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A Method of the Determination of Sex from Artificially Deformed American Indian Crania

Sharon A. Bolt
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To the Graduate Council:

I am submitting herewith a thesis written by Sharon A. Bolt entitled "A Method of the Determination of Sex from Artificially Deformed American Indian Crania." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

William M. Bass, Major Professor

We have read this thesis and recommend its acceptance:

Avery M. Henderson, Fred H. Smith

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Vice Chancellor
Graduate Studies and Research

A METHOD FOR THE DETERMINATION OF SEX FROM ARTIFICIALLY DEFORMED AMERICAN INDIAN CRANIA

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee

Sharon A. Bolt

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ABSTRACT

Birkby (1966) cautions against the use of discriminant functions based on American Whites and Negroes to determine the sex of American Indian skeletal material. Two problems become apparent in the application of these methods to American Indian crania: (1) the existence of population differences in craniometric means and ranges of variation between American Indians and American Whites and Negroes; (2) the influence of artificial cranial deformation characteristic of many series of American Indian skeletal material. This study develops a multivariate discriminant function for the determination of sex in Arikara Indian crania and demonstrates its applicability to artificially deformed crania from the Southeastern United States.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Much of the anthropological knowledge to be gained from an analysis of human skeletal material depends upon an accurate assessment of individual age and sex. Although the age/sex composition of a skeletal series is no longer an end in itself, such information is vital to anthropological studies of prehistoric populations. Although the concept of a prehistoric population is frequently employed by anthropologists, the term is used here with caution. A mendelian (local) population is defined as "the community of potentially interbreeding individuals at a given locality"(Mayr 1970:82); locality implying a particular point in space and time. The nature of archeological remains is such that these limitations on time and space may not be met. It is possible, by making assumptions of time and space, to study population parameters in prehistoric cultural groups. Studies of this kind including examinations of prehistoric mortality rates, growth rates, and health and disease parameters and their relationship to sociocultural phenomena cannot be undertaken without a prior knowledge of the age/sex composition of the skeletal series examined. Vallois (1960), Angel (1969a, 1969b), Morse (1969), Blakely (1971), Coale (1972), Weiss (1973), Lallo (1974), and Swedlund (1975) demonstrate the applicability and potential value of these studies in the interpretation of prehistoric cultures.

Assessments of individual sex may utilize a variety of postcranial and cranial elements (Bass 1971; Krogman 1973). Ideally, as many of these techniques as possible are applied to the determination of sex for each individual. However, the often fragmentary nature of archeological material--due in part to the unpredictability of preservation and in part to the modes of burial--is such that only one or two skeletal elements may remain. Studies involving the use of cadaver collections, for whom individual sex was known, established that the best single element for sex determination is the innominate (Stewart 1948; Krogman 1973). The cranium is normally the most sexually dimorphic element when the innominates are not preserved (Giles 1964).

Traditional techniques for the assessment of sex from cranial remains involve a visual assessment of discrete traits. As in other primates, human males of a given population are relatively larger and more robust than the females. Thus, human males may be recognized as those specimens having larger supraorbital tori, larger mastoid processes, heavier muscle markings and a generally more robust appearance. Hrdlička found that it was possible to predict sex on a morphological basis with an accuracy of 80% (Hrdlička 1920). The problem with this methodology lies in its dependence on the number of subjective judgements (i.e., how large is "large") that the observer must make. Differences in the degree of sexual dimorphism may vary between populations. Knowledge of the range of variation of sexually dimorphic characteristics for the population under consideration is therefore necessary. These problems and considerations are such that it is sometimes difficult to resolve the differences in the sexing of an individual that two or more observers may encounter.

Keen (1950) attempted to sex individual crania by establishing population means and ranges of variation for a variety of measurements and then comparing individual cases to his standards. He recognized significant male/female differences in glabello-occipital length, bizygomatic breadth, mastoid length and the depth of the infretemporal fossa within a specific population. Keen continued the use of subjective judgements by introducing the position of the posterior root of the zygomatic process as a means of sex determination. Using a combination of four measurements and three anatomical features he found that it was possible to accurately differentiate sex in 84% of the individual cases. With his study, the importance of craniometrics as sex indicators was established.

With the development of computer technology and the concomitant development of multivariate statistical techniques and their introduction into anthropological methodology, Giles and Elliot (1963) applied the then new multivariate linear discriminant function to the problems of individual sex assessment of the cranium. Utilizing a series of American White and Negro crania of known sex from the Terry collection, Giles and Elliot generated 21 discriminant functions from nine measurements. The measurements were: (1) glabello-occipital length (2) maximum cranial width (3) basion-bregma height (4) basion-nasion length (5) bizygomatic diameter (6) basion-prosthion length (7) prosthion-nasion height (8) external palate length and (9) mastoid length. Their most accurate discriminants had a calculated probability of misclassification of 12.4% to 13.6%. This technique was the first to assign sex to individual specimens on an objective basis.

Since the work of Giles and Elliot, a number of other workers have applied the discriminant function technique to the problem of sex determination. In addition to cranial vault measurements, mandibular measurements (Giles 1964) and tooth measurements (Ditch and Rose 1972) have undergone discriminant function analysis with good results. However, during the course of these studies a number of problems appeared in the use of this method.

The test populations which generate the coefficients must be specimens of known sex from a specific population. For this reason the samples chosen for the original studies were from American White and Negro dissecting room collections. When the discriminant functions developed from this material were applied to individual cases from American White and Negro populations, a high percentage of individuals could be correctly sexed. However, documentation, most recently by W.W. Howells (1973) indicates the existence of interpopulation differences in the means of cranial measurements. Additionally, the magnitude of male/female differences are not the same in all human populations. In those breeding units where males are small in size, or females large, the magnitude of sexual dimorphism diminishes. This implies that, while a discriminant function for sex based on material from one population may be used to determine sex for skeletal remains drawn from the same restricted gene pool, the functions are not a priori applicable to individual specimens drawn from other populations. Birkby (1966) cautioned against the use of discriminant functions based on American Whites and Negroes to determine the sex of American Indian skeletal material. First, Birkby established that discriminant functions that could be used to sex American Indian crania would have to be developed from adequate sample sizes of American Indian skeletal material for which sex could be determined , postcranially.

Second, some series of American Indian crania exhibit artificial cranial deformation, which may be intentional or the accidental result of some cultural practice (Hrdlička 1905; Stewart 1959). Artificial cranial deformation of the occipital, fronto-vertico-occipital and fronto-parieto-occipital forms have been reported among many Southeastern skeletal series, especially those recovered from the Mississippian period (Neumann 1942). This deformation has a pronounced effect on the cranium. Not only does it lead to increased occipital robusticity, but flattening of the frontal, which may accompany occipital flattening in the Southeast, produces a compensory skull growth that is vertically oriented. Simultaneous flattening of the frontal, parietals and occipital will influence the lateral development of the cranium. In addition, flattening of any form may produce a skull with an asymmetrical shape (Neumann 1942). Thus, a number of cranial measurements, including cranial length and width (measurements traditionally considered as sexually dimorphic) are altered. An effective male/female discriminant which could be used on artificially deformed crania would have to use measurements not significantly affected by the deformation.

These problems illustrate the need, especially in the Southeast where artificial cranial deformation is common, for a method of sex determination for American Indian crania. This study was undertaken to provide such a technique via discriminant function analysis.

CHAPTER II

MATERIALS

An undeformed American Indian skeletal series was chosen as a standard on which to base the statistical analysis. Male and female differences established from these crania are therefore assumed to be of a biological rather than cultural nature. Eighty-nine males and eighty-three females from three South Dakota Arikara sites, Leavenworth, Larson and Sully, were chosen for this purpose (Figure 1). These specimens were selected as they could be sexed postcranially. The Southeastern sample used to test the discriminant functions generated from the Arikara consists of fifteen females and eleven males from Mississippian period sites in Alabama (Moundville), Georgia (Etowah), and Tennessee (Fain's Island, Dallas and Hiwassee Island). These specimens were also selected as they could be sexed postcranially.

Leavenworth was an historic site occupied between 1803 and 1832 (Wedel 1955). The twelve male and twelve female crania used in this study include some excavated by M.W. Stirling in 1923. The rest were recovered by William Bass in the summers of 1965 and 1966.

Thirty-five male and twenty-six female crania were utilized from the Sully site. These were excavated in 1957, 1958 and 1961 by the Smithsonian Institution River Basin Survey crews directed by William Bass; and in 1962 with National Science Foundation support, again under the direction of Bass. While this site may be multicomponent, all burials are believed to be protohistoric (Wedel 1961; Jantz 1972).

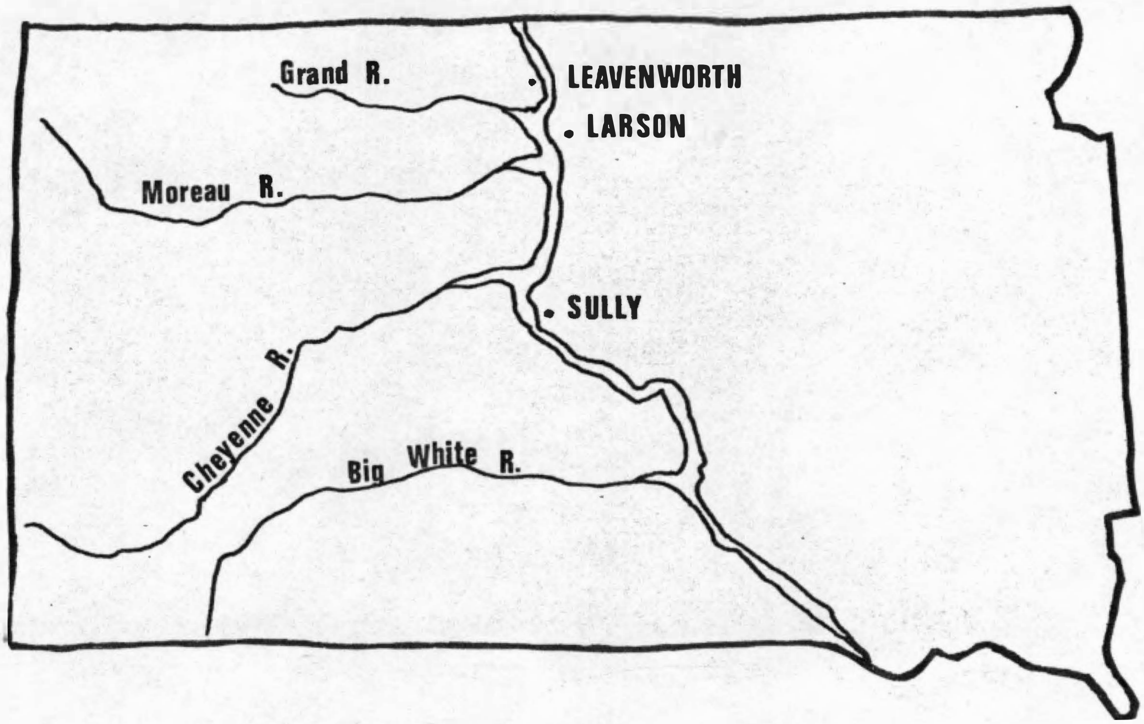

Figure 1 Location of the Arikara sites.
(After Jantz 1973)

The Larson material, of which forty-two male and forty-five female crania are used in this study, was recovered by William Bass in 1966 and 1967 (Bass, et. al. 1971) with the support of the National Science Foundation and the National Geographic Society. Associated grave furniture indicates that these burials are of an early contact period.

The Southeastern material comes from Mississippian period sites in Tennessee, Alabama and Georgia. The regional phases are Dallas in Tennessee (Lewis and Kneberg 1946); Moundville in Alabama (McKenzie 1966); and Etowah in Georgia (Kelly and Larson 1957).

The thirty-two Dallas specimens examined were excavated from three Tennessee sites (Figure 2). The Fain's Island site, 40 (1) JE 1, is located on an island in the French Broad River near Dandridge in Jefferson County, Tennessee. The site contains the remains of both a village area and a temple mound (Kneberg 1959). Five male and two female crania were examined from the Dallas component of this site.

Hiwassee Island, 40 MG 31, is found at the confluence of the Tennessee and Hiwassee Rivers in Meigs County, Tennessee. The site contains burial mounds, a substructure mound, a village and midden areas. The three male and four female crania come from Units 63, VT 1 and 38, which were habitation areas of the Dallas component of the site (Lewis and Kneberg 1946; Kneberg 1959).

The Dallas site, 40 HA 1, is located in Hamilton County on the left bank of the Tennessee River. Two female and three male crania were obtained from the village area (Unit 7) and seven female and five male crania came from the substructure mound (Unit 8) (Lewis and Kneberg 1946).

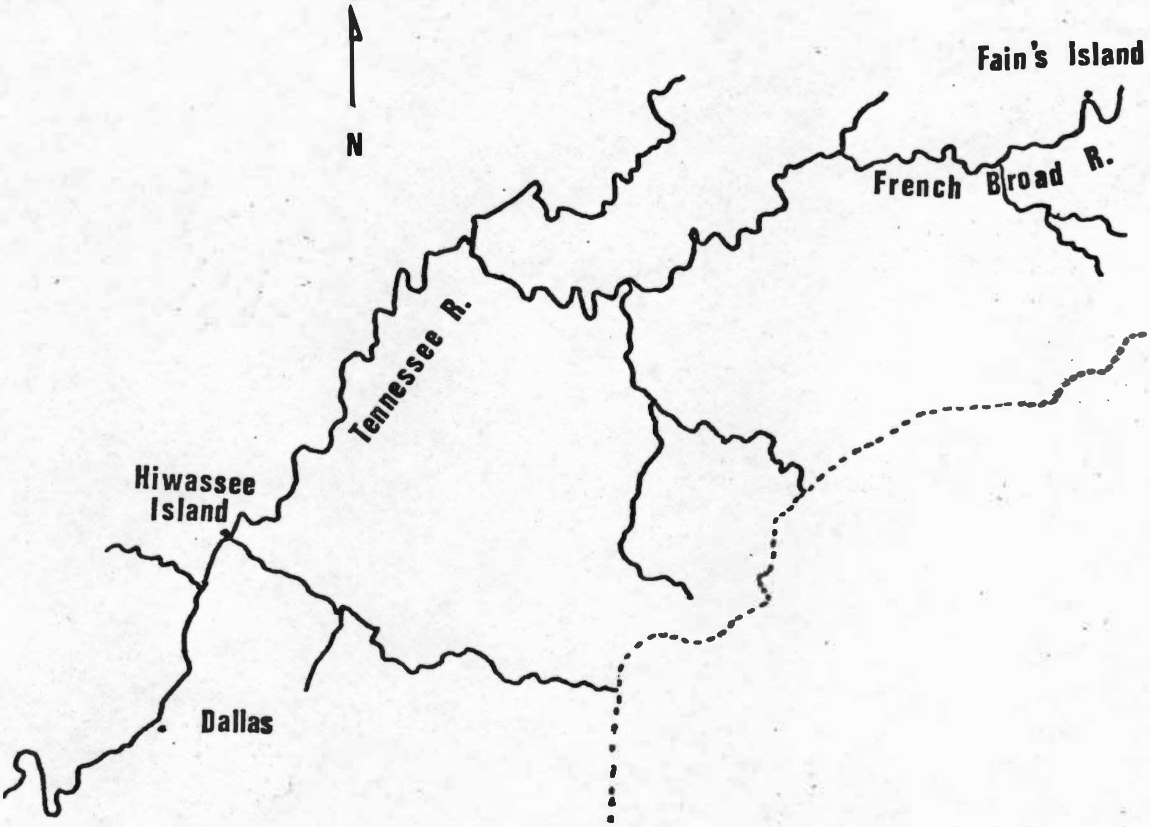

Figure 2 Location of the Dallas sites.
(After Kneberg 1959)

in the village area sample.

The Moundville phase material consists of two male and four female crania from the Moundville site in Alabama. This is a major Mississippian period site located on a plateau above the Black Warrior River in Hale and Tuscaloosa counties, Alabama. There is a plaza; four large mounds, one of which is associated with the plaza; and numerous smaller mounds. The site is multicomponent. Two components precede the Mississippian period and one follows it. The six crania used are among fifteen whose measurements are reported by Snow (1941). These specimens come from the southeastern portion of the village area of the site. All these specimens belong to the late Mississippian component (McKenzie 1966).

The Etowah site is located in Bartow County, Georgia, on the floodplain of the Etowah River near Cartersville. The site consists of three major pyramidal mounds, designated archeologically as A, B, and C. An extensive village area surrounds the mounds. Larson has excavated over two hundred burials from Mound C and seventy-five from the village area. Many of the Mound C burials were placed in log tombs which later collapsed as successive layers of clay were added during subsequent stages of mound building. Most of this material is more poorly preserved than the village area remains; thus only a few specimens could be utilized.

The Mound C material is assigned to a late Mississippian context. The village area material contains an additional Lamar component which extends into the protohistoric period. As many village area burials contain either no grave furniture or goods not exclusively characteristic of either period it is not possible to separate the Lamar burials from those contemporary with the mounds; therefore, these are included from those contemporary with the mounds; therefore, these are included in the village area sample.

CHAPTER III

ARTIFICIAL CRANIAL DEFORMATION

Artificial deformation is characteristic of many series of American Indian crania, especially those dating from Mississippian period. Artificial deformation has three sources: intentional, accidental and pathological. Intentional cranial deformation is purposely produced through a variety of methods, usually for asthetic appeal or as a symbol of status. Accidental deformation is the unintentional byproduct of some cultural practice. Cradle-boarding, a common practice among many historic American Indian tribes, produces an occipital flattening. When disease affects the cranial bones various kinds of deformities may occur as a result of pathological changes.

Neumann (1942) recognizes eight types of cranial deformation: obelionic, natural lambdoid, artificial lambdoid, occipital, bifronto-occipital, fronto-parieto-occipital, fronto-vertico-occipital and parallelo-fronto-occipital. Stewart (1939) recognizes a subtype of the parallelo-fronto-occipital form, pseudo-circular. He also describes another variety, the Aymara. Each of these deformities produces certain changes in the cranium with different kinds of compensory growth. Only a few of these form are found among Southeastern Mississippian cranial series; i.e., occipital, fronto-vertico-occipital and fronto-parieto-occipital deformation.

Occipital deformation is a flattening of the upper occipital and sometimes the posterior parietals, at right angles to the

Frankfort Horizontal. Neumann (1942) believes that this type of deformation was usually unintentional. Although it appears in crania from Adena and Hopewell contexts, it is usually a more common feature of crania from Mississippian sites in the Southeast. Persistence of this type of deformation extends into the historic period in this area.

Vertical deformation of the occipital, associated with a corresponding frontal deformation, is classified by Neumann (1942) as fronto-vertico-occipital deformation. This is almost exclusively a Southeastern phenomenon. Found as early as Middle Mississippian in Spoon River focus crania, it persisted into historic times in Creek and Cherokee crania (Neumann 1942).

Fronto-parieto-occipital deformation is similar to that of fronto-vertico-occipital deformation except that the top of the cranium is also flattened. This type of deformation is found in both late Mississippian and contact period crania (Stewart 1939).

Twelve crania from the Etowah site, nine from the village area and three from Mound C were examined to determine the types of compensory changes in cranial shape due to artificial cranial deformation. A list of these specimens and their ages and sexes is given in Table I. "MD.C" refers to burials from Mound C and "VA" indicates a specimen from the village area. The numbers which follow these designations are catalog numbers in the case of the Mound C specimens and burial numbers for the village area.

Figure 3 shows the varieties of deformation found at the Etowah site. These are compared to an undeformed Chippewa cranium (Wilkinson 1971). All adult cranial remains from Etowah had some form of

TABLE I

ARTIFICIALLY DEFORMED ETOWAH CRANIA

Specimen	Sex	Age
MD.C 456	male	50^+ years
MD.C 378	male	45 years
MD.C 2094	male	45-50 years
VA 31	female	40 years
VA 45	female	35-40 years
VA 73	female	15-20 years
VA 75	female	15-17 years
VA 32	female	25 years
VA 26a	female	20-25 years
VA 28	subadult	24 months
VA 29	subadult	15-18 months
VA 57	subadult	3 years

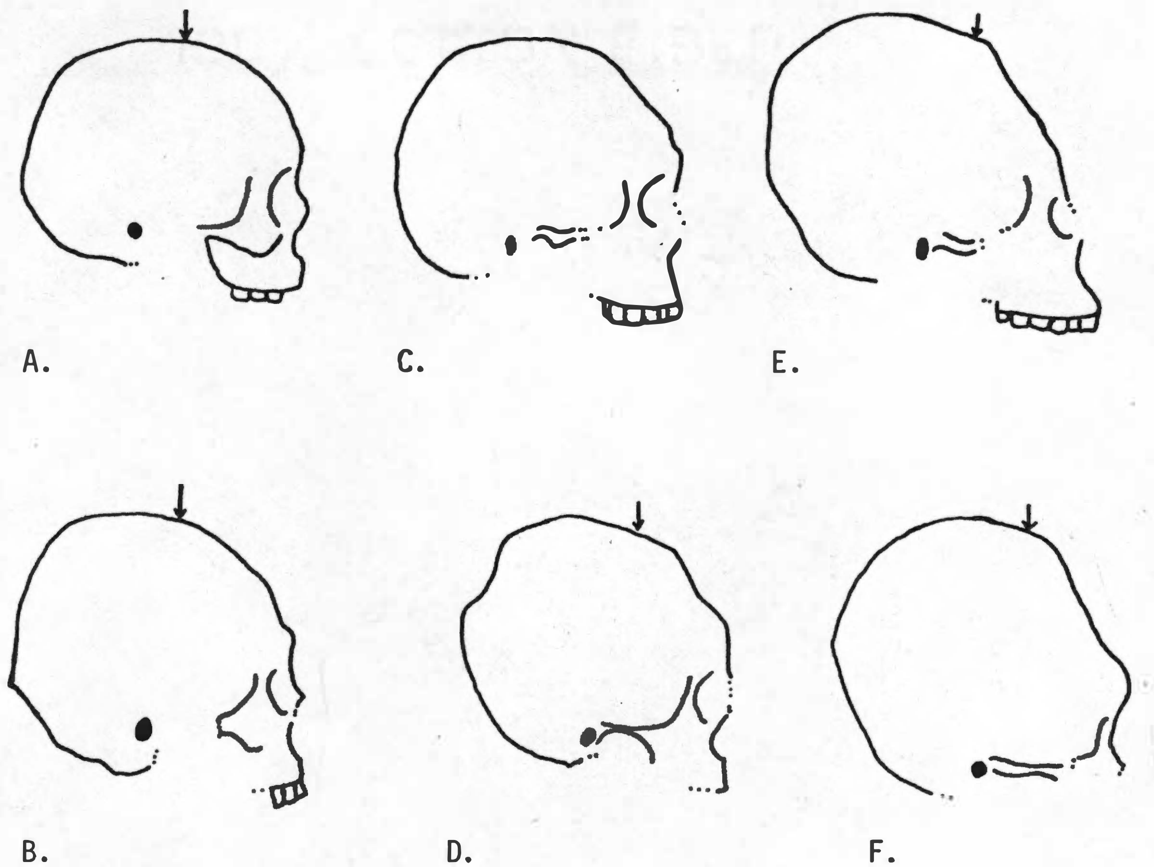

Figure 3 Deformation in the Etowah cranial series.

The arrows indicate the position of bregma.

A. Undeformed Chippewa crania.

B. MD.C 378 shows minimal occipital flattening.

C. MD.C 456 shows slight occipital flattening with associated frontal flattening. Ectocranial suture closure obliterates the position of bregma.

D. MD.C 2094 shows fronto-vertico-occipital flattening.

E. VA 45 shows fronto-vertico-occipital flattening. Note the steep slope of the frontal.

F. VA 31 shows an extreme form of fronto-vertico-occipital flattening.

occipital cranial deformation. The most common was a simple occipital flattening as seen in MD.C 378. In about 40% of these crania there is an occipital flattening associated with varying degrees of frontal flattening. This may be a flattening of the entire frontal, as in MD.C 456, or it may appear as a depressed band in front of the coronal suture, as in MD.C 2094. VA 45 and VA 31 both show a depression behind the coronal suture as well as frontal and occipital flattening. All forms were seen in both the Mound C and village area material.

The deforming mechanism was apparently applied from an early age. Although VA 29, fifteen to eighteen months old, shows only a slight frontal/occipital deformation; VA 28, a two year old child, has a pronounced fronto-vertico-occipital deformation. VA 57, three years old at death, also has a pronounced fronto-vertico-occipital deformation. At Etowah, the occipital flattening may well be the result of cradle-boarding as postulated by Neumann (1942). A marble female figurine, recovered from a log tomb associated with Mound C, is depicted with a knapsack-like object on her back. This may be a stylized cradle board (Kelly and Larson 1957).

Fronto-occipital flattening produces a short skull. Compensory growth is mainly lateral and vertical. In most deformed specimens, as in MD.C 2094, VA 45 and VA 31, this results in the development of large parietal bosses which extend both outward and backward. There is a large depression between the bosses along the posterior one third of the sagittal suture at the parietal foramina. The highest area of the skull is along the middle of the sagittal suture which may be exaggerated in those instances where there is a depressed band behind the coronal suture. The occipital is robust with strong nuchal lines.

The width of the face does not seem to be affected.

These changes affect many of the standard cranial measurements, including many of those comsidered to be sexually dimorphic. Maximum cranial length, for example, is substantially shortened. All measurements of the width of the vault, such as biporion and bi-euryon are increased. Measurements of height, such as basion-bregma, are also increased. The position of bregma seems more foreward in specimens with both occipital and frontal deformation. The position of inion in some specimens is difficult to locate. However, points of reference in the midline of the cranial base, such as basion, do not seem to be affected.

These types of cranial deformation and the resultant compensory changes affecting cranial width, length and height, as seen in the Etowah series, are also common to crania from the Dallas phase and to the Moundville series (Snow 1941).

CHAPTER IV

STATISTICAL ANALYSIS

Richard Jantz provided the author with measurements for each of eighty-nine male and eighty-three female Arikara crania. Most of these were measured by Jantz, the remainder by William Bass. These measurements were:

(1) maximum cranial length
(2) maximum cranial breadth
(3) basion-bregma height
(4) basion-nasion length
(5) basion-prosthion length
(6) minimum frontal breadth
(7) bizygomatic diameter
(8) nasion-prosthion height
(9) alveolar length
(10) alveolar breadth
(11) nasal height
(12) nasal breadth
(13) biorbital breadth
(14) basion-porion height
(15) auricular height

These measurements are defined by Bass (1964) and Jantz (1970) and were taken according to the standards set by Martin (1928).

A stepwise discriminant function analysis was used to obtain an indication of the relative power of the fifteen measurements to discriminate between males and females. The computer program chosen was a procedure from the biomedical series, BMD07M (Dixon 1970). The program ranked the means and standard deviations of the variables in the order of their degree of sexual dimorphism. The rank order obtained for the fifteen variables was:

Step No.	Variable entered
1	bizygomatic diameter (7)
2	basion-bregma height (3)
3	maximum cranial length (1)
4	biorbital breadth (13)
5	nasal height (11)
6	basion-porion height (14)
7	auricular height (15)
8	alveolar breadth (10)
9	nasal breadth (12)
10	basion-nasion (4)
11	basion-prosthion length (5)
13	alveolar length (9)

The remaining three variables, maximum breadth, minimum frontal breadth and nasion-prosthion length had an F-value of .005 or less and were therefore deleted from subsequent analysis by the program. Means and standard deviations for the variables are given in Table II. A summary of the results of the statistical analysis appears in Table III.

The rank order of these measurements was examined to select sexually dimorphic measurements that could be accurately measured on artificially deformed crania. As stated previously, measurements of length, width and height on the cranial vault are subject to considerable

TABLE II

MEANS AND STANDARD DEVIATIONS OF VARIABLES

FOR ARIKARA MALES AND FEMALES

	males		females	
variable	mean	S.D.	mean	S.D.
1	181.05	5.50	172.70	5.68
2	140.96	4.31	136.18	4.55
3	134.28	4.12	127.86	4.87
4	103.06	3.23	98.06	4.08
5	100.26	4.00	96.47	4.37
6	93.74	4.35	91.08	3.24
7	140.73	4.27	129.98	4.38
8	75.96	4.16	71.23	3.94
9	55.33	2.55	52.75	2.91
10	66.37	3.45	63.02	2.81
11	54.99	2.80	51.34	2.61
12	26.34	1.65	25.53	1.80
13	99.65	3.03	95.66	2.93
14	21.98	3.03	19.90	3.53
15	117.70	3.93	112.65	3.88

TABLE III

SUMMARY OF THE RESULTS FROM BMD07M

Step No.	Variable entered	Variable removed	No. males misclassed	No. females misclassed
1	(7)		11	6
2	(3)		8	8
3	(1)		8	6
4	(13)		8	5
5	(11)		5	5
6	(14)		4	5
7	(15)		3	6
8	(10)		4	5
9	(12)		4	6
10	(4)		4	6
11	(5)		4	5
12		(3)	4	5
13	(9)		4	5

compensory changes in deformed skulls. Therefore, measurements (3), (1), (14), (15) and (12) could not be used. As the maxillary palate is often poorly preserved, alveolar length (9) and breadth (10) were also not used.

Thus, six measurements: (4), (6), (7), (8), (11) and (12), remained for two group discriminant function analysis. A modified version of a program given by Davies (1971) was chosen as it computes the coefficients from a variance/covariance matrix. The calculation of the contribution of each variable to the power of the discriminant is most easily accomplished when the computation of the coefficients is done by this method. The percentage contribution was calculated as

$$\frac{z_i \ d_i}{D^2} \times 100$$

where z_i = the coefficient of the variable i; d_i = the difference between the means of the two groups for variable i; and D^2 = distance between the two group.

The Davies' program (1971) expresses distance as Hoetelling's T^2. D^2 and the normal deviates (D/2) were therefore computed on a desk calculator. Means and standard deviations were not printed out for the z-scores by the Davies' program. These were computed on a desk calculator.

The z values, d_i and the calculated percent contribution for each of the six variables in Function 1; i.e. (4), (6), (7), (8), (11), and (12); are given in Table IV. The mean z-score for the males was 93.178 and the standard deviation was 2.563. The mean for the females was 86.086 and the standard deviation was 2.705. The sectioning

TABLE IV

D_i, Z-VALUES AND PERCENT CONTRIBUTION FOR VARIABLES FROM EACH DISCRIMINANT FUNCTION

Variable	d_i	z_i	% contribution
Function 1			
(4)	2.76	.162	11.2
(6)	4.72	-.087	3.4
(7)	3.72	.525	80.4
(8)	0.77	.071	4.7
(11)	3.65	.188	9.9
(12)	0.80	-.189	2.1
Function 2			
(4)		.155	11.1
(7)		.491	77.9
(11)		.215	11.7
Function 3			
(7)	10.75	.158	58.0
(11)	3.65	.332	41.0
(13)	3.99	.238	32.0

point for this function was 89.636. D^2 = 7.092. Assuming that the sex of each individual as established by the observation of the post-cranial material is correct, the percent of Arikara specimens misclassed by this function was 7%. The theoretical (calculated) percent misclassed was 9.2%.

As indicated by BMD07M, minimum frontal breadth (6), nasion-prosthion height (8) and nasal breadth (12) contributed little to the power of the discriminant. These measurements were deleted and a second series of coefficients was generated for the remaining variables (Function 2). The mean z-score for the males was 96.949 and the standard deviation was 2.499. The mean z-score for the females was 90.105 and the standard deviation was 2.676. The sectioning point was 93.345. D^2 = 6.844. The theoretical percent misclassed was 9.5% while the percent of Arikara misclassed was 7.5%.

As basion-nasion length was ranked low by BMD07M and biorbital breadth had a higher ranking order, a third discriminant function (Function 3) was computed using variables (13), (7) and (11). The male mean for the z-scores was 69.816 and the standard deviation was 1.631. The female mean for the z-scores was 66.884 and the standard deviation was 1.756. The sectioning point was 68.354. D^2 = 2.93. The percent of Arikara misclassed by the function was 17.4% and the theoretical percent misclassed was 19.5%. Both biorbital breadth and bizygomatic breadth are measurements of the width of the face; hence they are highly dependent variables. This presumably accounts for the greater percentage of misclassification.

Of the three discriminant functions described, Function 1 proved to have the highest discriminatory power. However, the advantage of this function over Function 2 is negligible. Both of these functions appear to possess a high discriminatory power between males and females. As little additional information is given by the variables (6), (8) and (12), the discriminant function using only basion-nasion length (4), bizygomatic breadth (7) and nasal height (11) was chosen to be tested on Southeastern Mississippian crania.

CHAPTER V

APPLICATIONS

Twenty-six Southeastern Mississippian crania, for which sex could be determined postcranially, were used to test the discriminatory power of Function 2 which uses variables (4), (7) and (11). The test sample includes eight crania from Etowah (six specimens from the village area and two from Mound C); twelve Dallas crania (five from the Dallas site, four from Fain's Island and three from Hiwassee Island); and six from the village area at the Moundville site. All specimens except the six individuals from Moundville were examined and measured by the author. Measurements for the Moundville specimens are given by Snow (1941).

The spread of the z-scores for the Arikara males and females is found in Table V. The sectioning point calculated for this discriminant function is 93.345.

Four of the twenty-six Mississippian specimens were incorrectly sexed by the discriminant function by comparison with the postcranial material, giving a percentage of misclassification of 15.5%. This exceeds the theoretical percentage misclassification for this function. An examination of the range of variation in the z-scores for the Arikara (Table V) indicates a restriction of the male range of variation. In other words, the Arikara males appear to constitute a more homogeneous group than the female Arikara sample. A comparison of the spread of the z-scores of the Southeastern material (Table VII) indicates that there is a greater range of variation between the Mississippian

TABLE V

SPREAD OF THE Z-SCORES FOR THE ARIKARA

Range of scores	No. of male individuals	No. of female individuals
102.0-102.999	1	
101.0-101.999	4	
100.0-100.999	5	1
99.0- 99.999	7	
98.0- 98.999	10	
97.0- 97.999	20	1
96.0- 96.999	15	
95.0- 95.999	8	2
94.0- 94.999	5	
93.0- 93.999	6	3
92.0- 92.999	8	11
91.0- 91.999		9
90.0- 90.999		13
89.0- 89.999		16
88.0- 88.999		10
87.0- 87.999		13
86.0- 86.999		2
85.0- 85.999		1
84.0- 84.999		1
83.0- 83.999		
82.0- 82.999		
81.0- 81.999		1

TABLE VI

Z-SCORES OF THE MISSISSIPPIAN SPECIMENS

Specimen	Sex	Basion-nasion	Bizygomatic breadth	Nasal height	Z-score
Etowah					
VA 73	F	(95)	(127)	48	87.402
VA 32	F	98	(128)	48	88.294
VA 26a	F	101	(129)	51	89.873
VA 45	F	95	(127)	55	88.709
VA 75	F	88	(125)	47	85.120
VA 30	F	103	(125)	54	88.972
MD.C 2094	M	102	130	52	90.820
MD.C 378d	M	105	141	52	94.536
Dallas					
7 HA 77	M	97	(142)	51	95.722
8 HA 42	M	101	142	50	96.127
8 HA 43	M	112	153	55	104.308
8 HA 79	F	104	135	51	93.370
8 HA 133	F	(92)	121	45	83.346
1 JE 5	M	100	138	51	94.223
1 JE 155	M	103	137	56	95.272
1 JE 263a	M	95	143	50	95.688
1 JE 287a	F	99	137	51	93.577
36 MG 116	F	97	135	47	91.425
VT 1 MG 9	F	96	125	48	86.575
VT 1 MG 27	M	105	136	56	95.091
Moundville					
2681	M	107	(148)	55	101.078
2176	M	106	(142)	51	93.758
2178	F	108	(132)	46	91.442
2188	F	103	134	51	92.724
2548	F	97	(131)	46	89.246
2546	F	102	(137)	50	93.827

TABLE VII

SPREAD OF Z-SCORES FOR MISSISSIPPIAN CRANIA

Range of scores	No. of male individuals	No. of female individuals
104.0-104.999	1	
103.0-103.999		
102.0-102.999		
101.0-101.999	1	
100.0-100.999		
99.0- 99.999		
98.0- 98.999		
97.0- 97.999		
96.0- 96.999	1	
95.0- 95.999	4	
94.0- 94.999	2	
93.0- 93.999	1	3
92.0- 92.999		1
91.0- 91.999		2
90.0- 90.999	1	
89.0- 89.999		2
88.0- 88.999		3
87.0- 87.999		1
86.0- 86.999		1
85.0- 85.999		1
84.0- 84.999		
83.0- 83.999		1
82.0- 82.999		

males and females than between the Arikara males and females. This indicates that the sectioning point for the Southeastern material should be shifted with respect to the Arikara specimens.

Three of the four misclassed Mississippian specimens are females who fell into the Arikara area of overlap between males and females. A shift upwards of the sectioning point to 93.600 decreases the percentage of misclassed specimens to 8%. This does not exceed the predicted percentage of misclassification.

The greater range of variation in the sexually dimorphic characteristics of the Southeastern Mississippian males has been noted for the Dixon Mounds by Lallo (1974). This may indicate a more homogeneous female sample for the Southeast during Mississippian times. The male range of variation is large; therefore, this is not simply a decrease in sexual dimorphism. A number of reasons could be postulated for this phenomena, however, it will be necessary to examine distance between males and females from a number of sites as well as between sites in order to determine the most probable cause. This represents an area for futher research.

The value of this discriminant function is threefold. First, it was developed on American Indian material and successfully applied to other American Indian crania. It is hoped that interpopulation differences are minimized.

Secondly, this discriminant function uses variables that appear not to be affected by artificial cranial deformation. The high percentage of agreement between the sex of individuals on the basis of the postcranial material and this discriminant function indicates its value over those developed by previous workers. It therefore can be

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TABLE VIII

LIST OF ARIKARA SPECIMENS USED

Site	Males		Females	
	Feature	Burial	Feature	Burial
Sully	220	25	220	27B
		31A		21
		20B		7A
		15B		6
		15A		10
		12		8B
		1B	218	24A
	218	4C		22A
		14		8B
		15	320	19B
		33B	416	1C
		22C	420	8C
		27B	421	20B
		12		40
		6F		42B
	115	15		53C
		17B		105A
		19		97C
	421	117C		65E
		117A	115	2
		122B		6A
	320	17B		18
		22A	123	2
		10	116	1
	418	8C		3
	420	2		4A
	421	2A		8
		2B		
		30A		
		39		
		66D		
		31C		
	116	6A		
		9		
	117	3		
Leavenworth	101	3B	101	31A
		7		35
		18A		37
		30		48A
	102	3D	201	4
		17		6
		18D		
		22		

Site	Males Feature	Males Burial	Females Feature	Females Burial
Leavenworth, cont.	102	46	102	4
		50		14
		55		16
		13	202	10B
				17C
			220	9C
Larson	201	113B	201	Salvage 201
		124B		9A
		124G		13A
		127B		12I
		129A		14D
		130B		19D
		146B		34B
	101	3		35C
		27C		38B
		29C		47F
	301	11		111C
		2F		114B
		3H		163D
		12C		117
		11		120B
		17		124F
		19D		124C
		27D		124B
		29C		130A
		38A		132
		42		135
	201	2B		137C
		3E		141B
		4C		142
		6A	101	10D
		8D		12B
		8C	301	25
		32B		22
		32C		33C
		54A		36B
		54B		41A
		55I		43
		56E		49
		66		47
		68A		50B
		83		55F
		75A		64A
		86		76B
		85		93B
		97G		97D
		95		93D
		60C		55F
				66
				60B
				73

VITA

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