway between those of De Lee (13.0 cm.) and Williams (13.5 cm.).

Area of cross-section with biparietal and suboccipito-bregmatic diameters as axes. For 500 areas calculated from the ellipse formula, the range was 50.2 - 99.3sq.cm.,

the mean 68.64 ± 0.28 sq.cm., standard deviation 6.33 sq.cm., and coefficient of variation 9.23 percent. Only 7 areas were below 55 sq.cm. and 3 above 85 sq.cm., the deviations inside this range being uniformly distributed.

In English obstetric teaching the diameters under consideration are given as $3\frac{3}{4}$ inches each. This would give an area of 71.3 sq.cm. Although such a difference from the Bantu might be significant, both De Lee's and Williams' series give an area calculated from mean diameters which is less than the corresponding Bantu area.

Area of cross-section with biparietal and occipito-frontal diameters as axes. The range in 500 calculated areas was 62.0 - 112.7 sq.cm. with a mean of 80.64 ± 0.32 sq.cm., standard deviation 7.24 sq.cm., and coefficient of variation 8.97 percent. Five areas only were below 65 sq.cm. and 3 above 100 sq.cm.

The correlation between birth-weight and the biparietal X occipito-frontal area is shown in Table 24 The coefficient of correlation between these dimensions was found to be 0.364 ± 0.045. This coef-

- ficient -

ficient is more than 8 times its standard error, and may be accepted as being certainly significant. The relationship between weight and area is a rectilinear one, and the regression equation for the line was found to be

$$W = 0.04975A + 2.988 \quad \text{where}$$

W = weight in lb.

and A = area in sq.cm.

$$S_w = \sigma_w \sqrt{1-r^2}$$

$$= 0.921 \text{ lb.}$$

The standard error for this equation is thus 0.921 lb., i.e. the standard error of prediction in using the equation is $14\frac{3}{4}$ ounces.

From the data here reported on the dimensions of the head at birth, it must be concluded that the difference between Bantu and European foetal heads at term is not considerable. While there is great variability between the Bantu and certain European figures, many of the latter are smaller than the Bantu averages. Evidence has not been found to prove that the Bantu newborn has a smaller head than the European at birth.

Table 24. Bantu Newborn

Correlation table for birth-weight and the area of a cross-section in the plane of the occipito-frontal and biparietal diameters of the skull.

Head area (sq. cm.)	Birth-weight in pounds									Total
	3-	4-	5-	6-	7-	8-	9-	10-	11-	
60-	-	-	2	3	-	-	-	-	-	5
65-	1	1	6	11	8	2	-	-	-	29
70-	-	2	15	36	22	1	-	-	-	76
75-	-	3	12	60	30	11	3	-	-	119
80-	-	-	11	59	48	16	1	1	-	136
85-	-	-	4	32	40	17	5	-	-	98
90-	-	-	1	5	11	7	2	-	-	26
95-	-	-	-	2	4	1	1	-	-	8
100-	-	-	-	-	1	-	-	-	-	1
105-	-	-	-	-	1	-	-	-	-	1
110-	-	-	-	-	-	-	-	-	1	1
Total	1	6	51	208	165	55	12	1	1	500

APPENDIX 4

Histological preparation of tissue comprising the lateral wall of the 5th sacral foramen in the foetus

Difficulty was encountered in preparing, for histological examination, the tissue of the lateral wall of the 5th sacral foramen. The amount of cartilage present is small, and this is easily lost during preparation. In a few cases muscle tissue remained in the section, but cartilage which had been perceived macroscopically was entirely absent. What happened to this cartilage is not quite clear even now, for attempts were made to dissolve or dehydrate sacral cartilage, but without any success.

Method.

Tissues were tied in gauze for the purpose of washing in running water. It is advisable to treat tissues throughout the process in a special section container, the bottom of which is covered with wire gauze.

Fix tissue in formol saline for 12 to 24 hours.
Wash in running water for 30 minutes.
Then, 15 minutes in each of the following alcohols:-

70% - 90% - 95% - Absolute.

- Absolute -

Absolute alcohol and Chloroform aa - 30 minutes.
No. 1 Wax - 30 minutes.
No. 2 Wax - 30 minutes.
Cut sections at 10μ.
Mount section on albuminised slide.
Bake slide in incubator.
Stain with haematoxylin - 10 minutes.
Blue up in running water and counter-stain with oesin for 5 minutes.

APPENDIX 5 FOETAL PELVIC MEASUREMENTS. (millimetres)

The top figure in each compartment is that found by conversion of dimensions to a standard maximum pelvic height of 50.0 mm.

F = Female M = Male.
C.R. = crown-rump C.H. = crown-heel

No. and Sex	Weight l. ; C.R. length ; C.H. length	Conjugata vera	Transverse of Brim	Brim index	Inter-ischiosciatic	Tuberoacral	Outlet area	Brim area	Symphyseal height	Depth pelvis basin (D.P.B.)	Intertuberal	Intercristal (I.C.)	Interspinous (I.S.)	I.S./I.C. index	Maximum height (M.H.)	M.H./I.C. index	T.B./I.C. index	Length sacrum	Breadth sacrum	Sacral index	Greatest width (Sacro-sciatic notch)	Least width	Length: spine to notch	Diagonal conj.	D.P.B./M.H. index
I	---	30.0	28.0		18.9	23.3	348	660	10.1	20.8	20.2	56.7	54.0					28.8	26.5		9.4	8.2	11.6	36.0	
	11.7																								
F.	18.2	14.25	13.25	107.4	9.00	11.1	785	149	4.80	9.9	9.55	27.0	25.7	95.0	23.75	87.9	49.1	14.2	12.55	88.3	7.95	3.85	5.50	17.1	41.7
II	---	25.0	28.3		20.4	22.3	356	518	10.7	20.4	22.9	57.8	54.5					26.8	27.1		8.0	7.6	11.8	32.6	
	12.8																								
F.	19.0	12.90	14.60	88.3	10.50	11.45	945	148	5.55	10.5	11.75	29.75	28.05	94.2	25.75	86.5	49.0	13.8	14.00	101.4	4.05	3.90	6.10	16.8	40.7
III	11b.1oz.	22.7	25.7		21.0	23.0	377	458	11.5	20.6	20.1	59.0	52.5					27.4	28.2		9.3	8.8	13.1	31.5	
	19.8																								
F.	30.5	16.50	18.70	88.2	15.25	16.65	199.8	243	8.35	15.0	14.55	42.90	38.20	88.9	36.40	84.8	43.6	19.9	20.45	102.7	6.80	6.40	9.50	22.9	41.2
IV	11b.13½	24.6	25.9		17.4	20.4	325	503	11.4	20.8	17.6	58.9	53.2					30.6	26.2		8.0	6.3	11.0	32.3	
	21.0																								
F.	34.3	21.35	22.50	94.7	15.05	17.65	245	379	9.85	18.00	15.25	51.10	46.15	90.3	43.30	84.7	44.2	26.50	22.65	85.5	6.85	5.45	9.45	28.0	41.5
V	21b.6oz.	22.5	25.6		20.3	23.0	365	450	12.4	21.2	18.6	53.1	50.0					27.3	30.8		8.5	6.6	13.4	33.4	
	24.0																								
F.	35.6	21.75	24.75	87.8	19.65	22.25	344	424	12.00	20.5	18.00	51.50	48.50	94.1	48.50	94.1	48.0	26.50	29.75	112.2	8.15	6.35	13.00	32.4	42.3
VI	31b.5¢	24.9	26.2		18.0	21.6	305	510	11.1	21.1	17.5	59.4	53.3					29.5	29.8		8.9	6.9	12.4	33.3	
	27.7																								
F.	42.5	26.85	28.25	95.1	19.50	23.25	357	596	11.95	22.8	18.85	64.30	57.65	89.6	54.10	84.1	43.8	31.90	32.30	101.1	9.60	7.50	13.35	36.0	42.2
VII	41b.12oz.	23.6	32.4		20.9	26.2	430	563	10.2	20.9	18.6	57.3	53.5					26.6	24.7		10.0	9.4	11.9	31.4	
	31.3																								
F.	46.3	27.70	35.65	77.6	24.45	30.70	590	776	11.85	24.5	21.75	67.10	62.60	93.2	58.55	87.3	53.2	31.1	28.85	92.6	11.65	11.00	13.90	36.8	41.8
VIII	51b.8oz.	28.4	27.4		17.7	26.5	367	610	10.7	23.2	18.0	59.4	56.5					27.3	25.4		10.8	9.1	13.4	34.7	
	31.2																								
F.	47.7	34.40	33.15	103.8	21.35	32.10	539	897	12.95	28.0	21.65	71.85	68.30	95.0	60.55	84.3	46.2	33.0	31.0	93.8	13.05	11.00	16.20	42.0	46.2
IX	51b.10oz.	25.9	25.5		18.6	25.0	365	517	10.8	20.6	19.0	53.5	49.8					29.4	27.0		9.5	8.3	12.4	33.0	
	32.3																								
F.	47.8	34.35	33.85	101.3	24.65	33.30	645	914	14.25	27.3	25.15	71.05	66.25	93.2	66.45	93.4	47.6	39.0	35.75	91.7	12.60	10.95	16.50	43.8	41.2
X	61b.4oz.	27.6	28.8		23.6	25.0	463	623	10.0	21.9	24.7	59.8	56.4					28.4	25.7		9.7	8.6	12.1	34.4	
	32.0																								
F.	47.8	32.90	34.20	96.2	28.10	29.75	656	885	11.85	26.0	29.35	71.15	67.05	94.3	59.50	83.6	48.1	33.8	30.55	90.6	11.55	10.20	14.35	40.9	43.6
XI	51b.3½	28.2	29.8		21.5	24.0	405	657	10.1	22.6	21.6	60.2	54.5					32.0	30.4		8.8	9.4	12.4	33.3	
	32.6																								
F.	48.0	32.95	34.95	94.2	25.20	28.20	559	907	11.90	26.50	25.30	70.60	63.85	90.4	58.70	83.0	49.5	37.50	35.55	94.7	10.30	10.95	14.45	39.1	45.1
XII	51b.15	24.7	27.0		19.5	25.1	384	524	9.3	20.4	20.9	51.0	59.0					27.2	27.3		9.0	8.6	12.3	30.0	
	31.3																								
F.	48.2	30.65	33.45	91.7	24.20	31.10	592	807	11.60	25.3	25.90	63.35	60.80	96.0	62.10	98.0	52.8	33.7	33.90	100.5	11.20	10.65	15.20	37.2	40.7
XIII	51b.12½	27.8	25.0		20.2	25.3	400	544	10.5	20.4	18.1	55.5	51.5					25.7	24.6		9.2	8.1	11.5	34.8	
	32.0																								
F.	49.3	35.90	32.25	111.2	26.10	32.60	669	910	13.45	26.3	23.35	71.60	66.45	92.8	64.55	90.2	45.0	33.2	31.80	95.7	11.90	10.40	14.80	44.8	40.7
XIV	±6½ lb.	26.1	27.1		22.9	24.0	432	556	11.3	23.0	24.0	58.4	54.1					27.0	26.3		8.5	7.4	12.0	34.9	
	34.2																								
F.	49.3	29.30	30.45	96.2	25.75	27.00	545	702	12.70	25.8	27.00	65.65	60.75	92.5	56.20	85.6	46.4	30.3	29.55	97.5	9.55	8.35	13.45	39.2	45.9
XV	71b.+	25.9	26.0		21.7	25.9	441	530	7.8	21.0	21.0	57.4	57.2					31.5	28.0		8.2	7.9	10.6	32.2	
	34.0																								
F.	50.8	33.25	33.50	95.0	27.90	33.25	729	876	10.00	27.00	27.00	73.75	73.50	99.6	64.25	87.0	45.4	40.50	36.00	88.8	10.60	10.20	13.60	41.3	42.0

APPENDIX 5 (Continued)

No. and sex	Weight 1. C.B. length 2. C.H. length	Conjugata vera	Transverse of brim	Brim index	Inter-ischio-spinal	Pubosacral	Outlet area	Brim area	Symphyseal height	Depth pelvic basin(D.P.B.)	Intertuberal	Intercristal (I.C.)	Interspinous (I.S.)	I.S./I.C.index	Maximum height (M.H.)	M.H./I.C.index	T.B./I.C.index	(Sacro-sciatic notch) Length sacrum	Breadth sacrum	Sacral index	Greatest width	Least width	Length: spine to notch	Diagonal conj.	D.P.B./M.H. index
XVI	61b.11oz 33.8	25.0	29.0		21.3	23.1	387	571	10.1	23.0	19.8	62.8	59.3					30.5	28.4		8.2	6.3	12.9	32.5	
F.	51.7	29.65	34.45	85.9	25.25	27.40	544	803	12.00	27.3	23.45	74.55	70.45	94.4	59.30	79.6	46.2	36.2	32.35	89.5	9.70	7.45	15.35	38.5	46.0
XVII	‡7½lbs. 32.6	25.0	27.0		18.9	24.7	367	528	10.3	22.4	18.4	59.6	56.2					26.2	27.7		10.1	10.1	12.6	32.2	
F.	51.8	31.95	34.60	92.3	24.25	31.65	603	868	13.20	28.6	23.50	76.35	72.00	94.3	64.05	83.8	45.3	33.6	35.45	105.5	12.90	12.90	16.10	41.3	44.6
XVIII	71b.6oz 36.6	25.7	28.0		19.5	25.5	390	578	11.7	21.4	16.7	58.4	54.4					29.1	31.7		9.1	9.1	12.4	32.9	
F.	53.4	34.40	37.40	89.3	25.95	34.05	695	1013	15.60	28.5	22.30	77.95	72.70	93.3	66.75	85.6	48.0	38.9	42.15	108.1	12.05	12.05	16.60	43.9	42.7
XIX	----- 10.6	21.1	25.4		14.3	18.9	211	418	12.7	20.2	19.2	57.5	57.3					30.8	31.1		6.8	3.9	13.8	29.8	
M.	15.1	8.15	9.75	83.6	5.50	7.25	314	634	4.90	7.8	7.4	22.15	22.10	99.8	19.30	87.1	44.0	11.85	12.00	101.2	2.55	1.45	5.25	11.5	40.4
XX	----- 16.7	25.1	27.5		18.9	21.9	323	540	11.9	20.6	18.3	57.7	55.0					28.6	26.5		8.0	8.7	12.5	33.1	
M.	26.0	15.75	17.25	91.3	11.85	13.75	128	214	7.50	13.0	11.45	36.15	34.70	82.8	31.45	87.0	47.7	18.0	16.70	92.7	5.05	5.45	7.90	20.9	41.3
XXI	21b.½oz 22.5	22.6	25.3		19.0	22.1	327	450	11.6	21.8	16.4	55.1	50.8					30.6	25.9		9.3	9.0	12.7	30.1	
M.	35.9	20.80	23.15	89.8	17.35	20.25	276	379	10.70	20.0	15.05	50.55	46.65	92.3	45.85	90.7	45.8	28.05	23.80	84.8	8.45	8.30	11.65	27.7	43.6
XXII	41b.4oz 26.2	26.2	25.5		17.8	23.2	325	529	11.5	20.7	20.4	57.2	53.5					32.8	26.2		8.6	9.1	14.8	37.0	
M.	43.8	27.50	26.75	102.8	18.60	24.25	355	579	12.00	21.75	21.25	59.90	56.00	94.8	52.25	87.3	44.7	34.30	27.50	80.1	9.00	9.50	15.50	38.7	41.6
XXIII	31b.12 30.0	29.0	26.2		20.3	22.7	360	596	11.8	22.1	18.0	56.8	55.9					28.4	23.2		9.8	9.1	11.4	35.8	
M.	44.2	31.75	28.80	110.2	22.25	24.85	435	719	12.95	24.3	19.80	62.35	61.40	98.4	54.90	88.0	46.2	31.2	25.45	81.5	10.80	10.00	12.50	39.4	44.2
XXIV	51b.9oz 32.3	27.0	27.9		17.8	24.0	334	590	11.8	21.7	18.2	56.8	53.4					26.1	25.4		9.1	8.5	12.9	32.2	
M.	50.0	34.75	36.00	96.4	22.90	30.95	557	983	15.20	28.0	23.50	73.40	68.90	93.8	64.55	87.9	49.0	33.6	32.80	97.5	11.65	10.90	16.55	41.7	43.3
XXV	61b.1oz 34.0	27.5	27.6		16.2	22.9	293	596	10.2	22.6	16.6	63.4	57.5					28.3	27.5		8.5	8.5	12.2	33.8	
M.	51.8	34.40	34.45	99.8	20.30	28.70	458	933	12.80	28.3	20.65	79.25	71.95	90.7	62.60	78.9	43.4	35.4	34.40	97.1	10.60	6.85	15.25	42.3	45.2
XXVI	61b.3oz 34.0	25.8	29.6		19.4	23.3	354	595	12.2	22.1	18.8	60.6	58.2					26.6	29.8		9.2	8.0	11.6	32.8	
M.	51.8	32.65	37.60	86.8	24.55	29.55	572	965	15.50	28.0	23.85	76.85	73.90	96.1	63.55	82.6	48.9	33.8	37.80	111.8	11.65	10.20	14.70	41.7	44.0
XXVII	71b.0oz 34.3	25.6	30.5		19.9	20.9	326	613	12.0	21.7	18.2	59.4	55.8					33.0	32.8		8.3	7.2	13.5	32.9	
M.	52.1	31.90	38.00	83.9	24.80	26.00	508	453	14.90	27.00	22.60	74.20	69.50	93.7	62.30	84.0	51.2	41.20	40.90	99.3	10.40	9.00	16.80	41.0	43.3
XXVIII	61b.14 34.4	24.8	30.4		17.8	22.9	382	596	11.5	21.8	16.7	58.4	56.3					28.0	29.5		7.2	6.3	11.9	32.8	
M.	52.4	34.65	42.5	81.6	24.80	32.00	625	1159	15.95	30.5	23.30	81.60	78.60	96.3	69.75	85.4	52.1	39.0	41.15	105.3	10.00	8.75	16.55	45.8	43.7
XXIX	61b.8½ 35.7	24.8	28.2		20.2	24.6	391	550	11.4	22.2	21.2	57.0	49.8					25.0	28.8		9.8	8.0	12.4	35.6	
M.	53.5	32.70	37.25	87.7	26.60	32.50	680	960	15.10	29.30	28.00	75.30	65.80	87.4	66.00	87.6	49.4	33.00	38.00	115.1	12.85	10.60	16.40	47.0	44.3
XXX	71b.5oz 34.0	26.9	28.2		20.0	24.2	379	591	10.4	20.9	19.0	57.4	53.1					29.2	27.9		8.7	8.0	10.6	34.2	
M.	53.6	33.35	35.00	95.2	24.90	30.05	588	917	12.95	26.0	23.60	71.40	65.95	92.3	62.20	87.1	49.1	36.3	34.65	95.4	10.65	9.90	13.15	42.6	41.8

APPENDIX 6. Analysis of the dimensions of the series of Bantu pelves. Some comparisons have been made with Nicholson's rural English series (250 or 350) and Ince & Young's London series (375 or more).

Pelvic dimensions	Origin	No. of observations	Mean	Standard deviation.	Coefficient of var.	Range
Intercristal (cm.)	B. Male	100	24.29 ± 0.16	1.63	6.7	20.1-27.8
	B. Female	67	23.80 ± 0.17	1.40	5.7	20.9-26.5
Interspinous (cm.)	B. Male	100	21.68 ± 0.17	1.74	8.0	17.3-25.7
	B. Female	67	20.86 ± 0.19	1.60	7.7	17.0-23.8
External oblique (cm.)	B. Male L.	50	18.74 ± 0.14	0.97	5.2	16.9-21.1
	B. Male R.	50	18.67 ± 0.15	1.04	5.9	16.5-20.8
	Z. Male L.	50	19.18 ± 0.15	1.09	5.3	16.9-22.5
	Z. Male R.	50	19.18 ± 0.14	0.98	5.1	17.2-21.6
	B. Female L.	67	18.88 ± 0.11	0.88	4.7	16.2-20.6
	B. Female R.	67	18.93 ± 0.11	0.89	4.7	16.3-20.8
Maximum height of pelvis (cm.)	B. Male L.	100	19.74 ± 0.11	1.09	5.1	16.9-22.5
	B. Male R.	100	19.83 ± 0.11	1.08	5.1	17.1-22.8
	B. Female L.	67	19.08 ± 0.11	0.92	4.8	17.3-21.6
	B. Female R.	67	18.99 ± 0.11	0.88	4.6	17.0-20.9
Depth of pelvic basin (cm.)	B. Male L.	100	9.31 ± 0.05	0.55	5.9	7.7-10.5
	B. Male R.	100	9.27 ± 0.05	0.55	5.9	7.7-10.5
	B. Female L.	67	8.75 ± 0.06	0.51	5.9	7.9-10.9
	B. Female R.	67	8.77 ± 0.07	0.56	6.3	7.9-11.1
	B. Antenatal	87	8.77 ± 0.06	0.58	6.6	7.6-10.2
Length of symphysis pubis (cm.)	B. Male	100	3.58 ± 0.03	0.28	7.8	2.8- 4.4
	B. Female	66	3.45 ± 0.04	0.30	9.7	2.7- 4.5
	B. Antenatal	87	3.27 ± 0.04	0.40	12.2	2.5- 4.2

Intertuberal diameter (cm.)	B. Male	100	8.13± 0.11	1.12	13.8	5.5-10.3
	B. Female	67	10.20± 0.16	1.30	12.6	6.6-13.2
	B. Antenatal	87	11.47± 0.12	1.15	10.0	8.5-14.0
	London E.	474	10.90± 0.03	0.7	6.4	8.6-13.3
Width of sacro-sciatic notch (cm.)	B. Male L.	100	3.69± 0.05	0.53	14.4	2.5- 5.0
	B. Male R.	100	3.69± 0.05	0.53	14.4	2.1- 4.8
	B. Female L.	65	4.92± 0.11	0.88	17.8	2.8- 6.9
	B. Female R.	65	4.94± 0.10	0.82	16.6	3.0- 7.0
Conjugata vera (cm.)	B. Male	100	10.33± 0.11	1.06	10.2	7.9-12.8
	B. Female	66	10.76± 0.10	0.80	7.6	9.1-12.6
	B. Antenatal	100	10.59± 0.08	0.81	7.7	8.2-12.5
	Rural E.	350	11.64	1.05	9.0	8.35-14.35
	London E.	509	11.83± 0.04	1.0	8.5	8.7-15.0
Transverse of brim (cm.)	B. Male	100	11.26± 0.08	0.80	7.1	9.5-13.3
	B. Female	67	11.96± 0.10	0.80	6.5	9.8-13.8
	B. Antenatal	100	11.34± 0.08	0.78	6.9	9.15-13.0
	Rural E.	350	13.23	0.76	5.8	11.0-16.0
	London E.	509	13.06± 0.03	0.7	5.4	10.9-15.4
Oblique of brim (cm.)	B. Male L.	100	11.56± 0.07	0.74	6.4	9.8-13.4
	B. Male R.	100	11.48± 0.07	0.75	6.5	9.7-13.3
	B. Female L.	67	12.13± 0.08	0.70	5.4	10.2-13.5
	B. Female R.	67	12.27± 0.08	0.70	5.4	10.3-13.7
Antero-posterior of cavity (cm.)	B. Male	100	10.48± 0.10	0.98	9.4	7.7-13.0
	B. Female	67	11.75± 0.10	0.80	6.7	10.0-13.5
Diagonal conjugate (cm.)	Bas. Male	50	12.12			
	Z. Male	50	11.86			
	B. Female	66	12.26± 0.10	0.80	6.5	10.6-13.9
True area of inlet (sq.cm.) by planimeter	B. Male	100	99.35± 1.32	13.16	13.2	70.4-140.2
	B. Female	51	113.38± 1.31	9.29	8.2	94.0-135.8

Calculated area of inlet (sq.cm.)	B. Female	66	101.23± 1.25	10.17	10.1	74.75-126.8
	B. Antenatal	100	99.33± 1.21	12.09	12.2	66.6 -127.6
	Rural E.	350	121.0	12.9	10.7	86.0 -162.0
	London E.	375	126.8 ± 0.66	12.8	10.1	95.0 -165.0
Transverse diameter of cavity(cm.)	B. Male	100	10.91± 0.07	0.67	6.1	9.3 - 12.1
Area of plane of cavity (sq.cm.)	B. Male	100	89.56± 1.22	12.24	13.7	58.8 -113.2
	B. Female	67	111.78± 2.78	11.4	10.2	85.2 -135.2
	B. Antenatal	100	93.75± 1.26	12.58	13.4	60.0 -121.9
Inter-ischio-spinal diameter (cm.)	B. Male	100	8.05± 0.07	0.72	8.9	6.2 - 9.7
	B. Female	66	9.70± 0.13	1.00	10.3	6.5 - 12.4
	B. Antenatal	100	10.47± 0.09	0.93	8.9	7.45- 12.58
	Rural E.	250	10.54	0.77	7.3	8.25- 12.75
	London E.	376	9.95± 0.04	0.71	7.1	7.5 - 11.5
Pubosacral diameter (cm.)	B. Male	100	10.05± 0.07	0.73	7.3	8.3 - 11.7
	B. Female	66	11.65± 0.10	0.80	6.9	10.0 - 13.5
	B. Antenatal	65	12.20± 0.17	1.33	10.9	9.1 - 15.7
	Rural E.	250	13.01	0.96	7.4	10.3 - 16.0
	London E.	376	11.97± 0.04	0.86	7.2	9.5 - 14.5
Area of outlet (sq.cm.)	B. Male	100	63.27± 0.82	8.24	13.0	43.8 - 88.4
	B. Female	65	88.80± 1.52	12.30	13.8	58.1 -116.9
	B. Antenatal	65	100.12± 1.88	15.12	15.1	64.5 -131.0
	Rural E.	250	106.7	11.9	11.2	76.0 -142.0
	London E.	376	93.7± 0.54	10.4	11.1	65.0 -120.0
Anterior sagittal diameter of outlet (cm.)	B. Female	66	7.03± 0.08	0.7	9.4	5.6 - 8.5
Post-sagittal diameter of outlet (cm.)	B. Female	66	5.99± 0.13	1.1	17.6	3.5 - 8.4

Sum of post-sagittal and intertuberal diameters (cm.)	B. Female	66	16.2			

		SACRUM				
Anterior straight breadth (cm.)	B. Male	100	10.44± 0.07	0.68	6.8	8.8-11.9
	B. Female	66	10.66± 0.08	0.64	6.0	9.0-12.7
Midventral straight length (cm.)	B. Male	100	10.35± 0.11	1.10	10.6	7.5-13.0
	B. Female	66	9.97± 0.13	1.07	10.7	7.6-12.8
Midventral curved length (cm.)	B. Male	100	11.20± 0.12	1.23	11.0	7.7-14.0
	B. Female	66	10.85± 0.15	1.22	11.2	8.5-13.8
A.P. of lumbosacral joint (S1)(cm.)	B. Male	100	3.16± 0.03	0.30	9.5	2.0- 3.8
	B. Female	50	2.91± 0.05	0.34	11.7	2.3- 3.6
Transverse of lumbosacral joint (S1)(cm.)	B. Male	100	5.04± 0.04	0.44	8.7	3.7- 6.4
	B. Female	50	4.74± 0.08	0.54	11.4	3.4- 5.6
Length of auricular surface (cm.)	B. Male L.	96	5.94± 0.06	0.59	9.9	4.2- 7.2
	B. Male R.	96	5.95± 0.06	0.59	9.9	4.2- 7.2
	B. Female L.	50	5.64± 0.08	0.59	10.5	4.5- 7.0
	B. Female R.	50	5.60± 0.09	0.63	11.2	4.1- 6.9
Width of auricular surface (cm.)	Z. Male L.	50	3.34± 0.09	0.67	20.1	2.0- 5.3
	Z. Male R.	50	3.33± 0.08	0.60	18.0	2.0- 4.8
	Bas. Male L.	46	3.07± 0.10	0.66	21.5	1.7- 4.4
	Bas. Male R.	46	3.03± 0.11	0.74	24.4	1.8- 4.8
Area of auricular surface (sq.cm.) by planimeter.	B. Male L.	96	11.21± 0.20	2.04	18.2	7.0-18.2
	B. Male R.	96	11.43± 0.19	1.87	16.4	6.6-17.3
	B. Female L.	50	10.72± 0.23	1.62	15.1	7.8-13.3
	B. Female R.	50	10.68± 0.25	1.77	16.6	7.5-14.3

INDICES						
Interspinal / Intercristal Index	B. Male	100	89.52 ± 0.38	3.85	4.3	79.0-100.8
	B. Female	67	87.70 ± 0.45	3.72	4.2	76.0- 93.9
Height / Breadth Index	B. Male	100	81.70 ± 0.44	4.36	5.3	74.3- 97.8
	B. Female	66	80.47 ± 0.47	3.82	4.7	73.3- 88.7
Pelvic brim index	B. Male	100	91.56 ± 0.91	9.11	9.9	70.2-117.0
	B. Female	65	90.35 ± 1.02	8.20	9.1	69.6-104.4
	B. Antenatal	100	93.6 ± 0.72	7.2	7.7	79.7-121.2
	Rural E.	350	88.3	9.4	10.7	65.5-113.5
	London E.	509	90.8 ± 0.36	8.2	9.1	64.0-115.0
S A C R U M						
Sacral index / Straight breadth / Straight length	B. Male	100	102.2 ± 1.04	10.41	10.2	78.6-130.9
	B. Female	67	107.9 ± 1.35	10.90	10.1	82.0-146.2
	London E.	489	108.9 ± 0.43	9.6	8.8	82.0-141.0
Curvature index / Straight length / Curved length	B. Male	100	92.46 ± 0.44	4.37	4.7	80.5-100.0
	B. Female	67	91.87 ± 0.44	3.59	3.9	83.6-100.0
Sacral base index (S).	Z. Male	50	63.72 ± 0.71	5.04	7.9	51.7- 75.6
	Bas. Male	50	61.44 ± 0.67	4.74	7.7	50.0- 71.7
	B. Female	50	62.12 ± 0.84	5.92	9.5	50.0- 76.3
Index: Length auricular surface/ Midventral curved length.	B. Male L.	96	53.25 ± 0.63	6.15	11.6	41.3- 77.9
	B. Male R.	96	52.85 ± 0.60	5.86	11.1	39.3- 72.7
	B. Female L.	49	52.10 ± 0.86	6.09	11.7	41.1- 73.0
	B. Female R.	49	51.79 ± 0.76	5.37	10.4	41.1- 66.3

		INDICES (continued)				
Width / Length Index of auricular surface.	Bas. Male L.	46	52.72± 1.64	11.13	21.1	27.2-68.3
	Bas. Male R.	46	54.35± 1.61	10.91	20.1	30.5-75.0

B. = Bantu. Bas. = Basuto L. = Left R. = Right Z. = Zulu