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SEX DETERMINATION OF THE PELVIC BONE: A SYSTEMS APPROACH

ABSTRACT — The biological system of sexual dimorphism of the bony pelvis is described using a systems approach for the improvement of sexing techniques. The result is a method for simple and reliable sex determination of the skeleton. The problems with „sex diagnosis", so-called systems approach both in general and with special regard to research on pelvic sexual dimorphism, principles of sex determination and perspectives for further study are discussed. Representative metric-traits of two evolutionary, functionally and causally relatively independent sub-systems of pelvis (ischiopubic and sacroiliac segments) were found. Their multivariate discriminant functions serve as an identification key with maximum sex discriminatory effectivness, which under normal conditions yields up to 100 % accuracy in sexing. Remarks on „sex diagnosis" in practice deal with statistical inference, interpopulation differences, historic and prehistoric finds, pathological changes and morphoscopic sex characters. Practical recommendations are added.

KEY WORDS: Sex determination — Pelvic bone — Systems approach — Theory and practice

Sex determination of unknown skeletal remains is a problem faced by anthropologists all over the world since, from the biological point of view, the social position of the individual is primarily determined by age and sex. The study of skeletons from the viewpoint of sex identification offers a number of primary data to other branches of anthropology (e.g. archeology, demography, prehistoric and historic anthropology or evolutionary biology... etc.), and is of practical importance, e.g. not only for historical studies, but also for forensic medicine.

Research on sexual dimorphism is basically a problem of classification: the division of objects to be analysed (skeletons of the known sex and their parts) into male and female groups, according to a certain rule (i.e. evaluation of characters according to their affinity and similarity). Identification is the opposite process: arranging certain unidentified objects (skeletal parts) into a system formed by classification. The identification key should offer an exhaustive and exclusive determination.

PROBLEMS WITH "SEXUAL DIAGNOSIS"

Sex determination for unknown skeletal remains is a difficult problem, in general. The problem of sexing is given by the contradiction between the discrete classification according to genetically determined sex and the continuous transitions of somatic sexual characters of the phenotype. (Cf. Scharf, 1979.)

A simple analysis of sex differences shows always a certain overlapping of the two sexes, although a normal human is either a man or a woman. That is why it is so difficult to elaborate a method that would partition a given population into, males and females, i.e. that would determine correctly the sex of each unknown skeletal find with the minimum risk of error.

The sex of skeletal remains can be determined thanks to the fact that during its development the skeleton acquires certain specific characters typical of each sex. The human embryo is potentially bisexual and hence the characters originating on the skeleton

are neither exclusively masculine, nor exclusively feminine. The sexual characters of the skeleton are not binary, but of variable character, so they overlap even under normal conditions. The polarization of the expression of sexual characters (i.e. the degree of sexuality) gives the skeletons and their parts in males a wide scope ranging from hypermasculine to hypomasculine types, and in females ranging from hypofeminine to hyperfeminine types. A strict principle of the "sexual diagnosis" has already been stated by Hrdlička (1947): "...as a rule no single character of a skeleton, skull or bone, unless so developed as to be beyond the range of its variability in 1 of the sexes, should be relied upon in sex differentiation". In the hypomasculine and hypofeminine zones, the sex determination of the skeleton becomes especially problematic or even impossible.

The sexual variability of skeletons, and thus their sex diagnosis, is also influenced by a number of other factors. The fundamental pattern of sexual dimorphism is similar in all human groups (i.e. a homologous pattern of sexual dimorphism), but there are certain differences that cannot be overlooked: "...the expression of sexual dimorphism is relatively similar in pattern of all varieties of man. This means that the shape of the bimodal curve describing sexually varying characters within populations will be approximatelly the same... the locations of these curves on the scale of absolute size will vary" (Thieme and Schull, 1957). The criteria for distinguishing these characters can differ substantially.

The age factor is, naturally, very important: certain sexual differences do not appear prior to puberty; others, although inborn, are inconspicuous in the pre-adolescent age. As the age decreases, sex diagnosis becomes more difficult, then even impossible.

There are, in addition, other factors that cause variability in the sexual characters of the skeleton: e.g. pathological changes, differences caused by various geographical regions and historic periods, environmental and living conditions (i.e. social-economic standard, education, way of life, profession, the influence of various sports... etc.). (Cf. Acsádi and Nemeskéri, 1970.)

Prior studies on human sexual dimorphism have resulted in a wide range of conclusions, in contradictory data and theoretical disagreement. The accuracy of the sex diagnosis of the skeleton is dependent greatly on the character of the investigated object and on the method applied. For sex diagnosis we might have at our disposal a complete skeleton (series of skeletons), or its parts (several bones, respectively a single bone), or just bone fragments in various stages of preservation. This limits the selection of characters, whose number alone is of no decisive importance: "...when sex characters are well represented in the remains, even small portion of the pelvis, if from the right place, may be entirely competent, for scientific purposes or before court, to give the sex determination". (Hrdlička, 1947.)

The method is selected according to the discriminatory effectivness in determinig sex. The views of experts concerning the probability of correct sexual diagnosis are, however, rather contradictory and their plausibility or reliability also varies a great deal. When selecting a method, it is necessary to proceed with caution and to assess the original papers, procedures and conclusions, especially with regard to contemporary requirements. The confusion of criteria for determining the sex of skeletal remains also follows from various degrees of use of the methodological tools offered by the science as a whole consistent with contemporary knowledge.

The diagnostic valence of the sexing method generally follows both from the biological nature of sexual dimorphism and from the methodological approach. The development of knowledge follows primarily from meta-methodological approaches which influence the elaboration of concrete methods (techniques) as tools for acquiring new, deeper and more substantial knowledge.

The earlier analytical-summative and descriptive only concept of sexing does not take into account the fact that sexual characters have different relevance according to their position in a system of sexual dimorphism as a whole. Such a mechanistic approach reduces the object to just a sum of its elements and tries to understand the properties, even of complicated objects, through combinations alone. The living systems form not only the sum of their components, but thanks to the hierarchy of their organization, they also have the properties of the whole and these properties appear on each level of the hierarchy. This is one of the principles of the so-called "systems approach", which, thanks to its tendency to reflect the object as a whole, helps us to understand the problem in its deeper substantiality.

The lack of respect to systemic laws and rules during research on sexual dimorphism is — in our view — the main cause for the inaccuracy of certain recommended methods of sex diagnosis, and the main source of errors in practice: sexual characters are often selected at random and the evaluation of morphoscopic (visual) characters is quite subjective, the definitions for the metric characters are often inaccurate, the sexual characters are limited to certain sub-systems only, some of the characters are based on robusticity only and thus are much influenced by environmental conditions. These methods often fail to produce acceptable results when applied to other populations.

Therefore, in an attempt to contribute to the determination of sex according to the bony pelvis, we have applied the systems approach as a basic methodological orientation.

SYSTEMS APPROACH

The *systems approach* is understood to mean a method of thinking which enables us to comprehend reality as systems, and which enables us by its complexity to understand the problem in its deeper substantiality. It is a basic methodological orientation for the general strategy of research in science. It is a tool for investigating complexity and seeking a total comprehension.

A "*system*" can be defined as a complex of interacting elements. The wholeness (integrity) of the system and its unity with the environment are stressed: the whole is more than the sum of its parts, and wholeness, totality, is disclosed only in relation to the changing environment. Thanks to the hierarchic order, the characteristics of the whole appear on each hierarchical level. We should respect the following: the purposiveness of definitions of different systems, the difference between "system" and "object", the abstract character of the system as a conceptual model of reality, the importance of differentiating level and hierarchic order, and the dialectic of relationship of the potentially equivalent concepts of "element" and "system". — An element is a black box in which a system of lower level is hidden that will appear if we shift to a higher level of differentiation — and vice versa — the system can hide in the black box and becomes an element of a higher level system if we shift to a lower level of differentiation!

Systems applications are concrete processes or procedures aimed at determining the suitable level of differentiation, and at defining the system through discovering its elements and the connections among them. Such connections are stronger than the connections with the elements of the environment. This is done in accordance with the purpose of the investigation. The systems approach is not represent a super-complicated analysis. Rather, it advocates an adequate application of methods we have at our disposal. An analysis of the system under study (mathematical, logical, verbal) delimits its real degree of complexity, and enables its application in practice.

The contemporary systems-evolutionary approach is aimed at creating a picture of the studied object as a whole with regard to both its nature and complexity. — Such approach involves synchronous research at three levels: each forms a unity via two dialectical, contradictory trends of research. (*Fig. 1.*)

1. The *structural* level determines the elements of a system and their relationships. To determine the system as a whole is possible only from outside — the system is accepted as an element of a system of higher order: the connections between this whole and its part enable to obtain the necessary and sufficient conditions for existence of the investigated system.

2. The *functional* level investigates the behaviour of a system in space and time. If we accept the system under examination as an element of a system of higher order, it is possible to distinguish its external and internal functions. The internal functions are influenced by the system structure, and the external functions have various connections with the environment. The system specifically reacts to changes in the environment according to its substance, and changes these connections in turn.

3. The *historic* level investigates the origin of a system, the process of its formation and its development up to a future perspective — the scientifically anticipated future as a possible hypothesis. The system is examined in time and the research has its genetic and prognostic components.

The systems approach in biology and anthropology comes mostly from an organismic conception, holistic morphology, namely the theory of open systems and general systems theory by Ludwig von Bertalanffy. (Cf. e.g. Bertalanffy, 1968; Kagan, 1974; Blauberg et al., 1977; Dullemeijer, 1977; and Novotný, 1981a, 1983a for review.)

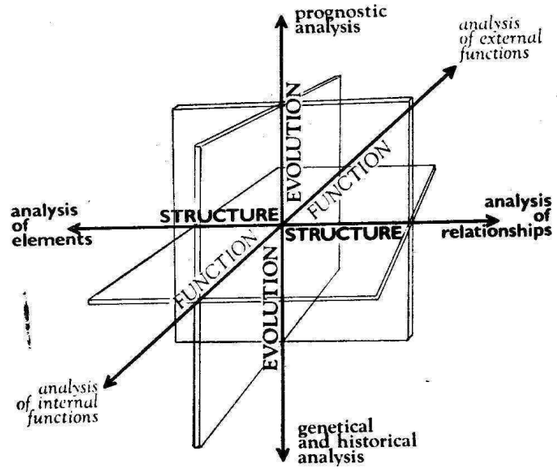

FIGURE 1. *Systems — evolutionary approach.*

THE SYSTEM OF SEXUAL DIMORPHISM IN THE BONY PELVIS

Sex differences of the skeleton are most marked in the pelvis, and the pelvic bone should be approached as a complete system as well. Although the individual bones of the pelvis belong to the group of long bones, the relative simple laws of tubular long bones cannot be applied to the development of the pelvic bones and to the pelvis as a whole. The bony pelvis is not a simple sum of its elements, but thanks to its expansive development (multidirectional, multidimensional and multifactorial growth and uneven timing of the development) forms a hierarchically complex system. (Cf. Coleman, 1969.)

Investigation of the individual and ethnic variability of sexual characters, of their phylogenetic and ontogenetic development and causal factors (both internal and external) leads to the discovery of key elements, an invariant structure, a set of system rules and results in construction of the system of the somatic sexual dimorphism as a whole.

Research on the system of sexual dimorphism of the pelvis is also the investigation of its structural, functional and historical levels:

1. At the structural level, it concentrates on the study of the shape of structural elements and their metric relations, leading to the discovery and assessment of the degree of sexual dimorphism.

2. At the functional level, sexual characters are considered both "internal" system functions (with regard to locomotion and reproduction) as well as "external" system functions (with regard to the

natural and social environment, e.g. to cultural evolution).

3. At the historic level, we follow the origin and formation of the system under study, both phylogenetically and ontogenetically, i.e. following morphogenesis from the viewpoint of both an individual's development and the evolutionary line.

Based on the systems viewpoint, the bony pelvis can be divided into two basic sub-systems of the ischiopubic and sacroiliac segment.

A. The *ischiopubic* segment (os pubis + os ischii) reflects well the different functions of the pelvis in the two sexes, namely in reproduction, showing the phylogenetic adaptation of the female small pelvis to the mechanical conditions of parturition with a relatively large fetus.

In all mammals where the head of the new-born is relatively large compared to the dimensions of the pelvic cavity, the following phylogenetic adaptation has occured: the female small pelvis has become extended into an adequately spatious birth canal. Through this sexual differences appear, since in males the pelvis is adapted during evolution solely to changes in the mode of locomotion. The ontogenetic development of this segment is controlled by hormones; the sexual difference is caused by remodelling of the feminine small pelvis into the birth canal during puberty. The most representative character of the small pelvis is the ratio of the longitudinal dimensions of the pubis and the ischium, i.e. ischiopubic index. (*Fig. 2.*)

B. The *sacroiliac* segment (os sacrum+os ilium) reflects the sexually differentiated process of hominization — adaptation to the verticalization of the body and bipedal locomotion. Dorsal extension and downward shift of the ilium is advanced further in males than in females where necessary dimensions of the pelvic cavity have to be preserved. Owing to the greater weight and stronger musculature of males, the greater sciatic notch is even more expressed with the downward tendency of the ilium. In females, the greater sciatic notch remains at a lower developmental stage, sometimes forming only a flat arch. The sexually dimorphic shape of the notch is inborn and seems to be under direct genetic control, but the degree of its expression is influenced by local factors. The incisura ischiadica major as a whole is the most representative character of the sacroiliac segment. (*Fig. 3.*) N. B. On the single os coxae the sacrum is represented through conditions in the sacro-iliac joint, e.g. inclination of facies auricularis etc. (Cf. e.g. Weidenreich, 1913; Washburn, 1948; Schultz, 1949; Genovés, 1959; Coleman, 1969; Leutenegger, 1970; Kummer, 1975... etc.; Novotný, 1981b and Brůžek, 1984 respectively for review.)

DISCRIMINANT ANALYSES AS METHODS OF SEXING

The purpose of the systems study of sexual dimorphism in the pelvic bone has been to contribute to an improvement in the sexing methods which should approach to the biological system of sexual dimorphism as a whole. The above-mentioned approach has

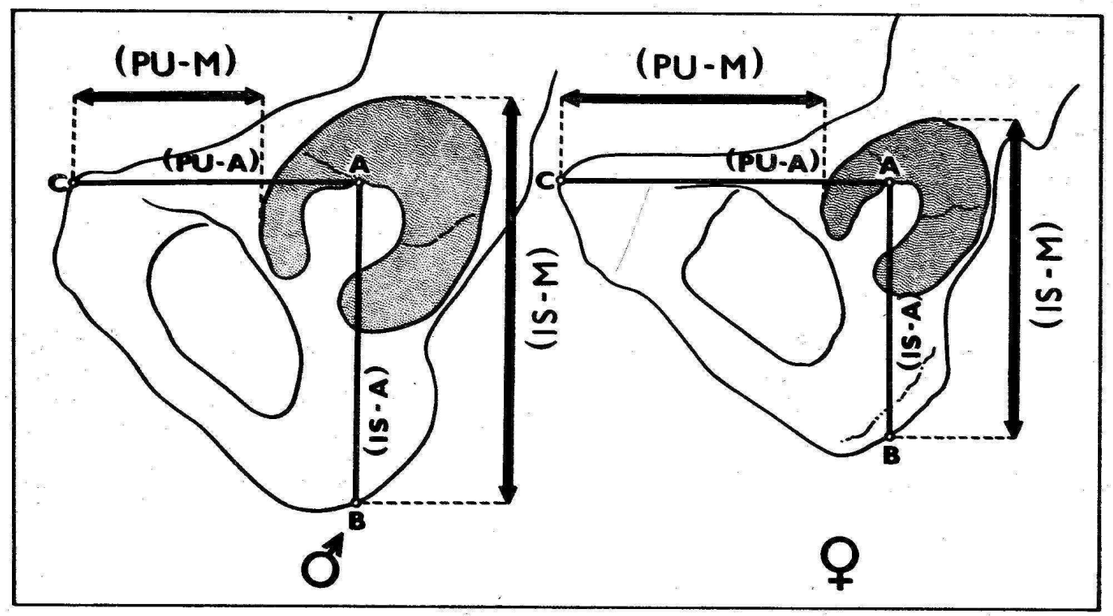

FIGURE 2. *Ischiopubic segment of the pelvic bone.*
Measuring points: *A = the natural „acetabular point"; B = the point where the axis of ramus superior ossis ischii crosses the surface of tuber ischiadicum; C = the midpoint of the superior border of facies symphysialis.*
Measurements: *(PU-M) = modified pubis-length: the rectilinear distance from C to the nearest point on the acetabulum rim; (IS-M) = the modified ischium-length: the rectilinear distance from B to the most distant point on the acetabulum rim.*

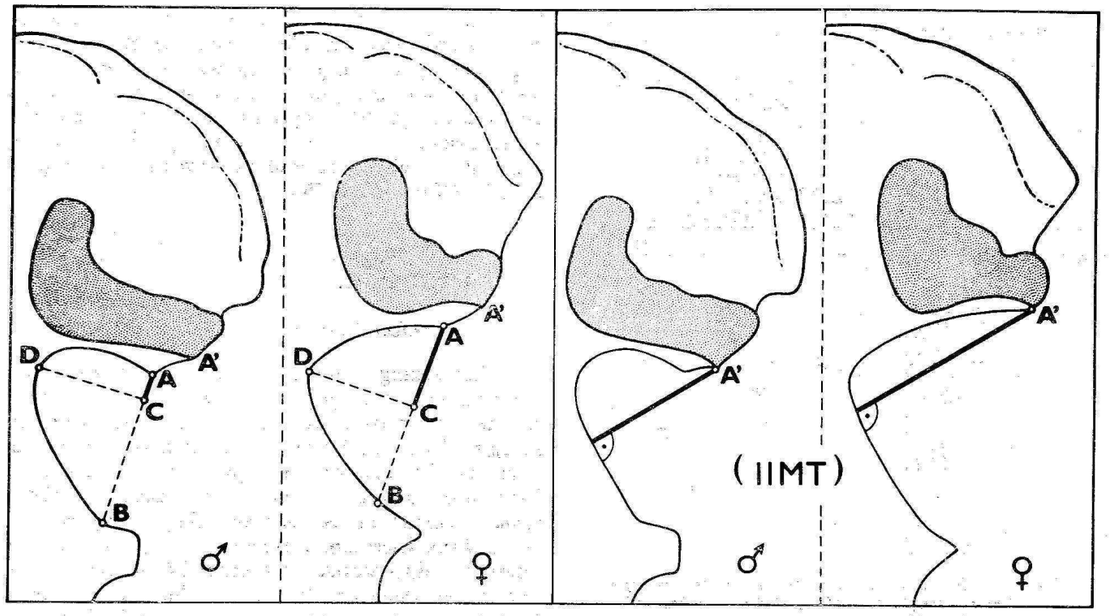

FIGURE 3. *Sacroiliac segment of the pelvic bone.*
Measuring points of incisura ischiadica major *(i.i.m.): A = the top of tuberculum musculi piriformis (if not developed, A'is used instead); A' = spina iliaca posterior inferior: the point where the upper branch of i.i.m. touches facies auricularis; B = the root of spina ischiadica: the point where the spina deflects from i.i.m.; C = the foot of the perpendicular line drawn from the deepest point of i.i.m. (D) to the width-line (A—B): D = the deepest point of i.i.m.*
Measurements of incisura ischiadica major: *(A—B) = the width; (C—D) = the depth; (A—C) = the upper part of the width; (C—B) = the lower part of the width; (IIMT) = the total height: the perpendicular distance from A'to the lower branch of i.i.m.*

enabled us to find a more fruitful way to select characters and to develop the measuring techniques and the identification key. Thus, through a suitable manipulation of the compatibly selected sexual characters, the risk of error can be minimized and the sex of each unknown skeletal find can be determined with the greatest degree of certainty.

In order to select the basic sex determining characters for the optimum identification key, it is necessary to combine the representative characters of both the evolutionary, functionally and causally different and relatively independent sub-systems of the pelvis. Thus evolutionary substantial sexual differences should be taken into consideration in sex diagnosis. The characters that are not directly correlated will contain the most information. The combination of such characters will enable us to reduce to a minimum the number of elements for the discriminant system and still be sufficient for the determination of sex.

Multivariate discriminant analyses can be regarded as a useful tool for sex determination, since these methods evaluate the sex characters as a whole with regard to their mutual relations, thus respecting the systems laws for the whole with respect to its parts. (See also Novotný and Vančata, 1985.)

First we tested by univariate methods 40 dimensions and 22 indices on 120 female and 115 male pelves of known sex, with special regard to various modifications of the ischiopubic index and of the indices of incisura ischiadica major. (*Fig. 2* and *3.*)

The samples were from the Departments of Anatomy in Prague and Brno, of German and Czech origin, from 19th and 20th centuries and socially underprivileged classes.

In our modification of the ischiopubic index (pubis-length × 100 : ischium-length), the determination of the longitudinal dimensions of the two bones was modified in such way that it was not necessary to establish their common point (acetabular point), i.e. the point of fusion of the ilium, pubis and ischium in the acetabulum, which is indistinct on a mature pelvis. The longitudinal dimensions of pubis and ischium in combination with the inverse sexually differentiated dimensions of the acetabulum, preserve the sexual difference of the ischiopubic index. In this case, the measuring points (landmarks) can be accurately and easily found, and thus we realized Thieme's and Schull's idea (1957). The above modified index reliably determined the sex in 85 % of the cases. The dividing value of the discriminant function for the two measurements determined the sex correctly in 97 % of the cases, but 11 % of the values (discriminant scores) overlap in both sexes. (*Fig. 4.*) The indices of incisura ischiadica major determined the sex correctly in about 65 % of the cases, while the discriminant function for all notch dimensions succeded in 92 % of the cases.

The analytical methods cannot be limited to a single part of a system of higher order, since the system laws for the whole cannot be neglected with regard to its parts. Thus, e.g. the female pelvis as

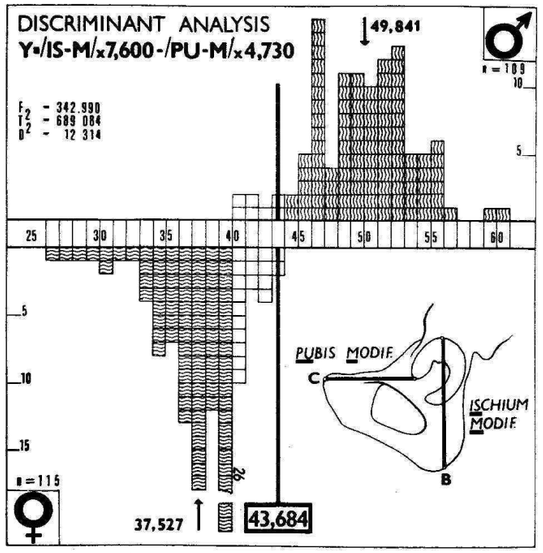

FIGURE 4. *Discriminant function based on the modified ischium-length (IS-M) and the modified pubis-length (PU-M).*

a whole makes parturition possible. Reduction of the female ischiopubic segment (which may thus acquire a masculine character) limits the capacity of the obstetric pelvis, which is usually compensated for by extension of the sacroiliac segment, or vice versa. This sometimes results in errors of sex diagnosis based on the single sub-system of the pelvis alone. Therefore, it is necessary to combine sex characters from both segments of the pelvis. (*Fig. 5.*)

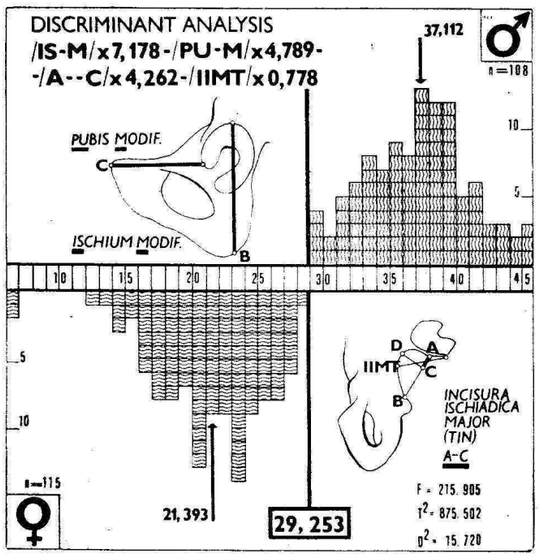

FIGURE 5. *Discriminant function based on the modified ischium-length (IS-M), the modified pubis-length (PU-M), the upper part of the width (A—C) and the total height of incisura ischiadica major (IIMT).*

The discriminant function for the modified pubis-length and modified ischium-length — these representing the ischiopubic segment — in combination with the two appropriate dimensions of the incisura ischiadica major (the upper part of the width and the total height) — these representing the sacroiliac segment — fully separated the sexes in our original sample. (Novotný, 1975.)

REMARKS ON THE "SEX DIAGNOSIS" IN THE PRACTICE

1. Statistical inference.

The sexing techniques based on metric traits can be used only for populations which show the same sexual dimorphism as the original, i.e. reference sample. The multivariate discriminant functions hold exactly only for the population in which they have been elaborated. The sex of unknown skeletal remains cannot be assessed according to the section point of the discriminant function alone, but must use reference values statistically inferred from the variability of the whole population. Reliable diagnosis (e.g. for forensic purpose) of a certain sex can be based on such values only as are behind the theoretically inferred range for the opposite sex of the same population.

2. Interpopulation differences.

The same metric methods for sexing are not usable for different races. Even various populations of the same race might have sexual dimorphism of the skeleton formed a little differently. It is very important, therefore, to study all the circumstances of the skeletal find: namely whether the find belongs to the same population from which the reference sample has been taken.

The above-discussed discriminant functions have been tested in the Laboratoire d'anthropologie biologique-Université Paris VII with regard to their validity, reliability and significance, respectively (Novotný and Brůžek, 1981). The French pelvic bones show certain deviations from the Czech-German sample. The original index values cannot be applied directly, owing to the shift in the interval of overlap and concomitant change in the discriminant values. For the discriminant functions, the mechanical application of the section point of the original reference sample always has poor results. That is why, although we used the original coefficients of the discriminant function, we have modified the section point by determining one half the difference between the means of discriminant scores for each sex of the French sample. After this correction, the discriminant function for the representative characters of both pelvic subsystems reaches, in statistical inference, the same probabilities of correct diagnosis as was the case with the original sample (*Fig. 6*).

The test series has shown that the differences in the French pelves have nothing to do either with the nature or the selection of the representative characters for our discriminant formulae.

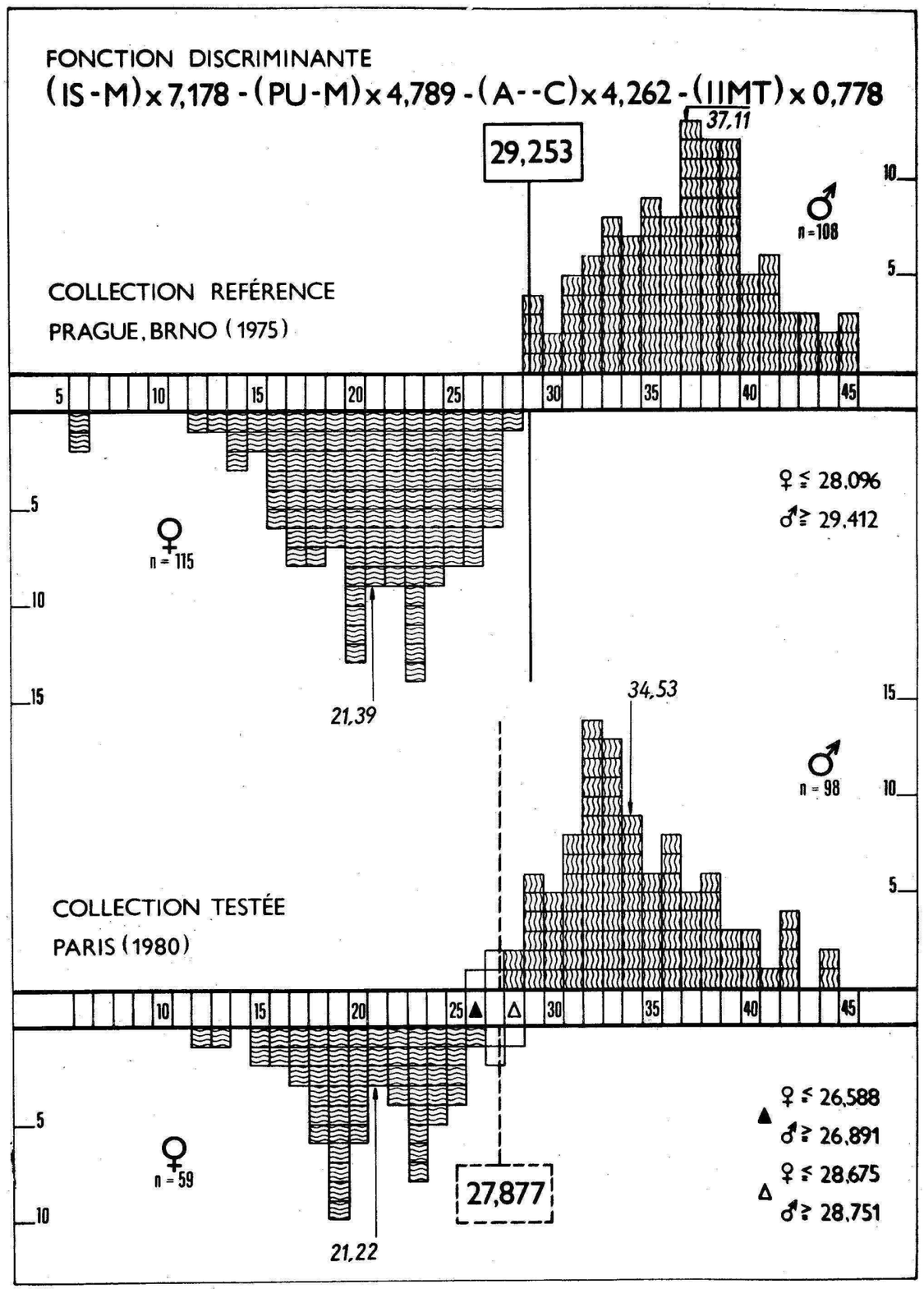

FIGURE 6. *The discriminant analysis of the original reference sample (above) and the application to the test series with the dividing value modified (below).*

The multivariate analyses are not necessarily limited to the population from which the selected reference sample originates. With suitable selection of the representative sex characters, and through the modification of the dividing value, they can be applied without great risk to other populations of the same race — in spite of certain interpopulation differences — assuming that sexual dimorphism shows the same homology. This, of course, presupposes the possibility of studying, even with a small skeleton series of known sex, the population to which this method is to be applied.

3. Historic and prehistoric finds.

The application of metric methods of sexing is complicated by both interpopulation and chronological differences. In recent populations we can compare materials of known sex and the method can be adapted, but in historic and prehistoric populations it is difficult to make a reliable diagnosis since there is no skeletal material of known sex at our disposal. In such cases it is advisable to test whether the studied population does not differ basically from the reference sample as regards the very formation of sexual dimorphism. This is possible only with skeletal material whose sex has been identified with a high degree of probability (e.g. skeletal remains of historic personalities, burial-grounds of monasteries, or according to the burial ritual).

Our analysis of the possible sex diagnosis of a series of skeletons from a monastery and the identification of the skeletal remains of the Czech sovereigns of the 9th—12th centuries recently subjected to an anthropologic-medical examination (by dr. E. Vlček), shows that in situation where the circumstances of the findings establish that this is the original population, the metric method can also be applied to population many centuries old. One of the most difficult and attractive problems is that of sexual dimorphism and sex determination of fossil finds. We have also made an attempt at the revision of the sex diagnosis of some fossil remains, e.g. the left pelvic bone of "Homo erectus" from the French locality of ARAGO and the ischiopubic segments of two Neanderthals "La Ferrassie I" and "Tabun I", and two Skhul skeletons IX and IV. — The conformity of these results with those obtained by morphoscopic methods shows that these discriminant functions reflect the nature of sexual dimorphism to such a degree that under suitable conditions, the metric methods can be used with fossil materials as well (Novotný, 1983b).

4. Pathological changes.

The sexual diagnosis of skeletons is complicated by the fact that when we speak about sex we have in mind normal individuals. One of the relatively less studied questions is: *if*, *how*, and *which* pathological changes of the skeleton have influenced the sex differences and thus the sex diagnosis as well. We must bear in mind these facts when working with incomplete skeletons or those at various stages of decomposition, where both the sex diagnosis and detection of possible pathological changes present quite a problem.

Our preliminary contribution to the determination of sex in the presence of some disorders of longitudinal skeletal growth, i.e. nanosomia, microcephalia + hyposomia, macrosomia and gigantismus, has revealed that it is impossible to use absolute dimensions which correlate with body height. Since, out of all of the pelvic measurements, the ischium-length correlates best with body height, the ischiopubic index is not suitable. The sacroiliac segment is best suited for sexing skeletons with abnormal growth since its basic shape is inborn and not subordinated to hormonal control as is the ischiopubic segment. The incisura ischiadica major also preserves its sexual character, both in its shape and in its dimensions, even in pathologically deformed pelves (see Jovanović et al., 1968). The discriminant function of the representative characters of both basic pelvic segments seems to be tolerant of growth variability. In the case of abnormal growth of the whole skeleton, as well as pathologically deformed pelvic bones, the sacroiliac segment is prefered as this segment is least touched by these disorders (Novotný, 1983c).

5. Morphoscopic characters.

The metric diagnosis must also be tested by an evaluation of the most significant morphoscopic characters. The most important is the so-called "sulcus praeauricularis" (pre-auricular groove). This pit-like groove is situated along the lower margin of the facies auricularis ossis ilii and is the result of pregnancy and birth-traumatic alteration. As a rule, it covers the usual furrow of the joint capsule and ligaments of the sacro-iliac joint (sulcus paraglenoidalis). This character clearly separates the group of males and childless females from women who have already given birth to children, namely multiparae (Cf. also Ullrich, 1975 for review).

For the sulcus praeauricularis, the shape of the greater sciatic notch, and the shape of the lower margin of the ischiopubic branch (these two branches form the sub-pubic angle of the pelvis), we have elaborated decision tables based on the logical analysis of an idealized shape, reducing the subjectivity of the observation, assessment and decision taking (Novotný, 1981b).

PRACTICAL RECOMMENDATIONS

1. In human skeletal remains of unknown origin, we search not only for the circumstances of discovery so as to establish the most suitable reference sample, but we also take into account the skeleton as a whole and search for pathological changes that might influence the sexual diagnosis.

2. In normal individuals, we use the discriminant functions from both basic sub-systems of the pelvis, and test these by the morphological characters. The identification key seems to be sufficiently tolerant to allow for growth variability.

3. In fossil finds we prefer the ischiopubic segment of the pelvis as it has been less influenced by hominization.

4. In the case of abnormal growth of the whole skeleton, as well as pathologically deformed pelvic bones, the sacroiliac segment is prefered as this segment is minimally touched by these disorders.

5. The sex diagnosis based on the skeleton holds exclusively for *somatic* sexual dimorphism — we cannot come to safe conclusions either about the genetically determined sex, or the social or psychosocial sex which is inscripted in the register of birth and deaths. The above-mentioned statement of the sex holds securely only for the individuals who are members of the population for which this method was elaborated.

This research has also enabled us to specify more exactly the present requirements for the method of sex diagnosis of the skeleton:

1. To use only fundamental characters with the greatest sexual dimorphism that meaningfully represent the evolutionary and functional nature of biological sexual dimorphism; the range of variation is to overlap as little as possible and the variability of characters within each sex is to be as low as possible.

2. To make use of samples with securely known sex from the population for which the method serves, and to interpret the results both anthropologically and statistically: the probable error depends greatly on these factors.

3. The method should be simple, clearly defined and practical.

The methods for sex determination should comply with the requirements of validity, reliability and significance.

PERSPECTIVES

The problem of sex identification of skeletal remains of unknown origin was investigated within the framework of the "Workshop of european anthropologists". The methods discussed in this paper formed also the agenda of the Conference of European Anthropologists in Prague (1972), in Budapest and Debrecen (1974) and Sárospaták (1979) where these methods were codified and included in the "Recommendations for Sex and Age Diagnoses of Skeletons" (see Ferembach et al., 1980). The methods are practical: they require only very simple instruments and can be used by everyone, under all conditions, both for routine examination of skeleton series and for unique sex diagnosis in forensic practice.

In theory, the future perspective consists in further development of the systems approach in this field, i.e. revealing the system of sexual dimorphism in its deeper relations and in its whole complexity (e.g. through the use of modelling etc.), and in examination of the methods themselves (their reliability, dependability, logic of definitions etc.). In order to reduce subjectivity in assessing the morphological characters, it would be possible to use decision theory, or computers working on the principle of pattern recognition.

In practice, it requires looking for further combinations of characters for discriminant functions and for an extension of the diagnostic possibilities to the bone fragments as well. Most important in our view is systematic research on sexual dimorphism in various populations which the user of the identification method might come into contact in order to elaborate identification keys (tables), at least for the large contemporary and past populations.

Interdisciplinary research on the system of sexual dimorphism is being activated under the pressure of practitioners ranging from anthropologists to medical examiners, and a number of new ideas are coming through feed back from these applications. The systems approach to sexual dimorphism and diagnosis is a good starting point for further research in this direction.

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