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ACKNOWLEDGMENTS

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SOME ANTHROPOLOGICAL AND CLINICAL ASPECTS OF NASAL MORPHOLOGY

by

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In the human species as in all the animal kingdom considerable individual variation is encountered, differences being seen in morphology, size, activity, and in reaction to factors in the environment. One such variation in reaction manifests itself in differing susceptibility to disease and to the effects of injury; an epidemic causing one individual to succumb while another escapes, one dies from a trivial electric shock while another survives contact with a high voltage. The factors known to be involved in this variability of response include race, heredity, nutritional state, climate, social environment, psychological outlook and bodily morphology. The gross anatomy of certain organs of the body such, for example, as the endocrine glands has little or no relation to their functional efficiency, so that the thyroid gland would probably produce its secretion equally well were it of a different shape or situated in another part of the body. Other systems and organs, such as the respiratory tract, depend for their efficient function upon their precise morphology and situation, the design of this particular system enabling it to condition the inspired air and transport it to the pulmonary alveoli where microanatomy then becomes of importance. The greater part of this conditioning of the inspired air takes place in the nasal cavities, whose function ensures that clean, warm and humidified air comes in contact with the delicate alveolar epithelium, and also recovers a proportion of the water vapour and heat from the expiratory stream. Many workers have contributed to our knowledge of this most important mechanism and their findings will be considered in detail when the results of the present study are discussed later in this thesis. Since this function of the nose depends to a large extent on the area of mucosa exposed to the air stream and to the pattern of flow through the nasal cavities, it is likely that morphological factors affecting the extent and configuration of this area will have a considerable effect on the physiological efficiency of the nose. The organs and systems of the body are possessed of a considerable functional reserve enabling the individual to adapt to a wide range of working conditions. As the limits of this reserve are approached efficiency is liable to decrease so that additional adverse factors become likely to precipitate a breakdown of the mechanism. It is therefore not inconceivable that where morphology of the nasal cavities in a particular subject renders them capable of a function less than optimal, added adverse factors may result in disease.

Such a concept would appear to be supported by clinical experience which suggests that there may indeed be a correlation between nasal morphology and the susceptibility to certain nasal disorders; previous studies (Jarvis 1963, 1965) having shown that the incidence of vasomotor rhinitis is strikingly different among members of various racial groups even when all are living in the same climatic environment. While Ordman (1958) has noted the effect of climate itself on this disorder, racial differences of nasal architecture may be a factor which permits certain groups better to withstand variations of temperature and humidity. The striking difference in nasal morphology between the various races has long been recognised, and anthropologists have included nasal dimensions routinely in the measurements that they have made. Topinard (1878) in his treatise on Anthropology quotes Broca as stating that the nasal index is one of the best for distinguishing the various races of mankind. Since then many studies of racial types from every part of the world have been undertaken in which nasal dimensions both in the living subject and in skulls have been recorded. Examples of such are the papers by Eichholz (1892), Leys and Joyce (1913), Thomson and Buxton (1923), Davis (1932), Cameron (1934), Johnson (1937), Galloway (1941), Trevor (1950,1958), Weiner (1954), Hertzberg et al (1954), and Talbot and Mulhall (1962). Besides putting these measurements on record, some of these authors have used them to study the relationship between nasal morphology and climate (Thomson and Buxton; Davis; Weiner),racial origins

(Galloway), and factors relevant to aviation (Hertzberg). More recently surgeons have become interested in nasal measurements in planning corrective surgery for nasal deformities, realising that in reconstructing a nose it should be made to conform to the norm for its particular type. Cottle (1953) has developed the concept of "nasal disharmony" and believes that abnormalities in the balance between the different dimensions of a nose may result in functional disorders, and that the relation between these measurements differs in the various racial groups. Williams (1956) has drawn on the work of Cottle and also emphasises the importance of distinguishing between the European and Negro type of nose when operating upon this organ. Bhoo-Chai (1964) works in Malaysia and is interested in remodelling both the nasal root and tip and comments upon the marked difference in form shown by orientals compared with the European. He uses a number of landmarks as guides for his operative procedures, one of which he has termed the "golden point" which is very close to the "sellion", which will presently be defined. Rozner (1964) has drawn attention to the disturbances of function resulting from a narrow bony inlet and has outlined the principles of operative correction, while Senechal et al.(1962) have given special attention to the root of the nose, and Figs.4 and 5 of their paper illustrate the variations in profile that may be encountered in this region. While these last workers are interested as reconstructive surgeons, variations in this area also affect the location of the upper point from which nasal height is measured, so that a study of the nasal root is relevant to the investigations described in this thesis.

The present investigation was undertaken therefore as an attempt to discover to what extent nasal morphology might be a factor in the differing incidence of nasal disease. The architecture of the nose is clearly only one of many possible factors that may be involved, and even where there may appear to be an association care must be exercised and other possibilities excluded before such morphological differences can be accepted as of etiological significance. The population of the western part of the Cape Province of the Republic of South Africa is particularly well suited to an investigation of this nature, for it contains many racial types giving a wide range of nasal forms for study. The patients attending the Groote Schuur Hospital are for record purposes classified as White, Coloured, Asian, and Bantu. The White population itself is derived from several different origins - Dutch, Huguenot, British, Jewish, and other European countries. The Cape Coloured in particular are highly heterozygous, being a mixture of European, Malay, Indonesian, Bushman, and Hottentot. The Asians came from India, Malaysia and Indonesia, while the Bantu are predominantly of the Xhosa tribe who have come from their ancestral homelands in the north to seek employment in the city. The students in the Medical School provided many of the normal controls while those of them found to be suffering from nasal disorders were added to the appropriate group of patients.

In planning the details of the investigation consideration was first given to the problem of selecting the measurements best suited to the calculation of indices that would reflect the efficiency of the nose as an air conditioning mechanism. It was realised that a large number of subjects would have to be examined, measured and recorded, so that the special measurements must be limited to those that could be made during routine out-patient consultation and with the minimum of disturbance to the patient. Once the dimensions to be recorded had been selected and the indices to be extracted approved, the technique of taking the measurements was studied in detail and the methods standardised so that consistent results could be obtained and to enable other workers to repeat the investigation if they so desired. The result of the many measurements made are recorded in the Appendix to this thesis, the readings being classified into groups according to race, sex, and clinical condition. Normals were provided by healthy students and patients attending a general E.N.T. department suffering from diseases other than those selected for comparison. Separate records were kept of those found to be suffering from one of the three conditions of vasomotor rhinitis, sinusitis, and atrophic rhinitis. These disorders were selected as being, it was felt, most likely to show a correlation with the architecture of the nasal cavities, but records have been kept of the diagnosis in all patients so that other conditions could be studied if it were felt of value to do so. In the course of the study it became desirable to extend the investigations to include dissecting room cadavers and the collection of skulls available in the Department of Anatomy. Besides the primary objective of the study, several subsidiary objectives emerged and provide information of value in other contexts. Measurements of children were further classified into age groups, enabling information on the growth pattern of the nose to be obtained in the case of the European and Coloured communities.

MEASUREMENTS AND INDICES

The classical anthropometric measure of nasal morphology is the Nasal Index (NI) which is defined as the percentage ratio of the nasal breadth (NB) to the nasal height (NH). This may be determined with precision on the dry skull since the measurements are taken from recognizable bony landmarks, and with rather less accuracy in the living subject. The numerical values obtained by the two methods are different but relatable by formulae such as that worked out by Thomson and Buxton. By means of this index three types of nose may be distinguished, the leptorrhine or narrow nose characteristic of the European races, the mesorrhine found mainly in the Asiatic peoples, and the platyrrhine or broad nose so typical of the indigenous people of Africa and other parts of the world. This index describes the form of the inlet to the nasal cavity which plays an important rôle in the arrangement of the pattern of air flow through the nasal fossae, but it gives no guide to the area of functional mucosa. In order to study other parameters of the nasal dimensions the depth of the nasal cavity is considered important and inclusion of an estimate of this enables both the total mucosal area and the volume of the cavities to be assessed. When a midline saggital section of the nose is examined it can be seen that the respiratory area of the septum, behind the vestibule with its squamous epithelium lining, is roughly a quadrilateral whose height is the distance between the upper surface of the hard palate and the cribriform plate, and whose length is the antero-posterior extent of the hard palate. The lateral wall is complicated by the presence of the conchae making the evaluation of the effective functional area less simple. There is some divergence of opinion regarding the pattern of air flow through the nose, some stating that a considerable part passes lateral to the conchae, while Proetz (1953) as a result of careful studies believes it mostly passes between the conchae and the septum. Although the presence of the conchae possibly doubles the area of the lateral nasal wall, it seems likely that their lateral aspects have less contact with the air stream so that as an approximation it has been assumed that they increase the functional area by 50%. Hence to obtain an index that is related to the total area of respiratory mucosa the septal area is taken and multiplied by five, two for the two sides of the septum and three for the two lateral walls. To this must be added a small factor to include the floor area, although according to Proetz it is not much in contact with the air current in the normal nose. The breadth at the alae is greater than that at the bony aperture, and the breadth includes the thickness of the septum. As an estimate it is felt that about 60% of the alar breadth represents the combined width of the floors of the nasal fossae. The palatal length is therefore multiplied by 60% of the nasal breadth and added. This has been named the Area Index (AI) and while not an accurate estimate of the area, is related to it and of value in a comparative study of this nature. The Area Index is therefore given by the formula:

$$AI = \frac{NH \times PL \times 5 + PL \times NB \times 0.6}{100}$$ (all lengths in mm.)

In a wide nasal cavity there is a greater opportunity for the air to pass without coming in effective contact with the mucosa, the well known difficulty experienced by the sufferer from atrophic rhinitis in expelling the crusts being an example. The volume of the nasal cavity may therefore be of importance leading to the concept of a Volume Index (VI) which is given by the formula:

$$VI = \frac{NH \times NB \times PL}{1000}$$ this again not being an accurate measure of the actual volume, but of value for comparative

purposes. The volume of the nasal cavities is of course greatly affected by the bulk of the conchae and other factors. It has not been considered practicable to assess these under the conditions of the present investigation and they are accordingly ignored.

These then are the indices that have been adopted for evaluation in the present study. The nasal cavities are very complex and irregular spaces, and it may well be that other parameters of their architecture would give measurements and indices that might be more closely correlated with their functional efficiency. But to measure such in clinical practice would be difficult if sufficient numbers of subjects are to be examined to provide figures of statistical significance. Different measurements and indices have in fact been employed by other workers for special purposes such as the "Salience Index" and "Tip Index" (Cottle); Nose Protrusion and Nasal Root Breadth (Hertzberg); Naso-Facial Angle and Naso-Frontal Depression (Senechal). Many of these are primarily of importance to the reconstructive surgeon and not particularly relevant to the present investigation, although the Tip Index, like the Nasal Index, is of considerable anthropological interest. Hertzberg's measurements were undertaken to assist in the design of masks and space suits for aviators and astronauts.

REFERENCE POINTS

The decision having been reached regarding the nasal measurements most appropriate to the investigation, the definition of the points from which these measurements are to be taken requires detailed consideration. A perusal of the published series soon makes it apparent that much confusion exists regarding the identification of the points used in nasal measurements, and if the present work is to be of permanent value it is essential that no ambiguity is allowed in the description of the points employed. Only then can the results obtained be used as a basis for the work of other investigators. The difficulties that may thus arise will become apparent later when an attempt is made to compare the findings of the present investigation with the published figures of others. At this stage it will be sufficient to give two quotations that illustrate some of the dangers that must be avoided in this type of work.

Trevor (1947) states:

> "For most metrical characters, the various series considered in this study seem to be comparable, but the mean facial and nasal heights of the Southern Bushmen and the Hottentots are so much less than those of the Northern Bushmen, Sandawe, Nyaturu and Dahomeans that it may be supposed that Dart and Schultze measured them in a different way from Lebzelter, Herskowits and myself. Professor Dart did not describe his technique in the paper he published in 1937 but possibly employed what Bunak (1941) has termed the "sellion" or the most depressed part at the root of the nose, as his upper terminal.

> This is the "nasion" of Topinard (1891) and the British Association Committee (1908) and still has several advocates (e.g. Speiser, 1928); Buxton, Trevor and Blackwood (1939). Schultze claimed that his facial and nasal heights had been taken from the Stirn-Nasennaht, a statement which he was kind enough to confirm in a conversation at Marburg in 1946. Nevertheless his values for these characters would appear to agree more closely with facial and nasal heights from the sellion (GH and NH) than from the nasion (GH' and NH'). While owing to the uncertainty involved it has been reluctantly decided to omit them and the indices of which they are components from the comparison of means in so far as the Southern Bushmen and the Hottentots are concerned, there is no equally substantial reason why they should not be included in that of the variabilities".

or again Goldstein (1936) writes:

> "The question of the reliability of the method when making anthropological observations on the living, and especially the face, is always a sore one ——— the classic example is the nasion, which is difficult enough to ascertain in many adults, and is specially liable to incorrect determination in the infant and young".

A number of authors and committees have laid down carefully defined criteria for the taking of anthropological measurements, among which may be cited Martin (1928) and Buxton and Morant (1933), but even so it is clear that different workers use the same term to mean different things, and the only safe method to follow is to give a precise definition of every point and measurement.

Much of the original anthropometric work was done on the dry skull, where it is comparatively easy to locate and define bony landmarks. When examining living subjects, it was natural that an attempt should be made to employ the same bony points, in spite of the difficulty of locating them with precision when covered by soft tissues; the quotation from Trevor has however already drawn attention to the type of confusion that may result from proceeding in this manner. The classical point which forms the upper extremity of the measurement of nasal height is termed the nasion, and is a well defined and easily located point on the majority of skulls. The nasion is the point where the mid-saggital plane cuts the fronto-nasal suture, and except in a few instances where the suture is irregular or obliterated, its location presents no difficulty. The lower point is the sub-nasal, and here there is opportunity for considerable variation. Some observers use the base of the nasal spine, and others the point where the tangent to the lower borders of the piriform aperture cuts the mid-saggital plane. Some consistently measure to the left side, others take the average of the two sides. Both Morant (1926) and Hooke (1926) measured to the base of the nasal spine and designated the height so measured as NH', using the symbol NH for that to the average of the lower borders of the right and left piriform aperture, stating that this last measure is 0.9 mm. greater on the average. Another difficulty encountered in this region, especially in the non-european races,

is that the lower margin of the piriform aperture is not sharp, but shelves away as a double margin containing the so-called "simian groove". Figs. 1 and 2 picture a European skull and a Cape Coloured skull respectively, the latter exhibiting a well marked simian groove. Wood-Jones (1931) comments on this in his study of the skulls of the prehistoric inhabitants of Guam, making the additional observation that skulls not showing this feature were all female. Krogman (1932) also found a similar condition to be present in 16% of male and only 3% of female Australian skulls. He calls it a "fossa prenasalis" following the nomenclature of Martin (1928) who illustrates the variations found in this region in his Fig.432. In the most pronounced examples of this condition even the lower margin of this fossa is absent, the groove shelving away rather indefinitely into the anterior surface of the maxilla, a condition named by Martin the "sulcus prenasalis".
Schaeffer (1920) also comments on the fossa prenasalis stating that it is a feature found nearly always in the infant and persisting to adult life in many of the "primitive" races.
In the present study the presence of a fossa prenasalis was noted in 12 out of 55 male skulls and in 9 out of 41 female skulls of Coloured individuals; a significant sex difference thus being absent in this race group. When such a fossa is encountered it renders the definition of the lower point for nasal height more difficult, the floor of the nose often being at a considerably higher level than the edge of the

Fig. 1. European Skull showing sharp Narial Margins.

Fig. 2. Coloured Skull showing Fossa Prenasalis and lateral grooves.

piriform aperture in sharp distinction to the situation in the European type of skull. Under these circumstances the level of the nasal floor has been taken, a procedure also advocated by Hrdlicka (1952), and logical in the present study since the level of the floor is more relevant to the functional aperture of the nose.

Nasal breadth is the maximum breadth of the piriform opening and normally presents no ambiguity, although occasionally a fossa prenasalis is continued round the sides of the opening, so that it is narrower deeper in than at the surface. Here again the smaller deeper dimension had been taken, and the skull shown in Fig.2 has both a fossa prenasalis and these lateral grooves. Where the edge of the bone is thin and sharp it is liable to fracture, and due allowance must be made for this if it is suspected to have occurred. The widest part of the aperture is usually just below the line of attachment of the inferior concha.

The length of the hard palate again is a measurement for which several alternative reference points have been used by different workers. Most agree in employing as the anterior point the place of intersection between the mid-saggital plane and a tangent to the hinder margins of the sockets of the central incisor teeth. For the posterior point variations include the tangent to the posterior concave margins of the hard palate, the base of the posterior nasal spine and the tip of this spine. Eichholz however has taken as his anterior point the summit of the eminence between the central incisor teeth and as his posterior the level of the posterior extent of the palatal process of the maxilla; a procedure that renders his figures not directly comparable to those of the present study in which the first of the above alternatives has been used. Where the tooth sockets have been absorbed, the most prominent ridge on the edentulous alveolus has been taken, an examination of this area having indicated that this closely corresponds to the former position of the hinder edge of the socket.

In the living subject, as has already been noted, all these measurements become less well definable both because underlying bony points are not easily located and because of the varying thickness of the soft tissues. While it is understandable that workers on the living subject should have attempted to measure from the accepted craniometric points, it will be seen that this practice has in fact led to considerable difficulty and confusion. Accordingly the present investigation has not adhered to bony points where it has been felt that alternatives exist that are simpler of determination and give information that is at least as good for the purposes of this study.

The difficulty of locating the nasion in the living has been admitted by many investigators. Hrdlicka (1920) states that the upper point chosen from which to measure nasal height should correspond as closely as possible to the anatomical nasion, and that in a proportion of cases it can be identified by palpation using the finger nail, but that in a majority its position must be estimated from knowledge gained from the study of skulls and dissecting room material. Davenport (1939) comments on this procedure advocated by Hrdlicka and states that it is "quite useless". He agrees regarding the difficulty experienced in locating the nasion in the living, giving as an example the figures of Schwerz (1910) whose values for nasal height are at least 3 mm. greater and the nasal index correspondingly lower than his, due to a difference in the location of this point. Connolly (1926) admits that it is difficult to locate the nasion in the living and estimates its position to be a point 10-13 mm. below the glabella or 8-10 mm. below the mid-orbital point. Experience in the present study suggests that the glabella itself may be an ill-defined point. Ashley-Montagu (1935) also admits this difficulty and uses the superior palpebral sulcus as his guide to the level of the nasion. Oetteking (1931) states that the determination of the site of the nasion in the living is exceedingly difficult and suggests a level mid-way between the supraorbital margin and the lacrimal caruncle as a guide to its position. The remarks of Goldstein on this subject have already been noted.

In view of the opinions of these workers and of the fact that an error of estimating the position of the nasion of only one millimeter affects the nasal index by at least two, the question of abandoning the use of the nasion in favour of an alternative more easily determined point was given serious consideration; it being realised that nasal height in the present investigation is relevant only as it indicates the vertical extent of the functional area of the nasal cavity. It was realised that the employment of such an alternative point would create problems when the figures derived from the present study came to be compared with those of previous workers, and a means of conversion from one set of indices to the other would need to be devised. By means of such a conversion formula it might indeed be found possible to determine if a previous investigator had in fact located the nasion correctly.

An alternative to the nasion does exist, and has been used by a number of workers as has already been indicated in the quotation from Trevor. He defined the sellion as the deepest point in the mid-saggital plane of the depression at the root of the nose. Davies appears to have used the same point, and Hertzberg and his associates have used the sellion in a large series of measurements made on American air force personnel, and they illustrate their method of applying the calipers on page 62 of their paper. Since the sellion is not defined in terms of a hidden bony landmark, but by a clearly visible external feature, it appeared to be highly suitable for the present study provided that it was at least as relevant as the nasion as a point from which to measure the functional dimensions of the nose. Before adopting this alternative a study was initiated to determine the relation of the sellion to the anatomical nasion and to evaluate its significance as an indication of the roof of the nasal cavity. The material for this investigation consisted of over 100 cadavers under routine dissection in the Department of Anatomy and a collection of over 100 skulls that had been derived from previously dissected cadavers. It was noted that Todd (1925) had stated that the process of embalming did not complicate the recognition of subcutaneous bony points, but, as will be seen, subsequent experience has not entirely confirmed his contention, making necessary a further study to determine the changes induced by embalming and to deduce a correction factor to apply to cadaver measurements to make them conform to those made on the living subject. The full results of this cadaver study will be given later, but the important conclusion was reached that the position of the sellion is lower than that of the nasion by an average of 5 mm. in the leptorrhine and 6 mm. in the subjects of higher nasal index after compensation has been applied to correct changes due to embalming. The procedure adopted was to locate and mark the sellion in each subject after which a short vertical incision was made down to the bone to expose the fronto-nasal suture and so find the anatomical nasion.

The distance from this to the previously marked sellion was measured, and the usual nasal height and breadth measurements were taken at the same time. Two nasal heights were thus available, one to the sellion and the other to the nasion, so that two versions of the nasal index could be calculated.

The skull collection was next examined after it had been observed that in a mid-line saggital section the cribriform plate, the roof of the nasal cavity, when projected to the surface parallel to the Frankfurt plane (which itself is closely parallel to the nasal floor) marks a point on the nasal bones that is almost always considerably lower than the nasion. Two skulls have been prepared to show the level of the cribriform plate and its surface projection which are illustrated in Figs. 3 and 4. It is now apparent that the anatomical nasion is not at the level of the roof of the nasal cavity so that the need to employ it ceases to be essential in the present study. It was therefore decided to define as a new point the projection of the centre of the cribriform plate of the ethmoid on the surface of the nasal bone made in a line parallel to the Frankfurt plane, the designation of "Cribrion" for this new point being suggested. Two methods were devised for marking its position and are shown in Fig. 5, the second being for use in skulls where the calvarium has not been removed and agreeing with the first to within 1 mm. When the position of the cribrion on the skull is now compared with that of the sellion in the cadaver, it is seen that they

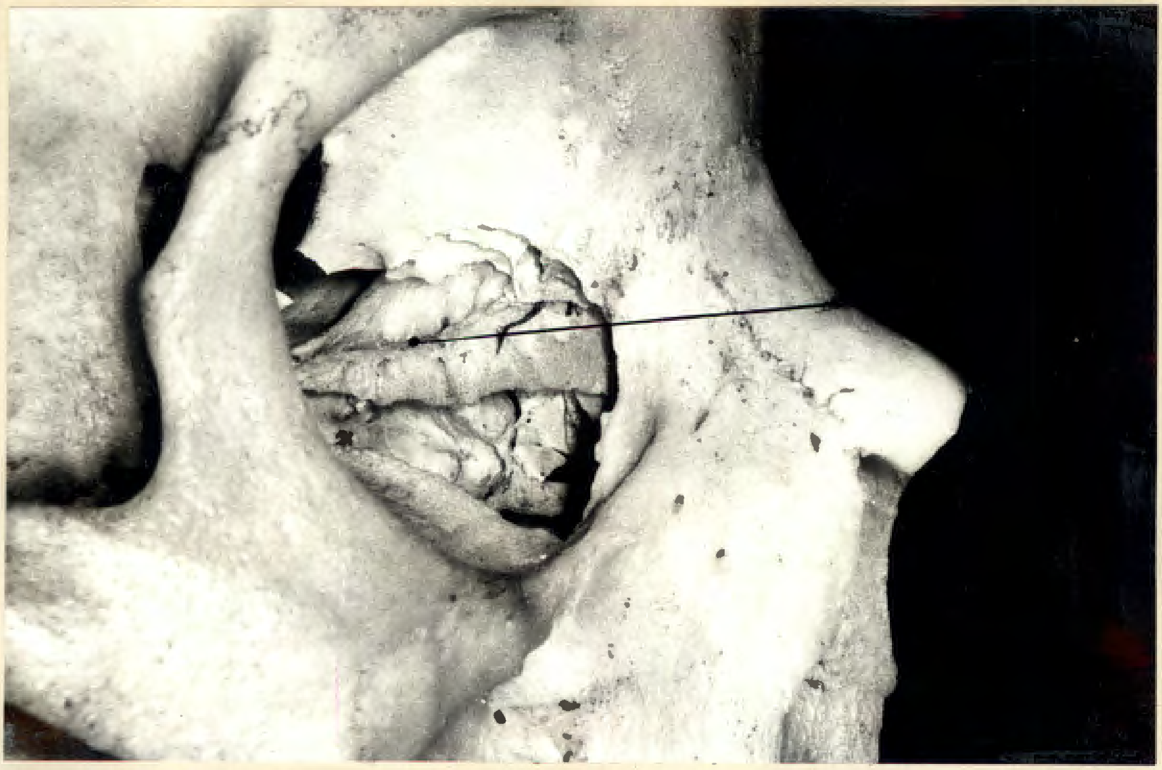


Fig. 3. The Location of the Cribrion.

Fig. 4. The Location of the Cribrion.

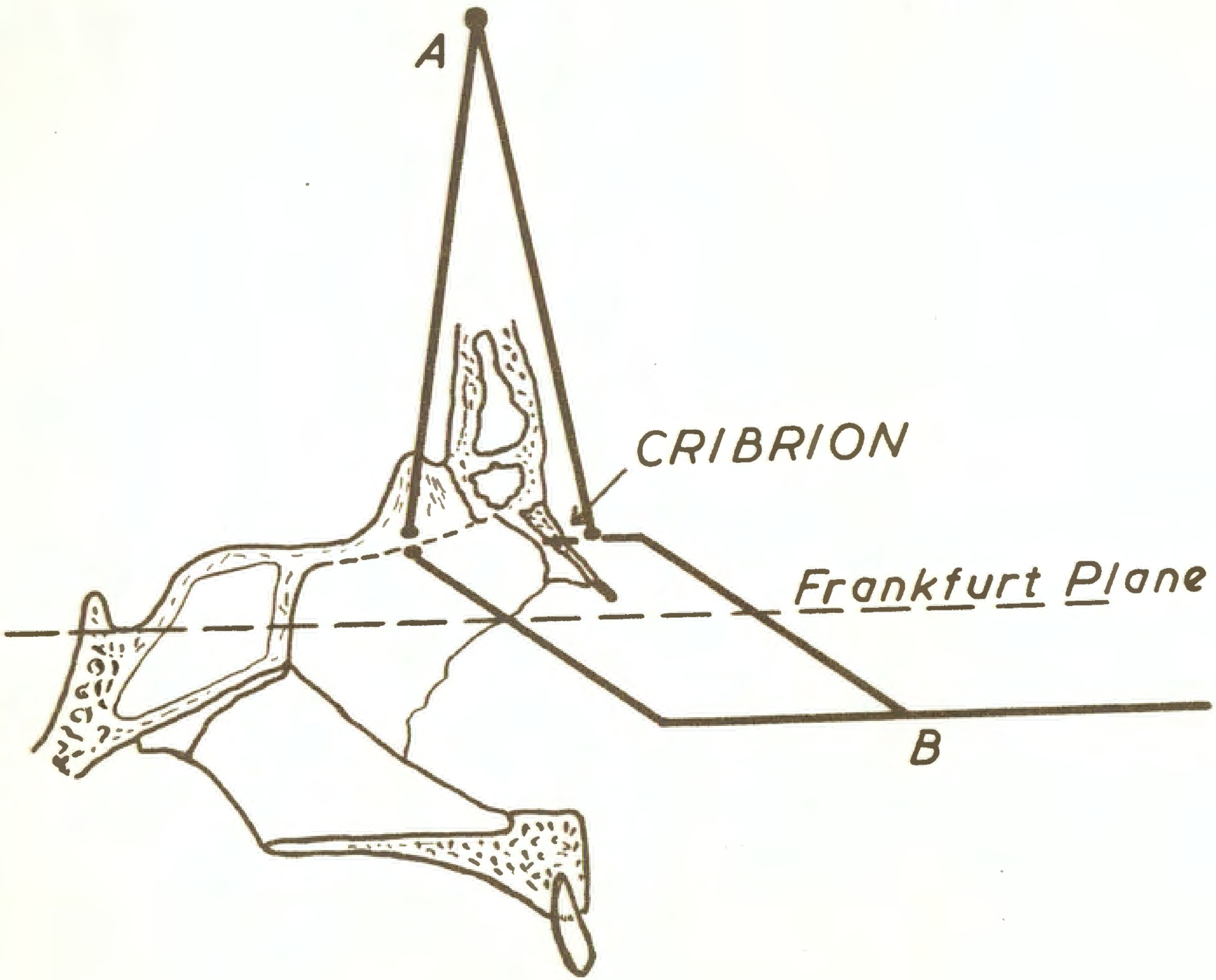


Fig. 5. Locating the Cribrion

Fig. 6.
Reference plane for Sellion

agree closely, the mean difference in their distances from the nasion amounting only to just over 1 mm. It is thus clear that the sellion is in fact a better guide to the nasal cavity roof than is the nasion, and its employment in the present study is fully justified. Not only is it more suitable on this account, but it is easier of determination during a routine clinical examination and less disturbing to the patient than probing for the nasion " with the finger nail" !

The lower point for nasal height is the subnasal, and is the point where the nasal septum and upper lip meet. This angle is normally sharp, but in some subjects there is a projecting fold of skin that conceals it. In such cases gentle pressure with the caliper to flatten this fold will reveal the true point. Apart from this the location of the subnasal presents no problem.

Nasal breadth has been taken by most workers as the maximum breadth at the alae, this procedure being followed in the present series of measurements. The nose must be in repose and for this reason it is often impossible to take this measurement in young children because of crying. Williams on the other hand attempts to locate the edges of the bony piriform aperture by palpation, mark them on the skin, and then measure between these marks. It is agreed that this is in many ways a more logical procedure, since variations in the thickness of the soft tissues may make the alar breadth a rather inaccurate estimate of the actual width of the air-way.

This is especially so when it is realised, as figures in the present study will later show, that the alar breadth is greater relative to the bony breadth in the male than in the female. It is felt however that any attempt to locate a bony point through soft tissues is fraught with inaccuracies, and that while a patient contemplating surgical reconstruction of the nose may submit to the procedures involved, its use as a part of a routine clinical examination is not justified.

The depth of the respiratory part of the nasal cavity has already been shown to be closely related to the antero-posterior length of the hard palate, the bony landmarks for which have been described. In taking this measurement in the living subject the thickness of the soft tissues is of course a complication, and from the values obtained it will be seen that the dimension in the living exceeds that on the skull by about 9 mm.

MEASUREMENT PROCEDURE

When the location of the sellion on the cadaver was undertaken, it became clear that the position of the deepest depression at the root of the nose could vary slightly according to the plane from which the depth is to be judged. Since nasal height is to be measured in a line from sellion to sub-nasal, it seems logical to use this line as an indication of the plane relative to which the depth of the nasal root is to be viewed, as shown in Fig. 6. The technique adopted was to place the tip of the left index finger firmly in the hollow at the root of the nose with the nail parallel to the reference plane. The centre of the nail was then taken as the required point and measurement was made to the subnasal as shown in Fig. 7. Fig. 8 shows the taking of nasal breadth and requires no comment. The measure most disturbing to the patient is that of palate length and the instrument devised for this purpose is shown in Fig. 9. It is employed by using the fixed leg to locate by palpation the junction between the hard and the soft palate, the sliding leg being adjusted until it just touches the point where the back of the central incisor tooth joins the palate. A high degree of precision is not possible in taking this measurement since many patients tense the soft palate and make the identification of the edge of the hard palate difficult, but with increasing experience the position of the edge could be estimated in most patients with fair accuracy. Fig. 10 shows why this measurement must always exceed that in the skull, and Fig. 11 illustrates the measurement being taken. Because of the slightly unpleasant nature of this procedure, it was not undertaken in children.

CHANGES DUE TO EMBALMING

As measurements on both the cadavers and the living subjects began to accumulate, it became apparent that the nasal indices obtained from the cadavers were higher on the average than those from living subjects of the same race and sex group. It was therefore suspected that changes may have been caused by the embalming process and a further investigation

Fig. 7. Measuring Nasal Height to the Sellion.

Fig. 8. Measuring Nasal Breadth.

Fig. 11. Measuring Palate Length.

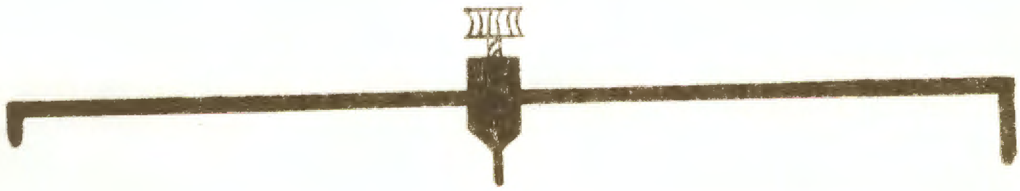


Fig. 9

Palatometer

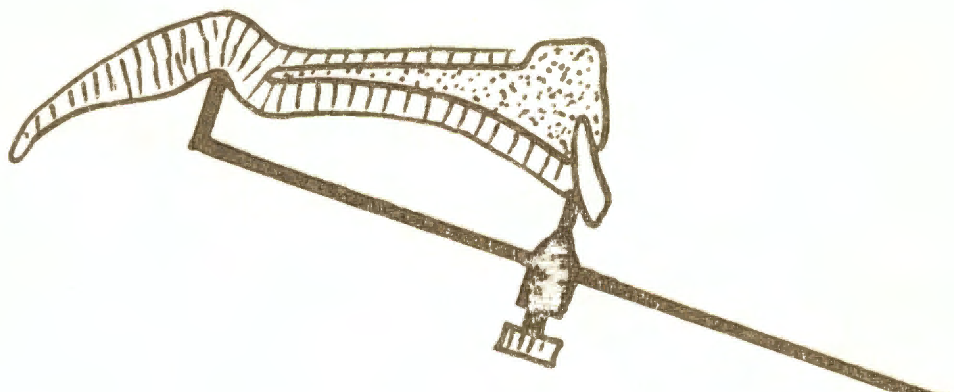


Fig. 10

Effect on soft tissues on dimensions of palate was initiated to detect such changes and to determine their extent. It was possible on 27 occasions to examine a cadaver immediately on receipt at the mortuary before embalming was commenced, and then again the same cadaver some months later when set out for dissection. Since it was felt essential that in this whole investigation all measurements should be taken by the same observer, the author was not always available when a body arrived, so that the numbers examined in this way are smaller than desirable. When the cadaver was later examined in the dissecting room it was clear in some cases that the body had been stored in such a manner that distortion of the nose had resulted, and the comparison between measurements before and after embalming showed a disturbing range of variation. However, when the means were taken, they showed that the nasal height had been reduced by 0.9 mm. and the breadth increased by 1.3 mm. The increase in breadth is not unexpected, being accounted for by pressure on the nose during storage and oedema of the tissues from fluid. The decrease in height is not so easily explained, but appears to be due in part at least to oedema of the tissues at the nasal root affecting the upper slope of the depression more than the lower, so depressing the level of the sellion. This is supported by the observation that the position of the sellion in the dry skull is much nearer to the nasion than when the soft tissues are present, showing that the thickness of the soft tissues does in fact depress the sellion. It has been shown that the mean interval between nasion and sellion in the cadaver is about 6 mm., while on the skull without soft tissue it averages about 3 mm., so that oedema from embalming fluid would depress it still further making it likely that the loss of nasal height may be attributable to this factor.

Although there is a possibility that the position of the sub-nasal point may have changed, it is felt that this depression of the sellion is most likely to be the source of the discrepancy. Accordingly to correct for embalming changes an increase of the nasal height by 0.9 mm. and a reduction of the breadth by 1.3 mm. has been adopted for use when calculating the nasal index. This corrected index should correspond more closely with the indices obtained from living subjects of the same sex and race group. It will be noted however that an assumption has been made that the nasal dimensions in the unembalmed dead subject are the same as in the living. This assumption may in fact be incorrect, since changes in body fluid content before death, wasting from terminal disease and loss of tone in the muscles of the nasal alae may have produced significant changes. It is clear that it is not practicable to measure a large series of subjects both in normal health and after death, so it is not possible to say how significant these changes might be.

ANALYSIS OF RESULTS

All measurements have been recorded in millimeters to the nearest half millimeter and indices calculated by slide rule to the nearest integer. The values have been grouped according to race, sex, and in the case of living subjects clinical condition. All subjects over 16 years have been taken as adults, but in fact very few have been included who are under 18 years. Alhtough there is some evidence that nasal indices change slightly with advanced years (Marquer and Chamla 1961a, 1961b), the number of elderly subjects in the present series is not great, so this factor has been ignored. Measurements of nasal height and breadth only have been recorded in the case of children and have been used to study the growth of the nose, which is of interest on its own account, and provides a correction factor that may be applied to enable values from subjects under 16 years to be included in the analysis of disease conditions. This is particularly relevant when atrophic rhinitis is studied as many of those suffering from this disorder are children in the second decade.

Each set of dimensions and indices has been analysed to determine the mean, the standard error, and the standard deviation, the resulting values being shown in Tables 1 - 5. Full details of the individual measurements are set out as an appendix where each skull, cadaver or living subject, is designated by a serial number by which it may be identified

TABLE 1.

STATISTICAL ANALYSIS OF SKULLS

Group	N	NH Mean	NH S.E.	NH S.D.	NB Mean	NB S.E.	NB S.D.	PL Mean	PL S.E.	PL S.D.
Eur.	M 14	52.8	0.6	2.1	24.8	0.7	2.7	44.4	1.1	4.1
	F 9	47.6	2.7	0.9	22.6	0.5	1.6	42.3	2.9	1.0
Col.	M 61	48.8	0.5	3.9	25.7	0.3	2.0	46.4	0.5	3.9
	F 41	45.4	0.4	2.4	25.3	0.3	2.0	43.8	0.4	2.4
Af.	M 17	49.0	0.7	2.8	27.0	0.5	2.1	48.7	0.8	3.4
	F 6	47.8	-	-	27.3	-	-	43.6	-	-

Group		N/S Mean	N/S S.D.	N/CR Mean	N/CR S.D.	NI			VI		
Eur.	M	2.3	1.3	7.9	2.4	47.1	1.6	5.9	58.2	2.9	10.9
	F	2.2	1.6	6.9	2.7	47.6	0.8	2.5	45.6	2.5	7.6
Col.	M	3.4	1.4	7.1	2.3	52.5	0.6	4.8	58.7	1.1	8.5
	F	2.5	1.7	6.2	2.8	56.0	0.9	5.4	50.2	1.0	6.0
Af.	M	4.6	1.2	8.0	1.8	55.2	1.1	4.4	63.8	2.6	10.7
	F	2.0	-	7.8	-	57.5	-	-	57.3	-	-

NH Nasal Height from Nasion
NB Nasal Breadth
NI Nasal Index
PL Palate Length
VI Volume Index
N/S Interval from Nasion to Sellion
N/CR Interval from Nasion to Cribrion
S.E. Standard Error
S.D. Standard Deviation
N.I.(Sel) Nasal Index using Sellion without embalming correction
N.I. (EC) Nasal Index using Sellion but with embalming correction by adding 0.9 to NH and subtracting 1.3 from NB.
N.I. (Nas.) Nasal Index using nasion as identified directly on each Cadaver

$$S.E. = \frac{S.D.}{\sqrt{N}}$$

Means only calculated when N is less than 9.

TABLE 2.

STATISTICAL ANALYSIS OF CADAVERS

Group		N	NH (Sel.)			NB			N/S		
			Mean	S.E.	S.D.	Mean	S.E.	S.D.	Mean	S.E.	S.D.
Eur.	M	16	53.8	0.8	3.1	40.1	0.8	3.2	6.2	0.4	1.7
	F	9	49.4	0.9	2.7	34.4	1.0	3.1	6.3	0.4	1.3
Col.	M	44	44.8	0.7	4.7	45.5	0.5	3.5	6.6	0.2	1.9
	F	20	41.5	0.8	3.9	41.9	0.8	3.4	7.4	0.4	1.8
Af.	M	15	45.5	1.0	4.0	46.4	1.1	4.2	7.8	0.5	1.8
	F	7	41.2	-	-	43.1	-	-	7.6	-	-

Group		NI(Sel)			NI(EC)	NI(Nas)
Eur.	M	74.8	2.0	8.1	71.3	65.0
	F	69.9	2.5	7.5	65.8	59.9
Col.	M	102.5	1.9	12.6	97.5	86.5
	F	101.9	3.2	14.4	96.3	83.8
Af.	M	102.2	2.7	10.7	97.2	84.9
	F	104.7	-	-	99.6	86.0

TABLE 3

STATISTICAL ANALYSIS OF LIVING SUBJECTS

Group		N	NH (Sel.)			NB			PL		
			Mean	S.E.	S.D.	Mean	S.E.	S.D.	Mean	S.E.	S.D.
NORMALS											
Eur.	M	100	53.3	0.4	3.7	35.9	0.2	2.3	55.5	0.3	3.2
	F	71	49.3	0.4	3.2	32.8	0.3	2.3	52.5	0.4	3.3
Col.	M	59	50.1	0.5	3.6	40.3	0.3	2.6	54.6	0.4	3.3
	F	51	45.6	0.5	3.7	36.8	0.3	2.5	52.7	0.5	3.5
As.	M	26	52.3	0.5	2.3	39.0	0.5	2.4	52.5	0.5	2.6
	F	3	46.0	-	-	35.3	-	-	55.0	-	-
Af.	M	16	47.2	0.7	2.9	45.7	0.7	2.9	57.3	1.0	4.1
	F	28	44.7	0.6	3.0	41.3	0.4	2.2	55.0	0.7	3.8

Group		NI (Sel.)			AI			VI		
Eur.	M	67.7	0.7	6.6	159.9	1.5	15.3	106.4	1.3	12.7
	F	66.7	0.7	5.6	138.8	1.3	13.1	84.8	1.3	11.2
Col.	M	81.1	1.2	8.9	148.8	2.0	15.3	110.8	1.6	12.6
	F	81.3	1.2	8.7	131.5	2.0	14.2	88.6	1.8	12.9
As.	M	74.8	1.2	6.3	150.0	2.1	10.9	107.3	2.0	9.9
	F	82.3	-	-	138.0	-	-	89.3	-	-
Af.	M	97.2	2.5	10.0	153.1	4.0	16.1	123.0	3.4	13.7
	F	93.0	1.3	6.9	136.5	2.7	14.5	101.6	2.6	13.9

TABLE 4

STATISTICAL ANALYSIS OF LIVING SUBJECTS

Group		N	NH (Sel.)			NB			PL		
			Mean	S.E.	S.D.	Mean	S.E.	S.D.	Mean	S.E.	S.D.
VASOMOTOR RHINITIS											
Eur.	M	41	53.0	0.6	3.7	36.2	0.4	2.4	55.3	0.6	3.6
	F	11	49.4	0.9	3.1	33.1	0.8	2.7	51.0	0.9	2.9
Col.	M	13	50.2	1.2	4.4	40.9	0.9	3.3	52.8	0.8	2.7
	F	18	48.3	0.8	3.6	35.8	0.7	3.1	53.2	0.9	3.9
As.	M	4	50.0	-	-	38.5	-	-	55.3	-	-
	F	2	51.5	-	-	33.0	-	-	52.6	-	-
Af.	M	2	53.0	-	-	45.5	-	-	60.8	-	-
	F	3	45.1	-	-	39.8	-	-	57.0	-	-

Group		NI (Sel.)			AI			VI		
Eur.	M	68.5	1.1	6.8	158.3	2.3	14.7	105.8	1.9	12.1
	F	67.5	2.0	6.5	136.3	3.5	11.5	84.0	3.8	12.5
Col.	M	82.4	3.6	12.9	145.5	4.1	14.8	108.2	3.9	14.2
	F	74.4	2.3	9.6	140.9	3.0	12.7	92.4	3.1	13.1
As.	M	77.0	-	-	150.3	-	-	106.3	-	-
	F	64.5	-	-	145.5	-	-	89.5	-	-
Af.	M	86.5	-	-	178.0	-	-	146.5	-	-
	F	89.0	-	-	135.3	-	-	103.0	-	-

TABLE 5

STATISTICAL ANALYSIS OF LIVING SUBJECTS

Group		N	NH (Sel.) Mean	NH (Sel.) S.E.	NH (Sel.) S.D.	NB Mean	NB S.E.	NB S.D.	PL Mean	PL S.E.	PL S.D.
SINUSITIS											
Eur.	M	9	52.5	1.8	5.4	35.5	0.4	1.1	55.1	0.9	2.7
	F	3	49.3	-	-	36.0	-	-	50.7	-	-
Col.	M	5	48.3	-	-	38.9	-	-	51.9	-	-
	F	2	43.5	-	-	33.8	-	-	52.5	-	-
Af.	M	1	43.5	-	-	51.0	-	-	56.0	-	-
	F	4	42.8	-	-	40.6	-	-	54.8	-	-

Group		NI (Sel.) Mean	NI (Sel.) S.E.	NI (Sel.) S.D.	AI Mean	AI S.E.	AI S.D.	VI Mean	VI S.E.	VI S.D.
Eur.	M	68.4	2.5	7.5	156.9	6.5	19.6	102.9	4.4	13.2
	F	73.3	-	-	136.0	-	-	90.0	-	-
Col.	M	81.2	-	-	137.0	-	-	97.8	-	-
	F	77.5	-	-	125.0	-	-	77.0	-	-
Af.	M	117.0	-	-	139.0	-	-	124.0	-	-
	F	96.8	-	-	130.5	-	-	94.5	-	-

if so required in any future analysis. From the results of this analysis figures have been drawn to demonstrate the relationship between the nasal index derived from the sellion to that from the nasion, between that of the skull and that of the cadaver, and to show the development of the nose during childhood. Other results are summarised in tables which allow comparison with the findings of other workers. In the discussion the significance of the findings will be considered fully.

Before it is possible to relate indices employing the nasion to those where the sellion is used as the upper terminal for nasal height, the mean distance between these two points must be ascertained. Fig. 12 sets out the interval between sellion and nasion as observed directly in 111 cadavers, relating it to the nasal index using the sellion without any correction for embalming. By displaying the results in this manner any correlation between the interval and the type of nose may be demonstrated. There is in fact only a slight difference between the leptorrhine and the wider noses, so that after 0.9 mm. has been subtracted to allow for the embalming change it is seen that to convert nasal height from sellion to that from nasion 5 mm. should be added in the case of noses with an index below 75 and 6 mm. for those with a higher index. This means in practice that 5 mm. is added for the European nose, and 6 mm. for the other race groups. In the case of the cadavers, the actual interval in each case may be employed to

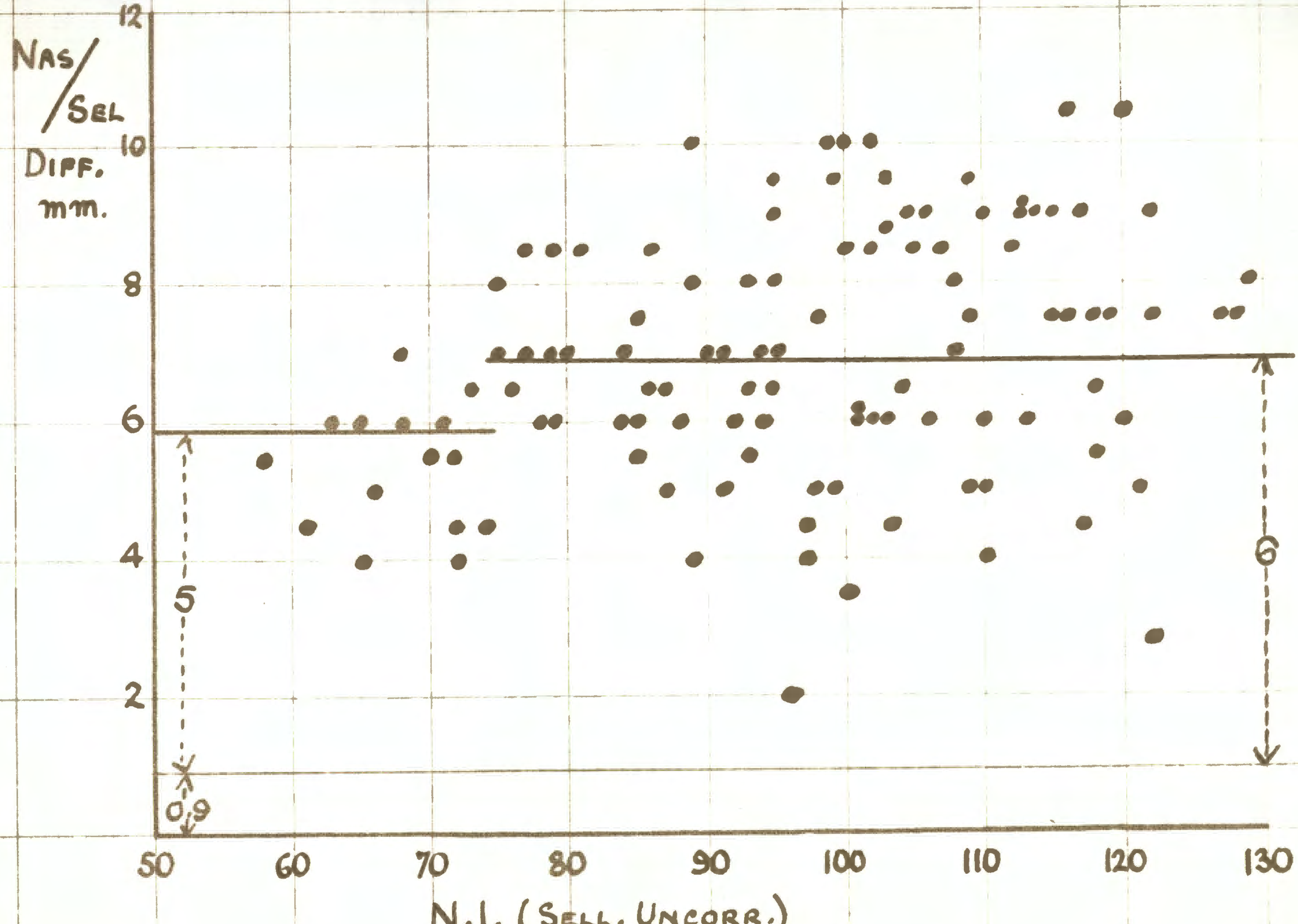


Fig. 12. Interval between Nasion and Sellion

convert one nasal index to the other, while in the case of the living subjects the mean values found above must be employed. In Fig. 13 is shown the relation between the two ways of calculating the nasal index in the case of the cadavers, the nasal height to the nasion being that directly observed in each particular specimen. The cadaver measurements have been corrected for the embalming changes by adding 0.9 mm. to the height to the sellion and subtracting 1.3 mm. from the alar breadth. There is some degree of scatter of the points because of the considerable variation observed in the nasion/sellion interval in individual cases, but a line that fits the readings well has been drawn through the points marked. This line can be defined by the equations:

$$\text{N.I.(Sel.)} = \frac{5(\text{N.I.Nas.})}{4} - 10 \text{ or N.I.(Sel)} = 1.25(\text{N.I.Nas}) - 10$$

$$\text{N.I.(Nas.)} = \frac{4(\text{N.I.Sel.} \quad + 10}{5} \text{ or N.I.(Nas)} = 0.8\ (\text{N.I.Sel}) + 8$$

In the living subjects of course the actual position of the nasion is unknown, but by using the mean values derived above, it is possible to calculate the nasal height to the nasion. Fig. 14 shows some representative values for European subjects, selected only in so far as to give as wide a range of nasal indices as possible. The points for the female subjects are very similar, but correspond to a value for the N.I. Nasion which is about 1 lower than that of the male. A line of best

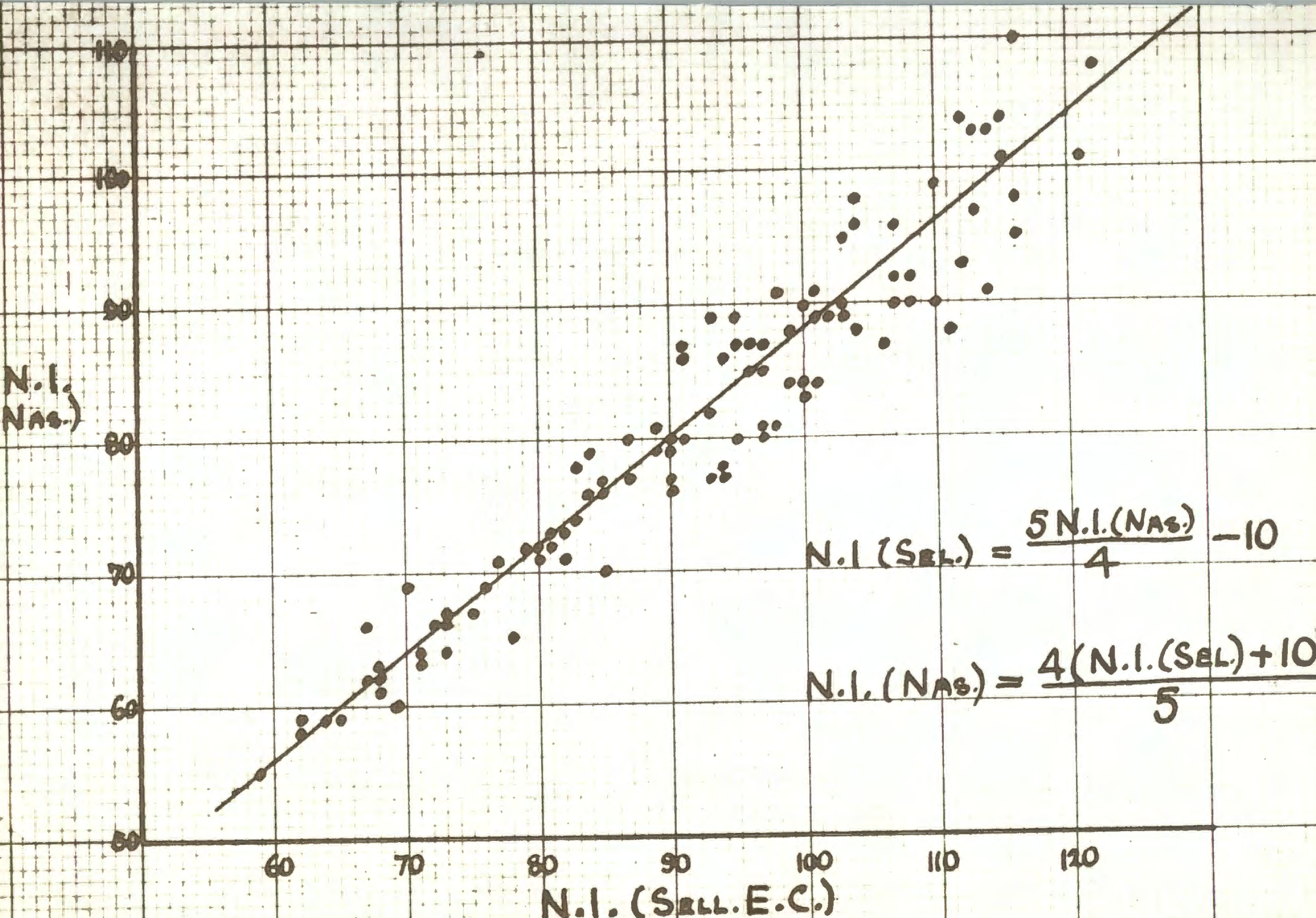


Fig. 13 Relation between Nasal Index using Sellion and using Nasion in Cadavers

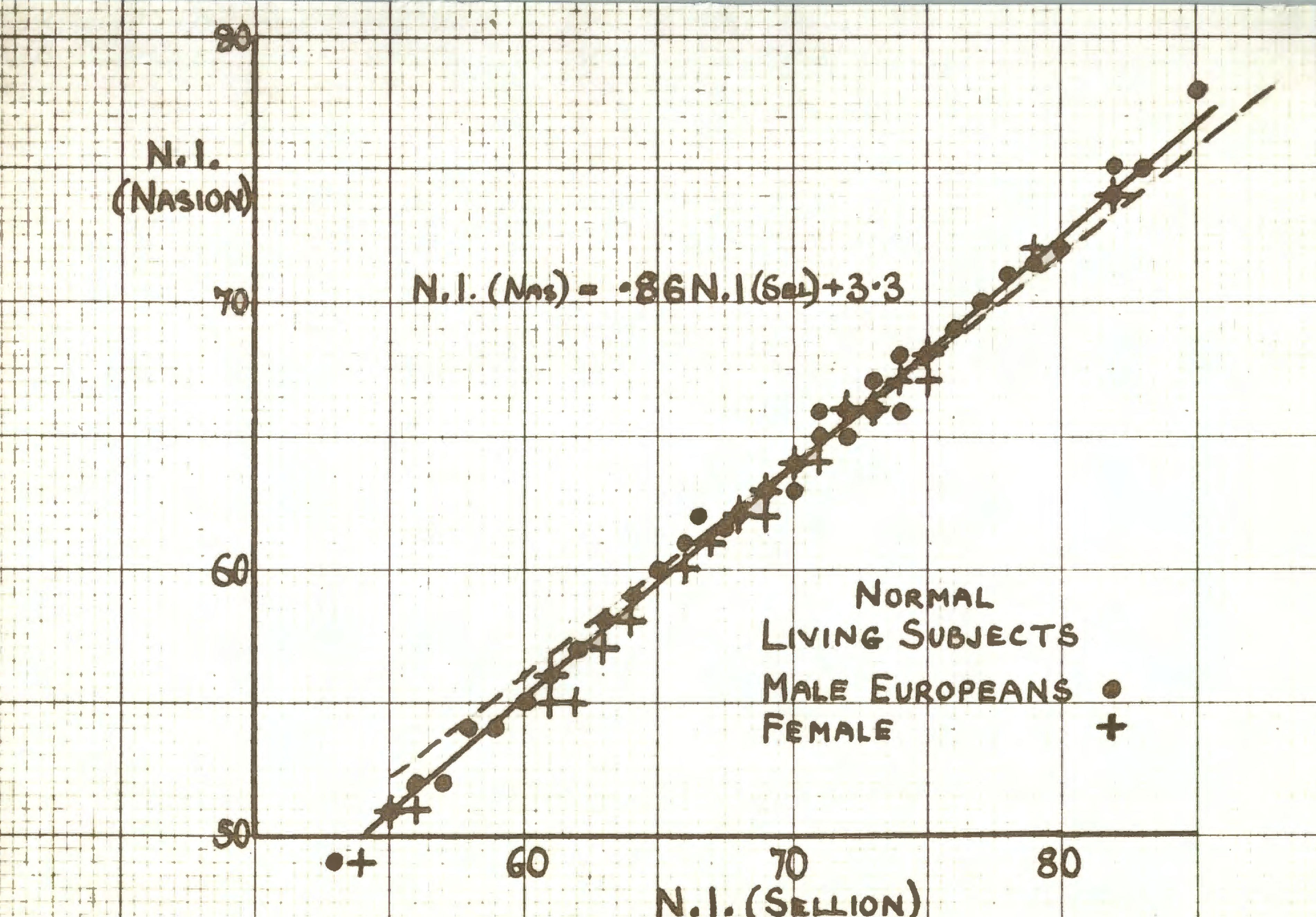


Fig. 14 Relation between Nasal Index using Sellion and using Nasion

fit is drawn and is found to be defined by the equation:

$$N.I.\ Nas. = 0.86\ N.I.\ Sel. + 3.3$$

When the dashed line for the previous equation is added, it is seen that there is not a great difference in the values given by the two relationships. The corresponding points for the Coloured subjects are set out in Fig. 15 and here the line is almost identical with the line derived from Fig. 13, the indices being only different by $\frac{1}{2}$ unit. This equation is:

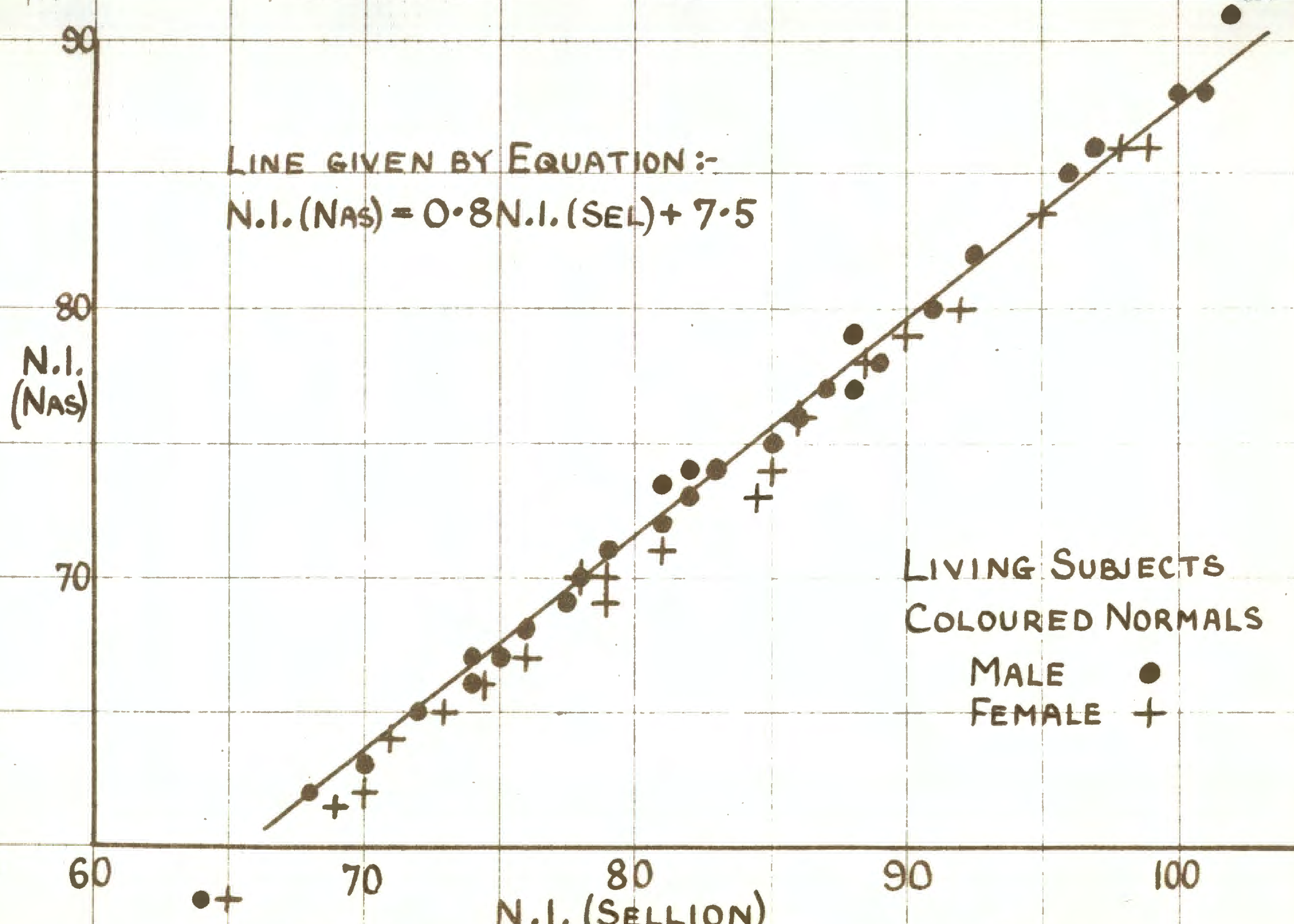
$$N.I.\ Nas. = 0.8\ N.I.\ Sel. + 7.5$$

females again being about one unit less than the males.

In 46 instances it has been possible to measure a cadaver and then, after dissection has been completed, obtain the cleaned skull for craniometry. In this way the nasal index of the skull may be related to that of the cadaver, using the nasion on both instances. Assuming that the corrected cadaver measurements approximate to those of the living subject, the index in the latter may now be compared to that of the skull in each race and sex group. Fig. 16 shows such a comparison using the cadavers and their own skulls, the line drawn through the points being that required by the equation of Thomson and Buxton which is:

$$N.I.\ Living = N.I.\ Skull \times 2.327 - 38.1$$

Fig. 17 shows a similar relationship, but here the open circles are values for published series of skulls and living subjects as quoted by Davies, except in the case of the Tirolese, where



Relation between Nasal Index using Sellion and using Naston

Fig 15

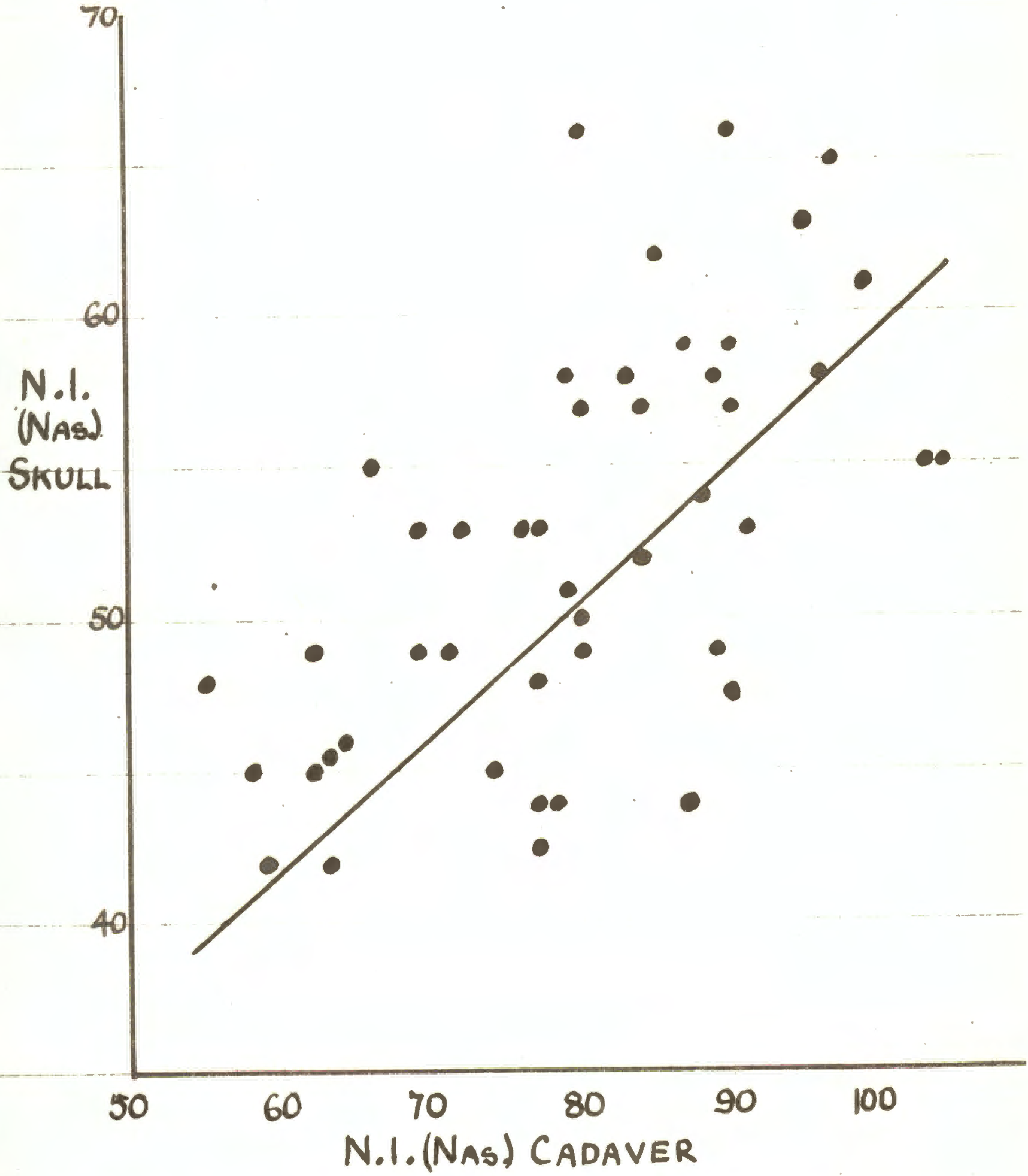


Fig. 16 Relation between nasal index of skull and cadaver.

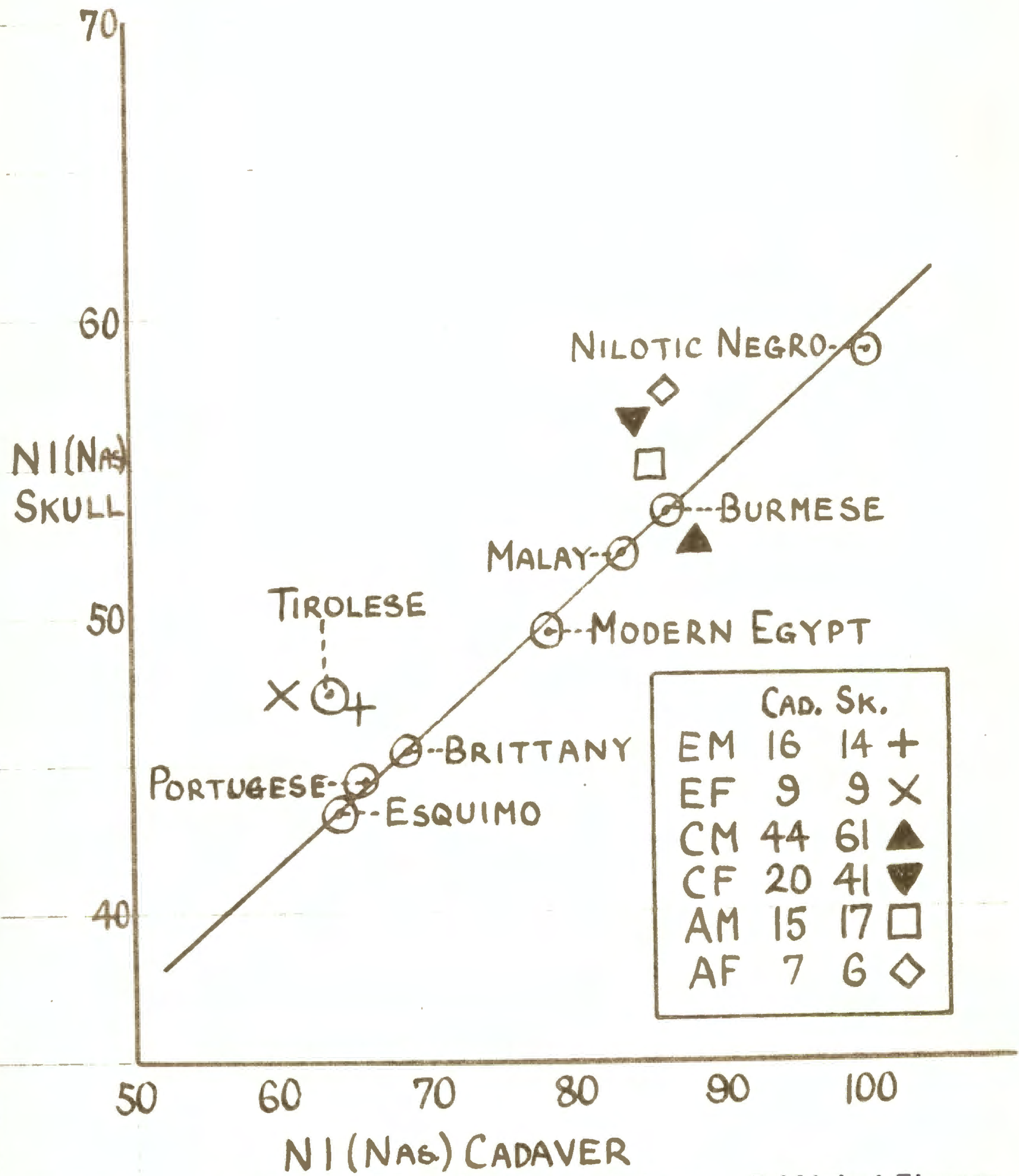


Fig. 17. Relation between Skull and Cadaver. Published Figures

the skull index is from Morant (1928) and the living subjects from Thomson and Buxton. On this same figure are also shown the mean values obtained from all the skulls and cadavers examined in the present study, each race and sex group being designated by a symbol as shown in the key against which is also the number of skulls and cadavers averaged in each group.

The measurements obtained from children who were patients in the Ear, Nose and Throat Department at Groote Schuur Hospital have been grouped into two-year periods and the means calculated. The results of this are set out on Fig. 18 for the European and Fig. 19 for the Coloured patients. The numbers in brackets show the size of each group and on the same figure are added the findings of Goldstein in the case of the European, and of Herskowitz (1930) in the other race group. The numbers of African children available were too small to be of value.

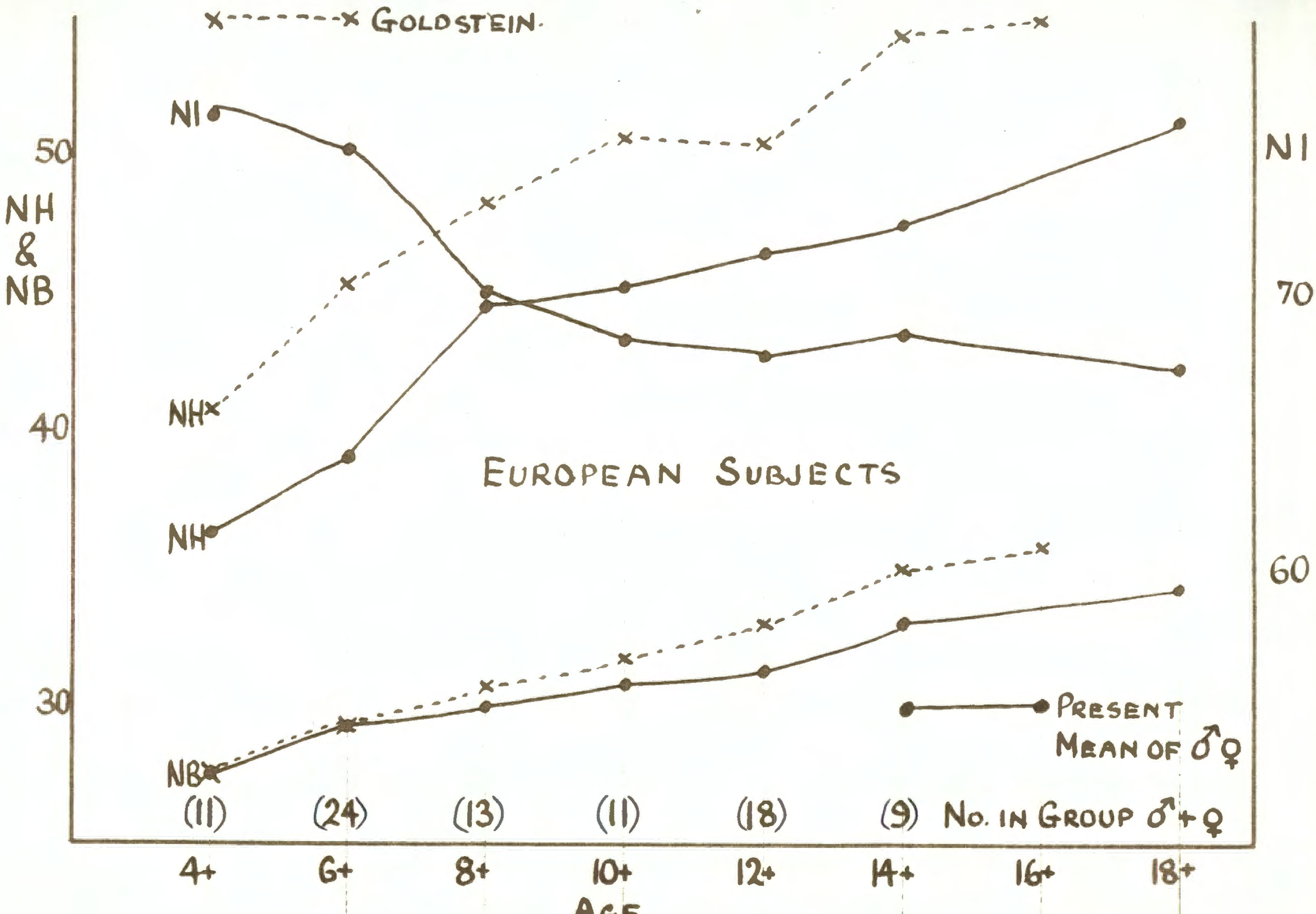


Fig.18 Changes in nasal height, breadth, and index, with age

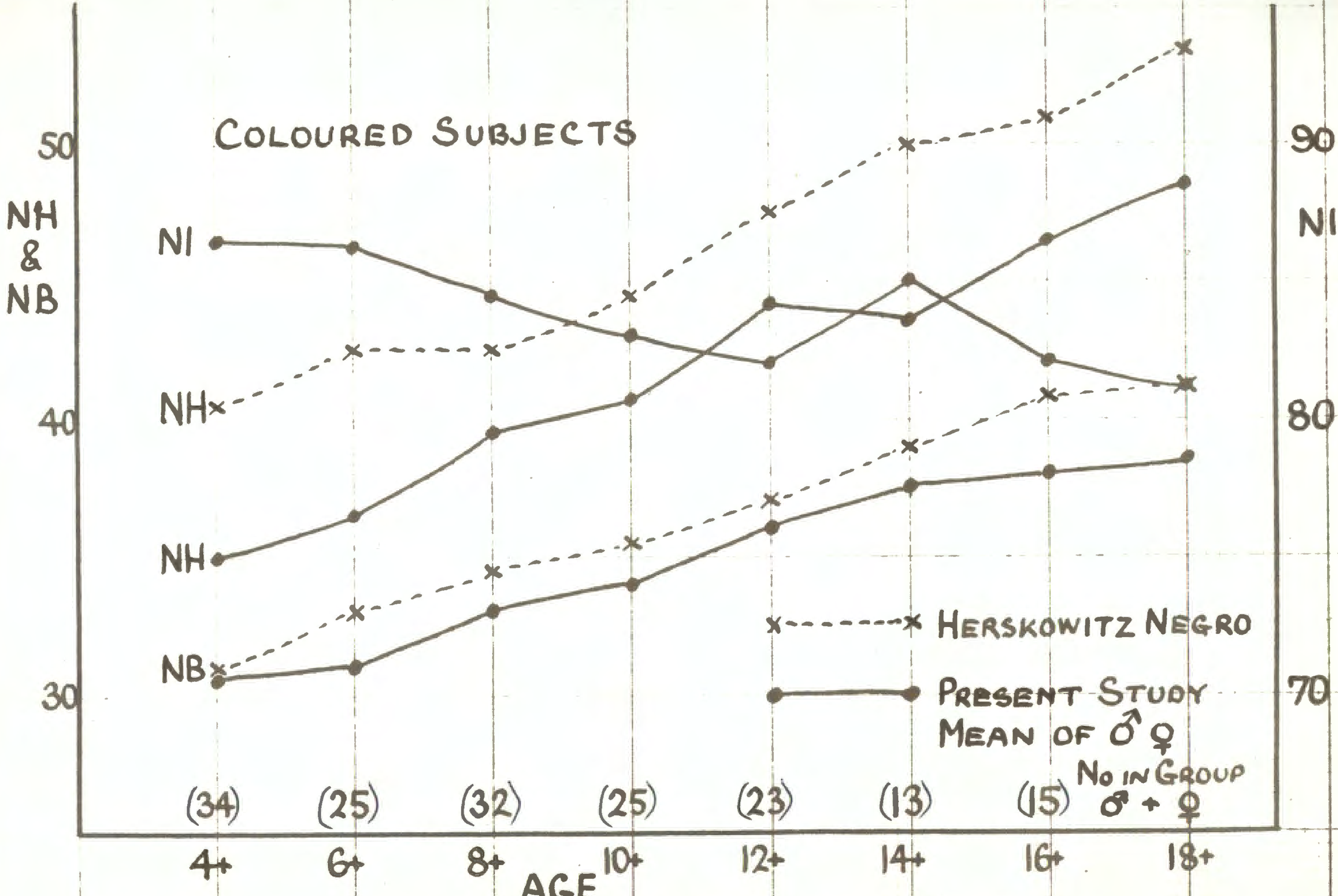


Fig.19 Changes in nasal height, breadth, and index, with age

DISCUSSION

In the introduction the concept behind this investigation was outlined and the proposition advanced that, in the case of the nose, pathology may be related to physiological function which in turn is dependent upon the architecture of the nasal cavities. This concept must now be examined in more detail, taking note of the contribution to the understanding of the functions of the nose that have been made by many workers. Of these two stand out in particular, Negus (1958) for his study of the comparative anatomy and physiology of the nasal cavities, and Proetz (1953) for his investigations into the air currents in the nose. Both these workers have given great attention to the importance of ciliary action and to the rôle of the nose as an airconditioner. Negus has shown in his comparative studies that the acuity of the olfactory sense is closely related to the extent of the mucosal area available for humidification, the sensitivity of the receptors being very dependent on adequate moisture. Dawes (1952) has studied the air-stream patterns in the nose of animals, and has shown how the inspired air reaches the olfactory area. He demonstrated that changes in the inspiratory pressure and in the configuration of the nasal cavities determine the direction of the stream and so affect olfactory acuity. Were it possible to collect the records of a sufficient number of patients with diminished olfactory capacity not traceable to trauma, gross nasal obstruction, or mucusal atrophy, it might be found that there is a correlation between the factors affecting the direction of the air stream and olfactory acuity. Such is suggested as a possible future study. Humidification, besides being of importance to olfaction, ensures that the inspired air reaches the alveoli and air sacs of the lungs adequately laden with water vapour so that there is no tendency for the delicate lining of these respiratory cavities to become dry. Proetz (1941) states that by the time that the air reaches the lungs it is 95% saturated, while Cole (1953) gives an even higher figure, estimating that under average conditions about half a litre of water is added to the inspired air daily. Ingelstedt (1956) states that an average of 570 g. of water is added in 24 hours of which 20% - 25% is recovered by condensation in the nose on expiration. By far the greater part of this water is added in the nose, although the lower respiratory tract can in time adapt itself to give a larger contribution, for example after laryngectomy. While it is understandable that defective humidification of the inspired air may lead to a drying of the pharynx and lower respiratory tract, it is possible that it may affect even the nose itself. Ciliary action is of great importance in the nasal cavity and is responsible for the continuous transport of the blanket of mucus which covers the mucosa and traps bacteria and dust particles. Proetz (1934) has pointed out the importance of this mucus being of a correct viscosity if it is to be fully effective, and also that ciliary action itself is highly dependent upon an adequate humidity. In addition to the mechanical removal of bacteria by the mucus blanket, anti-bacterial substances, the lysozymes described by Fleming (1928) are present in the secretions, and also depend for their activity on moisture. It can thus be seen that the degree of humidification can affect the health of the nasal cavity in all three of these ways, so that any anatomical defect that affects the efficiency of the process may show a correlation with infective conditions in the nose.

The inspired air varies greatly both in temperature and in humidity in different climates, so that the contribution of heat and moisture given by the nose must be adaptable over a wide range. Since both heat and water come ultimately from the blood, vasomotor control plays an important part in the homeostasis of this function. Changes in the degree of congestion of the cavernous tissue not only affect the rate at which heat and water become available, but also regulate the patency of the airway to the optimum for producing laminar flow through the cavity. The vessels supplying this cavernous tissue are under the control of the autonomic nervous system, the degree of congestion depending on the balance between sympathetic and parasympathetic tone. Drettner (1961) has described the reaction of the mucosa to cold, both in the inspired air or applied to other parts of the body. He noted the initial shrinkage of the mucosa followed in some cases by a phase of vasodilation even when the cold is still being applied. Fowler (1943) has described a case of unilateral vasomotor rhinitis subsequent to a stellate ganglionectomy that had been performed on the same side, while both Heetderks (1927) and Stoksted (1953) speak of the rhythmic alteration of nasal patency by which one side of the nose is more open for a period of about two hours, the other then taking over. Not only does this obtain in the nasal airways, but it extends also to the lungs themselves, the so-called "Naso-Pulmonary Reflex" described by Sercer (1930). He showed that each nasal cavity appears to be in some unexplained way related to the lung on the same side, and that changes in the patency of one of the nasal cavities are reflected in changes in the air entry to the homolateral lung. This interesting phenomenon is the subject of a more recent study by Ogura et al.(1964) who showed that there is a reduced pulmonary compliance in the lung on the side of an obstructed nostril and discussed the possible relation of this observation to the naso-pulmonary reflex. This "change of breath" about every two hours is well known to those who study Yoga, and was described to me many years ago by one of them before the writings of Heetderks and Stoksted had come to my notice.

Thomson and Buxton have already been mentioned for their work on the correlation of nose shape and climate, and they attempted to show that races who had lived for a long time in a particular climatic environment had noses adapted to a shape that made them the most efficient air-conditioning organs for that climate. They showed that the dwellers in the tropics have a wide nasal cavity, while that of the Esquimo is narrow. They also studied the skulls of prehistoric man in the British Isles and contended that the present-day inhabitants have noses nearer to the ideal shape for the climate. Negus comments on this work, but feels that other explanations are possible, and from considerations of comparative anatomy suggests that the wide nose is related rather to vital capacity and the requirements of greater activity. Thomson and Buxton themselves give due consideration to this possibility stating on p.99 of their paper:

> "It would be interesting to compare in the living the vital capacity of the lungs with the development of the nasal channels, for it seems reasonable to suggest that a man engaged in work which entails continued muscular effort would, under normal conditions, either develop a freer respiratory tract or else have recourse to deeper breathing. It is possible that we may account in this way for the individual variations that may be met with. It may generally be conceded that active exercise during childhood and youth is the best preparation for such developments within the nose as are best adapted to fulfil the functions of a perfectly adjusted apparatus. These will include not only the capacity to transmit an adequate supply of air, but according to environmental conditions will provide for the adequate heating and moistening of the inflowing stream".

However, the author's experience of many years in tropical Africa would suggest that while the indigenous inhabitants may be capable of greater physical activity, they do not demonstrate this in practice ! Possibly in times before the advent of western civilisation when life was harder and more hazardous, they did need to exert greater physical effort to survive.

From these considerations it would appear that changes in climate require adjustments in the blood supply to the nose, and that the most extreme climates may force the nose to function near to the limit of its physiological reserve. In a former study on the effect of race and tropical climate on the prevalence of vasomotor rhinitis (Jarvis 1962, 1965) it was shown that the incidence of this disorder was lowest in the indigenous population, and much higher in immigrant European and Asian people; moreover there was a different incidence between the hot and humid climate of the coast of East Africa and the hot but dry climate of a place such as Nairobi, a difference also noted by Ordman (1958). It was shown that immigrant races usually developed the condition only after a few years residence, and were relieved on returning to their homelands. Excessive demands on the air-conditioning function of the nose leading eventually to a breakdown was suggested as a possible explanation. An artificial climate problem may arise even in temperate lands when winter brings the need for central heating in houses. Proetz (1956) speaks of the very real disability so produced, and discusses the air-conditioning of living rooms in the light of this problem.

He finds that patients begin to come to him complaining of a dry nose when the relative humidity drops to 25%. He advocates maintaining it at 40%, and states that even at this level at a temperature of 72°F the nose must evaporate almost a pint of water daily.

The effective conditioning of the inspired air is dependent on its contact with the nasal mucosa, and Proetz (1953) has given considerable attention to the pattern of air flow through the nasal cavity. He used actual cadaver specimens, or models made from casts of the nasal cavities, pointing out that the inaccurate models used by previous workers introduced errors that made them useless for such studies. By employing smoke or fine particles of powder in suspension he traced the path of the air currents down into the lower respiratory tract, and noted that particulate matter was deposited at certain points more than at others, making the interesting observation that it is at these very points that the lymphoid masses of the pharynx- the adenoid, faucial and lingual tonsils, and the paralaryngeal lymph tissue - develop. His illustration of the patterns of flow on inspiration is reproduced as Fig. 20 and shows that it is laminar and free from eddies, passing in a smooth curve from anterior nares through the middle meatus into the nasopharynx. The expiratory stream shown in Fig.21 is more turbulent, but since this air is clean and warm this is of no practical disadvantage. Any abnormality of the nasal cavities that causes the inspiratory stream to become turbulent

Fig. 20
Inspiratory Air Currents. After Proetz.

Fig. 21.

Expiratory Air Currents. After Proetz.

increases the resistance to inspiration, causes particles to be deposited at certain spots and leads to abnormal drying of the mucosa in these situations. In his paper he illustrates experiments that he performed by passing smoke through tubes of various shapes showing that there is a marked deposition of carbon beyond any area of constriction in the tube. It is therefore likely that any undue narrowing of the nasal inlet would be liable to cause turbulent flow which would lead to the deposition of bacteria in an area beyond the constriction; the same area would suffer excessive drying, imparing ciliary action and altering the state of the mucus blanket.

In the normal nose there is an area narrower than the cavity beyond which is called the "ostium internum". It is situated where the vestibule joins the respiratory part of the nose and its cross section area is given by Negus as from 20 to 40 sq. mm., while from tracings made from skulls in the Museum of the Royal College of Surgeons of England he found that the area of the bony piriform aperture ranged from 92 sq. mm. for a Negro, through 79 for a European, to 69 for an Esquimo. These dimensions make it clear that the soft tissues in the region of the upper lateral nasal cartilage are mainly responsible for the production of this ostium internum, although in very narrow noses the cochae may cause the greater resistance. Uddstömer (1940) states that in the normal nose 70% of the total resistance may be attributed to the ostium internum, the size of which can be changed by contraction of the muscles associated with the nasal alae. In the leptorrhine nose the narrowing produced by the soft tissues would be proportionally greater, and de Wit (1964) has observed that the lower edge of the piriform aperture being at a higher level than the floor of the nose in the leptorrhine gives the air stream a more upward direction and predisposes to turbulence. Both de Wit and Proetz note the sense of obstruction that may be experienced by a patient in whom no visible block can be detected, and suggest that turbulent flow in a wide nose may cause this phenomenon. The narrowing caused by the ostium internum is also responsible for pressure changes in the nasal cavity during the phases of respiration. Van Dishoek (1942) measured the rise and fall of pressure in the nasopharynx and found it to be -10 mm. of water during inspiration and +8 mm. during expiration. This range of 18 mm. is equivalent to about 1.4 mm Hg. or 1/550th of atmospheric pressure. Proetz (1953) states that it changes 1/2000th of an atmosphere to the negative side in inspiration and a similar amount positive during expiration. Tonndorf (1958) has also demonstrated similar changes of pressure during respiration, and Stoksted remarks that these pressure changes may be increased greatly in nasal obstruction.

These respiratory pressure changes cause a small tide of air to flow in and out of the sinuses at each respiratory cycle. If we take the values given by Proetz of a total change of 1/1000 th atmosphere, only this fraction of the air in a sinus will be changed; but when abnormal obstruction is present, a much greater air flow into the sinuses will result. This may render it easier for pathogens to gain access to the sinuses from the nose, rendering them more susceptible to infection. It is therefore conceivable that a narrowing of the anatomical inlet to the nose may in this way show a correlation with the susceptibility to sinusitis.

Atrophic rhinitis is a condition in which there is a great increase in the capacity of the nasal cavities caused by an atrophic change in the mucosa. Drying secretions form crusts that are difficult to expel since the air stream on blowing the nose can pass easily through the wide cavities without dislodging them from the walls. It has long been taught that surgical procedures such as turbinectomy that cause an undue widening of the nasal cavities may lead to the development of this most distressing condition. If this is indeed the case, it should be possible to show that patients with abnormally wide nasal cavities have a predisposition to the development of this disorder; for which reason measurements have been made on such subjects during this study. On the surface there appears to be support for this contention, since atrophic rhinitis in East Africa was found to be common in the African, less common in the mesorrhine Asian, and very rare in the European with the narrow nasal cavities. There are however many other possible factors that may be at work, and it is hoped that this present study may make it possible to show if the width of the nasal cavity is indeed relevant. A personal case of a European boy comes to mind who developed a juvenile fibro-angioma of the post-nasal space. Thus tumour grew into the nasal cavity on the right side expanding it greatly, deflecting the septum to the left and compressing the conchae. After removal he was left with a very wide cavity, but although observed for several years there was no tendency at all for atrophic rhinitis to develop. Quite apart from the known racial characteristics of the architecture of the nose, race may affect the mucosa by other genetic factors; differences in diet, personal hygiene or living conditions may be involved; the liability of refugees to develop the disease when crowded together in camps on a poor diet having already been mentioned. Much work of great interest has been done on the influence of the sex hormones on the nose, and oestrogens have been employed in the treatment of atrophic rhinitis. Schaeffer (1920) devotes a considerable section of his book to naso-sexual relationships, pointing out the many reflexes that have been described involving both the nose and sex organs. He quotes the work of Fleiss (1895) who advocated the application of the cautery to certain spots in the nose as a treatment for dysmenorrhoea, and described the reflex sneezing that may follow sexual activity. More recently

Taylor and Young (1961) and Taylor (1961) have noted that the volume of the cavernous tissue in the nose is related to sex hormone concentration and is greatest at the periods of life when sex activity is greatest. Since sex plays a greater part in the life of certain communities than in others, and its expression is variously regulated by social conventions, these differences may well have an effect on the incidence of nasal disorders such as atrophic rhinitis and vasomotor rhinitis.

To summarise the physiological concepts behind this investigation, it is contended that variations in the architecture of the nose by influencing its efficiency as an air-conditioning mechanism may determine areas of deposition of irritants, affect ciliary action, and alter the physical properties of the mucus blanket. The width of the ostium internum will modify the extent to which air enters and leaves the sinuses during the respiratory cycle and will determine flow patterns through the nasal fossae. An unduly wide cavity may render efficient cleansing difficult, and reduce contact between the air stream and the mucosa. Adjustments to climatic changes are effected by the vasomotor control within wide limits, but if these limits are reduced by unfavourable anatomical factors the demand may overstep these bounds and lead eventually to a breakdown of the mechanism evidenced by the clinical condition known as vasomotor rhinitis.

FINDINGS

It is hoped that a study of the dimensions and indices set out in the tables and figures will contribute towards the answers to a number of problems. These include the following:-

a) An evaluation of the adequacy of the measurements adopted in this study as evidenced by the agreement with the work of other investigators.

b) Sex differences in the nose.

c) The genetic composition of race groups with special reference to the Cape Coloured community.

d) In view of the confusion that has been noted in the way that nasal dimensions have been measured, to provide a means of assessing what methods have in fact been employed by previous workers.

e) Provision of conversion factors by which measurements taken from one of alternative points may be adjusted to conform to those taken from the other.

f) To evaluate the changes produced by the process of embalming and to indicate the suitability of cadaver material for a study of this nature.

g) To test the validity of the formula of Thomson and Buxton for the conversion of skull indices to those of the living subject.

h) To add to the knowledge of the manner in which the nose grows during childhood, providing thereby a means by which values obtained in the juvenile nose may be included in the present investigation into the susceptibility to nasal disease.

i) To enable a correlation to be made between subjects who are normal and those suffering from a selected list of nasal disorders, so demonstrating if in fact nasal architecture plays a part in the causation of these diseased conditions.

A CRITIQUE OF THE METHODS ADOPTED FOR USE IN THIS STUDY

The measurements and indices used in this study may be evaluated on theoretical grounds, by internal self consistency in the results, and by comparison with the published findings of other workers. The rationale behind the points adopted for these measurements has been fully described earlier and need not be elaborated further, it being contended that the points employed are in fact the most practicable of any for this study. The accuracy with which the various dimensions can be measured varies with the nature of the measurements. It has already been noted that skull dimensions are usually precise, and of these nasal breadth is probably the easiest to measure. It would have been possible to record this dimension with an accuracy less than the nearest half millimeter, but unless all the others could be similarly evaluated, no purpose would have been achieved by so doing. The breadth of the fronto-nasal suture varies from a fine line to a broader irregular area up to one millimeter in extent, so that inaccuracies up to half a millimeter are inevitable in the nasal height. In the living and the cadaver, repeat measurements were routinely done and variations up to one millimeter often found. However, individual errors of this magnitude will become of little importance where a large series is averaged, and the means of the indices and measurements are therefore expressed to the first decimal place. When the findings set out in the tables are studied, a good degree of internal consistency in the values is seen. For example, in the larger groups, the European and Coloured, the male and female nasal indices agree to within less than the sum of the two standard errors, the small differences observed between the sexes being discussed later.

In Tables 6-11 comparisons are made between the findings in the present study and those of others, some comment being needed. The values obtained in the case of the European skulls lie well within the range reported by other workers except for some in the case of the female; the very small series of 9 however making this likely to be due to sampling errors. Since in the skull measurements the nasion is always employed, no factor of uncertainty on this account exists. For the Coloured skulls the only truly comparable figures are those of Keen (1951, 1952) whose findings are in very good agreement with the present study. His nasal indices are 54.2, 54.6 and 57.9 for male, female, and sex unstated, respectively, while the present study gives 52.5 and 56.0 for male and female. As will be seen later, these Coloured skulls are of a type nearer to the African than is the case in the Coloured community as a whole. Nasal indices from other workers for Asiatic peoples of unspecified sex range from 51.4 for Javanese to 53.4 for Burmese. When the smaller series of African skulls is compared with published figures the great range of values found in the

TABLE 6

COMPARISON WITH OTHER PUBLISHED SERIES EUROPEAN SKULLS

Series	No. M	No. F	MALE NH	MALE NB	MALE NI	MALE PL	FEMALE NH	FEMALE NB	FEMALE NI	FEMALE PL
Present study	14	9	52.8	24.8	47.1	44.4	47.6	22.6	47.6	42.3
Whitechapel (a)	70	50	51.2	24.3	47.6	48.3	48.7	23.2	47.8	45.1
Farringdon St.(b)	80	70	51.8	24.6	47.5	46.0	48.1	23.5	49.2	43.8
Tyrolese (b)	130	-	53.8	25.5	47.7	-				
Slovenes (b)	60	-	50.5	23.9	47.1	45.7				
Predynastic Egypt (b)	50	-	50.2	25.0	49.8	48.0				
Scot.Short Cist (c)	15	-	49.9	24.8	50.4	51.6				
Long Cist (d)	8	-	50.5	22.6	44.7	-				
Iceland 11-12 century (e)	19	6	51.9	23.6	45.0	-	50.0	23.1	46.6	
Swedish (e)	13	12	52.8	23.8	45.2	-	48.0	22.7	47.6	
Moorfields (f)			50.4	24.0	47.6	44.3				
West scottish (f)			50.9	23.3	46.1	45.6				

(a) Hooke 1926
(b) Morant 1928
(c) Reid & Morant 1928
(d) Wells 1956
(e) Steffensen 1953
(f) Trevor

TABLE 7

COMPARISON WITH OTHER PUBLISHED SERIES — COLOURED SKULLS

Series	No. M	No. F	MALE NH	MALE NB	MALE NI	MALE PL	FEMALE NH	FEMALE NB	FEMALE NI	FEMALE PL
Present Study	61	41	48.8	25.7	52.5	46.4	45.4	25.3	56.0	43.8
Keen 1951	141	60	49.2	26.3	54.2	-	46.6	25.0	54.6	-
Keen 1952	201		45.4	25.8	57.9	(sex unstated)				

Nasal indices only quoted by Davies Malay 51.9 Burmese 53.4

Nasal indices quoted by Topinard Chinese 48.5 Javanese 51.4

Palate length quoted by Galloway Chinese 45.0

TABLE 8

COMPARISON WITH OTHER PUBLISHED SERIES — AFRICAN SKULLS

Series	No. M	No. F	MALE NH	MALE NB	MALE NI	MALE PL	FEMALE NH	FEMALE NB	FEMALE NI	FEMALE PL
Present Study	17	6	49.0	27.0	55.2	48.7	47.8	27.3	57.5	43.6
Keen 1947	220	-	49.4	28.0	57.0		-	-	-	-
Trevor 1958										
U.S. Negro			53.3	27.3	51.4	49.4	49.3	26.3	53.4	46.8
Ashanti			49.3	27.9	56.8	48.6				
Cameroons			49.9	27.4	54.9	49.4				
Fernando Vaz			49.8	27.5	55.4	48.9				
Tetela			48.5	27.5	56.7	49.5				
Hottentot Keen 1947	35		47.4	27.8	58.4	(sex unstated)				
Bushman do.	31		42.2	35.8	61.3	(sex unstated)				

TABLE 9

COMPARISON WITH OTHER PUBLISHED SERIES — **EUROPEAN LIVING**

Series	No. M	No. F	MALE NH	MALE NB	MALE NI	MALE PL	FEMALE NH	FEMALE NB	FEMALE NI	FEMALE PL
Present Study	100	71	53.3	35.9	67.7	55.5	49.3	32.8	66.7	52.5
Hertzberg (1954)	4000		50.93	33.4	65.5					

Nasal Indices only quoted by Thomson & Buxton (1923)

Paris 69.1; Brussels 68.3; Landes, France 69.9; Italian soldiers 68.5; Bretons 67.5; South France 65.7; Tirolese 63.0

Nasal Indices only quoted by Davies (1932)

Average in France	67
Greenland Esquime	64
Bordeaux	69

TABLE 10

COMPARISON WITH OTHER PUBLISHED SERIES — **COLOURED LIVING** ~~ASIAN & MALAY~~

Series	No. M	No. F	MALE NH	MALE NB	MALE NI	MALE PL	FEMALE NH	FEMALE NB	FEMALE NI	FEMALE PL
Present Study Col.	59	51	50.1	40.3	81.1	54.6	45.6	36.8	81.3	52.7
Asian & Malay	26	3	52.3	39.0	74.8	52.5	46.0	35.3	82.3	55.0

Nasal Indices only quoted by Thomson & Buxton:-

Malay 84.2; India, United Provinces 80.8; India, Bombay & Poona 76.2; Tibet 74.4

Nasal Indices only quoted by Trevor (1947)

Southern Bushmen 109.3; Hottentots 100.2;
Northern Bushmen 73.0 (nasion probably used here)

TABLE 11

COMPARISON WITH OTHER PUBLISHED SERIES AFRICAN LIVING

	No.		MALE				FEMALE			
Series	M	F	NH	NB	NI	PL	NH	NB	NI	PL
Present study	16	28	47.2	45.7	97.2	57.3	44.7	41.3	93.0	55.0
Leys & Joyce (1913)										
Baganda			44.9	42.8	95.6	-				
Wanyamwezi			47.9	42.9	89.8	-				
Masai			50.1	38.1	76.2	-				
Herskowitz (1930)										
American Negro	960		53.5	41.0	76.5	(sex unstated)				

Nasal Indices only quoted by Thomson & Buxton:-

South Gaboon 104.6 ; Wanyamwezi 89.7; Kikuyu 87.1

East African Bantu 86.9

Nasal Index quoted by Davies Hausa 100

various tribes is striking. The United States Negro has an index much less than that found among peoples living at present on the African continent, due without doubt to the considerable admixture of other races in their ancestry. Apart from the American figures, the present findings agree well with those from the rest of the continent except in the case of the Bushmen who are an entirely different people with a nasal index of the hyperplatyrrhine type.

Examining now the values obtained from the living subjects, the nasal index for the male European is 67.7 and for the female 66.7. Published series in which the sex is not specified range from 63 for the Tirolese to 69.9 for the French, so the present values lie well within these limits. For the Cape Coloured no other published series has been found, but Thomson and Buxton give indices for mesorrhine types that include 74.4 for Tibetans and 84.2 for Malay. The present values are 81.2 for all Coloureds, and 74.8 for the Asian and Malay group males, the females here being too few to be significant. The mean of African male and female subjects gives a nasal index of 95, published figures for other African tribes being in the range 86.9 to 104.6, the American Negro again being much lower at 76.5 (Herskowitz,1930). In these African indices the doubt expressed by Trevor regarding the upper point for nasal height employed must be borne in mind. The measurements and indices obtained in the present study are therefore shown to be in good agreement with the findings of other workers.

SEX DIFFERENCES IN THE NOSE

While the nasal indices are very similar in the sexes it is noteworthy that in every published skull series included in the comparative tables the female index is slightly the greater; a finding also observed in the present study. While the difference in any one series may not reach statistical significance, as it does not in the present findings, yet taken collectively the evidence is strong that the female in every race has an index that is slightly the greater. In the living subjects the values obtained in the present study show no difference between the sexes, but those of Davenport give a female index that is about 4 units greater. He states that this sex difference is recorded in some but not in all other series of European measurements. However, if the mean height and breadth are taken from his Figures 1 and 14 and the nasal index calculated from these means, the sex difference is not apparent as can be seen from Table 9. Taken together it would appear that the trend towards a wider nose in the female is consistently present in the skull, but not always found in the living subject.

This would suggest that the nasal breadth in the female skull is larger in proportion to that at the alae compared with the male. This difference was suspected independently from consideration of the Volume Indices in the sexes. The mean volume index of the male and female living subjects in the four race groups is 106 - 85; 111 - 89; 107 - 89, and 123 - 102, giving sex differences of 21, 22, 18 and 21 respectively. When the individual values are plotted as in Fig. 22 it is seen that this difference would make it possible to determine the sex of a subject with considerable accuracy. If we examine the volume indices of the skull in a similar way, the figures are 59 - 50, 64 - 57, and 58 - 46 with differences of 9, 7, and 12, there being no Asian skull group. When set out as in Fig. 23 it is seen that there is a much less degree of sex predictability in the volume indices of the skull, and on considering the factors that contribute to this index it is found that it is the nasal breadth that is responsible for most of the sex difference. Comparison of these two sets of indices makes it clear that the alar breadth in the female is less, relative to the bony breadth, than in the case of the male. This is brought out clearly if the relation between the two nasal breadths is expressed as a percentage as in the table that follows:

TABLE 12

NASAL BREADTH AT PIRIFORM APERTURE AS A PERCENTAGE OF ALAR BREADTH

		Cadaver	Living Subject
European	Male	62%	69%
	Female	66%	69%
Coloured	Male	57%	64%
	Female	61%	69%
African	Male	58%	59%
	Female	63%	63%

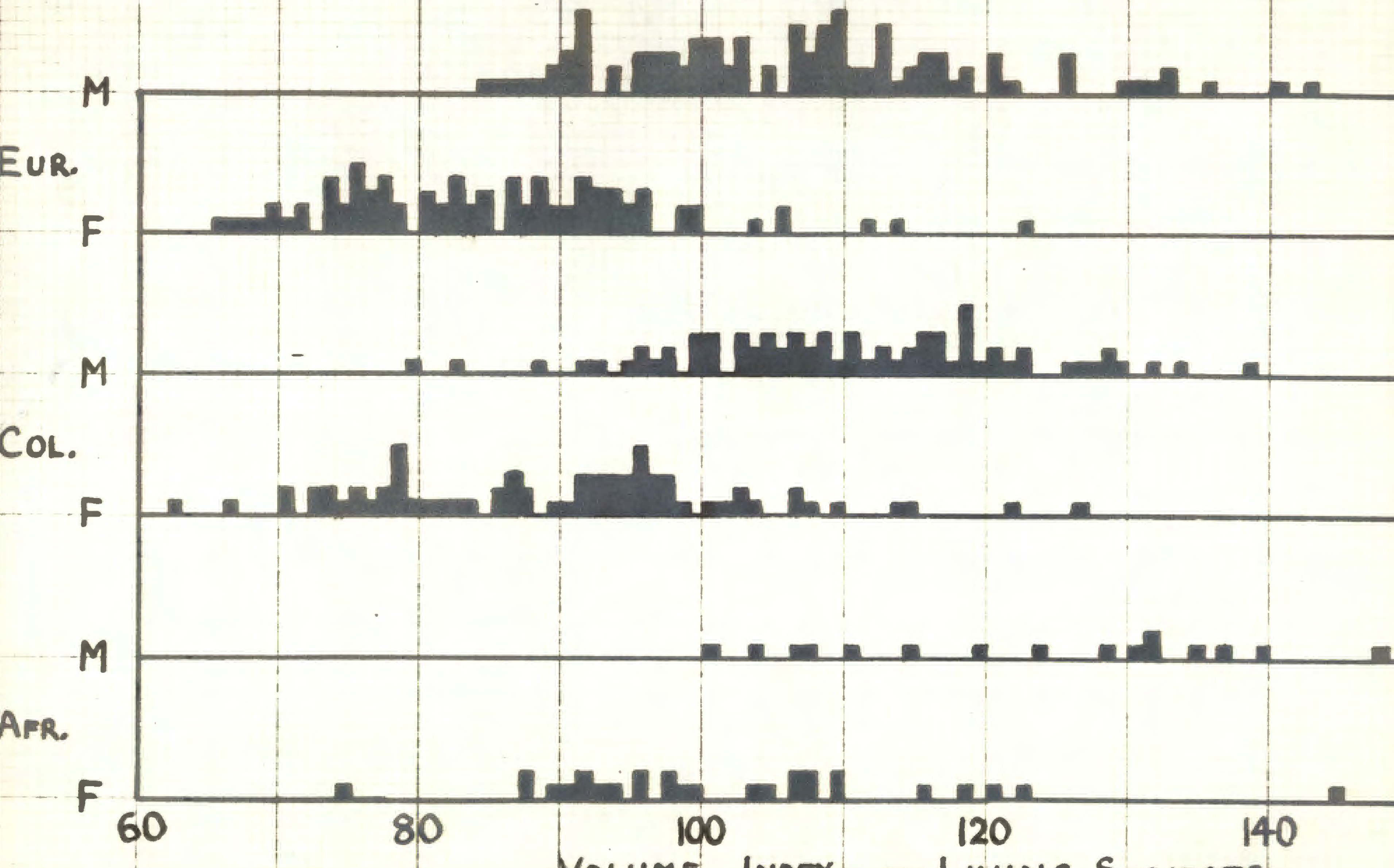

M
Eur.
F
M
Col.
F
M
Afr.
F
60
80
100
120
140
Volume Index — Living Subjects

Fig. 22

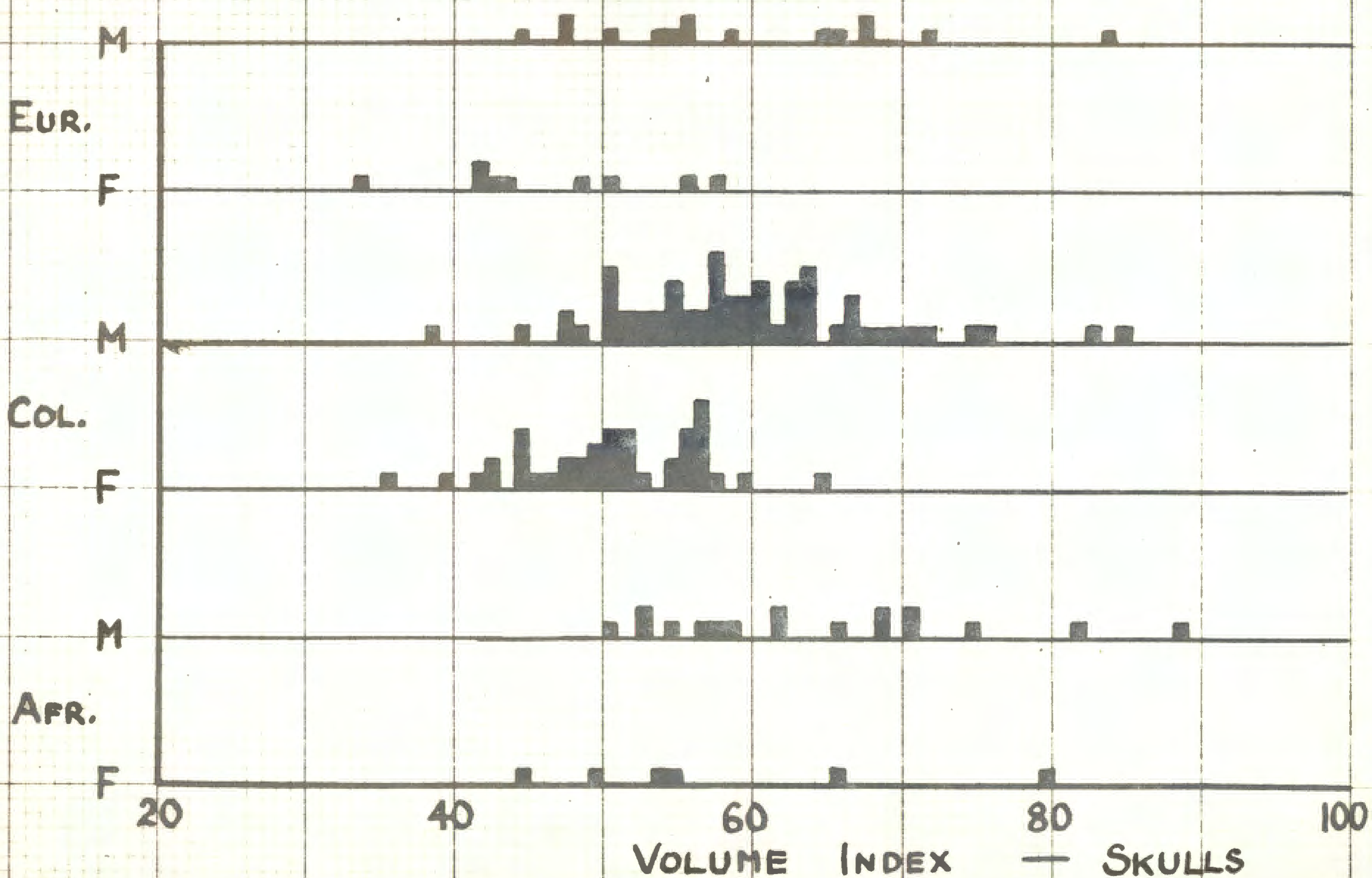


Fig. 23

In all except the European living subjects the female percentage is the higher, the difference between the cadaver and living being an indication of the embalming changes. If now 1.3 mm. is deducted from the cadaver breadth to compensate for this, the two sets of figures are brought nearer together, the two values for the Coloured subjects remaining further apart because the two populations - cadaver and living - are not comparable. These figures all support the main contention that the alar breadth in the male is relatively greater than in the female. The dimensions of the nose being smaller generally in the female it is obvious that indices derived from the product of two or more dimensions, such as the volume index and the area index, must also have a smaller value in the female.

THE CAPE COLOURED COMMUNITY AND OTHER RACIAL CONSIDERATIONS

The many race groups that have contributed to the genetic material of these interesting people have already been mentioned, and it would not be surprising if this were to be reflected in a polymorphism of the group. This is not as striking as might have been anticipated, but Table 13 shows that there is a trend in this direction.

TABLE 13

Standard Deviation of Means of Living Subjects by Race

Values are mean of male and female

	NH	NB	PL	NI	AI	VI
European	3.5	2.5	3.2	6.1	14.2	12.0
Coloured	3.6	2.6	3.4	8.8	14.7	12.7
Asian & Malay	2.3	2.4	2.6	6.3	10.9	9.9
African	3.0	2.5	3.9	8.4	15.2	13.8

In this table the standard deviations for various parameters in the race groups are set out, showing that the Coloured people have a slightly greater variability than the European(themselves of very mixed origin), about the same as the African, but very much greater than in the Asian and Malay who are shown by this to be a rather homogeneous community. The Asian community in South Africa is composed of peoples from several countries, and even those from India itself may be the lighter skinned Aryians from the north with a mesorrhine type of nose or the Dravidians from the south with a more platyrrhine form. Mistry (1965) has recently reviewed the ethnic groups present in this community and points out the relevance of this study to the susceptibility to certain diseases, notably diabetes. The Asian subjects examined in the present investigation come mainly from south and west India so that they are more homogeneous than those in the country as a whole.

When however the cadaver measurements are compared with those from the living subjects a highly significant difference emerges. Even after due allowance has been made for probable embalming changes, the cadaver index is 97.5 for male and 96.3 for female, while the corresponding values for the living subjects are 81.1 and 81.3. This great difference is not seen in the other race groups where the figures are:- European 71.3, 65.8 against 67.7, 66.7; and African 97.2,99.6 against 97.2, 93.0. The only conclusion that can be drawn from these striking figures is that the population sampled in the case of the living subjects is different from that in the cadavers. On reflection the reason for this is not difficult to see. The cadavers drawn upon to provide dissecting room subjects are mainly unclaimed bodies likely to be from persons low on the social scale. In the Cape Coloured community social level is closely related to colour, the darker skinned individuals who have a greater admixture of Bantu blood being on the whole those who tend to gravitate to the lower places. This supposition is confirmed when it is observed that the indices for the Coloured cadavers are very close to those for the pure Bantu subjects, showing that the dissecting room material represents only an extreme fringe of the spectrum of racial types found in this community. The close agreement with the figures of Keen confirms this, since he too used dissecting room specimens which were drawn probably from a similar section of the population. This raises the important question of the suitability of dissecting room material for certain anatomical investigations where the population in question presents a social stratification that is linked to racial type; for the nasal index is not the only anatomical feature that is known to be race dependant. The frequency of anomalies of the aortic arch, of bifid cervical spinous processes and several other characters have been found to be race linked, while the rarity of the otosclerotic focus in the Negro is well known to all otologists. There may well be areas where this problem has not existed in the past but where present immigration trends may lead to this complication in the future, especially where an immigrant race tends to gravitate to a particular social level. This source of error must be kept in mind when statistical information regarding the frequency of incidence of a character is sought by a study of dissecting room cadavers. Once attention has been drawn to this possibility, it may well be asked whether the living subjects themselves are representative of a true cross section of the Coloured community. The out-patients at Groote Schuur Hospital are normally limited to those of the lower income group, so that a certain amount of selection may operate even here. All therefore that can be claimed is that the measurements obtained are from this particular section of the community mixed with a proportion of the higher income levels drawn from the medical students.

The genetic constitution of the Cape Coloured people has recently been studied by Gordon (1965). He has examined many genetic characteristics such as blood groups, P.T.C. tasters, finger print patterns etc., and comes to the conclusion that these people are closer to the European than to the Bantu, and also show clear distinctions from the Malay. The present evidence from the nasal indices of living subjects would appear to give support to his findings, the mean male indices being European 67.7; Coloured 81.1; Asian 74.8; and African 97.2; giving a difference between European and Coloured of 13.5 and between Bantu and Coloured of 16.0. The area and volume indices also have racial correlations, and in Fig. 22 it may be seen that in each sex the European has the smallest volume, the Coloured a larger, and the African the largest; the values being for males 106, 111 and 123, and for females 85, 89 and 102 respectively. Here again the Coloured stands nearer to the European than to the African. It is interesting to compare these figures with the previously quoted values for the area of the piriform aperture given by Negus, where it may be seen that the aperture area of the European is 86% of that of the Negro, the similar relationship between the volume indices is 86.5% for the male and 83.5% for the female. When however the area indices are examined, it is seen that the European has the largest, the African next, and the Coloured the smallest, the means being for males in that order 160, 153 and 149 and for females 139, 137 and 132. The area and volume indices indicate therefore that the African has the most capacious nose as well as the largest aperture area, while the European has the largest mucosal area. This could be interpreted as a confirmation of the influence of climate on the form of the nose, dwellers in cold climates requiring a greater area of mucosa for air-conditioning and narrower cavities to ensure more efficient contact with the inspiratory air currents. It would be most interesting if area and volume indices could be obtained for the Esquimaux. These should show an even greater mucosal area and smaller nasal volume if the above suggestion is correct. One indication that this may indeed be the case is the palate length as given by Eichholz. Although he used a different method of measuring this dimension, yet for purposes of comparison his findings are valid; the Esquimo palate being 41.3 and the European 37.5 mm. For reasons that are not apparent, the area index of the Coloured is lower than either of the European and African; and while the values for the Asian group are higher than in the case of the Coloured, the numbers in the sample are rather small for definite conclusions to be reached.

THE CONFUSION BETWEEN NASION AND SELLION

"It is regrettable" remark Talbot and Mulhall (1962), "that divergence in practice among different observers has vitiated to a considerable extent the comparability of somatometric measurements. Mahalanobis (1928) has estimated that between 55 and 70% of the usefulness of the material has been wasted owing to lack of agreement in definitions and technique". It is statements such as this that have impressed on the present author the need to define carefully points and measurements, and also encouraged an attempt to provide a means by which in retrospect some of the past confusion may be resolved.

It has already been noted that the nasal index found for the European living subjects lies well within the range of values quoted by Thomson and Buxton, making it almost certain that they in fact used the sellion for their measurements. If the index found in the present study were to be converted to that employing the nasion, the values would fall by an average of 7 putting them quite outside the range of these values from other workers. In this instance therefore it would appear that we can confidently determine which point was employed in these published series. The same conclusion seems probable in the case of the Coloured and Asian, since conversion to the indices from the nasion puts them below almost all published values except those of European series.

Values for African tribes recorded by other workers show a wide range, the majority lying below the index found in the present study, but a few being significantly higher. Here it is difficult to arrive at a dogmatic conclusion, but it is likely that many of the workers used a point approximating to the true nasion or alternatively that the Xhosa tribe has a nasal index that is higher than the majority of Bantu tribes in other parts of the continent of Africa.

The two different points that may be employed as the upper terminal for nasal height give values of the nasal index that are so different, that in many cases it is possible to say with certainty which point has in fact been employed in a published series. Where a worker has attempted to estimate the position of the nasion by one of the methods previously described, it may well be that he has in fact selected a point that is intermediate between the nasion and sellion, and this would make an evaluation in retrospect more difficult. This enhances the value of the large series examined by Hertzberg et al.(1954). Here the actual technique used is illustrated making it quite certain that they employed the sellion. Their nasal index differs from that of the Europeans in the present study by only 2.2, a remarkably good agreement when the very mixed origin of both the American and the South African White races is considered.

CONVERSION OF INDICES EMPLOYING THE SELLION TO THOSE USING NASION.

Figures 13-15 set out the relation between the indices employing the two alternative points, and the equations so deduced have been described. It can be seen that the two indices differ by about 7 for a leptorrhine nose up to about 15 in the platyrrhine type, making it clear that any ambiguity regarding the point employed will make very great discrepancies in the values obtained. It is contended that for this reason any attempt to "estimate" the position of the nasion is unsatisfactory and renders it an unsuitable point to employ in the living subject, particularly as it is clear that the region of the root of the nose is one where great variation occurs as evidenced by the large standard deviation of the measurements of the interval between nasion and sellion. As far as can be ascertained the present study is the first that has been made in which the precise interval between nasion and sellion has been determined, and the conversion of one index to the other made possible. It is hoped that this information will be of value to other workers in this field.

EMBALMING CHANGES

The discrepancies that led to an investigation into possible embalming changes have already been noted and the procedure that was adopted has been described. It is realised, for reasons already explained, that the number of subjects available on which to base conclusions is limited so that the factors worked out must be regarded as tentative. There is however the possibility of obtaining independent evidence of the accuracy of the values adopted by observing how well the cadaver measurements so corrected are in accord with the values obtained from the living subjects and with other published results. That such a change due to the embalming process is likely was observed by Duckworth (1917) who remarked that the lapse of time brought with it pressure effects which distort the soft parts. He stated that the greatest discrepancy occurs in respect of the transverse measurements of the dissecting room bodies, suggesting that the divergence may be so great that some aberrant data might have to be excluded.

It has been already shown that the Coloured cadavers are not a fair sample of the living subjects of this race group so they cannot be used in a comparison between corrected cadaver and living measurements. This is unfortunate as they constitute the largest group of cadavers, so that reliance must be placed on the much smaller European and African series. Table 14 sets out such a comparison, based on 16 male and 9 female European cadavers, and 15 male and 7 female African. There is good agreement except in the case of the nasal breadth of the European males, and nasal height in the African females. These differences are probably attributable to sampling errors, as there is no consistent trend to indicate that the correction factors that had been applied should be changed. What is clear is that had no such correction factor been applied, the discrepancies would have been greater.

TABLE 14

Comparison of means for Corrected Cadaver Measurements with those from Living Subjects

		NH	NB	NI
European males	Cadaver (E.C.)	54.7	38.8	71.3
	Living	53.3	35.9	67.7
European females	Cadaver (E.C.)	50.3	33.1	65.8
	Living	49.3	32.8	66.7
African males	Cadaver (E.C.)	46.4	45.1	97.2
	Living	47.2	45.7	97.2
African females	Cadaver (E.C.)	42.1	41.8	99.6
	Living	44.7	41.3	93.0

Another method of evaluation derives from a study of Figs. 13-15. If we exclude Fig. 14 which refers to the smaller European series, the close agreement to within a half unit of the equations derived from Figs. 13 and 15, would not have been seen had the embalming correction been significantly in error. Later in this thesis the evidence for the accuracy of the equation of Thomson and Buxton for the conversion of skull to living subject indices will be examined, and here again there will be a test for the embalming factor.

RELATION OF NASAL INDEX OF THE SKULL TO THAT OF THE LIVING

After the study of a large series of measurements from many parts of the world, Thomson and Buxton derived an equation by which the skull and living index could be related. This formula is: -

$$\text{N.I. (Living)} = \text{N.I. (Skull)} \times 2.327 - 38.08$$

Fig. 16 shows this relation in the case of 46 cadavers which had been measured in the dissecting room and from which the cleaned skull subsequently became available for craniometry. Each point represents the value for one cadaver and its skull, the cadaver indices having been corrected by the use of the embalming change formula. Through these points is drawn the line required by the above equation, from which it may be seen that rather more of the points lie to the left than to the right of the line. If all the cadaver indices were to be augmented by an average factor of 3 the line would lie through the centre of the points. This lack of a perfect fit may be due to one or more of three possible factors. It may be explicable solely as a sampling error; it may indicate that the embalming change factor is not correct; or it may cast doubt on the equation of Thomson and Buxton. Fig. 17 shows a similar display, but here the open circles are the values for a number of population samples quoted by Davies. These fit the line very well indeed, so well that one is almost tempted to feel they are too good to be true considering the small size of some of the groups he uses. The figures for the Tirolese are not taken from Davies, but the skulls are given by Morant (1928) and the living by Thomson and Buxton. This point is some way to the left of the line, and more in the region occupied by the values shown in Fig. 16. There are relatively few other series published where the skull and living indices are available for an identical group, but were the range of European skulls and living indices to be taken it could be seen that they would fall in an area that is also to the left of Thomson and Buxton's line. On Fig. 17 is also shown the mean values of all the skull and corrected cadaver indices, each group being denoted by a symbol as shown in the key. The size of the sample employed is also given. In the case of the largest race group, the Coloureds, the means fall quite near to the line, the males a little to the right and the females to the left, fitting the formula well. The European and African means are further removed, the former being near the Tirolese figures quoted above. Since the values obtained in the case of the Coloured subjects are a good fit, and these form the largest group, it would appear that the embalming factor is correct, and that the formula of Thomson and Buxton is satisfactory here. The less satisfactory fit in the case of the European and African may mean that the formula is not so accurate here or that it may be discounted as a sampling error.

CHANGES OF THE NOSE WITH AGE

During childhood the nasal index changes greatly due to a disproportionally rapid growth in nasal height compared with breadth, so that the infant has a wide nose and a high nasal index. The ideal manner in which to observe growth is by a longitudinal study such as that undertaken by Meredith (1959). Here individual children were followed over many years, and the growth pattern in each observed. In such a study not only can the average mode of growth be seen, but the individual variations in this pattern ascertained. Davenport also has studied the growth of the external nose in considerable detail. He collected mass statistics of the dimensions at various ages and was able also to study the progress of individual children in some cases. He has presented his results in the form of growth curves and tables that show the rate of change at various periods. In the present investigation such a longitudinal study has not been possible, and a transverse method has been adopted, giving the mean dimensions and index for two-year age categories from 4 to 16. European and Coloured subjects and male and female have been analysed separately but as the number available is limited and the nasal index is almost identical for the sexes, males and females have been added together and the values averaged. This procedure renders the graphs more regular and makes the general trends more obvious. Shown on the same figures are the values obtained by Goldstein in the case of the Europeans and Herskowitz in the case of the Coloureds. Goldstein's figures were obtained from males only and 92% of these were Jewish. His general trends are similar to those of the present study, but his higher values for nasal height are partly because his subjects were males, but also because it appears that his upper point may have approximated to the anatomical nasion, his breadth values being almost identical to the present male findings. His study was done on groups of 50 subjects, so the resulting graph of growth has few irregularities due to sampling errors. Similar trends can however be seen in both sets of figures. The nose grows rapidly in height up to about 10 years, then slows down until puberty when there is again an accelerated growth. The breadth growth is more regular, so that the progressive fall in nasal index halts for a time and even reverses somewhat before falling to the adult value in the four years after puberty. Davenport's findings shown in his Fig. 1 indicate the pause in growth in nasal height to be somewhat earlier, the puberty acceleration commencing after 8 years in the boys and a little later in the girls. For purposes of adjusting measurements in later childhood to make it possible to include them in the adult figures for the disease categories, it can be seen that there is very little change in the nasal index after the age of 10 years.

The European measurements and index are set out in Fig. 18. Fig. 19 shows a similar examination of the Coloured children, and here the series is larger, making more definite conclusions possible. Again the increase in breadth goes on steadily up to 18 years, while the height shows a pause between 12 and 14. The figures of Herskowitz (1930) for Negro subjects are included and again his values are somewhat higher probably because he used males and may have employed a different point for nasal height. It is of interest that the pause in height growth appears much earlier, between 6 and 8 in his figures, suggesting an earlier onset of puberty as a possible explanation. In the present study the irregular high value of the nasal index at the 14 year period may probably be ignored as due to the small sample of 13 available for analysis, but apart from this it is shown that from the age of 10 upwards, the nasal index of children is close to that of the adult, and a correction may be obtained by subtracting 2 from the nasal index between 10 and 15 and 1 after this up to 18. These correction values have in fact been employed to enable the figures for atrophic rhinitis to be computed.

CORRELATION WITH NASAL DISORDERS

The reasons why it has been felt that such a correlation might be apparent have been discussed earlier, and the dangers of making unwarranted assumptions pointed out. In this connection the observation of Davies is of interest when he was considering the nasal index of the skulls obtained from the plague pits in London, Whitechapel Moorfields and Farringdon St. By using Thomson and Buxton's formula he has calculated the corresponding living index, and finds it to be 73, much higher than that of the general population of England. Could it be that those with wide noses were more susceptible to plague ? At first sight this would seem a possible deduction, but it does not seem likely on medical grounds and other explanations must be considered. One suggested source of the high nasal index is the possibility that the population most affected by the plague contained a proportion of immigrants and seamen of Non-European stock. Plague is especially prevalent near docks with their high rat population, and it is in these areas that people of other races tend to be found.

The measurements obtained from patients in this study have enabled some definite conclusions to be reached. Among the European subjects, 41 males and 11 females were examined and diagnosed as suffering from vasomotor rhinitis. The mean values for all three indices are so close to those obtained from the normal controls that no formal statistical procedure is needed to see that no correlation exists between nasal morphology and the susceptibility to this disorder, the numbers being sufficiently large to enable definite conclusions to be reached. The same applies in the case of the group of 13 Coloured male subjects, but the mean nasal index obtained from 18 females is 74.4, 6.9 less than that of the normals. By the use of the "t" test, this difference is shown to be highly significant (P > .01) but it is difficult to see why this should be so when there is no such relation in the other groups. The European male group of sufferers from sinusitis is large enough to show a correlation were such to be present, but the indices are not significantly different from the normals.

If the nasal indices of the male and female Coloured subjects suffering from atrophic rhinitis are taken together, and the values from juveniles added after age correction, a total of 12 cases becomes available. The mean value obtained is 86.7, 5.5 above the mean for normal males and females. Not only is this the case, but only one patient shows a nasal index less than the normal mean, two being equal to it, and nine above. Applying the "t" test to this difference between the means, it is shown to be significant with a probability better than .05. It is thus clear that there appears to be a definite trend towards a wider nose among sufferers from atrophic rhinitis. This finding does not in itself necessarily justify the assumption that a patient with a wide nose is more prone to this disease, for the previously noted findings regarding the social stratification in the Coloured community may be relevant here.

It is possible that the section of this community that is closest to the African genetically and therefore lower in the social scale, is also the one whose living conditions make its members prone to this disorder.

From the findings of this study it may be concluded that there is no evidence that nasal dimensions have any significant influence on the susceptibility to vasomotor rhinitis or sinusitis, with the possible exception of the Coloured female group. There is however a definite trend towards a wide nose in sufferers from atrophic rhinitis among the Coloured community.

In this connection it is of interest to examine the total incidence of these three disorders among the patients who attend the Ear, Nose & Throat out-patients department at Groote Schuur Hospital. A random sample of 8550 new patients was taken covering a 2½ year period, and the race and sex composition was studied. The result is shown in Table 15, where the Coloureds are seen to provide most of the patients, the Europeans being the next largest group, while the Africans form only 6½% of the total. By comparison the cases of the three selected nasal conditions that were seen personally by the author show on analysis a disproportionately high incidence of vasomotor rhinitis and sinusitis in the European male group, while the incidence of atrophic rhinitis

TABLE 15

TOTAL OUT-PATIENT ATTENDANCE AT GROOTE SCHUUR HOSPITAL EAR NOSE & THROAT DEPARTMENT COMPARIED WITH THE INCIDENCE OF SELECTED NASAL DISORDERS

Total new patients seen were sampled alternate months from January 1963 to May 1965. Numbers given as suffering from selected diseases were those seen personally by the author at one session per week.

Race Distribution	Total	Eur. M	Eur. F	Col. M	Col. F	Afr. M	Afr. F
All patients	8550	19%	21%	26%	28%	3.4%	3.1%
Vasomotor Rhinitis	94	43%	12%	18%	21%	2%	3%
Sinusitis	24	38%	13%	21%	8%	4%	16%
Atrophic Rhinitis	18	6%	12%	22%	44%	0%	18%

in the Coloured community, particularly the female, is brought out. Since nasal morphology appears to have been excluded as a predisposing factor in vasomotor rhinitis and sinusitis, the very definite racial differences in the incidence of these diseases must have some other explanation. Alternative factors have already been listed and the investigation of these could well form a suitable subject for further research.

SUMMARY

This study set out to demonstrate what correlation, if any, existed between nasal dimensions and the susceptibility to certain nasal disorders - vasomotor rhinitis, sinusitis, and atrophic rhinitis. The physiology of the nose has been discussed and reasons adduced for relating its efficiency as an air-conditioning mechanism to the causation of these diseases. The dimensions that should be recorded and the definition of the points from which such measurements must be made have been considered, and good reasons found for employing the sellion as the upper point from which to measure nasal height. The need for precision in the localisation of such points has been pointed out, and the exact relation between the sellion and the nasion determined from examination of a large series of cadavers. The interval between these two points, and

formulae by which nasal indices employing one may be converted into those using the other have been worked out; it is believed for the first time. By the determination of a new craniometric point for which the name of cribrion is suggested, the level of the roof of the nasal cavity has been shown to be represented better by the sellion than by the nasion, a point which is well known to be difficult to locate in the living subject. By employing the findings of these studies comparison has been made between values arrived at by workers employing the nasion with those of others who have used the sellion; and it has been possible in many cases to determine in retrospect which of the two points had in fact been employed in published series. By measuring the depth of the palate a further dimension of nasal morphology has been introduced, and an instrument for obtaining this measure in the living subject has been devised. It has been shown that the palate depth is a good measure of the antero-posterior extent of the nasal cavity, enabling two new indices, the area index and the volume index to be calculated. From a study of skulls, cadavers, and living subjects it has been shown that the European has the largest mucosal area but the smallest nasal volume, the reverse being true for the African. The possible significance of this fact in relation to climate has been discussed. The genetic composition of the Cape Coloured community has been studied and the findings shown to agree well with independant genetic investigations employing other criteria, both methods of assessment showing that they stand nearer to the European than to the African. Comparison between the living subjects and the cadavers from the Coloured community has brought to light the fact that the cadaver specimens do not represent a typical cross-section of this community but are drawn from individuals nearer to the African type. Changes induced in the dissecting room subject by the process of embalming have been studied, their extent determined, and correction factors worked out and tested. Measurements from children have enabled the growth of the nose to be observed and correction factors for age worked out whereby values from juvenile subjects may be included in the series of adults suffering from nasal disorders. The values obtained have been tested both for internal consistency and for agreement with the published findings of others, and shown to be satisfactory. Finally the measurements and indices found for normal subjects have been compared with those from patients suffering from nasal diseases. No correlation between nasal morphology and vasomotor rhinitis or sinusitis could be shown, but sufferers from atrophic rhinitis have been found to have noses that are wider than the average for their race group. Other possible explanations for this last finding are examined.

By means of this study satisfactory methods have been devised to obviate the confusion that has often arisen in the past from lack of consistency in the nasal reference points employed. It is now possible for other workers to build on the foundation laid and to accumulate a large series of records, obtained under standardized conditions, from patients suffering from nasal disorders. In this way the relation between nasal morphology and pathology may be studied more effectively and in greater detail. Using these measurement techniques the author has himself already embarked on a fresh study designed to follow up the suggestion made by Thomson and Buxton that a correlation might be found between the width of the nasal cavities and the vital capacity of the lungs.

REFERENCES

Ashley-Montagu, M.F. Location of Nasion in the Living, Amer.J.Phys.Anthrop. 1935, 20,81-93.

Boo-Chai, K. Augmentation Rhinoplasty in the Orientals, Plast.&.Reconst.Surg. 1964, 34, 81-88.

Buxton, L.H.D. & Morant, G.M. The essentials of Craniological technique, J.Roy.Anth.Inst. 1933, 63, 19-47.

Cameron, J. The skeleton of British Neolithic Man, London: Williams & Northgate Ltd., 1934.

Cole, P. Some aspects of Temperature, Moisture and Heat Relationships in the Upper Respiratory Tract, J.L.O. 1953, 67, 449.

Connolly, C.J. The Location of the Nasion in the Living, Amer.J.Phys.Anthrop. 1926, 9, 349-353.

Cottle, Maurice H. Corrective Surgery of the Nasal Septum and External Pyramid, Study Notes and Laboratory Manual, Amer.Rhin.Soc. 1960, Chicago 15.

Davenport, C.B. Post-natal Development of the Human Outer Nose, Proc.Amer.Phil.Soc. 1939, 80, 175.

Davis, A. A Re-survey of the Morphology of the Nose in relation to Climate, J.Roy.Anth.Inst. 1932, 62, 337-359.

Dawes, J.D.K. The course of the Nasal Airstreams, J.Laryng. 1962, 66, 583.

Drettner, B. Vascular Reactions of the Human Nasal Mucosa on Exposure to Cold. Acta Oto-Laryng.(Stock),Supp.166, 1961.

De Wit, G. De Verstopte Neus, Ned.T.Geneesk 1964, 108, 193-197.

Duckworth, W.L.H.	Notes on some measurements made on subjects in the Dissection Room, J.Anat.,1917, 51, 167-179.
Eichholz, A.	Racial Variation in the Palatal Process of the Maxilla, J.Anat.&.Phys.,1892, 26, 538.
Fleiss	The Relation of the Nose and Female Genitalia, Leipzig, 1897.
Fleming, A.	The Bactericidal Power of Human Blood and some methods of altering it, J.L.O., 1928, 43, 385.
Fowler, E.P.	Unilateral Vasomotor Rhinitis due to Interference with the Cervical Sympathetic System, Arch.Otolaryng. 1943, 37, 710.
Galloway, A.	Palatal Measurements of Negro and other Crania, S.A.J.Sci., 1941, 37, 285-292.
Goldstein, M.S.	Changes in Dimensions and Form of the Face and Head with age, Amer.J.Phys.Anthrop. 1936, 22, 37-89
Gordon, H.	Genetics and Race, S.A.Med. J.,1965, 39, 547.
Heetderks, D.R.	Reaction of Normal Mucous Membrane, Amer.J.Med.Sci., 1927, 174, 231.
Herskowitz, M.J.	The Anthropometry of the Negro, Columbia Univ.Press, N.York,1930.
Hertzberg, H.T.E., Daniels, G.S., & Churchill, E.	Anthropometry of Flying Personnel, Wright Air Development Center Technical Report 52/321, U.S.Dept. of Commerce, Washington (1954).
Hooke, Beatrice G.E.	A Third Study of the English Skull with special reference to the Farringdon St. Crania, Biometrika, 1926, 18, 1-55.
Hrdlicka, Ales	Anthropometry, Wistar Inst. 1920.

Hrdlicka, Ales — The Old Americans, 1925, 438, Baltimore.

Hrdlicka, Ales — Practical Anthropometry, Wistar Inst. 1952.

Ingelstedt, S. — Studies on the Conditioning of Air in the Respiratory Tract. _Acta O.L._ (Stock). 1956, Supp. 131.

Jarvis, J.F. — Climatic and Racial Factors in Vasomotor Rhinitis, _S.A.Med. J._, 1962, 36, 859-862.

Jarvis, J.F. — Climatic and Racial Factors in Vasomotor Rhinitis, a Further note recording the Incidence in the African, _S.A.Med.J._, 1965, 39, 702.

Johnson, E.H. — The Narial Margins in Man, _J.Ant._, 1937, 71, 356-361.

Keen, J.A. — A Statistical Study of the differences between Bantu, Hottentot and Bushman Skulls, Soologiese Navorsing van die Nationale Museum, Bloemfontein, Deel 1, 16th stuk, 1947.

Keen, J.A. — Craniometric Study of the Cape Coloured population, _Tr.Roy.Soc.S.A._ 1951, 33, Part 1, 29-51.

Keen, J.A. — Craniometric Study of the S.A.Museum Collection of Bushman, Hottentot and Bushman/Hottentot Hybrid skulls, _Ann.S.A.Museum_, 1952, 37, 211-226.

Krogman, W.H. — The Morphological Characteristics of the Australian Skull, _J.Anat._, 1932, 66, 408.

Leys, N.M. & Joyce, T.A. — Notes on a series of Physical Measurements from East Africa, _J.Roy.Anth.Inst._, 1913, 43, 195-203.

Mahalanobis, P.C. — On the need for Standardization in Measurements on the Living, _Biometrika_, 1928, 20A, 1.

Marquer, P. & Chamla, M.C. — Studies on the Evolution of Human Morphology after Puberty, C.R.Acad.Sci.,(Paris) 1961, 252, 318-320.

Marquer, P. & Chamla, M.C. — Changes in Physical Characters with Age in 2089 Frenchmen from 20 to 91 years, Bull.Soc.Anthrop.(Paris),1961, 21.

Martin, R. — Lehrbuch der Anthropologie, Gustav Fischer, Jena 1928, 937.

Meredith, H.V. — A Longitudinal Study of the Growth in Face Depth during Childhood, Amer.J.Phys.Anthrop.,1959,17,125-135.

Mistry, S.D. — Ethnic Groups of Indians in South Africa, S.A.Med.J., 1965,39, 691-694.

Morant, G.M. — A First study of the Craniology of England and Scotland from Neolithic to Early historic times with special reference to the Anglo-Saxon skulls in London Museums, Biometrika, 1926, 18, 56-98.

Morant, G.M. — A Preliminary classification of European Races based on Skull measurements, Biometrika, 1928, 20B, 301-378.

Negus, V.E. — The Defence of the Air Passages with special reference to Ciliary Action, Oxford Med.Sch.Gaz. 1952, 4, 74.

Negus, V.E. — The Comparative Anatomy and Physiology of the Nose and Paranasal Sinuses, 1958, Livingstone, London.

Oetteking, B. — The Nasion and the Measurement of the Nose in the Living, Amer.J.Phys.Anth.,1931,15,469-476.

Ogura, J.H., Nelson, J.R., Dammkoehler, R., Kawasaki, M., & Togawa, K. — Experimental Observations of the Relationships between Upper Airway Obstruction and Pulmonary Function, Annals O.R.L.(St.Louis), 1964, 73, 381-403.

Ordman, O. — Respiratory Allergy in the Coastal Areas of South Africa, S.A.Med.J., 1958, 32, 117.

Proetz, A.W. — Nasal Ciliated Epithelium with special reference to Infection and Treatment, J.L.O., 1934, 49, 557.

Proetz, A.W. — Effects of Temperature on Nasal Cilia, Arch.Otolaryng.1934,19,607.

Proetz, A.W. — Essays on the Applied Physiology of the Nose, Annals Publishing Co. St.Louis, 1941.

Proetz, A.W. — Respiratory Air Currents and Clinical Aspects, J.Laryng.1953, 67, 1.

Proetz, A.W. — Humidity, a problem in Air-Conditioning, Annals O.R.L. (St.Louis), 1956,65, 376.

Reid, R.W. & Morant, G.M. — A Study of the Scottish Short Cist Crania, Biometrika, 1928, 20B, 379-388.

Rozner, L. — Nasal Obstruction due to Restriction of the Bony Nasal Inlet, Br.J.Plast.Surg., 1964,17,287-296.

Scott, J.H. — Heat Regulating Function of the Nasal Mucous Membrane, J.Laryng. 1954, 68, 308-317.

Sercer, A. — Investigations sur l'influence reflectoire de la cavite nasale sur le poumon du meme cote, Acta Otolaryng.(Stock).1930, 14, 82.

Schaeffer, J.P. The Nose, Paranasal Sinuses, Nasolacrimal Passageways, and Olfactory Organ in Man, Blakiston, Philadelphia, 1920, 62-66 & 296.

Schwerz, F. Versuch einer Anthrop.Monographie. d. Kantons Schaffhousen, Denks d.schweizer.naturt.Ges. XLV, 1910.

Steffensen, J. The Physical Anthropology of the Vikings, J.Roy.Anth.Inst., 1953, 83, 86-97.

Stoksted, P. Measurements of Resistance in Nose during Respiration at Rest, Acta.Otolaryng.(Stock). 1953, Supp.109, 143-158.

Talbot, P.A. & Mulhall, H. The Physical Anthropology of Southern Nigeria, Cambridge University Press, 1962.

Taylor, M. An Experimental Study on the influence of the Endocrine System on the Nasal Respiratory Mucosa, J.Laryng. 1961, 75, 972.

Taylor, M. & Young, A. Histopathological and Histochemical studies on Atrophic Rhinitis, J.Laryng., 1961, 75, 574.

Thomson, A. & Buxton, L.H.D. Man's Nasal Index in Relation to certain Climatic Conditions, J.Roy.Anth.Inst., 1923, 53,92-122.

Todd, T.W. The Reliability of Measurements based upon Subcutaneous Bony Points, Amer.J.Phys.Anthrop.(Series 1), 1925, 8, 275-279.

Tonndorf, J. A Note on the Measurement of Nasal Flow Resistance, Annals O.R.L., 1958, 67, 984.

Topinard, P. Anthropology, Tr. by R.T.H.Bartley, Chapman & Hall, London, 1878.

Trevor, J.C. Anthropometry, in Chamber's Encyclopedia Vol.1, 461-462. Geo.Newnes Ltd. London.

Trevor, J.C. The Physical Characters of the Sandawe, J.Roy.Anth.Inst.1947 (pub.1950) 77, 61-78.

Trevor, J.C. Quantitative traits of the U.S. Negro Cranium, Leech. 1958, 28, 131-138.

Uddströmer, M. Nasal Respiration; critical survey of some current Physiological and Clinical aspects on Respiratory Mechanism with description of New Method of Diagnosis, Acta Supp. 1940, 42.

van Dishoek, H.A.E. Inspiratory Nasal Resistance, Acta Otolaryng. 1942, 30, 431.

Weiner, J.S. Nose Shape and Climate, Amer.J.Phys.Anth., 1954,12,615-618.

Wells, L.H. A survey of Human remains from Long Cist Burials in the Lothians, Proc.Soc.Antiq.Scotland.1956/57, 90, 180-191.

Williams, R. The Nasal Index, Anthropological and Clinical, Annals O.R.L.(St.Louis), 1956, 65, 171-190.

Wood-Jones, The Non-Metrical Morphological Characters of the Skull as Criteria for Racial Diagnosis, J.Anat. 1931, 65, 376 & 444.

A P P E N D I X

Individual Measurements of Skulls, Cadavers and Living Subjects

Dimensions measured and Indices calculated as described in Thesis

NH	Nasal Height - To Sellion in the case of the Cadaver and Living Subject- to Nasion in the Skull.
NB	Nasal Breadth
PL	Palate Length
N/S	Interval between Nasion and Sellion
N/CR	Interval between Nasion and Cribrion
NI	Nasal Index using Sellion in the Cadaver and Living Subject and Nasion in the Skull.
AI	Area Index
VI	Volume Index
NIN	Nasal Index to Nasion
NI(S)	Nasal Index to Sellion
NI(EC)	Nasal Index using correction for Embalming Change
NIN(Sk)	Nasal Index of skull obtained from this cadaver.

NORMALS EUROPEAN MALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	49	35½	53½	70	142	91
2	51½	34½	54½	67	151	97
3	53	39	57	74	164	118
4	55½	34	58	61	173	109
5	49	33	57½	67	152	93
6	54½	33	55½	61	162	100
7	53	37	56	70	160	109
8	58½	38	63	65	199	140
9	56	34½	57	62	171	110
10	53	36	59	68	170	112
11	47½	33	54	69	139	85
12	54	38	54	70	157	111
13	50	34½	52½	69	143	91
14	57	32½	53	57	161	98
15	49	36½	53½	74	143	96
16	53	38	54	72	155	108
17	55½	35½	57	64	170	112
18	56	36½	56	65	169	114
19	47	33½	57½	71	147	91
20	54	34	57½	63	167	106
21	51	37½	52½	73	146	100
22	56	34	51	61	153	97
23	54	39	61½	72	181	130
24	51½	37½	57½	73	161	111
25	48	34	52½	71	137	86
26	50	36	53	72	145	95
27	53	38½	57½	73	166	117
28	56	34½	59	62	177	114
29	52	37	56½	71	159	109
30	53½	38½	59½	72	172	113
31	59	32½	57	55	179	109
32	56	36	57	64	172	115
33	57½	35½	57	62	175	116
34	57½	41	60½	71	189	142
35	53	33½	50	63	142	89
36	53	35	58	66	165	107
37	48	37½	49½	78	130	104
38	52	41	64	79	183	135
39	59½	34½	61	58	194	125
40	51½	36	51	70	142	95
41	49½	33	57	67	153	93
42	51	36	55	71	152	101
43	48	36	52	75	135	90
44	47½	36½	54½	77	141	95
45	56	37½	57	67	172	120
46	58	35½	57	63	178	120
47	55½	37	59	66	176	121
48	59	36	59	61	186	125
49	57	38	61	67	188	132
50	49	34½	54	70	143	91

NORMALS EUROPEAN MALES OVER 16 (contd.)

No.	NH	NB	PL	NI	AI	VI
51	56	35	54	63	162	106
52	48½	37	60	76	160	108
53	47	35	51	75	137	84
54	59	33	56	56	176	109
55	51½	34½	56	67	156	99
56	50½	37½	56	74	154	106
57	54	32	57½	59	166	99
58	49	36	57½	74	153	101
59	54½	34½	53	63	155	100
60	59½	37	53	62	170	116
61	49½	35	55	71	149	96
62	53	33	52	62	147	91
63	55	33	59	60	174	107
64	48	39½	57	82	149	108
65	56	38½	58	69	176	125
66	55	38	57½	69	171	120
67	53½	34½	57½	64	166	106
68	52	37	60	71	168	115
69	58½	37	56	63	176	120
70	54	34½	58	64	169	108
71	56½	36	55	64	167	112
72	49	36	53	74	141	97
73	56	33	53	59	158	98
74	61½	31½	60	50	196	116
75	55	32	49½	58	145	87
76	53½	39½	53	74	154	112
77	51	36	49	70	136	90
78	52½	38	52	72	148	104
79	49½	35½	52	72	139	91
80	46	38	51½	83	131	100
81	57½	33½	53	58	163	102
82	54	36½	59	68	172	116
83	52	38	55½	73	156	110
84	51	31½	60	62	163	96
85	54	36	56	67	162	109
86	57	37	56	65	171	118
87	45	36	54½	80	134	88
88	51½	38	50½	74	141	99
89	57	36	50	63	153	102
90	57½	38	52	66	161	112
91	59	41	54	70	172	131
92	57	35	54	61	165	108
93	51	36	55½	71	153	102
94	53	45	55½	85	163	132
95	45½	36	55	79	137	90
96	58	37½	49	65	153	107
97	55	35½	52	65	154	102
98	48	35½	58	74	151	99
99	55	36	58	65	171	115
100	57½	30½	51	53	156	89

NORMALS EUROPEAN FEMALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	44	27	54½	62	129	65
2	50½	36½	53½	72	147	98
3	48½	34	53½	70	140	90
4	43	30½	53	71	124	69
5	43½	32½	47½	75	112	67
6	45	31	51	69	124	71
7	46	32½	54	71	135	81
8	52	31½	54	61	150	89
9	53½	32½	57	61	164	99
10	52½	34½	51	66	143	93
11	45½	34	52	75	129	80
12	50	31½	56	63	150	88
13	47	32	54½	68	138	82
14	48½	36	54½	74	144	95
15	52	33	54	64	152	91
16	52	28	53	54	147	77
17	48	32	49½	67	128	76
18	50	36	54½	72	148	98
19	45	33	58½	73	143	87
20	47	32½	54	69	137	82
21	51½	35	50½	68	141	91
22	51	32½	52	64	143	86
23	50	30½	49	61	131	75
24	52½	29½	53½	56	149	83
25	53	32½	53½	61	152	92
26	47½	31	49½	66	127	73
27	47	32½	49½	69	126	76
28	48½	32	49½	66	130	77
29	45	37	51½	82	127	86
30	49	31	45	63	118	68
31	48½	35	45	72	118	77
32	49½	31½	48½	64	129	75
33	48½	27	50	56	129	66
34	47	31½	50	67	126	74
35	56	31	53	55	158	92
36	52	32½	50	62	139	84
37	50	34½	52	69	140	90
38	48½	35	52	72	137	88
39	50	33	55	66	136	91
40	53	32	51	60	145	86
41	46½	32	49	69	124	73
42	45½	33	51	72	126	76
43	49	32	49½	65	131	78
44	51	32½	54	64	147	89
45	52	34½	53	66	148	95
46	47	32½	49	69	125	75
47	45½	31½	54½	69	134	77
48	48½	32	52½	66	137	82
49	54½	32½	47½	60	138	84
50	48½	36	47½	74	125	83

NORMALS EUROPEAN FEMALES OVER 16 (contd.)

No.	NH	NB	PL	NI	AI	VI
51	57	33	48½	58	148	91
52	44	34	52	77	124	78
53	50	32½	49	65	132	80
54	48	29	51	62	131	71
55	47	30½	57	65	144	82
56	45½	31	52	68	128	73
57	48	38	52	79	136	95
58	50	33½	61½	67	166	103
59	48½	32½	52½	67	137	93
60	52	39	55	75	156	111
61	52	33	50	63	140	86
62	47	32	50	68	128	75
63	57	37	58	65	178	122
64	50	33½	62½	67	168	105
65	46	32	46½	70	116	69
66	54	34½	50½	64	146	94
67	49	32	56	65	148	88
68	51½	32½	53	63	147	88
69	51½	31½	57	61	158	92
70	55	34	53	62	156	99
71	51½	38	54	74	151	105

NORMAL COLOURED MALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	49	41½	58	85	158	118
2	55	37½	57	68	169	117
3	53½	42	57½	79	169	129
4	52	37½	61	72	172	119
5	53	42	55	79	160	122
6	47	38½	52½	82	135	95
7	52	40½	59½	78	170	125
8	48½	42	57	87	153	116
9	54	40½	55	75	162	120
10	52½	43	50½	82	145	114
11	46	44	54	96	139	109
12	49½	37½	54	76	146	100
13	52½	37	52½	70	149	102
14	55	39	55	71	164	118
15	54½	35	54	64	156	103
16	54½	43	54½	79	162	128
17	52	38	53	73	149	104
18	49½	41	57	83	155	116
19	46	39½	54½	86	138	99
20	49	40	61	82	164	120
21	44½	39½	61	89	151	107
22	44	44	54½	100	135	105
23	42	42½	53½	101	130	92
24	53	38	56	72	161	113
25	50	41	44½	82	122	91
26	54½	38	54	70	124	112
27	45	41	54	91	134	100
28	55½	41	56	74	169	127
29	51½	38	58	74	163	114
30	53	37½	50½	71	144	100
31	48	40	60	83	159	115
32	53½	41½	57	77	166	126
33	45½	35½	47	85	118	82
34	43	38	54	88	128	88
35	54	39	52½	72	153	110
36	50	38	57	76	139	108
37	48	39½	54	82	143	102
38	45½	44	54	97	137	108
39	53	42½	52½	80	184	118
40	48	39	52	81	137	97
41	47½	41	51½	86	133	102
42	50½	41½	53	82	149	111
43	48	39	55½	81	147	104
44	46	39	54	85	137	97
45	50	40	53½	80	147	107
46	48	41	53½	85	141	105
47	45	41	54	91	134	99
48	52½	42½	59½	81	171	133
49	52½	36½	55	69	156	106
50	53½	37	58	69	167	115

NORMALS COLOURED MALES OVER 16 (contd.)

No.	NH	NB	PL	NI	AI	VI
51	57	40	48	70	109	149
52	49	40½	50	82	135	99
53	53½	46	53	86	155	131
54	51	45	53	88	149	122
55	50	38	50½	76	138	96
56	46½	43	54	93	140	108
57	54½	39½	56½	72	167	121
58	47	45½	53½	96	141	115
59	47	48	58	102	153	128

NORMALS ASIAN AND MALAY MALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	53	35½	52	67	150	98
2	52	38	54	73	152	105
3	50½	40	52	79	143	103
4	51	37½	56	74	156	119
5	52½	37	58½	70	166	114
6	53	39½	54	74	171	113
7	51½	39	55	76	154	110
8	53½	42	53½	79	156	120
9	52	40½	52½	78	149	111
10	54	40½	49	75	144	107
11	47	39	50	83	130	92
12	52	37	54	71	153	102
13.	55	37	48	67	142	98
14	51	41½	53½	81	149	113
15	58	39	54	67	169	122
16	55	33½	54	61	160	99
17	52	40	49½	77	140	103
18	51	41½	49½	81	138	105
19	46½	39	55	84	141	100
20	56½	36	50	64	152	102
21	50	41½	50	83	137	104
22	49½	40	51	81	138	101
23	52	39	48	75	136	96
24	52	39	53	75	150	107
25	56	45½	54½	81	167	139
26	53	37	54½	70	156	107

NORMALS ASIAN AND MALAY FEMALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	46	35½	55	72	138	90
2	47	34½	57	95	146	92
3	45	36	53	80	130	86

NORMALS COLOURED FEMALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	43	34	54	79	126	79
2	48½	38	52	78	137	96
3	44	38	54½	86	132	91
4	44	39	53½	88	130	92
5	46½	36½	48½	78	124	83
6	45	34	56	76	137	86
7	40	34	45½	85	100	62
8	52	37	52½	71	148	101
9	39	36	51½	92	111	72
10	48½	35	53½	72	141	91
11	42	35	50	84	115	74
12	51½	33½	56½	65	156	97
13	49½	34	49	69	131	82
14	41	37	48	90	109	73
15	43	35	52	81	123	78
16	39½	43	57	108	127	97
17	45½	38½	54½	85	136	95
18	49	43	60	88	163	126
19	48	35	57½	73	150	97
20	44	36	54½	82	132	86
21	49	36½	53	75	142	95
22	48½	34	53	70	139	87
23	48½	37	53	76	141	95
24	42	35	45	83	102	66
25	47	38	54	81	139	96
26	40½	40	57	99	129	92
27	45½	36	52	79	129	85
28	40½	34½	50	85	111	70
29	43	42	53½	98	128	96
30	53½	41	52	77	152	114
31	44	39	50½	89	123	87
32	48	37½	56½	78	148	102
33	45	36	55	80	136	89
34	43	35½	52½	83	123	80
35	45	38	55	85	137	94
36	45½	38	45	84	112	78
37	41½	38	50	92	115	70
38	44	39	55	88	134	94
39	49½	37	49	75	132	90
40	46	37½	49	82	124	85
41	45½	34½	49	76	121	77
42	47	33	49	70	125	76
43	48	37	53	77	140	94
44	48	38	54½	79	142	100
45	53½	37	54	69	156	106
46	42½	40½	54	95	128	93
47	42½	32	54	75	125	73
48	41	35	50	85	112	72
49	45	40	59	89	146	106
50	46	36	52	78	131	86
51	54	35	60	65	154	113

NORMALS AFRICAN MALES OVER 16.

No.	NH	NB	PL	NI	AI	VI
1	46½	46	61½	99	161	131
2	47½	45	63½	94	167	136
3	53½	47½	55	89	163	139
4	43	51½	59	120	145	130
5	47	43	54½	92	142	110
6	42½	47½	49½	112	121	100
7	45½	43	59½	95	150	116
8	48	43½	61½	91	164	128
9	51	45½	63½	89	179	147
10	45	45	53	100	135	107
11	47½	50½	54½	106	145	131
12	49	40½	57½	82	155	114
13	45½	48½	56	107	173	123
14	51	44½	59	87	166	134
15	45½	45½	52	100	130	103
16	47½	43½	58	92	153	119

NORMALS AFRICAN FEMALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	44	38½	55	87	134	93
2	40	42	53½	105	120	90
3	44	40½	51½	92	126	92
4	51	43	65½	84	184	144
5	42	39½	57	94	134	95
6	45	40	59	89	147	106
7	44	43	55	98	135	104
8	49	43	54½	88	146	115
9	46½	39	54	84	138	98
10	48	45	57	94	152	122
11	44	39	55½	89	135	95
12	44½	45½	54	102	134	109
13	46½	43½	59½	93	153	120
14	45	41	49	91	122	91
15	48	40½	53	84	140	103
16	41½	39½	54	95	125	89
17	46	40½	52	88	133	97
18	44	42	52	96	128	97
19	47	44	52	94	136	107
20	47½	40	57	84	150	109
21	39	43	54	110	119	91
22	45	44	54	98	135	107
23	44½	42½	52½	105	130	99
24	42	38½	46	92	108	74
25	41½	38	55½	92	129	87
26	39½	37½	59	95	130	87
27	48½	41	59	84	156	118
28	43	41½	59	97	142	106

VASOMOTOR RHINITIS EUROPEAN MALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	48	36	57	75	149	98
2	47½	35½	57	75	147	96
3	52½	34	55	65	155	98
4	50	35	62	70	168	108
5	47	36½	53	78	137	91
6	55	31	59	56	173	100
7	52	36½	55½	70	156	105
8	48	35	57	73	149	96
9	47	36	53½	76	138	91
10	50	36½	61½	73	168	112
11	59	35	57	59	180	118
12	56	32½	56½	58	169	103
13	54½	36½	47	67	138	93
14	56½	34	60	60	181	115
15	57	39	62	68	191	138
16	52	37½	54½	72	153	104
17	52	37½	57	72	160	111
18	53½	36	55½	67	161	107
19	51	39½	55½	77	155	112
20	50	38½	56½	77	154	108
21	60	36	58	60	187	125
22	51	40	54	78	149	110
23	52½	35	55	67	156	101
24	49	36	54	73	144	95
25	51½	39	51	76	143	102
26	59½	36	56	60	178	120
27	58	33½	51½	58	159	100
28	55	41	61	75	182	138
29	51	34½	52	68	143	92
30	53	41	50½	72	146	110
31	52½	37	61½	71	175	119
32	57	34	57	60	174	110
33	46½	32½	55½	69	140	83
34	58	37½	56	65	174	122
35	54½	35	55	64	162	105
36	60½	31½	49	52	157	93
37	51	39	51½	76	143	102
38	54	37	51½	69	150	103
39	52	34½	51½	66	145	92
40	53	40	53½	75	155	114
41	53	35½	52	67	148	98

VASOMOTOR RHINITIS EUROPEAN FEMALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	54½	32½	53	60	154	94
2	49	30½	54	62	143	81
3	46	34	53	74	133	84
4	46	32	50	70	125	73
5	52½	36	49	69	140	93
6	51	39½	55½	78	154	113
7	53	29½	48	56	136	75
8	48½	33½	49	69	129	80
9	48	33½	54	70	140	87
10	45	32	48½	71	118	70
11	50	31½	47½	63	127	74

VASOMOTOR RHINITIS COLOURED MALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	47	38½	52½	82	135	95
2	52	38½	54	74	153	106
3	54	34	51	63	148	94
4	49	43	52	88	141	110
5	52	40	57	77	162	118
6	53½	41	50	77	146	110
7	51½	40½	50	79	141	104
8	48	44	56	92	150	118
9	51	47½	57	93	160	138
10	50½	42	50	83	139	106
11	37½	43	49	115	105	79
12	54	38	54½	70	159	112
13	53	41½	53	78	152	116

VASOMOTOR RHINITIS COLOURED FEMALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	51	41	58	80	162	121
2	45½	33	50	72	124	75
3	50	29½	53	59	141	78
4	47½	33½	47	70	121	75
5	49½	31½	50	64	133	78
6	46	39	61	85	154	109
7	41½	41	56	99	151	95
8	52	36	51	69	143	93
9	51	35	57½	69	159	103
10	54	37	53½	69	156	107
11	44	36½	58	83	140	93
12	45½	36	55½	79	138	91
13	54	37	49	69	143	98
14	43½	38½	51	88	122	95
15	51½	37	53	72	148	102
16	48½	34	49	70	129	81
17	47	33	50	70	128	78
18	48	35	55	73	144	92

VASOMOTOR RHINITIS ASIAN AND MALAY MALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	48	34½	57½	72	150	95
2	51	42	54	82	151	116
3	50	39½	57	79	156	113
4	50½	38	52½	75	144	101

VASOMOTOR RHINITIS ASIAN AND MALAY FEMALES OVER 16

1	56	32½	51	58	152	93
2	47	33½	54½	71	139	86

VASOMOTOR RHINITIS AFRICAN MALES OVER 16

1	49	45½	60½	93	165	135
2	57	45½	61	80	191	158

VASOMOTOR RHINITIS AFRICAN FEMALES OVER 16

1	41	39½	53	96	120	86
2	44	43	61	98	134	116
3	50½	37	57	73	152	107

SINUSITIS EUROPEAN MALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	48	36	55	75	143	95
2	46	36	57	78	143	95
3	47	37	52	79	134	91
4	51	34½	52	68	143	92
5	62½	36	56	58	190	126
6	51	34	52	67	144	90
7	54½	36½	59½	67	175	118
8	57	34	57	60	174	110
9	55½	35½	55½	64	166	109

SINUSITIS EUROPEAN FEMALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	45	38	50	84	123	86
2	53	34	52	64	149	94
3	50	36	50	72	136	90

SINUSITIS COLOURED MALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	44	38	53	86	128	89
2	41	36½	52	89	118	78
3	53½	40	49½	75	144	106
4	51	37½	53	74	147	101
5	52	42½	52	82	148	115

SINUSITIS COLOURED FEMALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	47	33	53	70	134	82
2	40½	34½	52	85	116	72

SINUSITIS AFRICAN MALE OVER 16

No.	NH	NB	PL	NI	AI	VI
1	43½	51	56	117	139	124

SINUSITIS AFRICAN FEMALES OVER 16

No.	NH	NB	PL	NI	AI	VI
1	45	40½	56½	90	142	103
2	35	43	57	123	115	86
3	44	40½	52½	92	128	93
4	47	38½	53	82	137	96

ATROPHIC RHINITIS EUROPEAN MALE

No.	Age	NH	NB	PL	NI	NI/AC	AI	VI
1	12	50½	33½	48	66	64		81

ATROPHIC RHINITIS EUROPEAN FEMALES

No.	Age	NH	NB	PL	NI	NI/AC	AI	VI
1	10	45	31		69	67		
2	Ad.	48	33½	52	70	70	135	84

ATROPHIC RHINITIS COLOURED MALES

No.	Age	NH	NB	PL	NI	NI/AC	AI	VI
1	Ad	50½	42½	52½	85	85	146	113
2	Ad	50	41	54½	82	82	149	111
3	14	38	41½		109	107		
4	Ad	49½	43½	55	88	88	150	118

ATROPHIC RHINITIS COLOURED FEMALES

No.	Age	NH	NB	PL	NI	NI/AC	AI	VI
1	Ad	42½	35	49½	82	82	115	67
2	Ad	48	39	54½	81	81	144	101
3	14	42½	36½	53	86	84		
4	Ad	41	31	49	76	76	109	62
5	Ad	38½	36	48	94	94	102	67
6	12	44	36½		83	81		
7	13	40	36		90	88		
8	Ad	42	39	55	93	93	128	90

ATROPHIC RHINITIS AFRICAN FEMALES

No.	Age	NH	NB	PL	NI	NI/AC	AI	VI
1	Ad	42½	40	57½	94	94	136	98
2	Ad	44½	39	54	88	88	133	94
3	Ad	41	41	54	100	100	123	92

NI/AC = Nasal Index Age corrected.

SKULLS COLOURED MALES

No.	NH	NB	PL	N/S	N/CR	NIN	VI
1	52½	22½	50	3½	9½	43	60
2	51½	23½	45½	2½	10½	46	55
3	45½	26½	45	2	11	58	54
4	44½	24	44½	3	6	54	47
5	51½	28	51½	3	12	54	74
6	49	24½	47½	3½	9	50	57
7	50	25½	47½	3	8½	51	61
8	55½	29	52½	7½	7½	52	84
9	55	22½	49½	0	7½	41	62
10	50	22	49	2	5	45	54
11	50	25½	55½	4	10	51	71
12	47	25	49	3½	9	53	58
13	50	24	42	0	7	48	50
14	45	26	45½	2½	5½	58	54
15	45½	27½	53	4½	5½	61	67
16	47½	25½	45½	3	6	53	55
17	49	25½	47	6	9½	53	59
18	46	24½	44	4	8	53	50
19	50	20½	48½	3	7	42	50
20	47	27	48½	5	5	57	62
21	46	23	45	3½	9	51	48
22	43½	24	50½	1½	7	55	53
23	52½	27½	52	4½	8	53	75
24	50½	26½	39½	2½	9½	53	53
25	55	24	43	2	7½	44	57
26	49	27½	47	4	5½	56	63
27	46½	24	39½	3	4½	52	44
28	50½	28	48½	4	14½	56	68
29	43½	23½	37½	3	4	54	38
30	50½	27½	40	5	10½	54	56
31	45	26	42½	4	5	58	50
32	50½	22½	44	2	3	45	50
33	47½	26	47	4½	7	55	58
34	47	25	40	3½	4½	53	47
35	50½	27	48	5	6	53	66
36	51	27½	49	5	8	54	69
37	43½	29	45	3	3	67	57
38	47	27	49	5	5	57	63
39	49	26	46	4½	4½	53	60
40	50	28	44½	5	8½	56	62
41	52½	26½	46½	3	6½	50	65
42	49½	27	44	1	3½	55	59
43	51	26½	46	3½	9½	52	62
44	52	26½	46	1½	3½	51	63
45	48½	24½	47½	5	7½	51	57
46	52½	27½	41	6	8	52	59
47	49½	26	40	3	6	52	51
48	54	23½	49½	3	7½	44	63
49	52½	25½	45	4	5½	49	60
50	48	24½	44	2½	5½	51	52

No.	NH	NB	PL	N/S	N/CR	NIN	VI
51	49½	26½	40	3	9	53	52
52	49	24½	47½	3½	6½	50	57
53	55½	29½	50½	3	10½	53	82
54	49	23½	44	0	7	48	51
55	47	27	49	5	5	57	63
56	47½	29½	50	1½	6	62	70
57	49	27	45	4	6½	54	60
58	45½	22½	55	4	10	49	56
59	50	29	45½	3	5	58	66
60	45½	27	47	3½	7½	57	58
61	47	25	46	3	5	53	54

SKULLS COLOURED FEMALES

No.	NH	NB	PL	N/S	N/CR	NIN	VI
1	44	23½	40½	0	4	53	42
2	44½	24½	46	2	4½	55	50
3	48	22½	49	5	10½	47	54
4	46	25	42	4	10	54	48
5	47½	25	41	1	5½	53	49
6	44½	28	47½	1	5½	62	59
7	45	24½	42½	1	6	55	47
8	43½	26	45½	3	5	59	51
9	44	26	42	0	0	59	48
10	42	25	43	1½	1½	59	45
11	45½	21½	43½	1½	5	47	42
12	42½	28½	45½	2	7½	67	55
13	44	23½	45½	4½	7	53	47
14	44½	24½	46½	2½	7½	55	51
15	49½	27	42½	3½	10½	55	56
16	48½	27½	48	7	9½	57	64
17	44	24	49½	3	6½	54	52
18	49	25½	44½	0	9½	53	56
19	47	22	39½	0	3	47	41
20	41½	22½	38	2½	13	54	44
21	47	27	43½	3	5	57	35
22	49	24½	43	2½	11	50	56
23	45	29	41½	6	7	65	54
24	46	26½	47	0	1	58	57
25	50	23	43	2	5	46	50
26	47½	25	42½	4½	8½	53	51
27	48	26	44	1	6	54	55
28	43	24	42½	0	4	56	44
29	46	26½	45	3	6½	58	55
30	41½	22	42½	2	2	53	39

No.	NH	NB	PL	N/S	N/CR	NIN	VI
31	43	27	43½	3	2	63	50
32	46½	28	43½	4	6	60	56
33	47	28	42½	3	6	60	56
34	45½	25	44	2½	5½	55	50
35	46	24½	45½	3½	5½	52	51
36	44	29	43	3	4½	66	55
37	46½	24½	43	2	9	57	49
38	47	22½	41½	4½	7	48	44
39	44½	25	44	3½	7½	56	49
40	40	26	42	2½	6½	65	44
41	42½	28	46½	3	7	66	56

SKULLS AFRICAN MALES

No.	NH	NB	PL	N/S	N/CR	NIN	VI
1	46	26	51	5	8½	56	61
2	48½	27½	46	5½	7	57	61
3	52	24½	44½	6	10	47	57
4	50½	32½	53½	3½	8	64	88
5	44½	23½	48	6	6	53	50
6	48½	26	41½	4	12½	54	52
7	52½	27	45½	5	8½	52	65
8	53	26½	47½	3	7	50	52
9	52½	29	53	6	10½	55	81
10	50½	27	51½	4½	8½	53	70
11	47	29½	50½	5	7½	63	70
12	46	26	45½	6	6	56	54
13	46	28	53	3	5½	61	68
14	47½	25	49	5½	8½	53	58
15	52	28	51	2½	8½	54	74
16	50½	27½	49½	4	6½	54	68
17	46	26	47	3½	7½	57	56

SKULLS AFRICAN FEMALES

No.	NH	NB	PL	N/S	N/CR	NIN	VI
1	45	26½	44½	0	8½	59	53
2	45	26	42	2½	5½	58	49
3	53½	32	46½	3½	12½	60	79
4	49½	25	43½	0	7	51	54
5	45	26	38	1	6½	58	44
6	48½	28½	47	5	6½	59	65

SKULLS EUROPEAN MALES

No.	NH	NB	PL	N/S	N/CR	NIN	VI
1	55	22½	47	2½	11½	41	58
2	50½	31	53½	2	7½	61	83
3	47	25	42½	1	2	53	50
4	52½	26½	48	2½	6	51	67
5	54	25½	39½	1½	9½	47	54
6	52½	22	40½	4	9½	43	47
7	52½	20½	41	0	5½	39	44
8	52	27	48	0	10½	52	67
9	55	24½	41½	3	7½	45	55
10	52½	22	40½	3	9½	42	47
11	53	26	46½	3½	10	49	64
12	55	23	42	3	5½	42	53
13	53½	24	43	3½	7½	45	55
14	54½	27	48	2	9	49	71

SKULLS EUROPEAN FEMALES

1	45	22½	40½	2½	8	49	41
2	48½	23½	42	2½	12½	49	48
3	45½	21½	43	0	3	48	42
4	50½	24½	44½	0	5½	48	55
5	43	21	37	2½	7	49	33
6	49	23½	43½	3½	9	48	50
7	50	25	46½	5	5½	50	57
8	46½	21	44	1	5	45	43
9	50	21	39½	2½	7	42	41

CADAVERS COLOURED MALES

No.	NH	NB	N/S	NI(S)	NI(EC)	NIN	NIN(Sk)
1	47	41	6½	87	83	74	45
2	47	43	7	91	87	77	43
3	52	45½	5	87	83	78	44
4	38	46½	3	122	116	110	
5	49½	41½	7	84	80	71	49
6	44½	42	7	94	89	79	51
7	48½	43	4	89	84	79	58
8	47	41½	6	88	84	76	53
9	47	44½	7	95	90	80	50
10	53	42½	7	80	76	69	53
11	46	43½	9½	95	90	76	
12	44	41½	8	93	90	77	48
13	41	45	5	110	104	95	58
14	36	44	9	122	116	95	
15	44	47½	8	108	102	89	
16	55	43½	8½	79	75	67	
17	52½	49	6½	93	89	81	
18	44½	49	6	110	103	94	
19	43	51½	6	120	114	103	55
20	44	51½	4½	117	112	104	
21	38½	43½	6	113	107	95	63
22	53	51½	4	97	93	89	58
23	39	42	7	108	101	89	49
24	43½	43	5	99	94	86	
25	42	43	6	102	97	87	
26	43½	45	4½	103	98	91	53
27	41½	42	6	101	96	85	62
28	46½	52	8½	112	107	92	
29	46½	52½	9	112	108	92	
30	40	47½	7½	119	113	97	
31	47	49	6	104	100	90	
32	46	44½	4½	97	91	86	
33	46	44	2	96	91	87	44
34	44	42	8	95	90	79	
35	51½	47	5	91	87	80	49
36	46	53	7½	115	110	99	61
37	46	42½	6	92	88	84	
38	42½	49½	7½	116	111	88	
39	34½	44½	8	129	122	108	
40	39	42½	9½	109	103	76	
41	39	46	7½	118	112	93	
42	46	45½	9½	99	94	77	
43	48	48	3½	100	95	89	
44	39	47	10½	120	114	91	

CADAVERS COLOURED FEMALES

No.	NH	NB	N/S	NI(S)	NI(EC)	NIN	NIN(Sk)
1	43	36½	5½	85	80	72	53
2	41	44½	7½	109	103	89	
3	40	40	10	100	94	78	
4	42	42	8½	100	95	80	57
5	35½	41½	9	117	110	90	66
6	38	39	9½	103	97	80	66
7	42	41½	10	99	93	77	53
8	38	43½	9	114	107	90	48
9	43	37	6½	86	81	72	
10	41	49½	5	121	115	104	55
11	40	44	4	110	104	97	65
12	42	44½	6	106	100	90	59
13	41	43	9	105	100	83	58
14	36	44	7½	122	116	98	
15	44	37½	6	85	81	72	
16	48	41½	8½	86	82	71	
17	49	37	7	75	71	64	
18	42½	40	6	94	89	84	52
19	48½	44½	5½	92	87	80	
20	36	46	7½	128	121	103	

CADAVERS EUROPEAN MALES

No.	NH	NB	N/S	NI(S)	NI(EC)	NIN	NIN(Sk)
1	54	38	5½	70	67	62	49
2	53½	36½	6	68	65	59	42
3	54½	38½	6	71	67	62	45
4	54	43	7	80	76	69	49
5	55	39	5½	71	68	62	45
6	58	38	4	65	62	59	
7	56½	35½	6	63	59	55	48
8	48	41	6	85	81	73	
9	54½	43	6	79	77	71	
10	59	40	7	68	64	59	
11	54½	40	4½	73	70	65	
12	55½	45	8½	81	77	68	
13	50½	36½	4	72	68	65	
14	54	39	4½	72	69	65	
15	52	46½	10	89	85	73	
16	47½	42½	8	89	85	75	

CADAVERS EUROPEAN FEMALES

No.	NH	NB	N/S	NI(S)	NI(EC)	NIN	NIN(Sk)
1	49	32½	5	66	62	58	45
2	51½	38½	8	75	71	63	42
3	51	39	6½	76	72	66	
4	46	33½	6½	73	68	61	
5	47	36½	8½	77	73	64	46
6	45½	35½	6	78	73	67	
7	52½	30½	5½	58	55	50	
8	50	32½	6	65	61	56	
9	52	31½	4½	61	57	54	

AFRICAN MALES

No.	NH	NB	N/S	NI(S)	NI(EC)	NIN	NIN(Sk)
1	39½	41½	8½	105	100	84	57
2	49	38	7	77	73	66	55
3	47	46	7½	98	93	82	
4	53½	45½	7½	85	81	72	
5	43	51	5	118	113	103	
6	43½	46	10½	106	100	83	
7	42	43	10	102	97	80	
8	43	45	6½	104	99	88	
9	49	52½	8½	107	102	89	
10	50½	50	5	99	95	88	54
11	50½	51½	8½	102	97	85	
12	43	47½	9	110	104	88	
13	41½	45	5	109	103	94	
14	44	51	9	116	110	94	
15	44	42	9	95	90	77	44

AFRICAN FEMALES

No.	NH	NB	N/S	NI(S)	NI(EC)	NIN	NIN(Sk)
1	40½	46	9	114	108	90	57
2	36½	41	9	112	106	87	
3	40	38	6½	95	90	79	
4	47½	48	6	101	96	87	59
5	44½	40	7	90	85	77	
6	39	40	9	103	97	81	
7	40½	49	6½	118	115	101	

NO.	Race	Sex	FRESH			EMBALMED			CHANGE		
			NH	NB	NI	NH	NB	NI	NH	NB	NI
1	C	M	47½	42	88	46	44	96	-1½	+2	+ 8
2	C	M	48	41½	86	44	42	95	-4	+0½	+ 9
3	C	M	55	45	82	51½	47	91	-3½	+2	+ 9
4	C	M	46	43½	94	46	42½	92	0	-1½	- 2
5	C	M	43	44	102	42½	49½	116	-0½	+5½	+14
6	C	M	48½	53	110	46	53	115	-2½	0	+ 5
7	C	M	36	46	128	34½	44½	129	-1½	-1½	+ 1
8	C	M	41	37	90	39	42½	109	-2	+2	+19
9	C	M	42	43½	104	39	46	118	-3	+2½	+14
10	C	M	49½	42½	86	46	45½	99	-3½	+3	+13
11	C	M	48	46	96	48	48	100	0	+2	+ 4
12	C	M	40½	45	111	39	47	120	-1½	+2	+ 9
13	C	F	44	38½	88	42½	40	94	-1½	+1½	+ 6
14	C	F	48½	46	95	48½	44½	92	0	-1½	- 3
15	C	F	39	43½	112	36	46	128	-3	+2½	+16
16	E	M	54	41	76	54½	40	73	+0½	-1	- 3
17	E	M	55½	41½	75	55½	45	85	0	+3½	+10
18	E	M	47	36	77	50½	36½	72	+3½	+0½	- 5
19	E	M	51½	35½	69	54	39	72	+2½	+3½	+ 3
20	E	M	55	47½	86	52	46½	89	-3	-1	+ 3
21	E	M	50	42	84	47½	42½	89	-2½	+0½	+ 5
22	E	F	53½	28½	53	52½	30½	58	-1	+2	+ 5
23	E	F	50½	35½	70	50	32½	65	-0½	-3	- 5
24	E	F	50½	31½	63	52	31½	61	+1½	0	- 2
25	Af.	M	39½	44½	113	41½	45	109	+2	+0½	- 4
26	Af.	M	45	49	109	44	51	116	-1	+2	+ 7
27	Af.	M	42	39	93	44	42	95	+2	+3	+ 2