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The Skeletal Biology of the Caddo Indians of the Kaufman-Williams Site, Red River County, Texas

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THE SKELETAL BIOLOGY OF THE CADDO INDIANS OF THE KAUFMAN-WILLIAMS SITE, RED RIVER COUNTY, TEXAS

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Carol Jackson Loveland

June 1980

Dedicated

To the Members of My Family--

Each of Whom Gave of Themselves

in Many Ways to Make This Dissertation

A Reality

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ABSTRACT

A comprehensive biological analysis of the skeletal remains from the Kaufman-Williams site, 41RR16, Red River County, Texas, was conducted. The primary purpose of the investigation was to expand our knowledge about the biological variability found among the prehistoric Caddo. Cranial and postcranial measurements were taken, and indices were calculated. Several non-metrical characters were observed. The health status of the group was assessed based upon the pathological conditions noted in the bones. Cranial deformation was studied in detail, particularly its effect on craniofacial measurements.

A further analysis attempted to relate the skeletal material from the Kaufman-Williams site to Caddoan skeletal samples discussed in Maples (1962) and Westbury (1978) and to skeletal samples from the Saint Helena phase in Nebraska and from the Mobridge and Rygh sites (Arikara) in South Dakota. All of these groups were members of the Caddoan Linguistic Family. The Penrose Size and Shape Coefficient was used in the analysis since only literature data was available for the Caddo studies.

Seventy-five skeletons were used in the biological analysis. They were dug by Gregory Perino of the Museum of the Red River,

Idabel, Oklahoma. The skeletal material was given to Dr. William M. Bass, University of Tennessee, Knoxville, Tennessee, who made them available to the author. There were 28 females, 26 males, and 21 subadults in the sample.

The two health conditions which probably caused the greatest problem for the inhabitants of the site were dental caries and abscesses and degenerative arthritis. Congenital defects, which probably caused no problems, occurred quite frequently.

Twenty-eight percent of the deaths occurred among subadults. The highest death rate for males occurred between 30.0 and 34.9 years of age. The females had two periods of high death rate--one between 30.0 and 34.9 years of age and the other between 45.0 and 49.9.

The skulls from Kaufman-Williams were almost all intentionally cranially deformed. Parallelo-fronto-occipital deformation was the most common type. Two ratios (Frontal Deformation Ratio and Occipital Deformation Ratio) were devised to quantify the amount of deformation observed. The skulls were then grouped into deformation classes based upon these ratios. The three-cluster arrangement of the skulls based on the deformation ratios agreed well with the author's subjective classification. However, small cluster groups necessitated realignment of the skulls into two groups--moderate and extreme--for later comparisons.

Three tests, based upon either the two deformation ratios or upon the two deformation classes, were conducted to determine which craniofacial measurements were affected by deformation. These tests showed that, in general, breadth measurements were most affected by deformation. Those measurements which seemed to be most significantly affected by deformation were not used in the Penrose Size and Shape calculation.

The Penrose distance calculation placed the Cooper Lake material (Westbury 1978) generally more distant from the other populations; however, among the females Cooper Lake and Sanders (Maples 1962) were close. The Penrose coefficient placed the Kaufman-Williams, Arikara, and Saint Helena morphologically close.

The discrete trait analysis showed no significant sex, bilateral, or deformation class differences in the frequency of the traits. However, there were several traits which occurred in higher frequencies in both sexes in either the moderate or extreme deformation classes.

This study broadens our knowledge about the Caddo Indians and about their placement within the Caddoan Linguistic Family; however, many more such studies need to be completed. Furthermore, comparison of the Caddo with other nearby groups in the Texas-Oklahoma area should be conducted.

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CHAPTER 1

INTRODUCTION

The Caddo Indians

The Caddo Indians, members of the Caddoan Linguistic Family, resided prehistorically in adjacent sections of Arkansas, Louisiana, Texas, and Oklahoma. They lived in a 70,000 to 80,000 square mile area centered geographically near the Great Bend of the Red River (Krieger 1946; Hatcher 1927; Newcomb 1969).

The word "Caddo" is a modern English term which is an abbreviation of the name "Kadohadacho" ("Cadodacho" in Spanish and "Caddodoquieux" in French). The name is derived from the native word for an administrator or chief, "Kaadi" or "Caddi" (Tanner 1972; Story 1978).

The name referred initially to one of the three Caddo confederacies: (a) Kadohadacho, (b) Natchitoches, and (c) Hasinai. The Kadohadacho or Caddo confederacy was composed originally of four principal tribes who lived in the vicinity of the Great Bend of the Red River in what is now southwestern Arkansas and northeastern Texas (Tanner 1972; Swanton 1931, 1942; Williams 1955; Ford 1936). The Hasinai confederacy, which comprised the largest group of Caddo, was the collection of nine to eleven villages in east central Texas along the upper reaches of the Neches and Angelina river valleys (Newcomb 1960; Griffith 1954). In the vicinity of the modern namesake town, Natchitoches, Louisiana, lived the third group known as the Natchitoches (Newcomb 1960) (see Figure 1).

Figure 1. The Caddoan Area and the Kaufman-Williams Site.

Source: Adapted from Davis (1961b:5)

Despite their linguistic affiliations with the Pawnee, Arikara, Wichita, and Kichai (all Plains dwellers), the Caddo faced east in a cultural sense. They shared a distinctive cultural tradition with other Indians of the southeast and particularly with the Natchez (Newcomb 1960; Lange 1954).

The four state area occupied by the Caddo was lovingly spoken of as "the beautiful country" by them. It was a country ideally adapted to their farming, hunting, and fishing way of life (Webb 1960; Blair 1950; Davis, H. 1970; Bolton 1908).

Mooney (1928) estimated that there were 8,500 Caddo in 1690 (protohistoric period); however, Swanton (1946) suggested that there were not more than 8,000. Some villages were contacted by Europeans (first by the French and then by the Spanish) as early as 1540; however, evidence of trade goods is non-existent or meager at most sites prior to 1700 (Dorsey 1905; Neuman 1974; Harris et al. 1965; Scurlock 1965).

Unfortunately for the Caddo their homeland was located at the point of contact of French and Spanish exploration and expansion activities. Like many other American Indian groups, their numbers dwindled rapidly as contact with Europeans increased (Glover 1935; Smith 1958). Gradual encroachment upon Indian land occurred and in 1859 the remaining Caddo were removed from their homeland and assigned to a reservation in the state of Oklahoma where their descendants still live today. The first accurate census taken by the Indian Office was in 1880 when the figure for the united Caddo people was given as 538 (Swanton 1952; Williams 1955). Almost 1800 people are now listed on the tribal roll (Marquis 1974).

The Kaufman-Williams Site, 41RR16

The village now known as the Kaufman-Williams site was located along the southern bank of the Red River in northern Red River County, Texas. It is near the town of Manchester, Texas, off state highway 410. The site was occupied from approximately 1100 to 1800 A.D. (Skinner et al. 1969) (see Figure 1, page 2).

The site was originally outlined and registered by R. K. Harris about 1970; it is bisected by two farms (see Figure 2). One portion was originally owned by Mr. Sam Coffman, who requested that his name be spelled "Kaufman" (Skinner et al. 1969). The registered site designation uses this spelling. The other portion of the site is owned by the Williams family (Perino personal communication).

The first archaeological work at the Kaufman site was reported by R. K. Harris (1953). His excavations took place on that portion of the site encompassed by the Kaufman farm.

In 1968 Southern Methodist University aided by members of the Oklahoma Anthropological Society again excavated a portion of the site located on the Kaufman property, which was then owned by Red River Ranches, Lepanto, Arkansas (Skinner et al. 1969).

Gregory Perino of the Museum of the Red River, Idabel, Oklahoma, was in charge of the excavation on the portion of the site located on the Williams farm (noted herein as the Kaufman-Williams site).

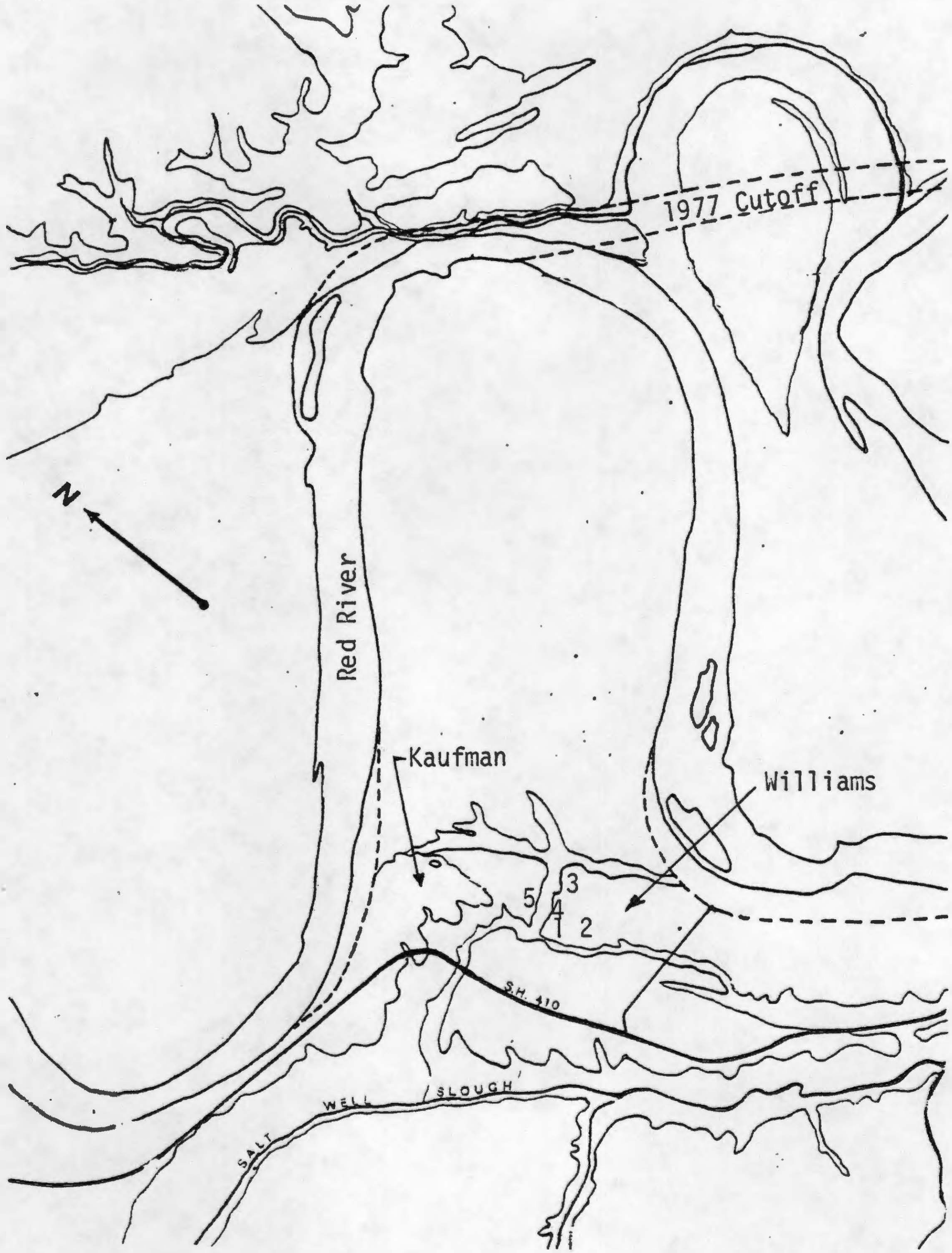


Figure 2. The Kaufman-Williams Site, 41RR16.

Burials were found associated with House Pattern Areas 1 through 5.

Excavations began in the spring of 1977, and the last of the skeletal material used in this study was obtained in June 1979. The burials were dated to the late prehistoric period (1550-1700 A.D.) (Perino personal communication).

General Problem Area and Goals

Documentation of the range of biological variation which occurs among human populations both through time and in space is one of the many concerns of physical anthropologists. Skeletal remains, of course, provide the only means of studying long-term temporal change. Whereas in the past such studies have stressed the taxonomic and historical implications of human variability more recent studies have attempted to unravel the evolutionary or adaptive significance of craniometric variation (Jantz 1970, 1972, 1973, 1977; Howells 1973).

Only a limited number of studies have been concerned with biological variation among the Caddo Indians. Most of those involving study of skeletal material have suffered from small sample size or poor preservation (Brues 1958, 1959; Buikstra and Fowler 1975; Navey 1975; Scurlock 1962). Thus, the Caddo Indians, who have been well-documented archaeologically, are still rather poorly understood from a biological perspective.

Furthermore, even though previous archaeological work has been conducted at the Kaufman site, there has been no detailed, comprehensive study of a relatively large sample of skeletal material. In the first report on the site published by R. K. Harris (1953) it was stated that the skeletal material was poorly preserved. Description of the burials themselves was scanty. Further papers on other burials obtained during this period (Harris et al. 1954; Perkins 1955; Harris and Wilson 1956; Huff 1960) again stressed the poor state of preservation. Stature estimates, in feet and inches, were made when possible, and rough age estimates were given. Eighteen burials were mentioned in these papers plus a cache pit containing 20 skulls. Nothing was stated about what happened to this material.

During the 1968 excavations by Southern Methodist University, 23 skeletons were recovered. Many of these were also reported as being fragmentary. Analysis of the skeletal material was by Barbara H. Butler who did not measure most of the crania ". . . because of distortion produced by post mortem warping or artificial deformation" (Butler 1969:118).

Due to the fact that the prehistoric Caddo Indians have not been extensively studied biologically, it was felt that the first objective of this study should be to ascertain and record the amount of biological variation occurring in the skeletal material recovered from the Kaufman-Williams site. This approach provided a basis for the comparative analyses undertaken in this dissertation and will also provide well-documented comparative material for the use of other researchers. Both metric and nonmetric characteristics of each individual were analyzed. Basic information about the relative homogeneity or heterogeneity of the sample as a whole as well as by sex was obtained. The pathological conditions which occurred on the individual skeletons were studied; this permitted inferences to be made about the general health status--disease, nutrition and injury--of the group.

Since cranial deformation has been commonly noted in Caddoan skeletal collections including that from the Kaufman-Williams site, an effort was made to determine the effect of parallelo-fronto-occipital deformation on metric and nonmetric traits. Furthermore, the degree of deformation was analyzed for possible sex or status differences.

The cultural practices associated with death and burial, such as burial position and associated grave goods, were examined. Possible sex, age, and status differences were noted.

Thus, the initial part of this study was concerned with the amount and type of biological variability occurring within this skeletal sample from the Kaufman-Williams site.

A secondary goal of this study was to craniometrically compare the skeletal sample from Kaufman-Williams with other Caddoan material and with other Indian groups belonging to the Caddoan Linguistic Family. This provided both a temporal and areal dimension to the variability found among one of the major North American linguistic families.

As mentioned earlier, much of the Caddoan skeletal material that has been reported in the literature comes either from very small samples or is very fragmentary in nature or both. Therefore, it was very difficult to locate suitable comparative material.

Maples (1962) compared skeletal material from a single Gibson Aspect site (T. M. Sanders) with several Fulton Aspect sites

(Womack Farm, Hunt Farm, Farrer, Jim Allen, Hatchell, Moore, and P. Mitchell). The Gibson site represented the early Caddo period (1200-1400 A.D.); the Fulton Aspect sites represented the later Caddo period (1500-1700 A.D.) to which the Kaufman-Williams site also belonged. Literature data concerning 49 skeletons from the Gibson Aspect and 81 from the Fulton Aspect were used in this study; however, many of the cranial measurements were missing due to the fragmentary nature of the material. For example, for some measurements only one cranium was complete enough to measure. Nevertheless, even though limited data were available for some measurements it was decided to use this study in a comparison with the skeletal material from Kaufman-Williams to provide a temporal-areal view of the biological variability occurring among the Caddo.

The second study of the Caddo that was used for comparative purposes was that of Westbury (1978) on the skeletal material from the Cooper Lake area. Twenty-two individuals were recovered from five sites (Arnold, Cox, Thomas, Tick, and Manton Miller) located along the South Sulphur and Middle Sulphur River drainages in north-eastern Texas. The material is fragmentary also, and many data were missing. These sites were dated to the pre-ceramic and early Caddo periods (700-1400 A.D.). Thus, they overlap into the same time period as the T. M. Sanders site utilized by Maples.

Even though the samples used for comparison were small, this material was used to analyze the biological differences occurring among the Caddo Indians over approximately a thousand year period.

The Caddo are linguistically affiliated with the Arikara, Pawnee, Wichita and Kichai who resided in various areas of the Plains. Hughes (1974) noted that with regard to most traits of culture the Caddo were very different from the Pawnee and Arikara and resembled some of their non-Caddoan neighbors more than they did their closest Caddoan relatives, the Wichita. The Caddo language is the most diverse and divergent of the Caddoan languages; glottochronology separates Caddo by 30, 33, and 35 centuries, respectively, from the Wichita, Pawnee and Arikara (Hughes 1974:298).

Biological comparisons of members of the Caddoan Linguistic Family have been made by a few researchers. Hrdlicka (1927) found the Wichita and Caddo to be of a different physical type than the Pawnee. Neumann (1952) classified the Arikara and Pawnee as northern Lakotids (hybrid Deneid-Lenapid) and the Wichita and Caddo as southern Lakotids (hybrid Deneid-Walcolid). In his detailed, comparative study Bass (1964) provided adequate confirmation of the similarity between the Arikara and Pawnee; however, his study involved no comparison with the Caddo.

Consequently, the skeletal material from the Kaufman-Williams site was compared with approximately contemporaneous Arikara material. As mentioned previously, the early Caddoan culture (1200-1400 A.D.) is known as the Gibson Aspect. The sample used by Maples (1962) from the Sanders site and the sample from Cooper Lake (Westbury 1978) are representative of this group. An approximately contemporaneous sample which is probably proto-Arikara (Jantz 1977; Jantz et al. 1978) is the material from the Saint Helena phase. The Saint Helena people lived in extreme northeastern Nebraska near the South Dakota and Iowa borders. The time span for the Saint Helena phase is roughly between 1400 and 1500 A.D. (Krause 1969). Measurements taken by Bass and Jantz on the Saint Helena group were used in this study.

Two Arikara sites in South Dakota were also used for comparative purposes. The Mobridge site is on the east bank of the Missouri River less than a mile north of Mobridge, South Dakota. The Rygh site, also located on the east bank of the Missouri, lies north of the Mobridge site approximately opposite the Leavenworth site. Both sites contained very few trade goods, and can, therefore, be dated somewhere between 1600 and 1700 A.D. (Jantz 1972, 1973). The measurements used in the comparative analysis were taken by Jantz. These sites were roughly contemporaneous with the Kaufman-Williams site and with the Fulton Aspect sites analyzed by Maples.

Thus, the second phase of analysis in this study focused upon the amount of variability occurring among Caddo Indians living at different sites during a thousand year period and upon the degree of biological similarity and/or divergence among approximately contemporaneous groups of the Caddoan Linguistic Family.

In summary, this study began with a comprehensive analysis of the skeletal material from the Kaufman-Williams site. Comparisons were then made with selected groups of the Caddoan Linguistic Family in order to determine the degree of resemblance between them.

<u>The Present Study in Relationship to Other Caddoan Studies</u>

The early decades of fieldwork in the Caddoan area focused primarily upon the recovery of artifacts; the success of an excavation was measured in terms of the quantity and quality of the artifacts recovered. The questions answered during this period provided only a very broad understanding of past Caddoan culture. The emphasis was on the large sites, especially those containing cemeteries, and since nonartifactual materials were not considered important, they were either only incidentally collected or completely ignored. This emphasis upon artifact collecting dominated much of the institutionally funded field work from the early 1900's to the beginning of World War II. It still continues today, usually in the form of the private collector (Story 1978).

Early excavations along the Red River were reported by Moore (1912) who excavated 47 sites. In his publication he briefly noted such details as burial position and number of burials in each grave. Hrdlicka (1909) discussed skeletal remains from both Arkansas and Louisiana.

W.P.A. crews, supervised by professional archaeologists, worked in all four states in the Caddoan area during the 1930's. Numerous amateurs were also active at this time. Most of the sites investigated were cemeteries which were dug in order to collect complete or restorable grave goods and to note their associations (Davis, E. 1970). Pearce (1932), for example, reported that at the end of the first season's field work more than 1000 pottery vessels were brought into the laboratory.

Unfortunately, reports about most of the sites dug at this time have never been published. Extant reports are limited almost entirely to the archaeological materials. The burials themselves are generally given only cursory mention. It is often stated that the burials were poorly preserved and seldom is it mentioned what happened to the bones. Typical publications of this type include Jackson (1933, 1934, 1935, 1938), Webb and Dodd (1939), and Lemley (1936).

A few publications, however, are somewhat more detailed about the skeletal material. Goldschmidt (1935) speculated about why most of the skeletal material from eastern Texas was so poorly preserved. Walker (1935) discussed the cranial deformation which he had noted in the skulls he had found. Hrdlicka provided information about the Caddo in the Proceedings of the United States National Museum (Hrdlicka 1924, 1927, 1940).

During the 1940's, undoubtedly due to the disruptions caused by World War II, publications which referred to skeletal material in the Caddoan area were scant. A comprehensive description of the dentition of the Texas Indians including the Caddo, was given by Goldstein (1948); Colquitt and Webb (1940) and Keith (1973) also discussed the dentition of the Caddo. A paper on cranial deformation among the Texas Indians was published by Goldstein also (Goldstein 1940). Publications in which the grave goods were described and the burials were ignored continued to appear (Harris 1945; Dickinson 1941; Orr 1946).

Comparative analysis of the archaeological remains which were recovered in the 1930's and early 1940's enabled Krieger (1946, 1947b) and Newell and Krieger (1949) to formulate the classification of Caddoan cultures which has formed the basis of all subsequent studies in the four state area. These publications have clearly delineated the older Gibson Aspect and the later Fulton Aspect. The McCurtain Focus of the Fulton Aspect is the culture associated with the Kaufman-Williams site.

Since 1949, several other workers have further clarified the cultural sequences in the Caddoan area (Suhm and Krieger 1954; Davis 1961a, 1961b, 1970; Orr 1952; Wycoff 1970, 1971; Webb 1945, 1959; Webb and Gregory 1978; Griffith 1954; Bell and Baerreis 1951; Hoffman 1969). Caddoan settlement patterns and house types were discussed by Bushnell (1922), Webb (1940) and Brown et al. (1978). A recent synthesis of Caddoan studies which has been of considerable value was written by Story (1978).

Several studies have helped in delineating Caddoan placement within the Caddoan linguistic family and in determining Caddoan relations with other Indian groups (Bell 1961; Lesser and Weltfish 1932; Krieger 1947a; Hughes 1974; Griffin 1961; Gray and Laughlin 1960; Webb 1961; Jelks 1961).

From the early 1950's to the present time papers which provided more detailed analyses of Caddoan skeletal material have become more common (Brues 1957, 1958, 1959; Maples 1962; Powell 1977; Goldstein 1957; Woodall 1969). However, reports written either by archaeologists, who were only interested in the artifacts and sometimes in burial customs, or by amateurs, continued to appear (Webb and McKenney 1975; White 1970). One element of the burials that is often mentioned, as in earlier descriptions, is the poor state of preservation (Johnson 1962; Scurlock 1962; Harris et al. 1965; Lawton 1956; Bell 1953; Brown 1975).

Among the most interesting but also very complicating features found on Caddoan skeletal material are the intentionally deformed skulls (Goldstein 1940; Walker 1935; Bennett 1961). Swanton (1911, 1946) gave an ethnographic account of the process of binding an infant in a cradleboard. Neumann (1942), Stewart (1973), and Dembo and Imbelloni (1938) provided a general discussion of cranial deformation, and Stewart (1940) suggested that cranial deformation was a rather late manifestation. Gill (1977) compared cranial deformation with motifs found on figurines (in Mesoamerica) and suggested that a single conceptual idea was held in common by those who artificially shaped infants' skulls. Gregory (1963) published a brief note on skull deformity in which he suggested that it was practiced by the Indians as a means to enhance personal appearance.

The question of which cranial and/or facial measurements and of which non-metric traits are affected by deformation has been addressed by several authors (McNeill and Newton 1965; Moss 1958; Dorsey 1897; Ossenberg 1970; Gottlieb 1978; Giles and Bleibtreu 1961; Rogers 1975; Leigh 1937; Shapiro 1928). Bennett (1965) concluded that wormian bones represent secondary sutural characteristics brought about by stress. Buikstra (1976) stated that the presence of deformation severely limits the use of cranial metrics as biological distance measures, and Howells (1973) felt that deformed skulls should be discarded from such studies. Experimental studies involving deformation in rats by Pucciarelli (1974, 1978) stressed the need to analyze the effect deformation stresses actually have on the human skull.

It has not been established whether deformation has any effect on the total volume of the brain case. It is likely that there is sufficient plasticity in the growing bones to permit the brain case to expand in a compensatory way when pressures are applied in any one direction and little or no change should result in cranial capacity (Moss 1958). However, in a small series of deformed and undeformed crania examined by MacCurdy, the deformed series averaged nearly 6% lower in volume than the undeformed specimens (MacCurdy 1923).

Summary

Studies about the Caddo Indians have been primarily from an archaeological perspective. Those investigations that have dealt with the biology of the people have generally been severely hampered by small sample size or fragmentary remains. The present study should broaden our knowledge of the people.

CHAPTER 2

MATERIAL

Skeletal Material from the Kaufman-Williams Site

The skeletal material which comprised the core of this study was dug by Gregory Perino of the Museum of the Red River, Idabel, Oklahoma, during the period between 1977 and 1979. The collection was given to Dr. William M. Bass, University of Tennessee, Knoxville, Tennessee. Dr. Bass brought 44 skeletons to Knoxville in 1978; 15 additional skeletons were brought from Oklahoma by the author in March, 1979. Sixteen more skeletons were obtained in June, 1979, at the close of the excavations. The sample was almost evenly divided among the sexes. There were 26 males and 28 females; 21 skeletons were sub-adult.

The Kaufman-Williams site is located along a river terrace about 30 feet above the south bank of the Red River bridging what was formerly a large meander in the river. In 1977 the river broke through its banks and created a new channel; thus the "Williams" side of the site which is located to the south is no longer adjacent to the river. The land is flat to gently rolling and it has been farmed for over a hundred years. Trees fringe the borders of the cultivated fields. A narrow copse of tangled vines and trees which is lower than the surrounding ground divides the Williams portion of the site. This area is sometimes boggy (see Figure 2, page 5).

The skeletal material was derived from five different areas which apparently surrounded former residential areas. Table 1 presents the burials which were found with each house pattern area.

The portion of the site located on the Kaufman property was apparently occupied earliest, according to Skinner et al. (1969). The architectural remains on that part of the site are attributed to the time period from the eleventh century to possibly as late as 1500 A.D. As the population grew, settlement began on the Williams portion of the site. Gregory Perino (personal communication) places the occupation there from 1550 to 1700 A.D. based upon pottery types found with the burials. The late burials were associated with Hudson Engraved bottles and Hodges Engraved deep conical bowls. Those graves containing Simms Engraved bowls were intermediate to late. Perino also notes that most, but not all, of the shallower burials were late. Burial 30 was found with an iron strike-a-lite and two dart point tips on the sternum; some of the pottery associated with this burial was made by the same potter who made part of the pottery associated with Burial 39. Thus, these two burials occurred in the early historic period.

Since all of the burials came from an area about eight hectares in extent and since Houses 3, 4, and 5 contained very few burials, the entire collection was lumped together as a single group in order to form as large a sample as possible.

TABLE 1

DISTRIBUTION OF SKELETONS AMONG HOUSE AREAS BY SEX AND TIME PERIOD

Burial No.	Sex	Time Period	Burial No.	Sex	Time Period
House No. 1			House No. 2 (cont.)		
1	M	Late	23	SA*	Early
2	M	Late	24	F	Early
3	F	Indeterminate	25	SA*	Early
4	M	Indeterminate	26	M	Early
5	M	Indeterminate	27	SA*	Early
6	M	Late	28	M	Late
7	M	Early	29	SA*	Indeterminate
8	F	Middle	30	M	Late
9	M	Middle	31a	F	Middle
10	F	Middle	31b	SA*	Middle
43	F	Early	32	F	Early
44	F	Early	33	SA*	Early
45	M	Early	34	SA*	Early
46	M	Early	35	F	Early
47	M	Early	36	F	Early
48	F	Early	37	SA*	Early
49	SA*	Early	38	SA*	Late
50	F	Indeterminate	39	F	Late
51	F	Early	40	F	Middle
52	M	Middle	41a	F	Middle
58	M	Middle	41b	SA*	Middle
59	M	Indeterminate	53	SA*	Indeterminate
60	M	Late	54	SA*	Early
61	M	Late	55	SA*	Early
62	M	Late	56	SA*	Early
63	M	Late	67	F	Late
64	F	Late			
65	F	Early	House No. 3		
66	M	Early	42	F	Late
			68	F	Late
House No. 2			69	SA*	Late
11	M	Early			
12	SA*	Early	House No. 4		
13	F	Middle	57	SA*	Late
14	M	Early	70	M	Indeterminate
15	F	Late			
16	SA*	Early	House No. 5		
17	M	Indeterminate	71	F	Late
18	SA*	Indeterminate	72	F	Middle
19	F	Middle	73	F	Early
20	M	Early			
21	SA*	Middle			
22	F	Early			

*Subadult-unsexed

Comparative Caddoan Material

Small sample size, poor documentation, and the fragmentary nature of much of the Caddoan skeletal material made it very difficult to find suitable material for comparative purposes. The study by Maples (1962) involving 49 skeletons from the T. M. Sanders site (Gibson Aspect, 1200-1400 A.D.) and 81 skeletons from seven Fulton Aspect sites (1500-1700 A.D.) offered the largest sample comparison. However, due to the fragmentary nature of the remains there was often only one cranium complete enough on which to take a particular measurement. [Maples reported that the Gibson Aspect material was in better condition than that from the Fulton Aspect sites (Maples 1962:7).]

The seven Fulton Aspect sites--Womack Farm site in Lamar County, Hunt Farm in Cass County, Farrer site in Titus County, Jim Allen site in Cherokee County, and the Hatchell, Moore, and P. Mitchell sites in Bowie County--had all been lumped together by Maples into one sample based upon visual observation; no statistical tests were done to establish the homogeneity or heterogeneity of this sample.

The more recent study of the burials from the Cooper Lake area by Westbury (1978) involved a small sample of 22 skeletons from five sites--Arnold, Cox, Thomas, Tick, and Manton Miller. The sites were located along the South Sulphur and Middle Sulphur River drainages in Delta and Hopkins Counties in northeastern Texas. The skeletal remains were dated to approximately a seven hundred year period and included the Gibson Aspect (1200 to 1400 A.D.). All of the material was treated as a sample from a single population. No grave goods were recovered with any of the burials. Unfortunately, as with the Maples study, there were a great deal of missing data so that the sample size for many measurements was much below 22.

However, these two studies provided the opportunity for some comparisons to be made between different Caddo groups.

Comparative Material from Other Members of the Caddoan Linguistic Family

Skeletal material from the Saint Helena phase in Nebraska was used as a representative of a probable proto-Arikara group. Bass (1964) used a combined sample from eight sites to first explore the relationship of crania from the Central Plains Tradition sites to those of the later Arikara in South Dakota. He concluded that no close relationship existed between the Central Plains crania and later Pawnee and Arikara crania. However, Jantz (1977) and Jantz et al. (1978) showed that crania from two Saint Helena phase sites, 25DK9 and 25DK13, were very similar to the Arikara from the Mobridge area. The Saint Helena people lived in extreme northeastern Nebraska near the South Dakota and Iowa borders between 1400 and 1500 A.D. (Krause 1969). The measurements used in this study were taken by Bass and Jantz both of whom kindly loaned their data. Data from four sites were combined to form a sample consisting of 21 males and 13 females.

Skeletal material from two Arikara sites, Rygh and Mobridge, constituted the comparative material from the northern Plains during the 1600-1650 A.D. period. Exploratory excavations were carried out by Strong in 1932 at Rygh, and between 1959 and 1963 Bowers conducted more extensive excavations there. In 1965 the University of Kansas field party excavated in the cemetery area west of the village (Jantz 1970). Measurements used in this study were from crania obtained from both the Bower's and University of Kansas excavations. Also included were a few crania which were obtained from amateurs.

The Mobridge cemetery was originally excavated by M. W. Stirling who recovered 40 skeletons from 11 graves. In 1968 and 1969 the University of Kansas field crew under the direction of Dr. William M. Bass conducted further excavations at the cemetery (Jantz 1970).

The skeletal samples from the two Arikara sites were pooled for use in this study since both sites dated to approximately the same time period, and they are located close to one another. This permitted use of a larger sample size. There were 32 males and 34 females in this combined population. All measurements on the skeletal material from both sites were taken by either Bass or Jantz, both of whom graciously consented to loan their data. Fifteen cranial measurements were available for both the Saint Helena and Arikara samples; these, therefore, dictated which measurements could be used for comparative purposes.

CHAPTER 3

ANALYTICAL METHODS

Sexing, Aging, and Stature Estimation

Analysis of an archaeological population requires correct determination of the sex and age of individual skeletons. In general, the methods available produce dependable results although there are some problems.

The major problem in the determination of sex from skeletal material is the difficulty of sexing subadults. Many of the techniques employed to sex subadult bones depend on roentgenograms taken during life (Reynolds 1945, 1947; Imrie and Wyburn 1958), and these techniques have not provided suitable results when applied to dry bones. The analysis of mandibular tooth development (Bailit and Hunt 1964) and of correlated bone and tooth ages (Hunt and Gleiser 1955) have also achieved only limited success when used on archaeological specimens. It is possible to sex subadults using multivariate discriminate analysis based upon measurements taken on the permanent dentition. The reliability of this approach was shown by Ditch and Rose (1972). It was not used in this study, however, due to the problems posed by the extreme dental attrition noted in many of the skeletons. Therefore, subadult material was not sexed.

Many criteria for assessing the sex of an adult skeleton have been published. Several of these were used in this analysis in order to obtain reliable results.

In general, pelvic morphology has proven to be the most reliable indicator of sex (Bass 1971; Krogman 1962; Phenice 1969; Washburn 1948; Kelley 1978; Coleman 1969; Stewart 1979a). The presence of "scars of parturition" was suggested by Stewart (1957, 1970) to be a result of the childbirth process. Pits on the dorsal surface of the pubic bone do seem to be a female characteristic; however, the extent to which they are associated with the childbirth process is still open to debate. Holt (1978) provided evidence against a strong association between pits and parity while Kelley (1979) found that pitting rarely occurs in nulliparous females. Suchey et al. (1979) found a statistical association between the number of full term pregnancies and the degree of dorsal pitting, but the correlation was not strong. Several nulliparous females were reported to have "medium to large" pits.

Cranial morphology is also useful for adult sex determination (Bass 1971; Krogman 1962; Stewart 1979a; Keen 1950). These methods were used in determining sex in this study.

Differences in long bones are also important in sexing skeletal material. Such indications as diameter of the femoral head (Dwight 1905, Bass 1971; Krogman 1962; Thieme and Schull 1957) and circumference of the femoral shaft (Black 1978) were recorded and utilized.

Aging a skeletal population also provides its own particular problems; however, in the case of aging it is the individuals over 40, rather than the young, who are most difficult to characterize.

Because of the difficulty of precisely aging skeletons, five-year age intervals were used.

Three methods were used to estimate the chronological age of immature skeletons. These were: (a) tooth eruption (Ubelaker 1978; Hurme 1948: Kronfeld 1954; Schour and Massler 1941, 1944), (b) epiphyseal closure (Johnston 1961; McKern and Stewart 1957; McKern 1970; Krogman 1962), and (c) length of long bones without epiphyses (Johnston 1962; Maresh 1955; Merchant and Ubelaker 1977). One additional method was used to age very young skeletons--those under five. Weaver's (1979) aging criteria, based upon the formation of the tympanic ring, was used when possible.

Determination of adult ages of the Kaufman-Williams population was based on several criteria; the metamorphosis of the pubic symphysis (McKern and Stewart 1957; Gilbert and McKern 1973; Gilbert 1973; Todd 1920; Hanihara and Suzuki 1978) was the most important factor considered for adult age determination. However, this method becomes less valuable at increasing ages--i.e., over 40. Stewart (1957) cautioned that distortion of the pubic symphyseal surface in females due to pregnancy may affect age determination.

The degree of epiphyseal closure (McKern and Stewart 1957; McKern 1957, 1970; Stevenson 1924) was used to age young adults.

The other aging criteria are much less reliable; hence they were used only for general age assessment. These methods are (a) development of vertebral osteoarthritis (Stewart 1958), (b) dental attrition (Miles 1963; Brothwell 1965), (c) ossification of rib cartilage at the costochondral junction (Kerley 1970), and (d) closure of endocranial and ectocranial skull sutures (Krogman 1962; McKern and Stewart 1957; Kerley 1970; Todd and Lyon 1924). Allison and Gersten (1977) have cautioned that deformation complicates the rate of suture closure.

The estimation of living stature from the length of long bones has been attempted by several authors (Trotter and Gleser 1952, 1958; Dupertius and Hadden 1951; Trotter 1970; Genoves 1967). These studies were all developed using cadaveral measurements or specimens whose stature was known during life. Neumann and Waldman (1968), on the other hand, attempted to develop formulae based upon grave length. Unfortunately, they did not present data on the long bone lengths of their sample; therefore, no comparisons of the measurements can be made with other populations. Furthermore, it has not been determined how grave length relates to living stature. The formulae given by Trotter and Gleser (1952, 1958) for White females and Mongoloid males and by Neumann and Waldman (1968) for American Indians were used in this study.

As a measure of sexual dimorphism in long bone length, the left femur length was compared. Mean femur lengths were calculated by sex and population. Using the formula

$$\frac{\bar{X}_{males} - \bar{X}_{females}}{\bar{X}_{males}} \times 100$$

the sexual dimorphism was calculated as a percent of the male mean.

Paleopathological Analysis

Determination of the health status of a prehistoric population in which there has been no preservation of soft tissues is limited to observations based upon changes which occurred in the skeletons as a result of disease, trauma, malnutrition or age. The pathologies which may be observed give some indication of the stresses under which the population lived. In this study the pathologies were analyzed and considered on an individual basis as well as in relation to the whole population.

Observation of Harris or transverse lines in the long bones has been heralded as a potentially useful indicator of health conditions in prehistoric populations (Wells 1967; McHenry and Schulz 1976). The long bones of all sub-adults in the numbered group between Burial 1 and Burial 57 were x-rayed using the Duocan 1 x-ray machine in the Speech and Hearing Sciences Department, The University of Tennessee, Knoxville, Tennessee. Films were developed by Student Services, The University of Tennessee, Knoxville, Tennessee.

Metrical Data

All measurements taken were recorded on data sheets taken from Bass (1964, n.d.) (see Table 2). The instruments which were used to measure the skeletal material are described in Table 3. Thirty cranial measurements, following Bass (1964), were taken on the Kaufman-Williams crania. The landmarks from which the measurements were taken correspond to those defined by Bass (1971). The measurements are briefly described in Table 4, and the instrument used in

TABLE 2

MEASUREMENT SHEET USED TO RECORD DATA

Craniometric Measurements — William Bass — P A

Site:________ Field No:________ Date:________
Site No:________ Culture:________ Observer:________
State:________ Period:________ Recorder:________
Material Housed:________ No:________ Dug by:________

Sex:____ Age:______

Max. lgt....______
Max. br.....______
Basion-br...______
Endoba-nas..______
Endoba-Alv.p______
Endob-gn....______

Min front br______
Bizygomatic.______
Na-alv.pt...______
No-gnathion.______
Ext.alv.lgt.______
Ext. alv.br.______

Nasal ht....______
Nasal br....______
L orbital ht______
L orbital br______
Biorbital br______

Ba-po ht....______
Nasal root h______
Nasal bone h______
Nas bridge h______
Min. na. br.______
Ba-ala......______
Ba-medial...______
Ba-lateral..______

Po-upper-orb....______
Po-lower-orb....______

Auricular ht....______
Porion-nasion...______
Porion-subnasale______
Porion-prosthion______
Porion-gnathion ______

MANDIBLE

Symphysis ht....______
Diam. bigonial...______
Diam. bicondylar.______
Ht.ascen.ramus..______
Corpal lgt go-ng______

INDICES

Cranial index...______
Cranial Module..______
Mean ht. index..______
Length ht. index.______
Breadth ht.index______

Fronto-parietal.______
Upper face ind..______
Total face ind..______
Nasal Index.....______
Orbital Index...______
Palatal Index...______
Flatness Crabase______

OBSERVATIONS R L

		R	L
Supra-orbital foramen	yes		
	notch		
	multiple		
	no		
Suture into infra.orb for.	yes		
	no		
Sutures in Pterion Region	wide H		
	narrow H		
	K		
	X		
Frontal to tempora			
Tempora to frontal			
Epipteric bone			
Sutural Bones	Coronal		
	Bregma		
	Inca		
	Wormian		
Dehiscences Tympanic Element	None		
	small		
	medium		
	large		
Sub-orbital Fossa	none		
	shallow		
	medium		
	deep		
Infra-maxill. Notch	none		
	shallow		
	medium		
	deep		
Mylo-hyoid Bridge	yes		
	no		
Parietal notch Bone	yes		
	no		
Ear Exos-toses	none		
	slight		
	medium		
	pronounced		
Parietal Foramen	yes		
	no		

TEETH WEAR:____

R								L							
M3	M2	M1	PM2	PM1	C	LI	CI	CI	LI	C	PM1	PM2	M1	M2	M3

A :Abcess
A- :Abcess missing
C :Carious
- :Missing (AM)
:Missing (PM)
. :Tooth pres. good condit.
:Bone missing
T :Tarter

ARCHAEOLOGICAL DATA

Burial type:________
Burial position:________

Head dir:________
Artifacts assoc:________

Depth from surface:______

Metopic sut. yes no — Pharangeal fossa yes no

DEFORMATION: Occipital R L
Lambdoid
Fronto - occipital

PATHOLOGY:

NOTES:

TABLE 2 (continued)

William Bass
Measurments on Plains Indians

P A
Post Cranial Sheet___

Site:______________ Field No:______________ Date:______________
Site No:______________ Culture:______________ Obser ver:______________
State:______________ Period:______________ Recorder:______________
Material Housed:______ No:______________ Dug by:______________

Sex:________ Age:______________ Symphyseal Component:______

HUMERUS

	R	L
Max. morph. length......		
Max. Diam. Mid Shaft....		
Min. " " "		
Circumference "		
Max. Diam. of Head......		
Humero-femoral Index....		
Index of Robusticity....		
Septal apertures: none		
Pin point		
small		
Medium		
Large		
Multiple		

Pathology______________

CLAVICLE

	R	L
Maximum length..........		
Claviculo-humeral index.		

Pathology______________

FEMUR

	R	L
Max. morph. length......		
Physiological length....		
Ant-post Diam mid shaft.		
Transverse " " " .		
Circumfance " " .		
Subtroch. transverse....		
" ant-posterior.		
Max. Diam of Head.......		
Pilastric Index.........		
Meric Index............		
Index of Robusticity....		

Pathology______________

TIBIA

	R	L
Max. morph. length......		
Physiological length....		
Ant-post.Diam nut.foram.		
Trans. " " " .		
Circumfance mid shaft...		
Tibio-femoral Index.....		
Cnemic Index...........		
Index of Robusticity....		

Pathology______________

RADIUS

	R	L
Max. length.............		
Humero-radial index......		

Pathology______________

ULNA

	R	L
Max. length.............		

Pathology______________

SCAPULA

	R	L
Maximum height..........		
Maximum breadth.........		
Scapula index...........		
Vertebral border convex.		
straight.		
concave.		
Scapula Notch absent.		
slight.		
medium.		
deep.		
foramen.		

INNOMINATE

	R	L
Isch. tub.-iliac crest...		
ASP-PSP.................		
Index..................		

SACRUM

Maximum length..........	
Maximum breadth.........	

No. of segments:________

PELVIS

Inlet ant-post..........	
" transverse.........	
Pelvic Index...........	

FIBULA

	R	L
Maximum length..........		

Pathology______________

VERTEBRA
Arthritis:______________
Pathology:______________

RIBS
Notes:______________

NOTES

TABLE 3

INSTRUMENTS USED IN TAKING SKELETAL MEASUREMENTS

	Instrument	Abbreviation
I.	Hinge caliper	HC
	A GPM (Gneupel) standard hinge caliper was employed to measure osteological points which were difficult to ascertain using a straight line measuring device.	
II.	Sliding caliper	SC
	A GPM sliding caliper was used to measure points which were fairly close together and which suffered no interference from skeletal contours.	
III.	Coordinate caliper	CC
	A GPM standard coordinate caliper was used to measure the distance between two points while the coordinate attachment measured the elevation of a third point above these two.	
IV.	Western Reserve model head spanner	WRHS
	A GPM Western Reserve model head spanner is designed to measure points along the mid-sagittal plane with reference to porion and was used in this study to determine auricular height and other measurements relating to facial profile.	
V.	Osteometric board	OB
	An osteometric board was used for the majority of the post-cranial measurements.	
VI.	Metric tape	MT
	A metric tape was used to obtain long bone shaft circumferences.	

TABLE 4

CRANIAL MEASUREMENTS AND INDICES

	Measurement	Instrument
1.	Maximum length The greatest length in the median sagittal plane from glabella to opistocranion was measured (Bass 1971:62).	HC
2.	Maximum breadth The maximum cranial breadth perpendicular to the median sagittal plane (above the supermastoid crest) was measured (Bass 1971:62).	HC
3.	Basion-bregma height The distance from the lowest point on the anterior edge of the foramen magnum (basion) to bregma was measured. If bregma was depressed, the reading was taken from the surface and not in the depression (Bass 1971:62).	HC
4.	Endobasion-nasion The distance from the most posterior point of the anterior border of the foramen magnum (endobasion) to nasion was measured (Hrdlicka 1952:144).	HC
5.	Endobasion-alveolar point The distance between endobasion and alveolare (the apex of the septum between the upper central incisors) was measured (Hrdlicka 1952:144).	HC
6.	Endobasion-gnathion The distance between endobasion and the lowest median point on the lower border of the mandible was measured (Wilder 1920:54).	HC or SC

TABLE 4 (continued)

	Measurement	Instrument
7.	Minimum frontal breadth The minimum breadth between the two temporal ridges (frontotemporale to frontotemporale) was measured (Bass 1971:67; Hrdlicka 1952:142).	SC
8.	Bizygomatic diameter The maximum breadth across the zygomatic arches perpendicular to the median plane (zygion to zygion) was measured (Bass 1971:67; Hrdlicka 1952:143).	SC
9.	Nasion-alveolar point The distance from the point where the two nasal bones and the frontal bone come together to alveolar point was measured (Bass 1971:67; Hrdlicka 1952:143).	SC
10.	Nasion-gnathion The distance from nasion to gnathion was measured. No estimation was made of what this height might have been had there been no tooth wear (Hrdlicka 1952:143; Bass 1971:67).	SC
11.	External alveolar length The anterior-posterior diameter, in the midline, from alveolar point to the midpoint of a line connecting the posterior limits of the arch was measured. A wooden rod was used to mark the posterior limit of the arch (Bass 1971:70; Hrdlicka 1952:146).	HC or SC
12.	External alveolar breadth The maximum breadth of the greatest bulge of the process above the molar teeth--usually opposite the second molars--was measured (Bass 1971:70; Hrdlicka 1952:147).	SC

TABLE 4 (continued)

	Measurement	Instrument
13.	Nasal height The height from nasion to midpoint of line connecting lowest parts of the borders of the 2 nasal notches was measured (Bass 1971:68; Hrdlicka 1952:146).	SC
14.	Nasal breadth The maximum breadth of the nasal aperature taken inferior to the inferior nasal concha was measured (Bass 1971:68; Hrdlicka 1952:146).	SC
15.	Left orbital height The maximum height from the upper to the lower orbital borders perpendicular to the horizontal axis of the orbit with the middle of the inferior border as a fixed point was measured (Bass 1971:69; Hrdlicka 1952:145).	SC
16.	Left orbital breadth The distance from maxillofrontale to ectoconchion was measured. This is the maximum distance of the orbit from maxillofrontale to the middle of the lateral orbital border (Bass 1971:69; Hrdlicka 1952:145). Maxillofrontale was located by extending the medial edge of the eye orbit with a pencil line until the line crossed the fronto-maxillary suture.	SC
17.	Biorbital breadth The measurement was between the two ectoconchion (Morant 1927:418).	SC
18.	Basion-porion height The ends of the sliding caliper were placed on the right and left porion. The coordinate attachment was moved until it was over basion, and basion-porion height was read from the calibrated bar when the tip of bar was placed on basion (Bass 1971:66).	CC

TABLE 4 (continued)

	Measurement	Instrument
19.	Nasal root height The two ends of the caliper were placed on right and left ectoconchion. The coordinate attachment was moved until it was over nasion, and the height was read from the calibrated bar (Snow 1948:383).	CC
20.	Minimum nasal breadth The minimum breadth across nasal bones was measured (Morant 1927:418).	SC
21.	Auricular height The two horizontal pieces of the head spanner were placed in the ear openings (porion). The attachment was placed on the left orbitale. Auricular height was read directly when the calibrated bar was placed at the apex (Bass 1971:67).	WRHS
22.	Porion-nasion The two horizontal pieces were placed in the ear openings at porion. The calibrated bar was placed at nasion and the reading taken (Snodgrasse 1951:448).	WRHS
23.	Porion-subnasale The two horizontal pieces were placed in the ear openings at porion. The calibrated bar was placed at subnasale and the reading taken (Snodgrasse 1951:448).	WRHS
24.	Porion-prosthion The two horizontal pieces were placed in the ear openings at porion. The calibrated bar was placed at prosthion and the reading taken (Snodgrasse 1951:448).	WRHS

TABLE 4 (continued)

	Measurement	Instrument
25.	Porion-gnathion The two horizontal pieces were placed in the ear openings at porion. The calibrated bar was placed at gnathion and the reading taken (Snodgrasse 1951:448).	WRHS
26.	Symphysis height The height in the midline from lowest point (gnathion) to the tip of bone between lower central incisors (infradentale) was measured (Bass 1971:72).	SC
27.	Diameter bigonial The distance from gonion to gonion was measured. This was the maximum distance between the external surfaces of the gonial angles (Bass 1971:72).	SC
28.	Diameter Bicondylar The maximum distance between the lateral surfaces of the condyles was measured (Bass 1971:72).	SC
29.	Height ascending ramus The distance from gonion to the uppermost part of the condyle was measured (Bass 1971:72).	SC
30.	Corpal length-gonion to gnathion The distance from gonion to gnathion was measured (Wilder 1920:55).	SC

Indices (Bass 1964:81)

1. Cranial index $\frac{\text{max. breadth} \times 100}{\text{max. length}}$

2. Cranial module $\frac{\text{length} + \text{breadth} + \text{height}}{3}$

TABLE 4 (continued)

	Measurement	Instrument
	Indices (Bass 1964:81) (Continued)	
3.	Mean height index	$\frac{\text{ba. - br. x 100}}{\text{mean of length + breadth}}$
4.	Length height index	$\frac{\text{ba. - br. x 100}}{\text{maximum length}}$
5.	Breadth height index	$\frac{\text{ba. - br. x 100}}{\text{breadth}}$
6.	Fronto-parietal index	$\frac{\text{min. frontal br. x 100}}{\text{breadth}}$
7.	Upper facial index	$\frac{\text{nasion-alv. point x 100}}{\text{bizygomatic br.}}$
8.	Total facial index	$\frac{\text{nasion-gnathion x 100}}{\text{bizygomatic br.}}$
9.	Nasal index	$\frac{\text{nasal breadth x 100}}{\text{nasal height}}$
10.	Orbital index	$\frac{\text{orbital height x 100}}{\text{orbital breadth}}$
11.	Maxillo-alveolar index	$\frac{\text{ext. alv. br. x 100}}{\text{ext. alv. length}}$
12.	Flatness cranial base index	$\frac{\text{basion-porion ht. x 100}}{\text{ba. - br.}}$

taking each measurement is cited. Cranial indices (Bass 1964) were calculated and are also described in Table 4. Postcranial measurements and indices are described in Table 5.

Metric analysis of the crania used in this study was considerably complicated by the Caddoan practice of intentional cranial deformation. During the initial analysis of the skeletal material visual observation of the amount of deformation noted was recorded into one of three categories: (a) none or slight, (b) moderate, or (c) extreme. However, it was felt by the author that it would be desirable to somehow quantify these visual observations.

Therefore, two ratios were devised to help ascertain how much the frontal and occipital bones were deformed. These were called the Frontal Deformation Ratio (FDR) and the Occipital Deformation Ratio (ODR). The measurements from which the ratios were calculated were taken with the GPM Standard Coordinate Caliper. The two measurements used to compute the Frontal Deformation Ratio were given the names Nasion-bregma chord (frontal chord) and Nasion-bregma subtense (frontal subtense) by Howells (1973). The measurements are described as follows:

1. Nasion-bregma chord (frontal chord)

The frontal chord is the direct distance from nasion to bregma taken in the midplane and at the external surface. Care was taken not to permit the points of the caliper to rest in any possible depressions occurring in the suture lines. If necessary, the caliper point was displaced slightly to obtain a more accurate reading (Howells 1973:181).

TABLE 5

POST CRANIAL MEASUREMENTS AND INDICES

Measurement	Instrument
1. Humerus	
a. Maximum length Head was placed against the fixed vertical of the board. The movable upright was adjusted to the distal end. The bone was moved slightly up and down and from side to side to obtain the maximum length (Bass 1971:114).	OB
b. Maximum diameter mid-shaft The midpoint of the shaft was located on the osteometric board and marked with a pencil. Measurement was in anterio-medial direction (Bass 1971:114).	SC
c. Minimum diameter mid-shaft The measurement was taken at right angle to the previous measurement (Bass 1971:115).	SC
d. Circumference The girth in the middle of the shaft was measured (Singh and Bhasin 1968:107).	MT
e. Maximum diameter of the head The measurement was taken from a point on the edge of the articular surface of the bone across to the opposite side (Bass 1971:115).	SC
f. Humero-femoral index $\frac{\text{length of humerus} \times 100}{\text{length of femur}}$ (Wilder 1920:146).	

TABLE 5 (continued)

Measurement	Instrument
2. Clavicle	
a. Maximum length	OB
One end of the bone was placed against the stationary end of the board and the movable end of the board was brought into contact with the opposite end (Bass 1971:103).	
b. Claviculo-humeral index (both bones must be from the same side)	
$\frac{\text{maximum length of clavicle} \times 100}{\text{maximum length of humerus}}$ (Bass 1971:103).	
3. Femur	
a. Maximum length	OB
The distal condyles were placed against the fixed vertical of the board and the moveable upright was placed against the head. The bone was raised slightly and moved up and down as well as from side to side until maximum length was obtained (Bass 1971:168).	
b. Physiological length	OB
Both condyles were placed against the fixed upright of the board and with the bone lying on the board the moveable end was applied to the head (Bass 1971:168).	
c. Anterior-posterior diameter mid-shaft	SC
The midpoint of shaft was marked with a pencil. The anterior-posterior diameter was measured (Bass 1971:168).	
d. Transverse diameter mid-shaft	SC
The measurement was taken at right angles to the previous measurement (Bass 1971:168).	

TABLE 5 (continued)

Measurement		Instrument
3.	Femur (continued)	
	e. Circumference	MT
	The measurement was taken at the middle of the shaft (Bass 1971:168).	
	f. Maximum diameter of head	SC
	The periphery of the articular surface of the head was measured (Bass 1971:168).	
	g. Pilastric index	
	$\frac{100 \times \text{anterior-posterior diameter}}{\text{transverse diameter}}$	
	(Oliver 1969:263).	
	h. Robusticity index	
	$\frac{\text{anterior-posterior + medio-lateral diameter of mid-shaft} \times 100}{\text{physiological length}}$	
	(Bass 1971:170).	
4.	Tibia	
	a. Maximum morphological length	OB
	The end of the malleolus was placed against the vertical wall of osteometric board. The bone was resting on its dorsal surface with its long axis parallel to the long axis of the board. The block was applied to the most prominent part of the lateral half of the lateral condyle (Bass 1971:187; Trotter and Gleser 1952:473).	
	b. Anterior-posterior diameter nutrient foramen	SC
	The maximum anterior-posterior diameter of shaft at the level of the nutrient foramen was measured (Bass 1971:187).	

TABLE 5 (continued)

Measurement	Instrument
4. Tibia (continued)	
c. Transverse diameter nutrient foramen	SC
The maximum diameter at right angles to the previous measurement was taken (Bass 1971:187).	
d. Circumference mid-shaft	MT
The maximum diameter at mid-shaft was measured (Hrdlicka 1952:170).	
e. Tibio-femoral index	
$\frac{\text{length of tibia x 100}}{\text{length of femur}}$ (Wilder 1920:145).	
f. Platycnemic index	
$\frac{\text{transverse diameter nutrient foramina x 100}}{\text{anterior-posterior diameter nutrient foramina}}$ (Bass 1971:187).	
5. Radius	
a. Maximum length	OB
The maximum length from head to tip of styloid process was measured (Bass 1971:124).	
b. Humero-radial index	
$\frac{\text{maximum length of radius x 100}}{\text{maximum length of humerus}}$ (Bass 1971:115).	

TABLE 5 (continued)

Measurement	Instrument
6. Ulna	
a. Maximum length	OB
The maximum length from the top of the olecranon to the tip of the styloid process was measured (Bass 1971:130).	
7. Scapula	
a. Maximum height	SC
The maximum straight line distance from the superior to the inferior border was measured (Bass 1971:94).	
b. Maximum breadth	SC
The measurement was taken from the middle of the dorsal border of the glenoid fossa to the end of the spinal axis on the vertebral border (Bass 1971:95).	
c. Scapula index	
$\frac{\text{maximum breadth} \times 100}{\text{maximum length}}$ (Bass 1971:95).	
8. Innominate	
a. Ischial tuberosity-iliac crest	OB
The ischial tuberosity was placed against the fixed vertical of the board and the moveable upright was placed against the iliac crest (Bass 1971:153).	
b. Maximum breadth (ASP-PSP)	OB
The distance between the anterior-superior iliac spine and the posterior-superior iliac spine was measured (Bass 1971:153).	

TABLE 5 (continued)

Measurement	Instrument
9. Sacrum	
a. Maximum length	SC
The distance from the middle of the sacral promontory to the middle of the anterior-inferior border of the last sacral vertebra was measured. Only sacra with 5 segments were used for comparative purposes (Bass 1971:88).	
b. Maximum breadth	SC
The greatest distance between the wings of the first sacral vertebra was measured (Bass 1971:88).	
10. Fibula	
a. Maximum length	OB
The maximum distance between the proximal and distal extremities was measured (Bass 1971: 187).	

2. Nasion-bregma subtense (frontal subtense)

The frontal subtense is the maximum reading taken from the coordinate arm of the GMP standard coordinate caliper when the points of the caliper are placed on nasion and bregma. The measurement was taken with the caliper in the midline position for the nasion-bregma chord. The coordinate arm was positioned at the highest point along the curve of the frontal bone in the sagittal plane (Howells 1973:181).

These two measurements formed the Frontal Deformation Ratio:

$$FDR = \frac{\text{Nasion-bregma subtense}}{\text{Nasion-bregma chord}} \times 100$$

Howells (1978) used what is called the FRI (Frontal Index) to determine the amount of frontal flattening occurring in populations world wide. Although the FDR and FRI are identical, the author was not aware that the FRI was a standard cranial index until it was too late to make the appropriate changes in this manuscript.

The measurements used to compute the Occipital Deformation Ratio are similar to Howells' (1973:182) Lambda-opisthion chord (Occipital chord) and Lambda-opisthion subtense (Occipital subtense). However, they differ in two respects. First, Howells used opisthion in his measurement; basion (the anterior border of the foramen magnum) was used in this study. Second, many of the skulls used in this study have very complicated lambdoidal suture lines often interlaced with numerous wormian bones. (Bennett [1965] and Dorsey [1897] also noted that wormian bones occurred in high frequency in artificially deformed skulls, and they suggested that they are probably the result of stress.) It was often very difficult to determine from which point the occipital bone should be measured. Therefore, Howells' (1973) measurement from lambda was not used. Rather, the circumferential distance in the sagittal plane from bregma to basion through lambda was measured using the Metric Tape, and the point halfway between these two landmarks was marked on the skull. This was taken as the uppermost boundary of the occipital bone irrespective of the suture line and/or wormian bones. On those skulls with uncomplicated suture lines the point marked was usually within a few millimeters of lambda. One end of the Coordinate Caliper was placed at this point; the other point was placed at basion. The coordinate arm of the instrument was positioned to obtain the maximum reading at the highest point rather than the reading obtained at the midpoint. The Occipital Deformation Ratio (ODR) was obtained by dividing the coordinate arm reading by the chord length and multiplying by 100.

Statistical Methods: Metrical Data

For later statistical comparisons both the male and female skulls were grouped according to deformation similarities based on the two deformation ratios defined above. Sneath and Sokal (1973) discussed several clustering methods that would have been appropriate for this procedure; however, the Fuzzy Isodata algorithm developed by Dunn (1974) and Bezdek (1973) was chosen for two reasons. First, a Tektronix 4051 computer belonging to the Mathematics Department, Utah State University, Logan, Utah, was available and already programmed for this algorithm. In addition, one of the co-developers of the program, J. C. Bezdek, was available for consultation.

A second reason for using this clustering method was that it uses "fuzzy" membership functions rather than assigning a skull a "0" for "not belonging" and a "1" for "belonging" to a given cluster. The advantage of this is simply that it helps identify the fringe elements of the cluster for closer scrutiny. Although these fuzzy-strength-of-membership numbers were not used in this study it was hoped that they would prove useful later when statistical tests are available which take them into account. The algorithm allows the user to specify the number of clusters desired and uses an iterative procedure to arrive at cluster centers and membership functions based upon Euclidean distances. The details together with an application to botanical data have been published by Bezdek (1974).

Using the two deformation ratios as variables, the skulls were initially clustered into two, three, four, and five groups for each sex, but with the higher number of clusters there were some groups which contained as few as two skulls. The three cluster grouping proved compatible with the visual classification of "slight," "moderate," and "extreme" deformation. Nevertheless, small cluster sizes made it necessary to base further statistical analyses upon the two cluster arrangement hereafter called "moderate" and "extreme."

With two such clusters for each sex, a t-test was used to help decide which cranial mean measurements varied significantly between the two groups. This analysis gave useful information which helped in deciding which craniofacial measurements were affected by deformation. The cluster means and the t-test were carried out on the Burroughs B6700 computer at Utah State University, Logan, Utah. The results are summarized in Table 25 of Chapter 6.

To further test for measurements affected by deformation a Pearson Correlation Coefficient (Nie et al. 1975) was calculated between each cranial measurement and the two deformation ratios. This correlation test was independent of the cluster analysis; that is, the clusters were not factors used in this procedure. Those cranial variables which correlated highly with the deformation ratios were suspected of being affected by deformation. Table 26 of Chapter 6 contains these correlation coefficients.

The third test which was used to determine which measurements were affected by deformation was Multiple Linear Regression (Nie et al. 1975) of each of the 15 measurements on the independent variables FDR and ODR. This test provided an estimate of the percent of variation in a craniofacial measurement that was due to the two deformation ratios. The regression program printed this approximate percentage as R^2 and also provided an F value which allowed a test for the significance of R^2; the results of this program are shown in Table 27 in Chapter 6.

A number of multivariate tests have been applied to anthropological data in order to quantify the morphological divergence among groups. These include Pearson's Coefficient of Racial Likeness (Pearson 1926), Penrose's Size and Shape statistic (C_H^2) (Penrose 1954), and Mahalanobis's D^2 (Mahalanobis 1936). Hiernaux (1964) demonstrated that there is close agreement in the results obtained in using D^2 and Penrose's Size and Shape; both methods have advantages in certain situations. In this study Penrose's Size and Shape statistic (Penrose 1954) was used because it requires only sample means and standard deviations. This allowed comparison among groups for which the raw measurements were unavailable.

In order to calculate the Penrose statistic, common standard deviations for each character had to be determined; the mean measurements were then expressed in terms of these standard deviation units (Penrose 1954:337). Ideally these common standard deviations would be calculated for each character over an extensive collection of crania related to those in this study. Practically, however, these deviations had to be estimated. The common standard deviations used for seven measurements in this study are presented in Table 28 of Chapter 6. These were calculated as the weighted averages of the sample variances from two samples--the Arikara and the Kaufman-Williams site--using the formula found in Nie et al. (1975:269).

The Size and Shape coefficient was derived from Pearson's earlier Coefficient of Racial Likeness (Pearson 1926) by Penrose (1954) who called it C_H^2. He broke it into two parts called the size and shape components although there is evidence that the shape component is not as good a measure of similarity in proportions as the name might imply (Sneath and Sokal 1973).

The close agreement in results using D^2 and the Penrose Size and Shape Coefficient can be demonstrated if a hypothetical intercorrelation value R is assumed between all pairs of the involved characters (Penrose 1954). The formulas for calculating the Penrose Size and Shape statistic using this hypothetical constant R are found in Rahman (1962). The average value of 0.233 for R recommended by Penrose (1954) was used in this study. All calculations of the Penrose Size and Shape coefficient were done on the Burroughs B6700 computer located at Utah State University, Logan, Utah.

Howells (1973) stressed the importance of making the correct choice of variables to be used in any distance test. Preferably, they are measurements which reflect biological diversity in both size and shape, and they should not be highly correlated (Rightmire 1969). The number of variables chosen is also important. Van Vark (1970) demonstrated that too large a number of variables will give deceptively neat discrimination among groups.

The choice of variables to be used in this study was complicated by two factors. The first of these was the presence of cranial deformation, which has been discussed in detail already, and the second factor involved the nature of the data available from the populations selected for comparative purposes. Fifteen standard cranial measurements were available for both the Saint Helena and Arikara groups. These measurements which formed the core of those selected for comparison are listed below:

1. Maximum length
2. Maximum breadth
3. Basion-bregma height

4. Endobasion-nasion
5. Endobasion-alveolar point
6. Minimum frontal breadth
7. Bizygomatic breadth
8. Nasion-alveolar point
9. External alveolar length
10. External alveolar breadth
11. Nasal height
12. Nasal breadth
13. Biorbital breadth
14. Basion-porion height
15. Auricular height

Of these, nasal breadth, basion-porion height, and auricular height had to be discarded because they were missing from either the Maples (1962) or Westbury (1978) studies. A further shortening of this list resulted from the deformation analyses discussed previously, the results of which are presented in Chapter 6. The following measurements were discarded on the basis of these tests:

1. Maximum length
2. Maximum breadth
3. Bizygomatic breadth
4. External alveolar breadth
5. Nasal height

Thus, of the fifteen measurements considered, the following were retained for the Penrose distance calculation:

1. Basion-bregma height
2. Endobasion-nasion
3. Endobasion-alveolar point
4. Minimum frontal breadth
5. Nasion-alveolar point
6. External alveolar length
7. Biorbital breadth

In order to better visualize and compare the distance calculations, the Penrose Size and Shape matrices were channeled into a Principal-Coordinates program developed from Gower (1972) and received from Dr. Richard L. Jantz, University of Tennessee, Knoxville, Tennessee. The object of principal coordinates analysis is to reduce the number of variables by representing the intergroup distances on orthogonal axes. Again, the computer facilities at Utah State University provided the calculations.

Non-metrical Data

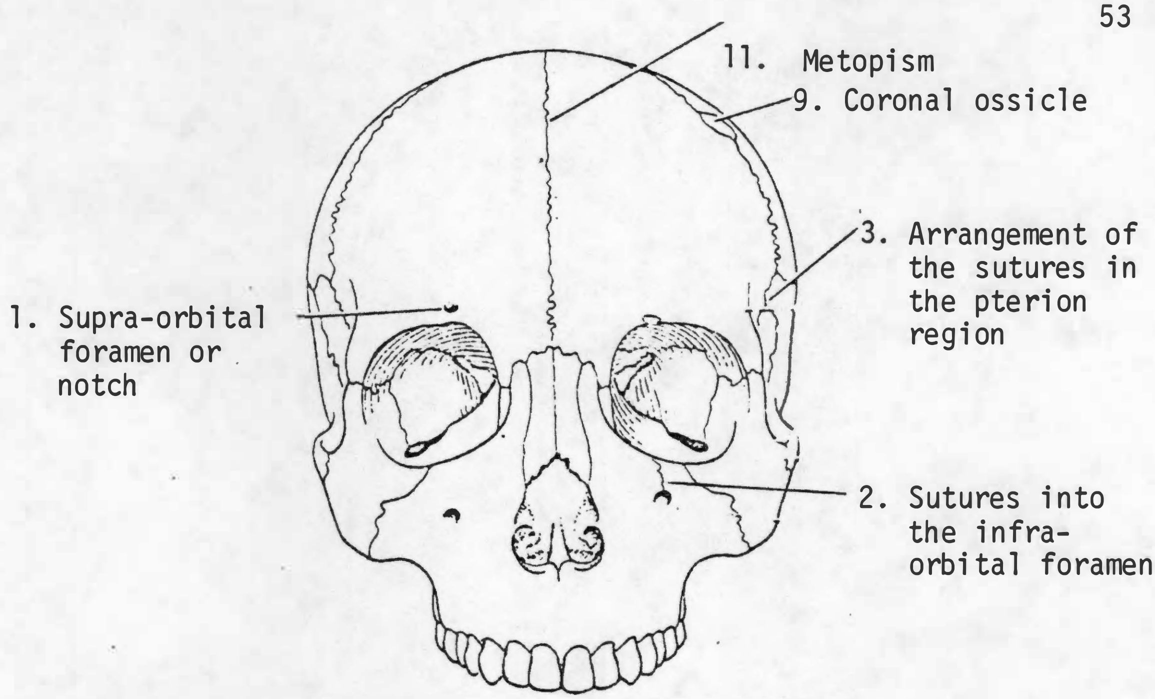
Initial interest in non-metrical or discrete traits began nearly 150 years ago; recently there has been a resurgence in the use of non-metric variants in assessing the affinities between groups (Berry and Berry 1967; Berry 1968). Ossenberg (1974, 1976, 1977) has illustrated the importance of using discrete traits to ascertain the biological distance between past human populations. However, Carpenter (1976) working with known material, found that non-metric traits considered by themselves have very little discriminatory value as predictors of race and sex. He stated that they are useful primarily as age indicators and as a supplement to metric measurements. Trinkhaus (1978) showed that bilateral asymmetry is common in non-metric traits; he suggested that environmental factors are important in determining trait frequency.

Cheverud et al. (1979) hypothesized that the underlying scale which determines the presence or absence of a cranial non-metric trait is an expression of general and/or local size variation in the cranium. Thus, metric and non-metric traits share a common developmental determination. Similarly, Corruccini (1976) found an association between non-metric and metric characters. Consequently, he felt that both traits should be used whenever possible in population studies. Green et al. (1979) have considered the statistical procedures used in analysis of non-metric traits.

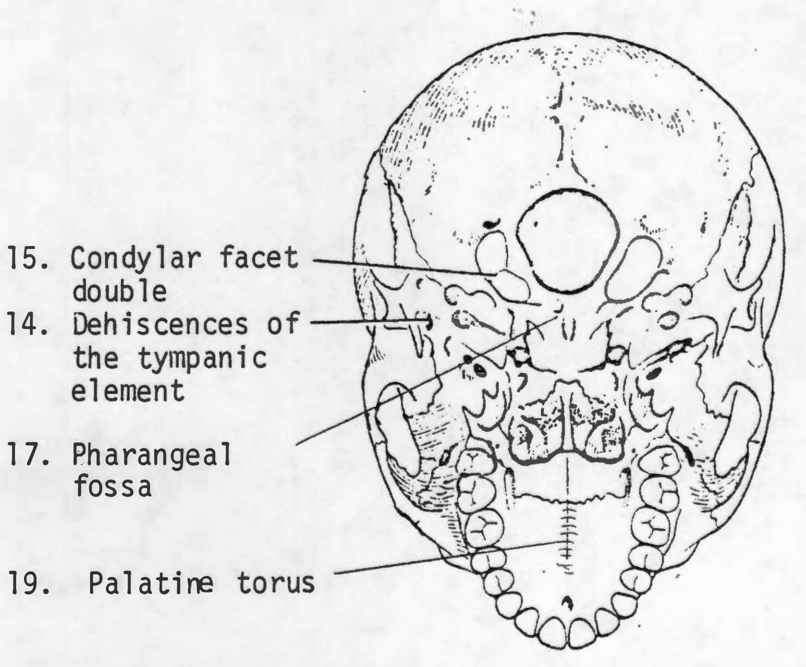
Twenty-two non-metric traits on the cranium and mandible were observed and recorded. All were scored as either present or absent. Originally, a few other traits were observed (i.e. Sub-orbital fossa [Hrdlicka 1909:203], Infra-maxillary notch [Bass 1964:81]); however, these were abandoned because of the subjectivity involved in such judgments as "absent," "shallow," "medium," or "deep." Each of the variants observed is described below. Figure 3 depicts all of the observations which were made; numbers in the figure correspond to the written description. Table 6 shows the data sheet used to record these traits.

1. Supra-orbital foramen or notch (Wood-Jones 1931:186; DeVilliers 1968:122-123; Anderson 1962:112).

This is a notch or foramen occurring on the superior, medial



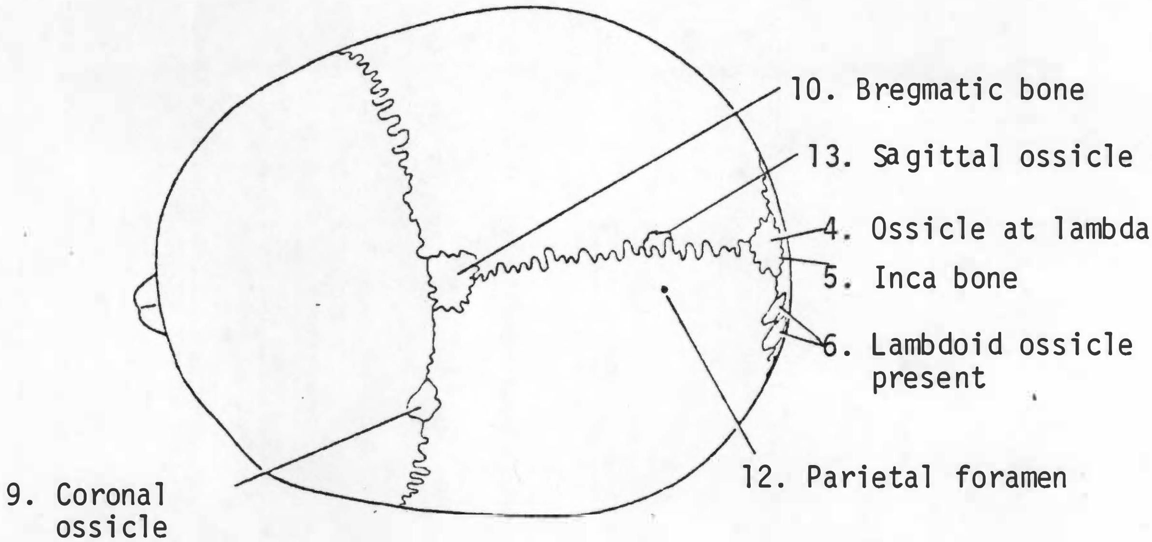
A. Facial aspect of the skull



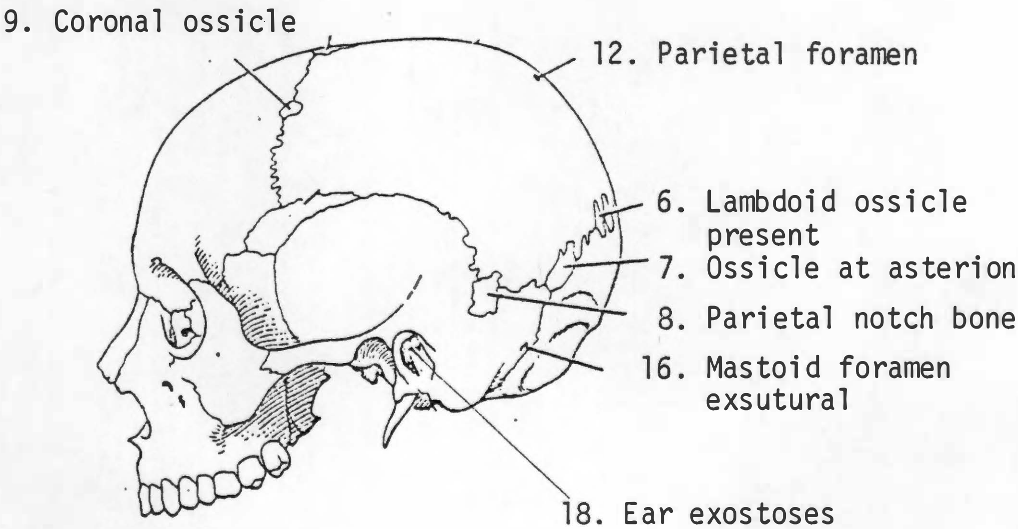
B. The skull viewed from below

Figure 3. Illustration of Non-metrical Traits Used in This Study

Source: Adapted from Berry and Berry (1967:365-367) and Jantz (1970:32)

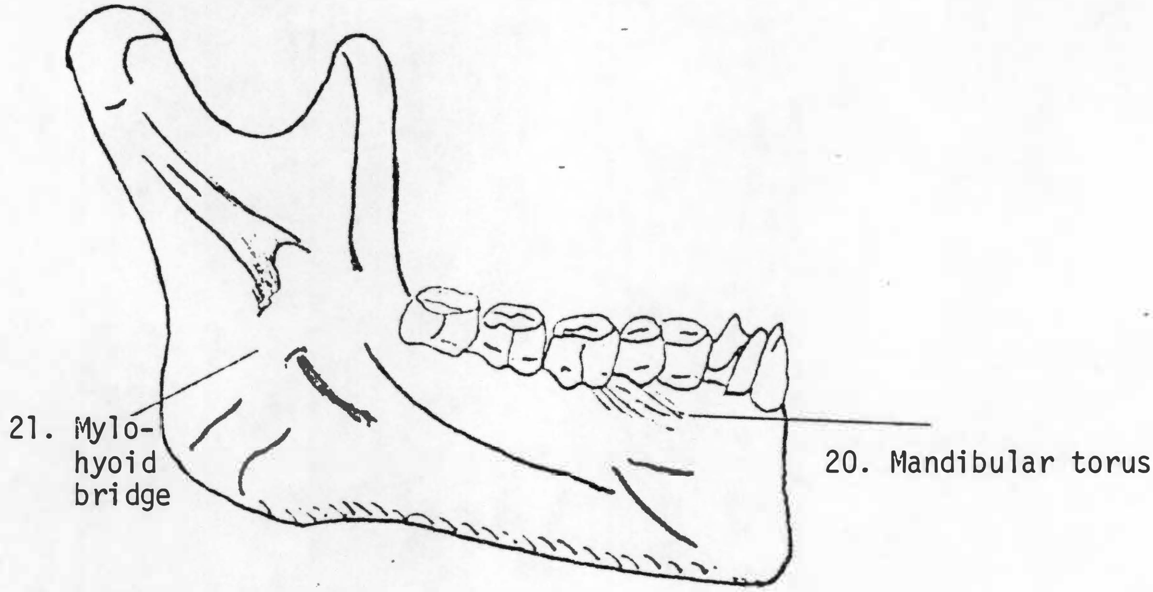


C. The skull viewed from above

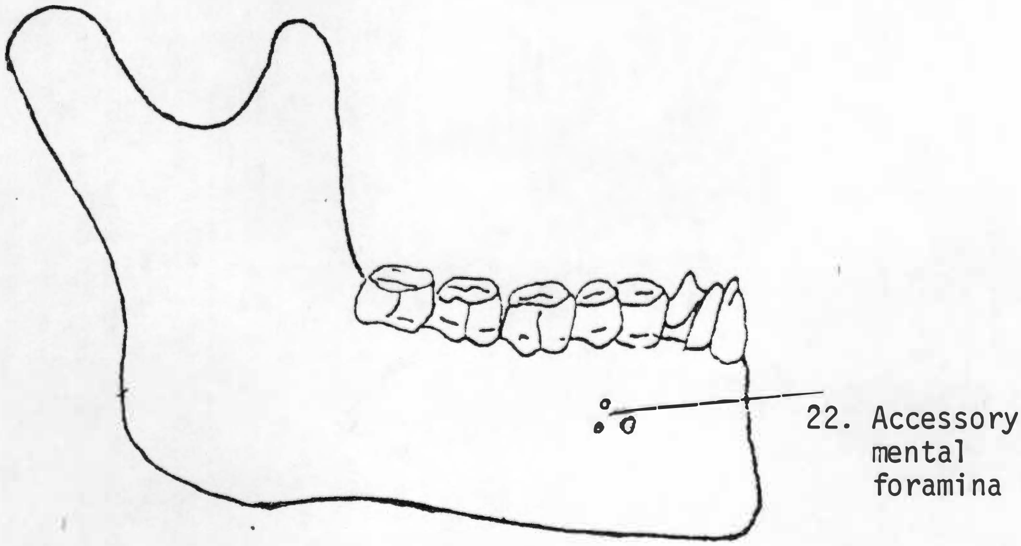


D. Left lateral aspect of the skull

Figure 3. (Continued)



E. Interior aspect of left mandible



F. Exterior aspect of right mandible

Figure 3. (Continued)

TABLE 6

DATA SHEET USED TO RECORD NON-METRIC TRAITS

Trait Observed	Present R	Present L	Absent R	Absent L
1. Supra-orbital foramen or notch				
2. Sutures into infra-orbital foramen				
3. Arrangement of sutures in pterion region				
wide H				
narrow H				
K				
X				
epiteric bone				
fronto-temporal articulation				
4. Ossicle at lambda				
5. Inca bone				
6. Lambdoid ossicle present				
7. Ossicle at asterion				
8. Parietal notch bone				
9. Coronal ossicle				
10. Bregmatic bone				
11. Metopism				
12. Parietal foramen				
13. Sagittal ossicle				
14. Dehiscences of tympanic element				
15. Condylar facet double				
16. Mastoid foramen exsutured				
17. Pharangeal fossa				
18. Ear exostoses				
19. Palatine torus				
20. Mandibular torus				
21. Mylohyoid bridge				
22. Accessary mental foramina				

aspect of the eye orbit which transmits the supraorbital nerve, vein and artery.

2. Sutures into the infraorbital foramen (Wood-Jones 1931:186; Ossenberg 1970:361).

These are sutures which extend into the infraorbital foramen from the rim of the eye orbit.

3. Arrangement of the sutures in the pterion region (DeVilliers 1968:85).

The arrangement of the suture lines between the parietal, sphenoid, temporal, and frontal bones is shown in Figure 4.

4. Ossicle at lambda (Berry and Berry 1967:365).

This is a bone which occurs at the junction of the sagittal and lambdoid sutures. An ossicle at lambda occurs in the occipital fontanel and is usually smaller than an Inca bone.

5. Inca bone (interparietal bone) (Jantz 1970:27).

The portion of the occipital bone which ossifies in membrane may persist as a separate bone.

6. Lambdoid ossicle present (Berry and Berry 1967:366).

Ossicles may occur in the lambdoid suture. As many as twelve distinct bones may be present on either side.

7. Ossicle at asterion (Berry and Berry 1967:368; Jantz 1970:25).

A separate suture bone may occur at the junction of the parietal and occipital bones with the mastoid portion of the temporal bone.

8. Parietal notch bone (Berry and Berry 1967:368).

The parietal notch is that portion of the parietal bone that

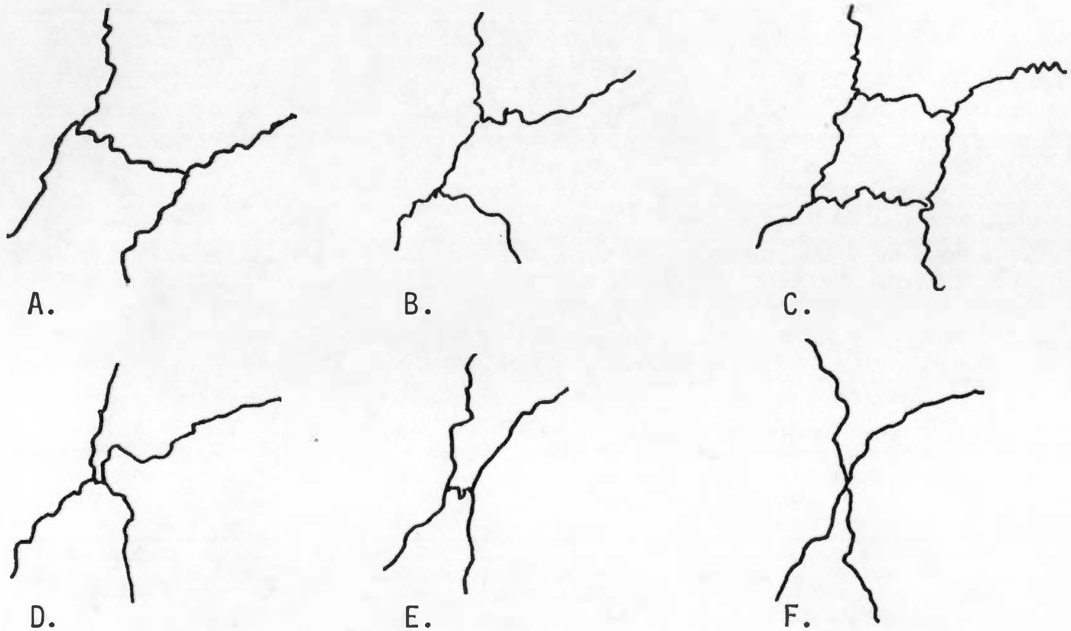


Figure 4. Arrangement of Sutures in the Pterion Region

The suture arrangement may be: (A) wide H, (B) frontotemporal articulation, (C) epiteric bone, (D) K, (E) narrow H, or (F) X.

Source: Adapted from DeVilliers (1968:Figure 5, opposite page 94).

protrudes between the squamous and mastoid portions of the temporal bone. A separate ossicle formed at that point is a parietal notch bone.

9. Coronal ossicle (Berry and Berry 1967:367).

This is an ossicle formed in the coronal suture.

10. Bregmatic bone (Berry and Berry 1967:367).

A sutural bone may occur at the sagittal-coronal suture junction (the position of the anterior fontanelle).

11. Metopism (Berry and Berry 1967:367; DeVilliers 1968:82-84).

The medio-frontal suture disappears within the first two years of life. If the condition persists throughout life, it is known as metopism.

12. Parietal foramen (Berry and Berry 1967:367; DeVilliers 1968:103-104).

This foramen pierces the parietal bone near the sagittal suture a few centimeters in front of lambda. It transmits a small emissary vein and occasionally a small branch of the occipital artery.

13. Sagittal ossicle (Jantz 1970:27).

A separate bone may occur in the sagittal suture.

14. Dehiscences of the tympanic element of the temporal bone (Foramen of Huschke) (Berry and Berry 1967:368; DeVilliers 1968:109).

This foramen occurs in the floor of the external auditory meatus. It is always present in young children, but usually it disappears by the fifth year.

15. Condylar facet double (Berry and Berry 1967:368).

The articular surface of the occipital condyle is sometimes divided into two distinct facets.

16. Mastoid foramen exsutural (Berry and Berry 1967:368).

The mastoid foramen, when present, usually lies in the suture between the mastoid part of the temporal bone and the occipital bone. If it occurs exsuturally, it most commonly is found on the mastoid part of the temporal bone.

17. Pharangeal fossa (Sullivan 1925:224-228).

A depression may occur on the basilar portion of the occipital bone.

18. Ear exostoses (Hrdlicka 1935:1-100; Gregg and McGrew 1970:37-40).

A bony ridge or torus may occur in the external auditory meatus.

19. Palatine torus (Jantz 1970:27).

A bony ridge may run along the midline of the hard palate.

20. Mandibular torus (Jantz 1970:29).

Tori may occur on the internal aspect of the mandible.

21. Mylohyoid bridge (Ossenberg 1970:363).

A bony bridge may occur over the mylohyoid groove on the internal aspects of the ascending ramus.

22. Accessory mental foramina (Jantz 1970:27).

In addition to the primary foramen, one or several accessory foramina may occur.

Statistical Methods: Non-metrical Data

The discrete trait analysis in this study was directed toward determining the effect of deformation on the occurrence of these traits. Therefore, the same two deformation classes (moderate and extreme) used in the metric analysis were used. Sex and bilateral differences were also analyzed; however, no comparisons were made with the comparative populations used in the metrical analysis because non-metrical data was generally unavailable for these groups. A chi-square test was used to determine whether any of the differences noted were statistically significant.

CHAPTER 4

DESCRIPTIVE ANALYSIS

This chapter deals with those aspects of the biological analysis which are basically descriptive in nature rather than analytical. Three major topics are discussed: (a) description of the burials, (b) pathologies, and (c) burial customs (burial position and grave goods).

Description of the Burials

Seventy-five burials were recovered during the Kaufman-Williams excavations. There were 26 males, 28 females, and 21 subadults. Table 7 provides a brief description of the burials.

Paleodemography

Demographic reconstruction of a past human population provides an indication of how well that population was adapted to its cultural and physical environment. The reliability of such a reconstruction depends upon two factors: (a) the accuracy of the estimates of sex and age of the skeletons in the sample and (b) the degree to which the sample reflects the total population. The second factor actually provides the greatest potential for error in demographic reconstruction. Sources of error include: (a) differential disposal of the dead which resulted in some categories of subadults or adults not being adequately represented in the sample, (b) inadequate archaeological sampling of a cemetery, and

TABLE 7

DESCRIPTION OF THE BURIALS FROM THE KAUFMAN-WILLIAMS SITE

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
1	M	30-35	Moderate	Severe	Arthritic lipping Button osteoma right frontal	Good
2	M	35-40	Moderate	Severe	Cribra orbitalia in both eye orbits Possible sprain on right tibia and fibula distal end	Good
3	F	30-35	Moderate	Moderate	Cervical vertebrae 3 and 4 fused	Good
4	M	18-21	Slight	Slight		Good
5	M	35-40	Left side of skull more deformed than right	Moderate, maxillary 3rd molars peg shape	Temporo-mandibular joint disease Arthritic lipping	Good
6	M	18-20	Moderate	Slight		Good
7	M	30-35	Extreme	Moderate		Good
8	F	45-50	Extreme	Severe	Arthritic lipping	Good

TABLE 7 (continued)

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
9	M	17-20		Slight	Maxillary sinuses showed evidence of infection and periosteal reaction	Skull badly warped post-mortem
10	F	40-45	Moderate	Moderate		Good
11	M	20-25	Moderate	Slight	Congenital hip dislocation on the right side	Good
12	SA	2-3				Fragmentary, Burial included remains of dog
13	F	35-40	Slight	Severe		Fragmentary, Weathered
14	M	25-30	Moderate	Moderate	Healed fracture distal end left ulna	
15	F	45-50	Slight	Severe	Lytic lesion right side 2nd lumbar vertebra	Fragmentary

TABLE 7 (continued)

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
16	SA	15-17		Slight		Fair
17	M	25-30				Fragmentary
18	SA	8-10				Fragmentary
19	F	45-50	Extreme	Severe	Cervical vertebrae 2 and 3 fused Arthritic lipping	Good
20	M	35-40	Extreme	Severe	Pseudoarthrosis left ulna Button osteoma distal end right femur	Good
21	SA	12-17	Moderate		Button osteoma right frontal	Fragmentary
22	F	25-30	Extreme	Moderate		Fragmentary, Rodent gnawing
23	SA	7-8				Fragmentary
24	F	20-25	Moderate Binding marks on skull	Slight		Good

TABLE 7 (continued)

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
25	SA	4-6				Fair
26	M	45+	Extreme	Severe, All teeth except one lost ante-mortem	Severe degenerative arthritis Fusion lumbar 1 and 2	Fragmentary Weathered Rodent gnawing
27	SA	9-11	Moderate			Fair
28	M	30-35	Moderate	Severe		Good
29	SA	3-5				Fragmentary
30	M	30-35	Extreme	Moderate	Right mastoid larger than left Nonsuppurative osteomyelitis distal end right tibia Right 4th metatarsal 11 mm shorter than left Healed fractures on right frontal and parietal	Good
31a	F	19-21	Extreme	Moderate		Good, Face damaged during excavation

TABLE 7 (continued)

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
31b	SA					Good, New-born infant buried with 31a
32	F	45-50	Extreme	Severe	Arthritic lipping	Fair Weathered
33	SA	9-11				Fragmentary, Weathered, Rodent gnaw-ing, Skull badly warped post-mortem
34	SA	6-8				Fair
35	F	40-45	Extreme	Severe		Good
36	F	45-50	Moderate	Severe	Colle's fracture right radius Arthritic lipping Localized periostitis both tibiae	Good
37	SA	7-8	Extreme		Hydrocephaly	Good
38	SA	9-12	Moderate			Fair

TABLE 7 (continued)

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
39	F	17-20	Moderate			Good
40	F	35-40	Moderate	Severe	Arthritic lipping	Good
41a	F	19-21	Moderate	Moderate		Good
41b	SA					Good, New-born infant buried with 41a
42	F	40-45	Extreme	Severe	Localized periosteal reaction both tibiae	Good
43	F	50-55	Extreme	Severe	Arthritic lipping	Good
44	F	45-50	Moderate	Severe	Cribra orbitalia left orbit Abscess left maxilla with bone regeneration	Fair Weathered
45	M	30-35	Extreme	Moderate	Smerl's nodule with partially collapsed thoracic vertebra created sciolosis Healed nasal fracture	Good

TABLE 7 (continued)

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
46	M	17-20	Extreme	Slight Supernumary tooth in premolar area left maxilla	Cribra orbitalia left eye orbit	Good
47	M	25-30	Extreme	Slight		Good Rodent gnaw-ing
48	F	30-35	Extreme	Severe		Fair
49	SA	13-15			Osteochondritis dissecans both distal femora	Fair Weathered
50	F	20-25		Slight	Periosteal reaction left ulna and tibia	Fair Weathered
51	F	30-35	Slight	Moderate	Button osteoma left occipital Large parturition pits Healed nasal fracture	Good

TABLE 7 (continued)

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
52	M	20-25	Moderate	Moderate Lateral incisor right side peg shape Malocclusion of canine and premolars right side		Good
53	SA	12-17			Cribra orbitalia left orbit	Skull only
54	SA					Newborn infant, Good
55	SA					Newborn infant, Good
56	SA	1-2			Generalized periostitis in long bones	Fair
57	SA	2-3			Porotic hyperostosis	Good
58	M	30-35	Moderate	Slight	First cervical vertebra fused to skull	Good

TABLE 7 (continued)

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
59	M	40-45	Slight	Severe	Arthritic lipping	Good
60	M	30-35	Moderate	Moderate	Cervical vertebrae 2 and 3 fused Arthritic lipping	Good
61	M	30-35	Extreme	Moderate	Cribra orbitalia both eye orbits 16 mm oval perforation body of sternum Bony spur distal, lateral edge right calcaneous Arthritic lipping	Good
62	M	40-45	Extreme	Severe	Arthritic lipping Localized periostitis right proximal tibia	Fair Weathered
63	M	20-25	Slight	Slight Right central mandibular incisor congenitally missing		Fair Weathered Rodent gnaw-ing

TABLE 7 (continued)

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
64	F	50-55	Slight	Severe		Fragmentary Weathered
65	F	30-35		Moderate	Arthritic lipping	Fair Weathered
66	M	30-35	Extreme	Moderate	Small circular perforation body of sternum	Good
67	F	35-40	Extreme	Moderate	Large parturition pits	Good
68	F	20-25	Extreme	Slight		Fragmentary Rodent gnawing
69	SA	3-5			Cribra orbitalia both eye orbits Both maxillary sinuses showed evidence of infection and periosteal reaction	Good
70	M	30-35	Extreme	Moderate		Good
71	F	35-40	Moderate	Moderate	Partial neural arch defect S-5	Fair

TABLE 7 (continued)

Burial Number	Sex	Age	Deformation	Toothwear	Pathology	Condition of Burial
72	F	20-25	Extreme	Slight		Fragmentary Rodent gnawing
73	F	30-35	Extreme	Moderate		Fair Rodent gnawing

SA - Subadult

(c) selection of only well-preserved, complete skeletons to use for study (Ubelaker 1978).

In this study there were 21 subadults and 54 adults. Thus, the subadults constituted only 28% of the total sample. This percentage is low in comparison with other studies of American Indian groups (Bass et al. 1971; Owsley 1975; Ubelaker 1974). It is possible of course that the subadult mortality occurring at Kaufman-Williams was lower than in most other Amerindian groups; however, that seems an unlikely explanation. Instead the sample probably did not accurately represent the true mortality. Many of the Caddo buried their children under the floor of the house (rather than in the cemetery area) (Perino personal communication). Conversely, the major thrust of the excavations at Kaufman-Williams was in the cemetery areas. This probably resulted in the recovery of more adult skeletons in proportion to subadults than the actual deaths in the group would have reflected. Consequently, it seemed inappropriate to present an elaborate demographic reconstruction (including such things as a life table or the crude mortality rate) since the sample was probably biased, but Table 8 presents an age distribution of the skeletons recovered from the Kaufman-Williams site.

Even though the number of subadults in this sample was lower than in most Amerindian groups, there were still many deaths among that group, especially in those 0.0-4.9 years of age. After the high frequency of deaths in the first five years, there was a steady decline through adolescence. The highest death rate occurred for adult males between 30.0-34.9. The females had two periods of high

TABLE 8

AGE DISTRIBUTION OF INDIVIDUALS RECOVERED FROM THE KAUFMAN-WILLIAMS SITE

Age Interval	SA	%	M	%	F	%
0.0- 4.9	10	13.3				
5.0- 9.9	6	8.0				
10.0-14.9	4	5.3				
15.0-19.9	1	1.3	4	5.3	3	4.0
20.0-24.9			3	4.0	3	4.0
25.0-29.9			3	4.0	2	2.6
30.0-34.9			10	13.3	5	6.6
35.0-39.9			3	4.0	4	5.3
40.0-44.9			2	2.6	3	4.0
45.0-49.9			1	1.3	6	8.0
50.0-54.9					2	2.6

death rate--one between 30.0 and 34.9 years of age and the other between 45.0 and 49.9.

Paleopathology

Some disease processes leave tell-tale marks upon bone; however, most diseases do not affect the skeleton. Therefore, even though it is possible to make some inferences about the illnesses and health problems of prehistoric peoples, it is not possible to provide an accurate assessment of their true health status. Furthermore, different pathological conditions may affect bone in a similar way; thus, the problem is further complicated. Perhaps in any pathological analysis it is most important to recognize an abnormal condition; speculation about the causes of such conditions should generally be avoided (Ubelaker 1978).

Congenital and developmental defects. Among the most frequently encountered defects noted in the Kaufman-Williams sample were various congenital and developmental abnormalities. According to Morse (1978) the majority of such abnormalities are inconsequential and cause no disability.

The vertebral column in the Kaufman-Williams skeletons displayed a high incidence of these defects (see Table 9). Fusion of the cervical vertebrae was noted in three cases. In two individuals the fusion involved C-2 and 3; in one case C-3 and 4 were fused. In burial 58, the atlas was fused to the occipital bone; Morse (1978) stated that this is a rare occurrence. One female had a partial neural arch defect on the twelfth thoracic vertebrae, and both T-11 and 12 had abbreviated transverse processes.

The most common area in which vertebral column defects were found was in the lower lumbar and sacral region. Table 10 provides a compilation of the defects in this region by age and sex, and Figure 5A illustrates a separate neural arch defect in S1-5.

Various defects in the lumbar-sacral area have been studied by different researchers. Willis (1931), Stewart (1931, 1953, 1956,

TABLE 9

DEFECTS OF THE VERTEBRAL COLUMN
(EXCEPT ARTHRITIC LIPPING)

Burial Number	Sex	Age	Cervical	Thoracic	Lumbar	Sacrum 1	2	3	4	5
2	M	35-40								PNAD
3	F	30-35	3,4 fused	PNAD-12 11, 12 abbreviated transverse processes						
4	M	18-21			L5 NAD left side from pars inter-articularis to midline	PNAD	PNAD	PNAD	PNAD	ANA
6	M	18-20				PNAD		PNAD	PNAD	PNAD
8	F	45-50							PNAD	PNAD
9	M	17-20			Sacralization of L5 right side L5 NAD midline	ANA	ANA	ANA	ANA	ANA
10	F	40-45							PNAD	PNAD

TABLE 9 (continued)

Burial Number	Sex	Age	Cervical	Thoracic	Lumbar	Sacrum 1	Sacrum 2	Sacrum 3	Sacrum 4	Sacrum 5
11	M	20-25						PNAD	PNAD	PNAD
14	M	25-30								ANA
15	F	45-50			Lytic lesion right side L2 Sacralization L5 right side	ANA				
19	F	45-50	2,3 fused			Partial lumbarization of S1 PNAD				
24	F	20-25						PNAD	ANA	ANA
26	M	45+			L1-2 fused					
28	M	30-35						PNAD	ANA	ANA
32	F	45-50			Bilateral sacralization of L5					

TABLE 9 (continued)

Burial Number	Sex	Age	Cervical	Thoracic	Lumbar	Sacrum 1	2	3	4	5
36	F	45-50			L5 bilateral arch defect at pars inter-arctularis	ANA	PNAD		ANA	ANA
40	F	35-40			L5 fused to sacrum (not sacralized)*					
41	F	19-21							PNAD	PNAD
42	F	40-45			Sacraliza-tion of L5--right side				PNAD	ANA
43	F	50-55				PNAD			PNAD	PNAD
45	M	30-35		Smerl's nodule						
46	M	17-20				ANA	ANA			

TABLE 9 (continued)

Burial Number	Sex	Age	Cervical	Thoracic	Lumbar	Sacrum 1	2	3	4	5
47	M	25-30			L5 Neural arch defect bilaterally at pars interarticularis, Incomplete fusion S1 to sacrum				PNAD	PNAD
58	M	30-35	Atlas fused to occipital			ANA	PNAD			
60	M	30-35	2,3 fused						PNAD	PNAD
61	M	30-35				PNAD				
63	M	20-25						PNAD	PNAD	PNAD
66	M	30-35							PNAD	PNAD
67	F	35-40								PNAD

TABLE 9 (continued)

Burial Number	Sex	Age	Cervical	Thoracic	Lumbar	Sacrum 1	2	3	4	5
70	M	30-35				Incomplete fusion S1 to sacrum				PNAD
71	F	35-40								PNAD

PNAD - partial neural arch defect
ANA - absent neural arch
NAD - neural arch defect

*According to Lanier (1954:364), this is a pathological fusion since there was no tendency toward sacralization of the transverse processes.

TABLE 10

VERTEBRAL DEFECTS IN L5 AND THE SACRUM BY AGE AND SEX

Location	Defect	Sex Incidence Male #	%	Sex Incidence Female #	%	Age* by Sex Young	Old
L5	Complete or partial Sacralization	1/26	3.85	4/28	14.29	1M	4F
L5	Neural arch defect	3/26	11.54	1/28	3.57	2M	1F 1M
S1	Lumbarization of S1			1/28	3.57		1F
S1	Incomplete fusion of S1 to sacrum	1/26	3.85				1M
S1	Neural arch defect	6/26	23.08	4/28	14.29	4M	4F 2M
S2	Neural arch defect	4/26	15.38	1/28	3.57	3M	1F 1M
S3	Neural arch defect	6/26	23.08	1/28	3.57	5M 1F	1M
S4	Neural arch defect	9/26	34.62	7/28	25.00	5M 2F	4M 5F
S5	Neural arch defect	12/26	46.15	9/28	32.14	4M 2F	8M 7F

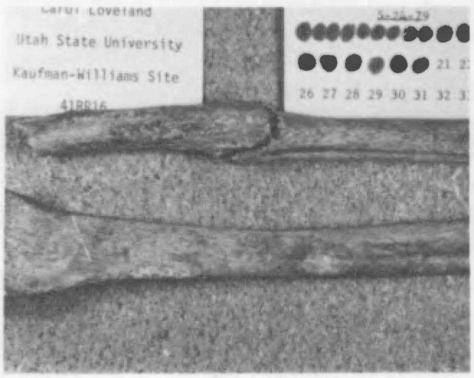
*Age division between old and young was taken as 25 years.

Figure 5. Representative Pathologies Noted in the Kaufman-Williams Burials.

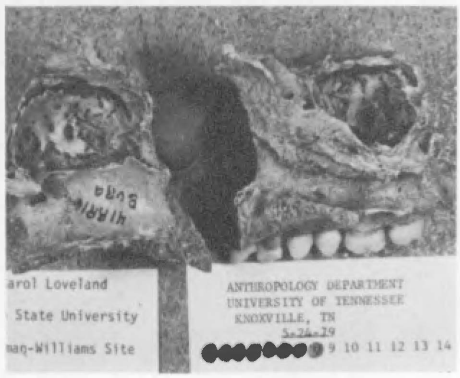
Among the pathologies found in the Kaufman-Williams burials were: (A) Separate Neural Arch Defect S1-5, (B) Congenital hip dislocation, (C) Pseudoarthrosis of the ulna, (D) Infected maxillary sinuses, (E) Osteochondritis dissecans, and (F) Porotic hyperostosis.

A

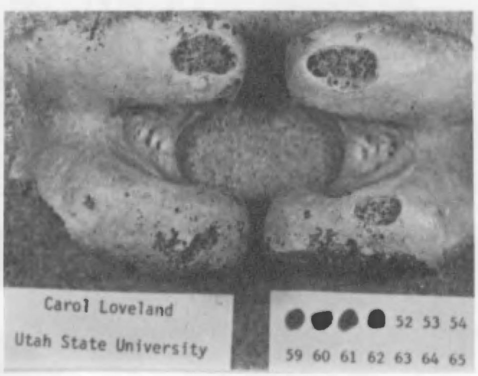
B



C



D



E

F

Figure 5

1969, 1979b), Lester and Shapiro (1968) and Roche and Rowe (1952) directed their attention to neural arch defects in the fifth lumbar vertebra. Stewart (1931) felt that a separate neural arch is a congenital anomaly. He attributed its high frequency among the Eskimo to the effects of inbreeding over a long period of time. However, he later noted (Stewart 1953) that the incidence of neural arch defects increased with age and, therefore, could not be congenital in nature. Instead he attributed the defect primarily to stress of a chronic nature which led to de-ossification and interarticular pseudofracture. He cited the awkward work position of females (in which they stand straight-legged and bent over in order to engage in hand operations at ground level) and the sitting position of the men in their kayaks as being sufficiently stressful to provoke the condition. More recently he stated that the defect usually arises mechanically due to an hereditary predisposition to the condition, but it can also be caused by direct injury (Stewart 1969, 1979b).

Table 11 provides comparative data concerning the frequency of neural arch defects in several populations. Unfortunately the methods of tabulation were not the same in each study; therefore, it is not possible to make direct comparisons. However, the Arikara population reported by Schmidt (personal communication) was tabulated using the incidence of L5 only. The frequency of neural arch defects noted in L5 in the Kaufman-Williams population is considerably lower than that noted in any of the other Amerindian populations cited and more nearly resembles that given for Whites and Blacks. It is

TABLE 11

PREVALENCE OF NEURAL ARCH DEFECTS IN SEVERAL POPULATIONS

Population	Group	Males		Females	
		No.	%	No.	%
Willis (1931)					
Hammann Museum	White		6.7		3.7
(Sample size of 1520)	Black		3.5		1.03
Stewart (1979b)					
Indian Knoll	Amerindian	30/171	17.5	30/139	21.6
Arikara (from United States National Museum)	Amerindian	29/94	30.8	18/69	28.1
Stewart (1931)					
Eskimos north of Yukon	Eskimo	39/96	40.6	34/91	37.4
Eskimos from southern Yukon Region	Eskimo	14/86	16.3	8/75	10.7
Roche and Rowe (1952)					
Dissecting room specimens	White		6.4		2.3
(Sample size of 4200; 178 affected)	Black		2.8		1.1
Lester and Shapiro (1968)					
*Point Hope Eskimo	Eskimo	121/295	41.0		
*Smith Sound Eskimo	Eskimo	2/5	40.0		
*Aleutians	Aleutians	2/6	33.0		
Schmidt (1980)**					
Arikara (University of Tennessee)	Amerindian	16/52	30.77	13/48	27.08
Present Study **	Amerindian	3/26	11.54	1/28	3.57

*No distinction for sex
**Tabulation of L-5 defects only

difficult to evaluate the reason for this especially since the frequency of neural arch defects in this population increases in the sacral region.

It is possible that the activity patterns of the Caddo Indians did not greatly stress the lumbar region or that this population did not have a strong hereditary predisposition to structural weakness in this area. This is certainly a topic that deserves further study among the Caddo Indians.

Two individuals had a perforated sternum. This anomaly is believed to be caused by a developmental error in ossification (Morse 1978). The perforation in Burial 61 was an oval 16 mm. in extent; the other hole (Burial 66) was a pinpoint size circle.

The most disabling congenital deformity noted in the Kaufman-Williams sample was the congenital hip dislocation found in Burial 11 (Terry personal communication) (see Figure 5B). The right acetabulum was essentially nonexistent. There was a pronounced atrophy of the right femur and tibia. The head of the right femur was considerably roughened. Asymmetric changes associated with this problem were noted in the foot bones and in the vertebrae.

Arthritis. Arthritis is a disease abnormality which involves one or more joints. Many different classifications of arthritis and rheumatism have been proposed (Morse 1978; Brothwell and Sandison 1967; Steinbock 1976). However, for purpose of this study only two conditions--osteoarthritis and vertebral osteophytosis--assumed importance. Both were associated with the degenerative changes noted as part of the aging process. Osteoarthritis was found associated with the weight bearing joints, especially the knees, in eight individuals. Vertebral osteophytosis was much more common; it was noted in 27 individuals. The lumbar vertebrae and sacrum were most commonly affected. The cervical vertebrae were the second most frequently affected.

Trauma. Several traumatic lesions occurred in the skeletons from Kaufman-Williams. Three skull fractures were noted. Burial 30 had a healed fracture on both the right frontal and the right parietal. The other skull fracture was on the occipital bone (Burial 45). Two broken noses were observed. Two ulnae were fractured; in the case of Burial 20, a pseudoarthrosis or false joint was created (see Figure 5C). According to Steinbock (1976), this type of joint may occur when the broken ends are poorly aligned and motion is excessive. The proliferating cells differentiate mainly into chondroblasts, producing a hyaline-like cartilage over the ends of the broken bones. Other cells form synovial tissue which surrounds the bone and acts as a lubricant.

Two fractures of the radii were noted. The right radius of Burial 36 suffered a Colle's fracture which was caused by falling on the hand (Key and Conwell 1942). There was one fracture observed on the distal end of the left humerus (Burial 63).

The right tibia was considerably heavier and more swollen in appearance than the left in Burial 30. This condition was attributed to a fracture followed by a low-grade, long-term infection which caused extensive buildup of bone (Terry personal communication).

Several traumatic injuries to tibiae that did not result in fractures were also noted. These included such probable conditions as sprains, "barked-shins," etc., in which varying degrees of periosteal reaction occurred. Seventeen tibiae from twelve individuals showed such reactions. Occasionally other long bones were similarly affected.

Goldstein (1957) noted a 2.2% postcranial fracture rate in the Texas Indians he studied. The 8% fracture rate observed in the present study more nearly approximates that observed in the late archaic populations studied by Morse (1978). It may be, however, that the high incidence of fractures noted here is due to the large number of adults (who are more prone to fractures) in the sample rather than to stresses imposed upon the population by a rigorous environment. The two fractures of the radii were on the skeletons of females. The other postcranial fractures all occurred on male skeletons. One broken nose was found on a female skeleton while the remaining craniofacial fractures were associated with males.

Inflammation of bone. Inflammation of the bone, other than that already mentioned in the cases of periosteal reaction in various long bones, was observed in two individuals (Burials 9 and 69). In both cases, there was evidence of infection in the maxillary sinuses followed by periosteal reaction in the form of new bone formation (see Figure 5D).

Tumors. Tumors are abnormal growth that may either originate in the bone tissue or spread to the bone from other tissues. Eight skeletons from the Kaufman-Williams site had tumors on them. None of these were malignant. In six of the individuals (8% of the population) the tumor was a button osteoma. Burial 2 had two button osteomas on the right frontal. One osteoma was located on a femur, another was on a tibia, and the remainder were all found on the cranium. Hooten (1930) noted a frequency of 2.2% of button osteomas among the Pueblo Indians. That is a much lower frequency than found in this study.

One osteochondroma was found on the proximal end of the left tibia of a 9-11 year old child. Three tumors, classified as hemangiomas, occurred on one skeleton; they were located on the left parietal, the left temporal, and the right illium.

Osteochondritis dissecans. One case of osteochondritis dissecans was noted on the medial condyles of the femora of a 13-15 year old male (Burial 49) (see Figure 5E). This condition is essentially a type of epiphyseal ischemic necrosis which involves a peripheral segment of the bony epiphysis. Insufficient circulation through the epiphyseal vessels provokes the problem. A plane of cleavage separates the dead fragment from the healthy bone. This may eventually loosen and fall into the joint space taking along the layer of healthy cartilage which covers it. Often there is mild to moderately severe pain in the affected joint, and there is usually some limitation of extreme motion. Eventually muscle weakness may occur, and there may be disuse atrophy (Aegerter and Kirkpatrick 1963).

Hydrocephaly. One subadult (Burial 37), aged 7-8, was afflicted with hydrocephaly. This condition which results from increased intracranial pressure is caused by infection, tumor, or injury (Morse 1978). The cranial capacity of this child, measured with bird-seed was 1370 cc. A subadult of comparable age (Burial 34) had a cranial capacity of 1210 cc.

Porotic hyperostosis. A 3-5 year old subadult was afflicted with a severe case of porotic hyperostosis (see Figure 5F). This condition has generally been associated with iron deficiency anemia in the Amerindians. Several causes have been suggested including (a) a simple dietary insufficiency of iron, (b) protosoal, helminthic, and bacterial infections of the intestine which prevent adequate iron absorption, and (c) cooking methods which destroy folic acid and vitamin B12 (Steinbock 1976).

Cribra orbitalia. Six cases of cribra orbitalia were noted in the Kaufman-Williams skeletons. Of those afflicted, two were subadults, one was female and three were males. Several hypotheses have been suggested regarding the etiology of cribra orbitalia. However, at the present time it is felt that some type of nutritional deficiency is the most probable cause of the condition. Both vitamin C and iron deficiencies have been suggested as possible producers of cribra orbitalia (Steinbock 1976).

Transverse lines. All of the long bones of the subadults in the group between Burials 1 and 57 were x-rayed. Thus, 20 of the 21 subadults were x-rayed. In this group the long bones of only two individuals showed evidence of transverse lines. In both cases the tibiae were the bones affected. Burial 37 (the hydrocephalous child) had three transverse lines on the distal tibiae. Burial 49 had four transverse lines on the proximal tibiae. All of the lines were very faint.

Transverse lines are thought to represent periods of renewed or increased growth following periods of inhibited bone growth. Thus, they are formed only in growing bone even though the lines themselves are sometimes visible in adults as well as children. The lines have generally been attributed to the effects of stress due to nutritional deficiency or disease (Steinbock 1976). However, Gindhart (1969) recorded the development of transverse lines following a disease episode in only approximately 25% of the children she studied. Furthermore, she noted that almost all of the subjects in her study had lines at some time. Even though the association between disease and line formation is high, there is a low predictability of line formation. The frequency of occurrence is much higher in males, but the lines tend to persist longer in females (Gindhart 1969).

The low incidence of transverse lines noted in the Kaufman-Williams skeletons suggests that the children were not subjected to especially severe environmental insults.

Dentition. Dental pathologies occurred commonly in the Kaufman-Williams population. Those found included caries, broken teeth in conjunction with caries, abscesses, and peridontal disease.

Table 12 shows the frequency of occurrence of caries, broken teeth, and abscesses along with the number of teeth which were lost antemortem. The females had a slightly higher incidence of these conditions than the males. The posterior dentition, especially the three molars, was more affected by dental disease than was the anterior dentition. Among the males M1 was the tooth most affected by dental disease. M2 was the most diseased tooth on the right side of the mouth while M1 was most affected on the left side among the females. Ten subadult teeth contained caries. Goldstein (1948) felt that the East Texas Indians were the most susceptible to dental disease of all the Texas Indians because of their agricultural lifeway.

Thirteen individuals had major buildups of tartar on one or more teeth. Again, the posterior teeth were most seriously affected.

Severe attrition was noted on the teeth of 7 males and 13 females; thus, 27% of the population had severely worn teeth. It is likely that the slightly longer lifespan noted in the females was responsible for the higher incidence of severe wear in that group. Eleven males and 10 females (28%) had teeth which were moderately worn. The group whose teeth showed only slight wear included eight males, five females, and seven subadults. Goldstein (1948) noted pronounced wear among 17% of the East Texas sample he studied. Thirty-six percent of his sample had moderately worn teeth.

Five congenital anomalies associated with the teeth were noted. Burials 2 and 5, both males, had peg-shaped third molars on both sides of the maxilla. These two individuals were buried in the

TABLE 12

FREQUENCY OF COMMON DENTAL PATHOLOGIES IN THE KAUFMAN-WILLIAMS SKELETAL MATERIAL

					right								left				
Males (26)																	
	M3	M2	M1	PM2	PM1	C	LI	CI	CI	LI	C	PM1	PM2	M1	M2	M3	Total
Maxilla	5AM	4C 3B 5AM	5C 2A 8AM	2C 7AM	6C 2A	4C 1B 1A	2C 1B	2C 1B	4C 1A	1A	4C	4C 2B 1A	1C 1A 3AM	5C 1B 4AM	4C 1B 3AM	3C 4AM	50C 10B 8A 39AM
Mandible	4C 1A 8AM	6C 7AM	5C 1A 9AM	1C 1A 3AM	1C 1B 1A 1AM	1B 2AM	1AM	1C 3AM	2AM	1C 1AM	1C	4C 1A	3C 2AM	6C 1A 7AM	4C 9AM	3C 1B 10AM	40C 6A 65AM
Females (28)																	
	M3	M2	M1	PM2	PM1	C	LI	CI	CI	LI	C	PM1	PM2	M1	M2	M3	Total
Maxilla	1C 1B 7AM	3C 1B 7AM	3C 2B 6AM	3C 1B 6AM	4C 1A 2B 3AM	3B 1AM	2C 2B 1A 1AM	2C 1B 1AM	3C 1A 1AM	1C 1B	2C 4B	2C 1B 5AM	5C 1B 1A 3AM	2C 3A 2B 5AM	5C 1B 4AM	3C 6AM	41C 20B 7A 55AM
Mandible	3C 1B 5AM	7C 5AM	1C 9AM	5C 1B 3AM	5C 1B 1A 2AM	3C 1B 1AM	1C 1B 2AM	1C 3AM	3AM	3C 2AM	3C 1B 1AM	3C 1B 2AM	5C 2B 6AM	6C 1B 9AM	3C 2B 6AM	1C 9AM	50C 12B 1A 68AM

TABLE 12 (continued)

	Subadults (21)																
	M3	M2	M1	DM2	DM1	C	LI	CI	CI	LI	C	DM1	DM2	M1	M2	M3	Total
Maxilla			1C		1C	1C	1C						1C				
Mandible			1C		1B							1C	1C	1C			

C - caries
B - broken teeth
A - Abscesses
AM - antemortem tooth loss

cemetery area associated with House Pattern 1; therefore, it is possible that they were related. Burial 46 had an extra premolar on the left maxilla. The tooth row was not crowded. Burial 52 had a supernumerary peg-shape lateral incisor on the right side of the maxilla. In this case the tooth row was crowded, and the canine, first and second premolars were out of alignment. A central incisor was congenitally missing from the right side of the mandible of Burial 63.

Summary. The two most serious problems associated with the Kaufman-Williams people (as reflected in their bones) were dental wear and disease and arthritis. Both severe dental wear, including loss of many teeth antemortem, and caries associated with both broken teeth and abcesses were serious afflictions affecting many people. In most cases these problems became more severe with increasing age. Degenerative arthritis also was more severe in older individuals. Twenty-seven individuals were afflicted to varying degrees. With the exception of one congenital hip dislocation, the congenital anomalies found in the group would have caused little or no problem to the individuals who had them. Several fractures were noted. The bones involved healed adequately and assumed near normal form. Cribra orbitalia in six individuals and porotic hyperostosis in one child suggested that the population was under some nutritional stress.

Burial Position and Grave Associations

The most common burial position utilized at Kaufman-Williams was the extended burial. All burials were single internments with the exception of two females who were buried with infants. Two intrusive burials were encountered; Burial 22 had intruded upon Burial 23 (see Figure 6H). Burial 65 intruded over part of Burial 66. Only one burial, Burial 59, was buried in a position that could be classed as anything other than a variant of the extended position. This burial was in a semiflexed position lying on the right side at a depth of 28 inches; according to Perino (personal communication) the individual appeared to have been buried in a hurry. No artifacts were found in the grave.

Several variations of the extended position were noted, however. Burial 20 (see Figure 6E) was buried partially turned to the side rather than on the back as the other burials were. The knees of Burial 46 (see Figure 6B) were slightly bent, but they were not contracted sufficiently to classify the burial as semiflexed. The legs of Burial 70 were crossed at the ankles.

One of the most interesting burials was the double burial of 41a and 41b. An adult female was buried in what can best be described as a sprawled position. The left arm and leg were thrown to the side in an awkward configuration (see Figure 6A). The skeleton of a newborn infant was between the left elbow and knee. The other female buried with an infant (Burials 31a and 31b) was in an extended position. The infant lay on its right side on the female's left arm from the shoulder to the pelvis.

Figure 6. Representative Burials from the Kaufman-Williams Site.

Some of the variations noted in the burials from the Kaufman-Williams Site are: (A) Burial of female (in sprawled position) with a newborn infant, (B) Extended position with knees slightly bent and hands resting on pelvis, (C) and (D) Extended position with placement of grave goods around the head and shoulder area, (E) Extended burial turned to one side with the arms folded toward the face, (F) Child buried with a dog, (G) Extended burial with head turned toward the side and with arms extended along side the body, and (H) One of two intrusive burials.

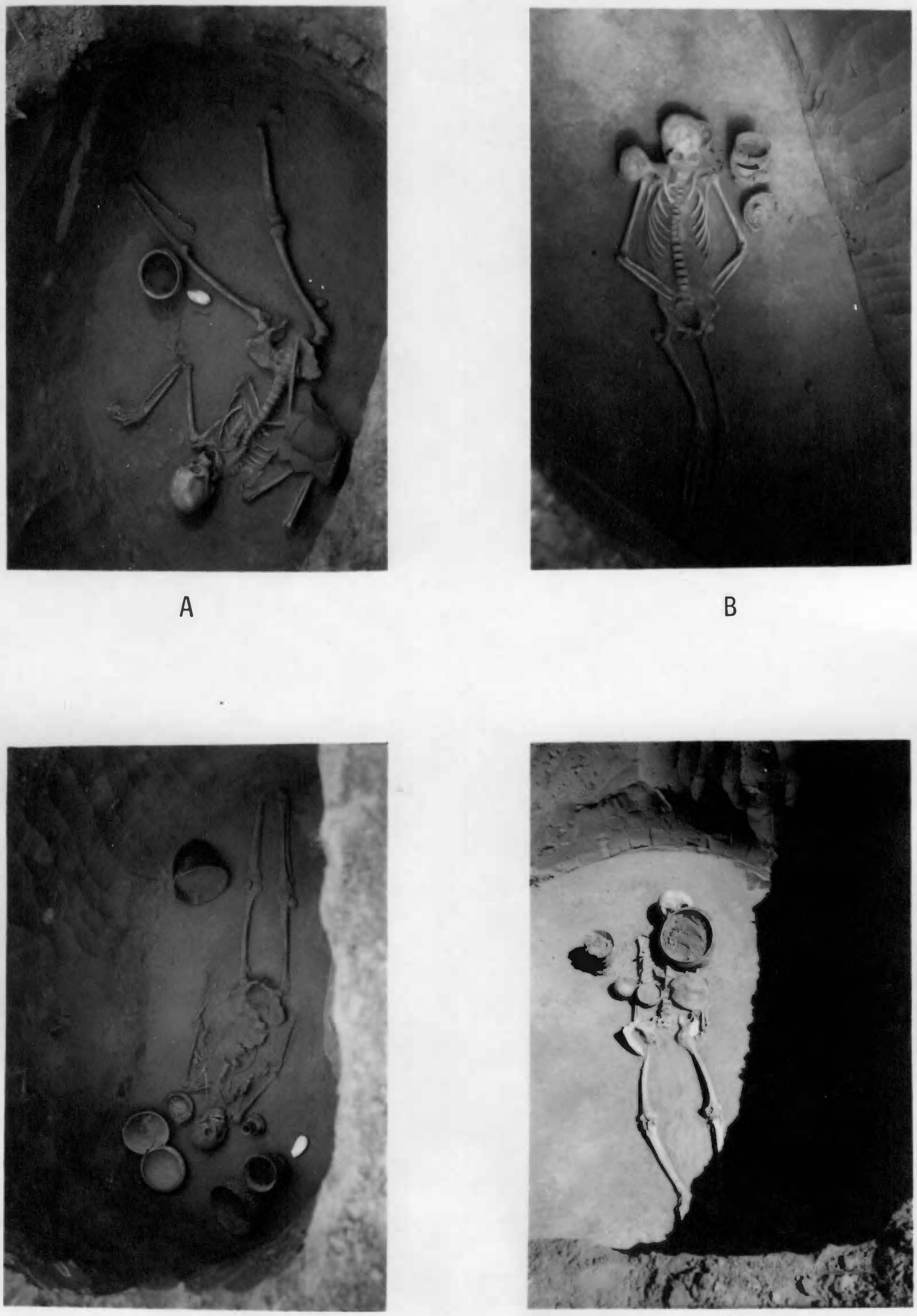


Figure 6

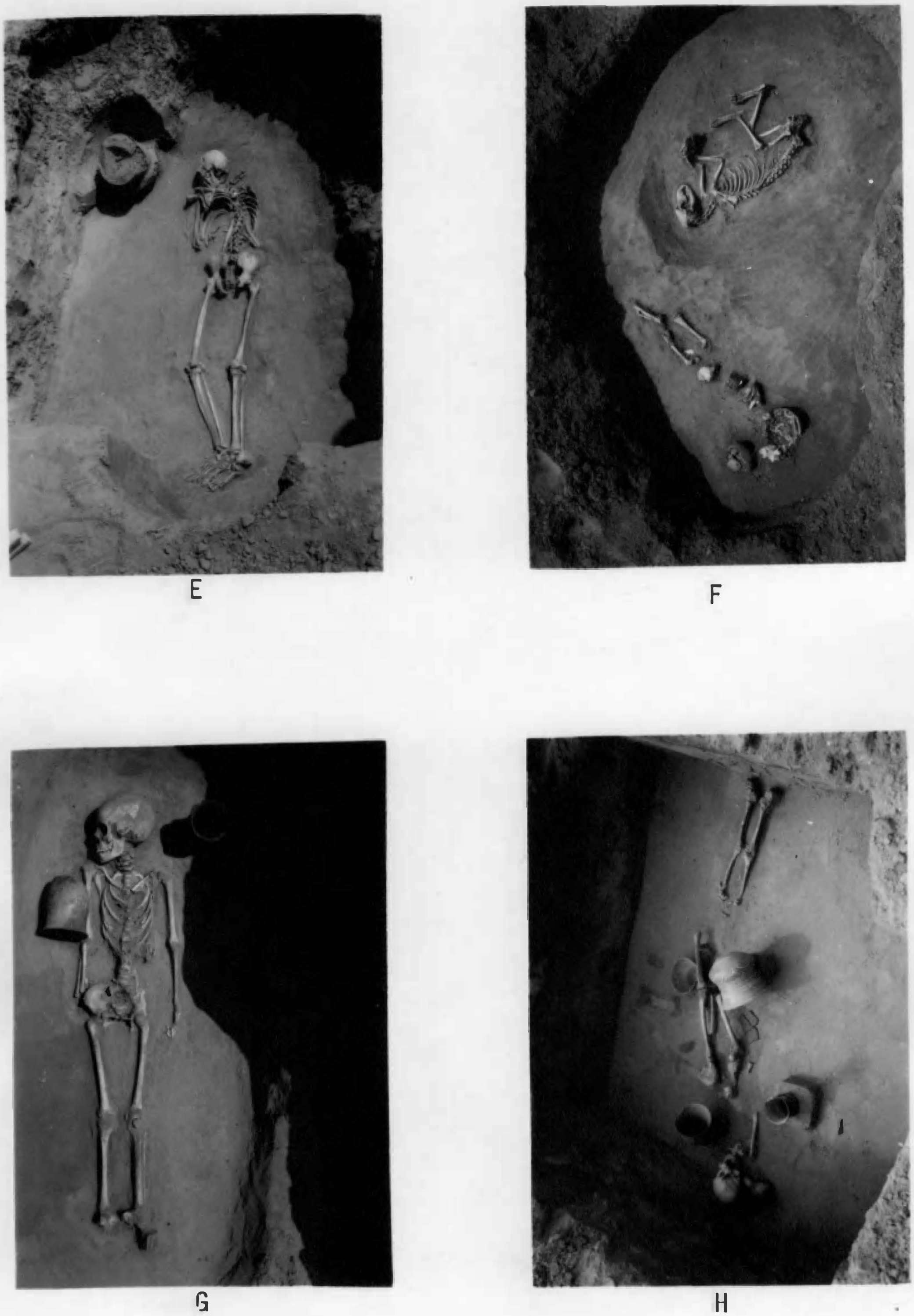


Figure 6. Continued

One internment (Burial 53) consisted of the single skull of a subadult, 12-17 years old. Since the Caddo occasionally buried the skulls of their enemies alone (without any postcranial bones) (Harris 1953), it is possible that the skull represented a "trophy." However, the shallow depth of the burial (only 8-12 inches below ground) and the fragmentary nature of the skull suggested that perhaps the burial was plowed up by farm equipment and lost. No marks of violence were found on the skull.

Arm position tended to vary slightly among the burials. The most common position was extended along the side of the body (see Figure 6G). Other positions noted were: (a) arms extended with the hands resting on the pelvis (see Figure 6B), (b) the arms flexed with the hands resting near or against the face, (see Figure 6E), and (c) one arm extended while the other rested on the stomach area. The lower right arm and the right hand of Burial 52 were under the pelvis. Rodent action had displaced bones in several instances. The Caddo occasionally buried dogs with their children as illustrated by Burial 57 (see Figure 6F). The dog skeleton was found about a foot from the right lower leg of the child and about four inches deeper. Burial 12 also contained fragments of dog bone. Separate dog burials were also found.

Only 9 of the 73 graves excavated did not contain grave goods. Of these, Burials 3, 4, and 5 showed evidence of previous disturbance and had, therefore, probably been "potted." Burials 29, 50, 53, 59, 61, and 70 appeared not to have been previously disturbed. It seems likely that those individuals were buried without burial offerings.

Within that group there was one female, two subadults (one was the isolated skull burial), and three males.

The most common offering included in the grave was pottery, and it was most frequently placed about the head and shoulders (see Figure 6B, C, D, G, H). Grave goods were less commonly placed about the lower body. Table 13 shows the grave good types as distributed by sex.

There were no stone tools or tool preforms associated with females. Those found with subadults probably were buried with the male children. However, there was no way to prove this since the subadults were not sexed. There were seven bone tools found with

TABLE 13

TYPES OF GRAVE GOODS DISTRIBUTED BY SEX

Group	Pottery	Shell or Shell Ornaments	Bone Bone Tools, Bone Ornaments	Large Sherds of Single Pots	Stone Tools or Preforms
Males	84	16	31	7	74
Females	101	27	7	2	0
Subadults	31	32	0	3	10

females. Six of these were deer jaw picks (or sickles); one was described as a deer ulna tool. Pottery was more often found in quantity with the females; the children were buried with the fewest grave goods. In addition to the artifacts shown in Table 13, three other artifact types were found with males. Red ochre was buried with one individual. Three clay pipes and one strike-a-lite were found.

Burials at Kaufman-Williams were found to a depth of 80 inches. Conversely the most shallow grave was only eight inches below ground level. The average of the 73 graves was 39 inches. All of the burials except 2 were placed with the head within 40° north of east and 30° south of east. Two children, Burials 55 and 56 (from House Area 2), were buried with their heads facing 10° south of west.

Thus, the most common burial position among the Caddo was the extended burial with the head toward the east. Most graves contained burial offerings with pottery being used most frequently. Stone tools were found only with males and subadults.

CHAPTER 5

CRANIAL DEFORMATION

Introduction

One of the first historical references to intentional cranial deformation among the southeastern Indians was by Garcilaso de la Vega in 1723. His description of the Indians who resided in southern Arkansas near Hot Springs was reproduced by Swanton (1946:537):

> Both men and women have ugly faces, and though they are well proportioned they deform themselves by deliberate distortion of their persons. Their heads are incredibly long and tapering on top, being made thus artificially by binding them up from birth to the age of nine or ten.

Many of the skulls found on Caddoan sites from both the Gibson and Fulton Aspects were intentionally deformed; however, the custom apparently died out about the time the French entered Louisiana near the end of the seventeenth century (Swanton 1946). An anonymous memoir printed at Luxemburg prior to 1718 described deformation among the Natchez (close neighbors of the Caddo) as follows:

> They have . . . their heads pointed and shaped almost like miters. They are not born so; this is a charm which is given them during their early years. What a mother does to the head of her infant in order to force its tender bones to assume this shape is almost beyond belief. She lays the infant on a cradle, which is nothing more than the end of a board on which is spread a piece of animal skin; one extremity of this board has a hole in which the head is put and it is lower than the rest. The infant being laid down on this entirely naked, she pushes the back of its head into this hole and applies to it on the forehead and under the head masses of clay which she binds with all her strength between two little boards. The infant cries, turns completely black, and the strain it is made to suffer is such that a white, slimy fluid is seen to

> come out of its nose and ears at the time when the mother presses on its forehead. It sleeps thus every night until its skull has taken on the shape prescribed by custom . . . . (Swanton 1946:537-538)

Cranial deformation among the Indians of the southeastern United States was also described by Adair who wrote:

> . . . The Indian nations, round South Carolina, and all the way to New Mexico, . . . to effect this, fix the tender infant on a kind of cradle, where his feet are tilted, about a foot higher than a horizontal position, . . . his head bends back into a hole, made on purpose to receive it, where he bears the chief part of his weight on the crown of the head, upon a small bag of sand, without being in the least able to move himself. The skull resembling a fine cartilaginous substance, in its infant state, is capable of taking any impression. By this pressure, and their thus flattening the crown of the head, they consequently make their heads thick, and their faces broad: for when the smooth channel of nature is stopped in one place, if a destruction of the whole system does not thereby ensue, it breaks out in a proportional redundancy in another (Adair 1775:9-10).

Classification of Deformation

Since many Amerindian groups in both North and South America intentionally deformed the crania of their children, the subject of deformation has received considerable attention from physical anthropologists. Classification of the various types of deformation has been an important aspect of these studies. Dembo and Imbelloni (1938) produced a nomenclature and classification system that is widely used today especially in Mesoamerica and in South America (Romero 1970; Gill 1971). Two large groups of deformation, tabular and annular, are distinguished; each of these is then further subdivided into either oblique or erect, depending upon the direction of the deforming pressure. The distinction between the two groups depends upon the type of deforming apparatus that was used. Tabular deformation was produced in one of two main ways: (a) by applying free tablets (boards, sandbags, etc.) to the head in a transverse direction and pressing them together by means of ropes tied around their ends, or (b) by the use of one free and one fixed tablet (the cradleboard) with the former tied to the latter. This type of deformation generally produced flattened areas on particular skull surfaces. Annular deformation was produced by wrapping a band around the head; this method left no marks of flattening on specific regions of the skull. The subgroups, oblique and erect, are determined by placing the skull in the Frankfurt Horizontal. If the general axis of the cranial mass forms an angle greater than 120°, the skull is classed as "oblique." If the angle is less than 120° the skull is "erect" (Dembo and Imbelloni 1938).

In the United States the classification presented by Neumann (1942) has been more widely used (see Figure 7). Actually the classification systems of Dembo and Imbelloni (1938) and of Neumann (1942) are somewhat interchangeable. Tabular oblique corresponds with parallelo-fronto-occipital and tabular erect is comparable to occipital, fronto-parieto-occipital and fronto-vertico-occipital.

Deformation at Kaufman-Williams

Fifty-six of the 75 skulls from Kaufman-Williams were sufficiently well preserved to ascertain the type of cranial deformation that was present. Only two of Neumann's deformation types (Neumann 1942) were observed in this group. Burial 11, a male,

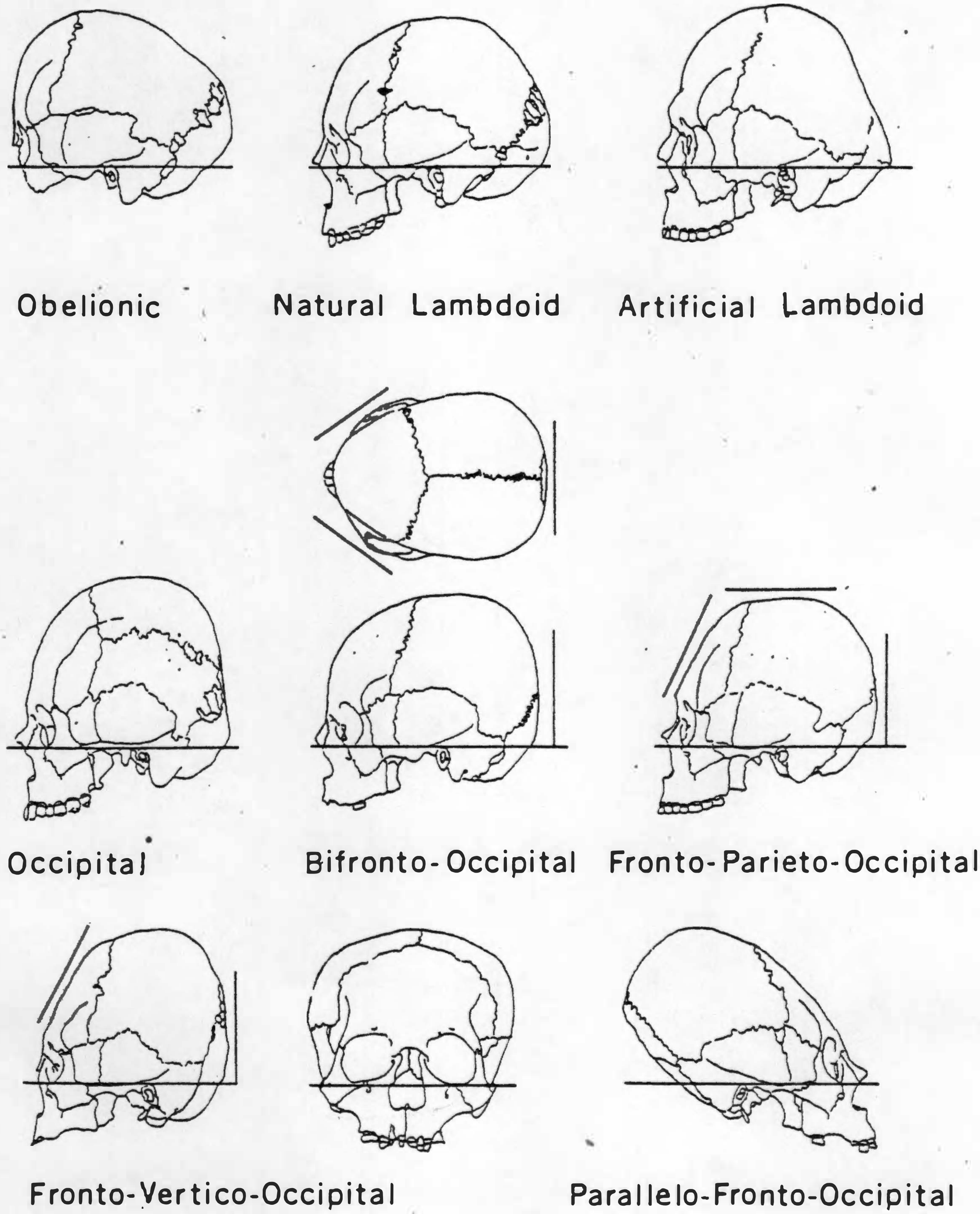


Figure 7. Types of Artificial Cranial Deformation in the Eastern United States.

Source: Neumann (1942:307)

and Burial 21, a subadult, exhibited fronto-vertico-occipital deformation; in both cases the skulls were moderately deformed. The remaining 54 skulls were deformed in the parallelo-fronto-occipital type. Thus, 96.4% of the observed crania exhibited the same type of deformation. This strengthens support for the suggestion by Gregory (1963) that the deformation represented a certain standard of beauty among the Caddo. Gill (1977) postulated a similar hypothesis regarding Mesoamerican Indians.

The Kaufman-Williams skulls were subjectively classified into three deformation classes (slight, moderate, and extreme) according to the extent the skull seemed to deviate from a normal skull. Column 3 in Table 14 indicates the subjective classification for each skull. Since conclusions were to be made based upon the amount of deformation, it was desirable to quantify the deformation and cluster the skulls using actual measurements. Two ratios, called the Frontal Deformation Ratio (FDR) and the Occipital Deformation Ratio (ODR) were developed to help quantify the extent of flattening of the frontal and occipital bones, respectively. A description of these deformation indices was given in Chapter 3, and the values of these ratios for each skull are presented in Table 14. The smaller numbers indicate a more flattened (deformed) bone.

The FDR in this study is identical to the Frontal Index (FRI) described by Howells (1978) and used earlier by others. In his 1978 paper he compared the amount of frontal flatness occurring in undeformed populations all over the world; he recorded values of

TABLE 14

CLASSIFICATION INTO DEFORMATION GROUPS

Burial Number	Sex	Subjective Deformation Group	Frontal Ratio	Occipital Ratio	Fuzzy Isodata Group	Final Group Classi- fication
1	M	Moderate	18.14	26.72	Moderate	Moderate
2	M	Moderate	18.78	29.66	Moderate	Moderate
3	F	Moderate	19.91	--	--	Moderate
4	M	Slight	23.08	32.87	Slight	Slight
5	M	Extreme	16.67	23.28	Extreme	Extreme
6	M	Moderate	17.12	25.97	Moderate	Moderate
7	M	Extreme	15.09	24.63	Extreme	Extreme
8	F	Extreme	16.83	25.87	Extreme	Extreme
10	F	Moderate	20.83	27.57	Moderate	Moderate
11	M	Moderate	17.65	27.78	Moderate	Moderate
13	F	Slight	21.93	36.00	Slight	Slight
14	M	Moderate	16.82	--	--	Moderate
15	F	Slight	19.44	--	--	Slight
19	F	Extreme	14.04	25.12	Extreme	Extreme
20	M	Moderate	13.91	27.48	Extreme	Extreme
21	SA	Moderate	--	--	--	Moderate
22	F	Extreme	16.50	28.05	Extreme	Extreme
24	F	Moderate	20.28	28.10	Moderate	Moderate
26	M	Extreme	15.04	25.47	Extreme	Extreme
27	SA	Moderate	19.16	--	--	Moderate
28	M	Slight	20.80	26.55	Moderate	Moderate
30	M	Extreme	13.82	25.11	Extreme	Extreme
31	F	Extreme	15.38	25.69	Extreme	Extreme
32	F	Extreme	15.04	26.84	Extreme	Extreme
33	SA	Slight	--	--	--	Slight
34	SA	Slight	22.22	28.11	--	Slight
35	F	Extreme	16.80	27.12	Extreme	Extreme
36	F	Moderate	14.36	--	--	Moderate
37	SA	Extreme	15.15	--	--	Extreme

TABLE 14 (continued)

Burial Number	Sex	Subjective Deformation Group	Frontal Ratio	Occipital Ratio	Fuzzy Isodata Group	Final Group Classi-fication
38	SA	Moderate	19.18	33.93	--	Moderate
39	F	Moderate	21.57	29.85	Moderate	Moderate
40	F	Slight	20.09	28.02	Moderate	Moderate
41	F	Moderate	20.75	28.18	Moderate	Moderate
42	F	Moderate	15.89	27.65	Extreme	Extreme
43	F	Extreme	15.81	26.94	Extreme	Extreme
44	F	Moderate	20.69	25.91	Moderate	Moderate
45	M	Moderate	14.81	28.14	Extreme	Extreme
46	M	Extreme	15.07	21.46	Extreme	Extreme
47	M	Extreme	14.42	25.11	Extreme	Extreme
48	F	Extreme	13.39	26.55	Extreme	Extreme
51	F	Slight	20.37	34.15	Slight	Slight
52	M	Slight	20.91	27.39	Moderate	Moderate
58	M	Moderate	15.92	29.39	Moderate	Moderate
59	M	Slight	22.91	32.63	Slight	Slight
60	M	Moderate	17.96	24.57	Moderate	Moderate
61	M	Extreme	13.85	24.15	Extreme	Extreme
62	M	Extreme	17.92	23.28	Extreme	Extreme
63	M	Slight	23.85	--	--	Slight
64	F	Slight	--	--	--	Slight
66	M	Moderate	18.01	22.81	Extreme	Extreme
67	F	Extreme	16.00	26.32	Extreme	Extreme
68	F	Extreme	17.14	23.21	Extreme	Extreme
70	M	Extreme	15.35	24.98	Extreme	Extreme
71	F	Moderate	19.23	27.14	Moderate	Moderate
72	F	Extreme	18.69	23.19	Extreme	Extreme
73	F	Extreme	15.18	24.12	Extreme	Extreme

SA - Subadult

the FRI ranging from a minimum of 15.4 on a Moriori skull to 30.6. The mean values given in his paper for males in certain American Indian groups were: Arikara 19.48, Peru 20.90, and Santa Cruz Island 21.71. In the Kaufman-Williams sample the lowest FDR was 13.39 on Burial 48. The average values of the FDR were 16.72 for males and 15.98 for females in this population, and the combined average for males and females was 16.33. These values suggest a greater flattening of the frontal bone in the Kaufman-Williams population than in the other Amerindian populations cited by Howells. Only 16 skulls in the Kaufman-Williams collection had a FDR above 19.48 which was the mean cited by Howells (1978) for the Arikara. No population comparisons can yet be made on the ODR since this ratio is not a standard measurement.

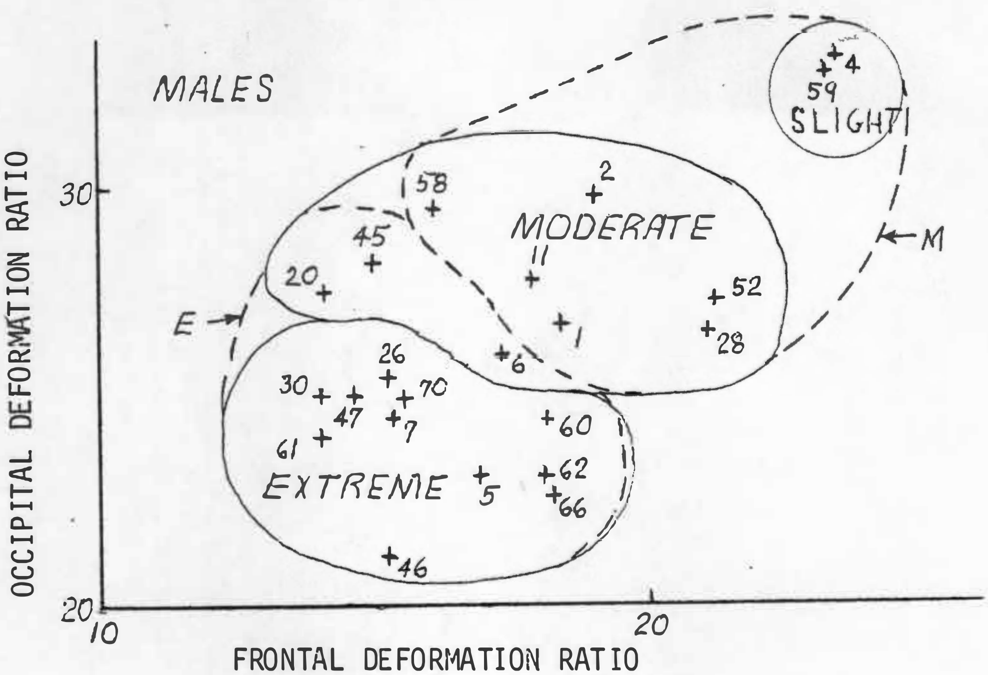
Since the FDR and ODR appeared to be valid measures of deformation, they were used as features for clustering the skulls using the Fuzzy Isodata algorithm. A brief description of this process was given in Chapter 3. The results of clustering the skulls into three deformation classes (slight, moderate, and extreme) based on the deformation ratios is given in the sixth column of Table 14. Subadults and skulls lacking crucial measuring landmarks were delected from this cluster program. Males and females were clustered separately.

The two methods of classification, the visual and quantitative, are in remarkable agreement. Of course, there are discrepancies; Burials 20, 28, 40, 42, 45, 52, and 66 had to be re-examined. The quantitative evaluations pointed out the fact that occipital deformation had been less heavily weighted in the subjective groupings than frontal deformation. The cluster analysis of the males provided a more scattered array with more poorly defined borders than did the female cluster (see Figure 8). This probably underscores the reason there were more discrepancies between the quantitative and visual classifications in the male group.

The Fuzzy Isodata clusters were accepted and have been used in the remaining discussion in this chapter. Both deformation ratios could be calculated on only 22 males and 22 females so the quantative groupings were restricted to these 44 crania. The remaining skulls were classified using visual classification. The final three-group classification for all of the skulls is given in the last column of Table 14.

A comparison of the deformation classes with the quantity of pottery found with the burials produced no obvious pattern (see Table 15). Thus, even though the quantity of pottery included with the burials probably does not provide an adequate measure of wealth or status, it should be noted that there is no apparent relation between the number of pots and deformation.

The frequency of the three deformation types during the early, middle, and late time periods (as delineated by pottery types) is shown in Table 16. Even though it appears that there is a slightly higher number of deformed skulls associated with the early period, this pattern may be because of the increased number of burials attributed to the early period (see Table 1, page 19). In speaking



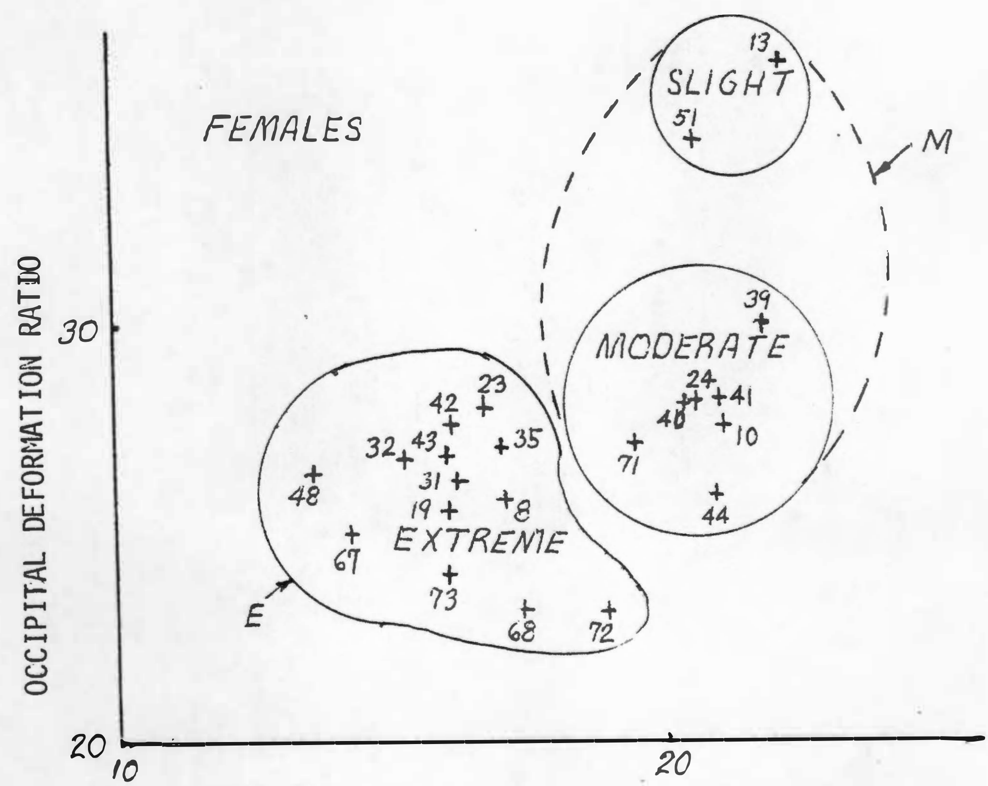


Figure 8. Deformation Clusters into Two and Three Classes Based on Two Deformation Ratios.

The three deformation classes are noted with solid lines; two deformation classes are represented by the broken lines.

TABLE 15

POTTERY ASSOCIATIONS BY DEFORMATION CLASSES

Group	Number	Deformation Class	Pots per Person
Males	3	Slight	2.33
	9	Moderate	3.33
	12	Extreme	3.42
Females	5	Slight	4.20
	8	Moderate	3.13
	13	Extreme	4.15
Subadults	2	Slight	2.50
	3	Moderate	1.67
	1	Extreme	1.00

about deformation among the Caddo in Louisiana, Swanton (1946:537) says ". . . that when the French entered Louisiana at the end of the seventeenth century the Caddo seem to have given up the custom . . ." Apparently, such was not the case at Kaufman-Williams because even though extreme deformation may have occurred less frequently during the late period it was still found among crania attributed to the 1650-1700 A.D. period.

Methods Employed in Deforming Skulls

Swanton (1946) quoted several historical sources regarding the method used to deform the cranium. Boards, masses of clay, and bags of sand were mentioned in several of the ethnohistorical accounts.

TABLE 16

DEFORMATION PATTERNS THROUGH TIME

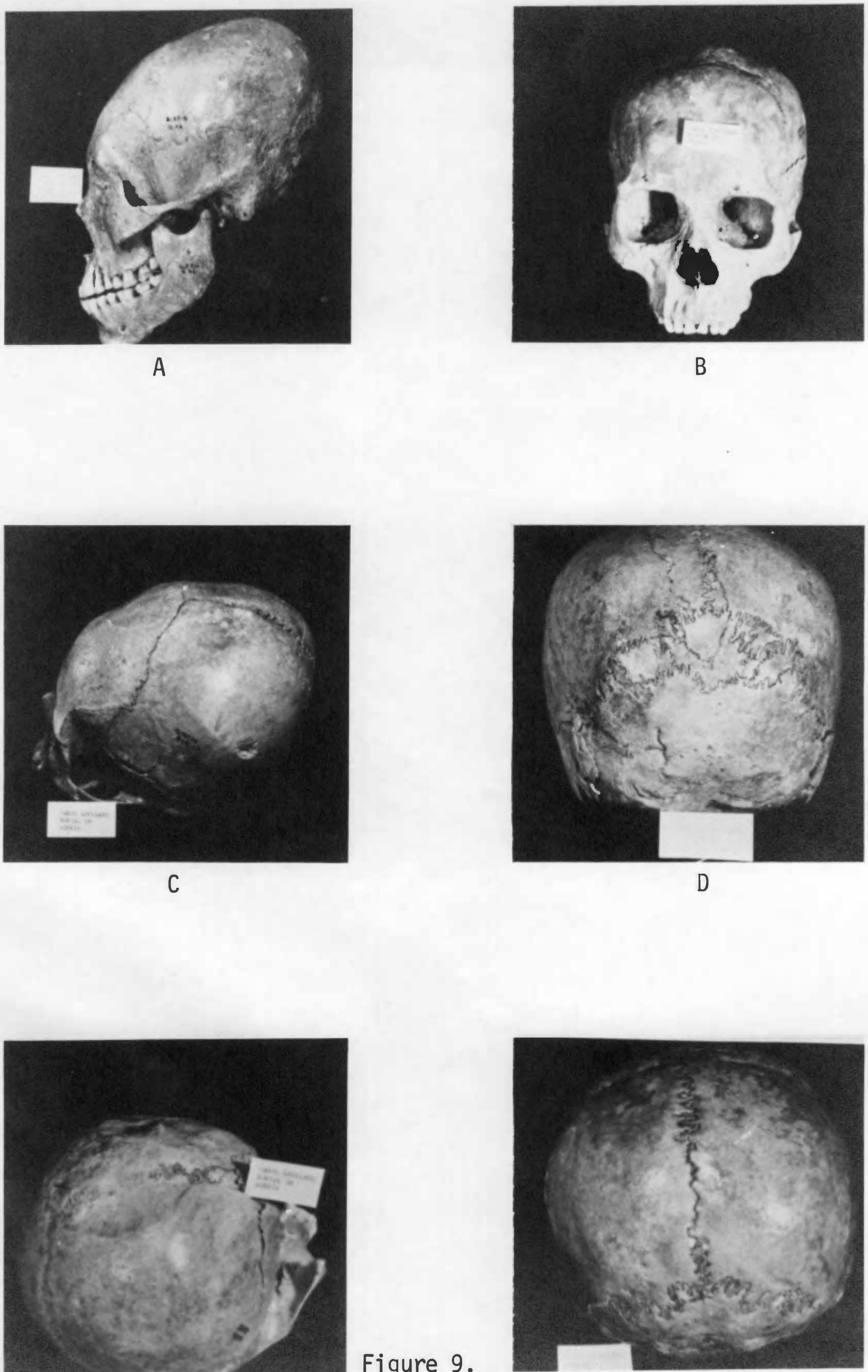
Group	Number	Deformation Class	Unknown Period	Early Period	Middle Period	Late Period
Males	3	Slight	2	0	0	1
	9	Moderate	0	2	2	5
	12	Extreme	2	7	0	3
Females	5	Slight	1	1	1	2
	8	Moderate	0	3	3	2
	13	Extreme	0	6	4	3
Subadults	2	Slight	2	0	0	0
	3	Moderate	0	1	1	1
	1	Extreme	1	0	0	0

These were secured in place with deerskin thongs. Since the most common deformation type noted among the Caddo in both the prehistoric and historic periods was parallelo-fronto-occipital deformation (see Figure 9A), it is likely that the same methods were employed prehistorically as historically. Therefore, analysis of the ethnohistoric accounts coupled with study of the marks left on the bones by the deforming device should provide accurate suppositions about the methods used.

Two boards were used to achieve parallelo-fronto-occipital deformation. The cradleboard served as a rest for the occiput;

Figure 9. Effects of Deformation upon Crania from the Kaufman-Williams Site.

Some of the manifestations of parallelo-fronto-occipital deformation that were noted on the crania from Kaufman-Williams are: (A) Side view of Burial 46, an extremely deformed individual, (B) Front view of Burial 35 showing depressed ridge, caused by the deforming device, just posterior to the coronal suture, (C) Flattened areas on the frontal and parietals caused by the deforming device (Burial 19), (D) Wormian bones in the lambdoidal suture (Burial 27), (E) Depressions on skull of Burial 58 caused by deforming device, (F) Posterior view of Burial 35 showing the depressed ridges just posterior to the coronal suture.



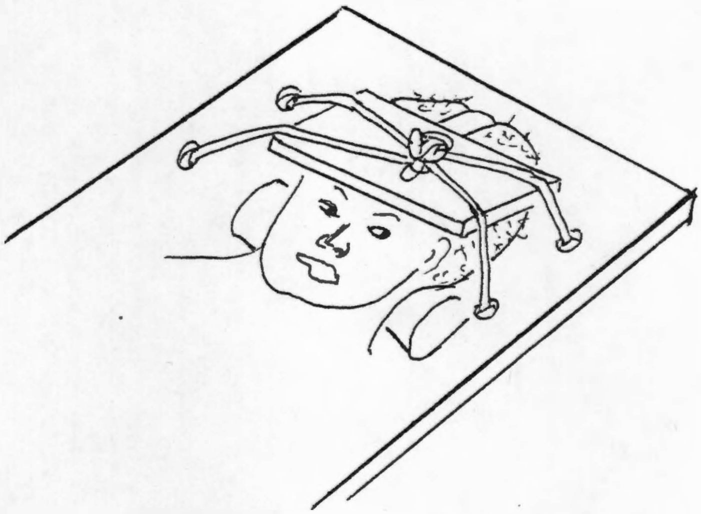
A B C D E F

Figure 9.

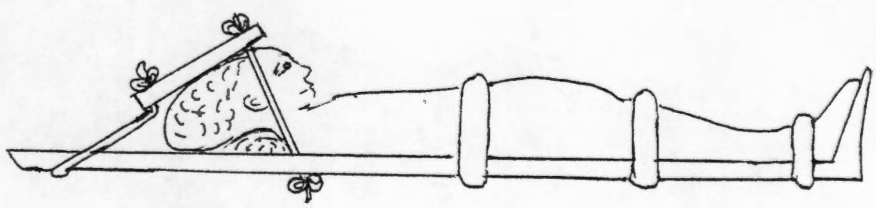
bags of sand or pieces of clay may have been placed near the base of the occiput to produce a more pronounced deformity. The second board was strapped in place over the frontal portion of the skull. Greater frontal deformation was probably achieved by placing sand or clay beneath the board (Swanton 1946). Figure 9C illustrates the flattened areas on portions of the skull caused by the deforming device. Figure 10 shows the possible appearance of such deforming devices.

The placement of the straps used to support the frontal board against the cradleboard probably varied from individual to individual. Several of the crania have depressions on them which appear to have been made by thongs or by knotted thongs. Burial 58 has three rather deep depressions on the rear of the skull which appear to have been caused by three large knots resting on the bone (see Figure 9E). On the other hand, some skulls appear to have had a single thong running down the sagittal suture to hold the deforming device in place.

A slight variant of parallelo-fronto-occipital deformation involved the formation of a coronal "saddle" or ridge. This ridge is usually found just posterior to the coronal suture. It was probably produced by means of an elongated bag of sand (or clay) being strapped transversely across the skull near the coronal suture and held in place by the board on top. Figures 9B and 9F illustrate this ridge.



A. Front view



B. Side view

Figure 10. Possible Appearance of the Deforming Device Used by the Caddo Indians.

The high incidence of wormian bones noted in deformed skulls (Figure 9D) has been attributed by Bennett (1965) to stress caused by the deforming device.

<u>Summary</u>

Intentional cranial deformation among the Caddo Indians was a very common practice. Since the practice was so widespread in both space and time and since parallelo-fronto-occipital deformation was the most common type throughout the area, it is likely that a deformed skull was considered attractive. The practice of the custom was undoubtedly left up to the individual family because there are varying degrees of deformity. Furthermore, differential markings on the skulls suggest that several methods were employed to achieve similar results.

Among the Indians from Kaufman-Williams the percentage of extremely deformed females was slightly higher than that of males. No association was found between the severity of deformation and the number of pots included as grave offerings. Furthermore, no evident changes occurred in the amount of deformation through time.

CHAPTER 6

ANALYSIS OF THE METRICAL DATA

Mean Measurements

All of the cranial and postcranial measurements for both the males and females are summarized below. Table 17 provides the summary statistics for the male cranial measurements; Table 18 concerns the postcranial measurements. Table 19 and Table 20 deal with the female cranial and postcranial measurements, respectively. It must be stressed that the cranial measurements and indices are reflections of various degrees of artificial cranial deformation. This factor must be considered when any comparisons are made with other populations.

Postcranial Analysis

The analysis of postcranial osteometrics involved consideration of long-bone lengths, stature estimation, and sexual dimorphism. Table 21 presents a comparison of the long bone lengths from several Caddoan Linguistic Family populations. The left bone measurements for the Kaufman-Williams and Leavenworth (South Dakota) (Bass et al. 1971) samples are given. The literature data concerning the other three samples (Westbury 1978; Butler 1969; Navey 1975) made no mention of whether right or left bones were recorded.

The long-bone proportions are about the same for all of the groups; however, the Kaufman-Williams long bones tended to be

TABLE 17

CRANIAL MEASUREMENTS (mm) OF KAUFMAN-WILLIAMS MALES

Measurement	No. of Cases	Mean	SD
1. Maximum lgt.	24	173.13	5.58
2. Maximum brdth.	24	140.54	5.89
3. Basion-bregma	22	137.23	6.00
4. Endobasion-nasion	22	102.27	5.18
5. Endobasion-alv. pt.	21	101.57	7.18
6. Min. front. brdth.	23	92.87	4.42
7. Bizygomatic brdth.	20	134.95	6.91
8. Nasion-alv. pt.	22	70.68	4.64
9. Ext. alv. lgt.	22	55.41	4.65
10. Ext. alv. brdth.	22	66.27	4.27
11. Nasal ht.	22	51.59	3.08
12. Nasal brdth.	22	25.41	2.06
13. Biorbital brdth	21	98.86	4.07
14. Ba-po ht.	21	23.67	3.83
15. Auricular ht.	22	118.36	4.87
16. Endob.-gn.	21	110.05	6.92
17. Na.-gnathion	22	117.73	6.15
18. L. orbital ht.	23	35.70	1.82
19. L. orbital brdth.	23	42.78	2.15
20. Nasal root ht.	21	17.38	2.18
21. Min. na.brdth.	23	10.35	1.87
22. Porion-nasion	23	90.22	4.37
23. Porion-subnasale	22	95.36	5.76
24. Porion-prosthion	22	100.86	6.49
25. Porion-gnathion	22	116.27	6.01
26. Symphysis ht.	24	34.08	3.64
27. Diam. bigonial	23	99.87	6.92
28. Diam. bicondylar	21	119.38	8.00

TABLE 17 (continued)

	Measurement	No. of Cases	Mean	SD
29.	Ht. Ascen. ramus	24	58.00	4.89
30.	Corpal lgt. go.-gn.	24	91.42	4.57
Indices				
	Cranial index	25	81.34	4.49
	Cranial module	24	150.24	3.34
	Mean ht. index	24	87.49	3.91
	Length ht. index	24	79.43	3.55
	Brdth. ht. index	24	97.44	5.91
	Fronto-parietal	24	66.12	3.99
	Upper face ind.	22	52.08	3.42
	Total face ind.	21	66.65	5.19
	Nasal index	24	49.94	4.79
	Orbital index	25	83.61	5.85
	Palatal index	24	119.94	10.91
	Flatness crabase	23	17.06	2.32

TABLE 18

POSTCRANIAL MEASUREMENTS (mm) OF KAUFMAN-WILLIAMS MALES

Measurement	No. of Cases	Mean	SD
Humerus			
1. Max. morph. lgt. R	23	319.61	14.68
2. Max. morph. lgt. L	22	317.23	15.23
3. Max. dia. midshaft R	23	21.48	1.34
4. Max. dia. midshaft L	22	20.95	1.33
5. Min. dia. midshaft R	23	15.91	1.24
6. Min. dia. midshaft L	22	16.18	1.30
7. Circumference R	23	62.70	4.42
8. Circumference L	22	62.27	5.08
9. Max. dia. head R	23	44.09	2.89
10. Max. dia. head L	21	44.00	3.08
11. Humero-femoral index R	22	71.58	2.18
12. Humero-femoral index L	21	70.64	2.04
Clavicle			
1. Max. lgt. R	22	142.91	6.26
2. Max. lgt. L	17	141.76	7.29
3. Claviculo-humeral index R	16	44.62	2.32
4. Claviculo-humeral index L	20	45.07	2.26
Femur			
1. Max. morph. lgt. R	24	444.92	23.26
2. Max. morph. lgt. L	23	448.13	23.52
3. Phys. lgt. R	23	442.61	23.93
4. Phys. lgt. L	22	446.86	23.20
5. Ant. post diam. midshaft R	24	29.38	2.02
6. Ant. post diam. midshaft L	23	29.78	2.34

TABLE 18 (continued)

	Measurement	No. of Cases	Mean	SD
Femur (continued)				
7.	Transverse diam. midshaft R	24	24.58	2.45
8.	Transverse diam. midshaft L	23	25.09	1.73
9.	Cir. midshaft R	24	86.88	5.41
10.	Cir. midshaft L	23	87.78	5.70
11.	Max. dia. head R	23	45.09	3.86
12.	Max. dia. head L	23	45.61	2.45
13.	Pilastric index R	24	120.43	10.23
14.	Pilastric index L	23	119.04	9.94
15.	Index of robust. R	24	12.21	0.82
16.	Index of robust. L	23	12.31	0.71
Tibia				
1.	Max. morph. lgt. R	22	372.55	19.91
2.	Max. morph. lgt. L	23	372.61	18.93
3.	Ant. post dia. nut. for. R	23	35.35	3.70
4.	Ant. post dia. nut. for. L	24	35.71	2.56
5.	Trans. dia. nut. for. R	23	23.17	2.48
6.	Trans. dia. nut. for. L	24	23.00	1.93
7.	Cir. midshaft R	22	84.77	7.45
8.	Cir. midshaft L	23	85.61	5.45
9.	Tibio-fem index R	22	83.96	2.29
10.	Tibio-fem index L	23	83.78	3.01
11.	Cnemic index R	23	66.12	5.40
12.	Cnemic index L	24	64.47	4.60

TABLE 18 (continued)

Measurement	No. of Cases	Mean	SD
Radius			
1. Max. lgt. R	17	247.41	11.41
2. Max. lgt. L	20	243.55	11.88
3. Humero-rad. index R	17	77.09	2.05
4. Humero-rad. index L	18	77.24	2.05
Ulna			
1. Max. lgt. R	17	263.53	10.98
2. Max. lgt. L	16	261.19	9.12
Scapula			
1. Max. lgt. R	2	137.50	17.68
2. Max. lgt. L	3	143.33	14.01
3. Max. brdth. R	8	100.50	5.35
4. Max. brdth. L	7	101.86	3.98
5. Scap. index R	2	74.6	6.51
6. Scap. index L	3	69.74	3.23
Innominate			
1. Isch. tub-iliac crest R	19	205.16	10.51
2. Isch. tub-iliac crest L	18	207.74	9.59
3. ASP-PSP R	19	147.05	9.90
4. ASP-PSP L	19	148.58	7.40
Sacrum			
1. Max. lgt.	15	108.53	6.85
2. Max. brdth.	17	118.82	7.21

TABLE 18 (continued)

Measurement	No. of Cases	Mean	SD
Fibula			
1. Max. lgt. R	11	338.91	34.05
2. Max. lgt. L	7	334.57	43.17

TABLE 19

CRANIAL MEASUREMENTS (mm) OF KAUFMAN-WILLIAMS FEMALES

	Measurement	No. of Cases	Mean	SD
1.	Maximum lgt.	26	167.38	4.40
2.	Maximum brdth.	26	136.38	4.63
3.	Basion-bregma	23	132.00	4.93
4.	Endobasion-nasion	23	97.87	2.90
5.	Endobasion-alv. pt.	21	98.48	5.35
6.	Min. front. brdth.	26	89.62	3.19
7.	Bizygomatic	23	128.30	4.35
8.	Nasion. alv. pt.	22	68.00	4.44
9.	Ext. alv. lgt.	21	54.24	3.67
10.	Ext. alv. brdth.	21	63.05	3.58
11.	Nasal ht.	22	49.14	2.83
12.	Nasal brdth.	22	26.32	2.21
13.	Biorbital brdth.	20	95.25	2.47
14.	Ba-po ht.	23	20.65	2.25
15.	Auricular ht.	23	115.48	4.88
16.	Endob.-gn.	22	104.86	4.02
17.	Na.-gnathion	23	108.74	6.50
18.	L. orbital ht.	23	35.22	2.09
19.	L. orbital brdth.	23	41.13	2.05
20.	Nasal root ht.	21	16.38	1.88
21.	Min. na. brdth.	22	9.95	1.50
22.	Porion-nasion	26	86.23	3.27
23.	Porion-subnasale	22	91.05	3.70
24.	Porion-prosthion	22	97.95	3.96
25.	Porion-gnathion	23	109.00	3.92
26.	Symphysis ht.	26	32.65	3.01
27.	Diam. bigonial	26	93.54	4.55
28.	Diam. bicondylar	22	116.45	5.33

TABLE 19 (continued)

	Measurement	No. of Cases	Mean	SD
29.	Ht. Ascen.-ramus	27	52.44	4.35
30.	Corpal lgt. go.-gn.	27	87.48	3.20
Indices				
	Cranial index	26	81.93	4.66
	Cranial module	23	145.41	3.14
	Mean ht. index	23	86.78	2.79
	Length ht. index	23	78.84	3.02
	Brdth. ht. index	23	96.58	3.52
	Fronto-parietal	25	65.92	2.95
	Upper facial index	22	53.09	3.79
	Total facial index	23	84.85	5.86
	Nasal index	22	53.66	4.95
	Orbital index	23	85.64	7.43
	Palatal index	21	116.52	8.75
	Flatness crabase	23	15.63	1.52

TABLE 20

POSTCRANIAL MEASUREMENTS (mm) OF KAUFMAN-WILLIAMS FEMALES

Measurement	No. of Cases	Means	SD
Humerus			
1. Max. morph. lgt. R	24	293.17	14.49
2. Max. morph. lgt. L	23	290.52	12.66
3. Max. dia. midshaft R	24	19.83	1.58
4. Max. dia. midshaft L	23	19.30	1.43
5. Min. dia. midshaft R	24	14.17	1.13
6. Min. dia. midshaft L	23	14.26	0.96
7. Circumference R	24	57.71	4.18
8. Circumference L	23	56.48	3.93
9. Max. dia. head R	23	38.04	1.75
10. Max. dia. head L	23	38.30	1.49
11. Humero-femoral index R	23	71.09	1.82
12. Humero-femoral index L	20	70.06	1.58
Clavicle			
1. Max. lgt. R	14	132.86	8.41
2. Max. lgt. L	16	132.44	7.04
3. Claviculo-humeral index R	13	45.22	2.33
4. Claviculo-humeral index L	13	45.12	2.02
Femur			
1. Max. morph. lgt. R	25	411.76	15.64
2. Max. morph. lgt. L	24	413.92	15.51
3. Phys. lgt. R	25	408.24	15.43
4. Phys. lgt. L	24	411.04	15.43
5. Ant. post diam. midshaft R	25	25.84	2.36
6. Ant. post diam. midshaft L	24	25.79	2.60

TABLE 20 (continued)

Measurement	No. of Cases	Means	SD
Femur (continued)			
7. Transverse diam. midshaft R	25	23.36	1.63
8. Transverse diam. midshaft L	24	23.54	1.38
9. Cir. midshaft R	25	78.36	6.22
10. Cir. midshaft L	24	78.92	5.74
11. Max. dia. head R	25	40.40	1.87
12. Max. dia. head L	24	40.46	1.93
13. Pilastric index R	25	110.88	9.85
14. Pilastric index L	24	109.62	11.44
15. Index of robust. R	25	12.04	0.65
16. Index of robust. L	24	12.01	0.62
Tibia			
1. Max. morph. lgt. R	21	343.19	13.92
2. Max. morph. lgt. L	25	345.32	14.49
3. Ant. post dia. nut. for R	21	31.14	2.01
4. Ant. post dia. nut. for L	25	30.96	2.20
5. Trans. dia. nut. for R	21	20.90	2.02
6. Trans. dia. nut. for L	25	20.56	1.96
7. Cir. midshaft R	21	76.29	5.90
8. Cir. midshaft L	25	76.04	4.88
9. Tibio-fem. index R	21	83.31	1.62
10. Tibio-fem. index L	22	83.26	2.21
11. Cnemic index R	21	67.13	4.74
12. Cnemic index L	25	66.60	4.89
Radius			
1. Max. lgt. R	20	223.85	8.05
2. Max. lgt. L	19	219.89	6.50
3. Humero-rad. index R	19	76.25	2.22
4. Humero-rad. index L	17	76.51	2.18

TABLE 20 (continued)

Measurement	No. of Cases	Means	SD
Ulna			
1. Max. lgt. R	17	244.94	12.28
2. Max. lgt. L	16	241.38	8.78
Scapula			
1. Max. lgt. R	1	133.00	0.00
2. Max. lgt. L	2	127.50	3.54
3. Max. brdt. R	4	90.75	4.86
4. Max. brdt. L	3	90.33	2.52
5. Scap. index R	--	--	--
6. Scap. index L	1	70.40	--
Innominate			
1. Isch. tub-iliac crest R	18	194.78	9.80
2. Isch. tub-iliac crest L	18	194.11	10.18
3. ASP-PSP R	19	143.53	7.40
4. ASP-PSP L	19	142.79	6.15
Sacrum			
1. Max. lgt.	11	105.82	7.14
2. Max. brdth.	13	115.62	4.50
Fibula			
1. Max. lgt. R	9	329.78	19.35
2. Max. lgt. L	10	327.40	11.45

TABLE 21

COMPARISON OF LONG BONE LENGTHS (mm.) AND INDICES OF VARIOUS GROUPS IN THE CADDOAN LINGUISTIC FAMILY

Bone	Sex	Kaufman-Williams	Kaufman Portion Kaufman-Williams Site	Cooper Lake	East Fork Trinity River	Leavenworth
Humerus	M	317.23 (22)	323.2 (4)	337.6 (7)	328.5 (4)	321.28 (18)
	F	290.52 (23)	297.6 (5)	307.8 (5)	301.0 (1)	300.68 (19)
Ulna	M	261.19 (16)	254.0 (1)	274.4 (5)	283.0 (3)	269.50 (12)
	F	241.38 (16)	251.4 (5)	257.3 (3)	235.0 (1)	250.78 (9)
Radius	M	243.55 (20)	244.0 (2)	267.3 (8)	261.3 (4)	255.62 (13)
	F	219.89 (19)	234.5 (4)	247.2 (5)	259.0 (1)	229.75 (12)
Femur	M	448.13 (23)	441.5 (2)	478.7 (7)	460.3 (4)	449.60 (25)
	F	413.92 (24)	419.9 (10)	447.4 (5)	446.0 (2)	418.63 (19)

TABLE 21 (continued)

Bone	Sex	Kaufman-Williams	Kaufman Portion Kaufman-Williams Site	Cooper Lake	East Fork Trinity River	Leavenworth
Tibia	M	372.61 (23)	360.0 (1)	414.3 (6)	387.0 (3)	384.50 (24)
	F	345.32 (25)	353.6 (8)	367.4 (4)	377.0 (2)	352.54 (13)
Fibula	M	334.57 (7)	372.0 (1)	384.0 (1)	340.6 (3)	379.93 (14)
	F	327.40 (10)	340.3 (3)	352.3 (3)	360.0 (1)	346.89 (9)
Humero-radial Index	M	77.09	75.50	79.18	79.54	79.60
	F	76.51	78.80	80.31	86.05	76.40
Tibio-femoral Index	M	83.78	81.54	86.55	84.08	85.50
	F	83.26	84.21	82.12	84.53	84.20

slightly shorter in most cases than in the other populations. The Humero-radial Index and the Tibio-femoral Index in the Kaufman-Williams males is midway between those of the other populations surveyed. The indices for the Kaufman-Williams females are slightly lower when compared with the other populations.

Stature estimates for the above-mentioned populations were obtained using the formulae of Trotter and Gleser (1952, 1958) for White females and Mongoloid males respectively, and of Neumann and Waldman (1968) for American Indians. The stature estimates are presented in Table 22. The femur was used in calculating all estimates since the upper limb bones do not produce estimates as reliable as the lower limb bones. The tibia was not used since different formulae require that the bone be measured in different ways.

The estimates obtained from Trotter and Gleser's and Neumann and Waldman's formulae differed by as little as 0.31 cm. in the Kaufman males to as much as 3.48 cm. in the Cooper Lake males. The two female estimates differed by 1.52 cm. in the sample from the East Fork of the Trinity River and by 2.56 cm. in the sample from the Kaufman-Williams site. The females produced a more heterogeneous set of estimates in spite of the fact that the Trotter and Gleser formula used was designed for White females.

There is little historical reference to the stature of the Caddo Indians. Scurlock (1965) reported that Mooney who visited the amalgamated Caddo in Oklahoma in the nineteenth century recorded that the Caddo were smaller and darker than the neighboring

TABLE 22

STATURE ESTIMATES OF VARIOUS POPULATIONS IN THE CADDOAN LINGUISTIC FAMILY

Formula	Kaufman-Williams	Kaufman Portion Kaufman-Williams Site	Cooper Lake	East Fork Trinity River	Leavenworth
Males					
Trotter and Gleser (1958)	168.91±3.80 cm. 66.50±1.5 in.	167.49±3.80 cm. 65.94±1.5 in.	175.49±3.80 cm. 69.09±1.5 in.	171.53±3.80 cm. 67.53±1.5 in.	169.23±3.80 cm. 66.60±1.5 in
Neumann and Waldman (1967)	168.55 cm. 66.36 in.	167.80 cm. 66.06 in.	172.01 cm. 67.72 in.	169.93 cm. 66.90 in.	168.71 cm. 66.42 in.
Females					
Trotter and Gleser (1952)	156.33±3.72 cm. 61.55±1.46 in.	157.82±3.72 cm. 62.13±1.46 in.	164.61±3.72 cm. 64.81±1.46 in.	164.26±3.72 cm. 64.67± 1.46 in.	157.49±3.72 cm. 62.00±1.46 in.
Neumann and Waldman (1967)	158.89 cm. 62.56 in.	159.61 cm. 62.84 in.	162.91 cm. 64.14 in.	162.74 cm. 64.07 in.	159.45 cm. 62.8 in.

tribes. However, no measurements were given that could be used as a comparison with the estimated stature presented here. Therefore, it was very difficult to evaluate which formulae did in fact provide the best stature estimate. Since the Trotter and Gleser formula for females was developed on a White sample rather than an American Indian sample, it is possible that the Neumann and Waldman formula provides the best estimate for the females.

As a measure of the amount of sexual dimorphism occurring in each of the sample populations, the difference in femur length between males and females was determined. Femur length was chosen to represent sexual dimorphism since Trotter and Gleser (1952) found the femur to be best suited for stature reconstruction. One additional Arikara population was included in the analysis of sexual dimorphism. The Sully site which is located on the east bank of the Missouri River about 20 miles north of Pierre, South Dakota, was included because it was inhabited just slightly later than the Kaufman-Williams site. The burials at the Sully site contained a minimum quantity of trade goods and have been assigned to the early contact period (1700-1750 A.D.) (Jantz 1972). The measurements used in this study were taken by Bass who kindly consented to loan his data. The mean left femur length for males was 442.81 mm. (sample size 32) and for females was 406.94 (sample size 18). The method used to calculate sexual dimorphism was discussed in Chapter 3, and the results are presented in Table 23.

TABLE 23

DIFFERENCE BETWEEN FEMUR LENGTHS OF MALES AND FEMALES
(Male-Female)

Site	Difference	Percent of Male Mean
Kaufman-Williams	34.21	7.63
Kaufman Portion Kaufman-Williams Site (1000-1500 A.D.)	21.60	4.89
Cooper Lake (1200-1400 A.D.)	31.30	6.54
East Fork Trinity River (900-1600 A.D.)	14.30	3.11
Leavenworth (1803-1830 A.D.)	30.97	6.89
Sully (1700-1750 A.D.)	35.87	8.10

Sexual dimorphism has been investigated by several researchers including Tobias (1972), Greulich (1951, 1957, 1958), and Dreizen et al. (1953, 1964). Tobias (1972) found that Bushman stature sexual dimorphism increased through time. He attributed the difference to an improved diet in which males were able to achieve more of their genetic potential. Greulich (1951), in support of Tobias' reasoning, found that even though the growth of school children of both sexes in Guam was slowed after World War II as a result of malnutrition, males suffered more extreme growth retardation. Similarly, Japanese males made more spectacular growth gains than females when environmental conditions were improved (Greulich 1957, 1958). Dreizen et al. (1953, 1964) also noted more severe retardation in males under nutritive stress. These studies suggest that males suffer more profound effects from stress than do females.

The Caddo from Kaufman-Williams were the second most dimorphic of the populations considered; however, the small sample sizes found in the Butler (1969), Westbury (1978), and Navey (1975) reports have perhaps distorted the findings in these samples. The amount of dimorphism found in the Kaufman samples (Butler 1969) and the Kaufman-Williams sample is interesting. The Kaufman portion of the site was occupied from the eleventh century to possibly as late as 1500 A.D. (Skinner et al. 1969). Therefore, the difference may represent a temporal trend toward greater dimorphism or the difference may be an artifact of small sample size. Both the Cooper Lake material (Westbury 1978) and the East Fork of the Trinity River sample (Navey 1975) date from a period prior to the Caddo occupation of the Williams portion of the Kaufman-Williams site. (The skeletal material from the Cooper Lake area is dated from 1200 to 1400 A.D.; the skeletal collection comprising the Trinity River sample is dated from 900 to 1600 A.D.) Therefore, a temporal trend may again be in evidence when these two samples are compared with the Kaufman-Williams sample or the difference may be due to small sample size.

The Sully site exhibited the greatest amount of sexual dimorphism while the Leavenworth site which was occupied later was somewhat less dimorphic than the Kaufman-Williams sample. The Arikara populations had a decrease in sexual dimorphism during the period between 1700-1750 A.D. and 1803-1830 A.D. Since both the Kaufman-Williams site and the Sully site were occupied during the late protohistoric to early historic period, it is possible that the amount of sexual dimorphism noted reflects a period of maximum well being for these populations prior to the cultural disintegration which accompanied extensive white contact.

Determination of Measurements Affected by Deformation

Three methods were used to ascertain which measurements were most affected by deformation. The first of these entailed comparison of each of the variables between the deformation classes. Second, a Pearson Correlation Coefficient was calculated between each of the craniofacial variables and the two deformation ratios. Finally, multiple linear regression analysis was used to delineate affected measurements. The results of each of these analyses are discussed below.

Comparison of variables between deformation classes. Due to the fact that the clustering of the skulls into three deformation classes produced such small sample sizes in two cases, it was decided that two deformation classes--moderate (M) and extreme (E)--would be more desirable for statistical purposes. Therefore, the skulls were reclassified using the cluster analysis procedures outlined in Chapter 3. Table 24 presents the burials included in

TABLE 24

CLASSIFICATION OF MALES AND FEMALES INTO TWO DEFORMATION GROUPS

Males		Females	
Moderate Burial No.	Extreme Burial No.	Moderate Burial No.	Extreme Burial No.
2	1	10	8
4	5	13	19
11	6	24	22
28	7	39	31
52	20	40	32
58	26	41	35
59	30	44	42
	45	51	43
	46	71	48
	47		67
	60		68
	61		72
	62		73
	66		
	70		

each of these classes; the cluster groups based upon two deformation ratios are shown in Figure 8, page 113. The analyses discussed in the remainder of this chapter and in the following chapter are based upon this grouping of the burials.

Since the Arikara data used for comparative purposes in this study consisted of 15 craniofacial measurements, the analysis of which measurements were affected by deformation was limited to those measurements. Table 25 contains a summary of the deformation cluster means of the 15 measurements along with a t-value for statistical comparison.

Among the males five measurements appeared to be most significantly affected by deformation: (a) maximum breadth; (b) minimum frontal breadth, (c) bizygomatic breadth, (d) external alveolar breadth, and (e) biorbital breadth. Only maximum breadth seemed to be significantly affected among the females. However, except for external alveolar breadth the direction of the measurement (larger or smaller) was the same in both sexes for all of the significant measurements.

Minimum frontal breadth was wider in the moderately deformed group than in the extremely deformed group; yet the other measurements of breadth were wider in the extremely deformed group. Perhaps this is due to constraints applied to the frontal bone during the deformation process. Several skulls showed evidence of pressure on both sides of the frontal which could have limited breadth growth there.

TABLE 25

COMPARISON OF MEANS OF 15 CRANIOFACIAL MEASUREMENTS BETWEEN MODERATE AND EXTREME DEFORMATION CLASSES

Measurement	Deformation Class	No. of Cases	Mean	SD	t-value
Males					
1. Max. lgt.	M	7	173.71	6.95	0.14
	E	15	173.40	4.03	
2. Max. brdth.	M	7	137.71	4.11	-2.03*
	E	15	142.73	5.86	
3. Bas.-breg.	M	7	137.00	5.60	-0.12
	E	15	137.33	6.37	
4. Endo.-nas.	M	7	101.71	5.88	-0.34
	E	15	102.53	5.03	
5. Endo.-alv. pt.	M	7	98.57	7.87	-1.38
	E	14	103.07	6.59	
6. Min. front. brdth.	M	6	96.17	2.99	2.33*
	E	15	91.47	4.52	
7. Bizygomatic brdth.	M	5	128.60	7.30	-2.82**
	E	14	137.43	5.54	
8. Nas.-alv. pt.	M	7	71.57	5.35	0.64
	E	14	70.14	4.55	
9. Ext. alv. lgt.	M	7	55.43	3.91	0.13
	E	14	55.14	5.17	
10. Ext. alv. brdth.	M	7	63.71	2.87	-1.97*
	E	14	67.43	4.52	
11. Nasal ht.	M	7	52.00	3.22	0.48
	E	14	51.29	3.20	
12. Nasal brdth.	M	7	25.00	2.24	-0.83
	E	14	25.79	1.97	
13. Biorbital brdth.	M	6	96.17	5.08	-2.08*
	E	14	100.07	3.25	
14. Ba.-po.ht.	M	7	23.43	3.31	-0.20
	E	14	23.79	4.17	

TABLE 25 (continued)

Measurement	Deformation Class	No. of Cases	Mean	SD	t-value
15. Aur. ht.	M	7	117.29	5.02	-0.70
	E	15	118.87	4.88	
Females					
1. Max. lgt.	M	9	168.22	3.93	0.63
	E	13	167.15	3.93	
2. Max. brdth.	M	9	134.56	4.19	-2.37*
	E	13	138.62	3.78	
3. Bas.-breg.	M	9	131.00	5.52	0.77
	E	13	132.69	4.79	
4. Endo.-nas.	M	9	97.33	2.12	0.37
	E	13	97.77	3.00	
5. Endo.-alv. pt.	M	8	98.63	4.90	0.36
	E	12	97.75	5.58	
6. Min. front brdth.	M	9	90.44	2.88	0.73
	E	13	89.38	3.62	
7. Bizygomatic brdth.	M	8	127.75	3.77	-0.17
	E	13	128.08	4.61	
8. Na.-alv. pt.	M	8	66.63	4.53	-0.84
	E	12	68.33	4.44	
9. Ext. alv. lgt.	M	8	54.00	4.54	-0.10
	E	11	54.18	3.49	
10. Ext. Alv. brdth.	M	8	63.50	4.11	0.39
	E	11	62.82	3.52	
11. Nasal ht.	M	8	49.63	4.37	0.65
	E	12	48.58	1.51	
12. Nasal brdth.	M	8	26.50	2.67	0.77
	E	12	25.75	1.71	

TABLE 25 (continued)

Measurement	Deformation Class	No. of Cases	Mean	SD	t-value
13. Biorbital brdth.	M	8	94.38	2.83	-1.33
	E	11	95.91	2.21	
14. Ba.-Po. ht.	M	9	20.33	2.45	-0.50
	E	13	20.85	2.27	
15. Aur. ht.	M	8	113.50	5.61	-1.42
	E	13	116.69	4.59	

*Significant at 0.05.

**Significant at 0.01.

M - Moderate

E - Extreme

Correlation of variables with deformation ratios. Pearson Correlation Coefficients were calculated between each of the craniofacial variables and the two deformation ratios to further test for affected measurements. The results of this test are shown in Table 26.

It should be noted that a positive correlation coefficient indicates that as the index (FDR or ODR) increases (as the skulls assume a more normal shape) the measurements get larger. Thus, for example, minimum frontal breadth on the males got smaller as the skulls became more deformed; this result was also revealed by the previous test.

The measurements which seem to be significantly affected by deformation in the males according to this test are: (a) maximum breadth, (b) endobasion-alveolar point, (c) minimum frontal breadth, (d) bizygomatic breadth, and (3) alveolar breadth. Among the females, maximum breadth, nasal height, biorbital breadth, and auricular height appeared to be significantly affected by deformation. This correlation test was independent of the cluster analysis; that is, the clusters were not used as factors. Yet these correlation coefficients support the previous results on several measurements: (a) maximum breadth, (b) minimum frontal breadth, (c) bizygomatic breadth, (d) alveolar breadth, and (e) biorbital breadth. However, biorbital breadth was significantly related to deformation only among males in the first test and only among females in the correlation test. Three additional measurements were found to be significantly

TABLE 26

PEARSON CORRELATION COEFFICIENTS BETWEEN DEFORMATION RATIOS AND CRANIOFACIAL MEASUREMENTS

Measurement	Males FDR	Males ODR	Females FDR	Females ODR
1. Max. lgt.	-0.2167 (24)	0.3096 (22)	-0.3200 (26)	-0.0455 (22)
2. Max. brdth.	-0.3673* (24)	-0.6822* (22)	0.1581 (26)	-0.7133* (22)
3. Bas.-breg.	0.1972 (22)	0.0489 (22)	-0.3176 (23)	-0.2952 (22)
4. Endo.-nas.	-0.0677 (22)	0.0389 (22)	-0.3108 (23)	0.0197 (22)
5. Endo.-alv. pt.	-0.4024* (21)	-0.1583 (21)	-0.1580 (21)	0.0512 (20)
6. Min. front. brdth.	0.3937* (23)	0.2504 (21)	-0.0216 (26)	-0.0848 (22)
7. Bizygomatic brdth.	-0.5470* (20)	-0.5533* (19)	-0.2002 (23)	-0.0757 (21)
8. Nas.-alv. pt.	-0.1475 (22)	0.0930 (21)	-0.3038 (22)	0.0657 (20)
9. Ext. alv. lgt.	-0.1650 (22)	0.0293 (21)	-0.2590 (21)	-0.1047 (19)
10. Ext. alv. brdth.	-0.6286* (22)	0.2935 (21)	0.1866 (21)	0.0531 (19)
11. Nasal ht.	-0.1511 (22)	0.0118 (21)	0.1179 (22)	0.6577* (20)
12. Nasal brdth.	-0.1863 (22)	-0.0278 (21)	0.1009 (22)	0.0628 (20)

TABLE 26 (continued)

Measurement	Males FDR	Males ODR	Females FDR	Females ODR
13. Biorbital brdth.	-0.2949 (21)	0.1616 (20)	-0.4085* (20)	-0.0410 (19)
14. Ba.-po.-ht.	0.2949 (21)	0.0994 (21)	-0.2293 (23)	-0.2619 (22)
15. Aur. ht.	-0.2251 (22)	-0.1425 (22)	-0.3797* (23)	0.2950 (21)

*Significant at 0.05

correlated with deformation: (a) endobasion-alveolar point (in males), (b) nasal height (in females), and (c) auricular height (in females).

Multiple Regression Analysis. A third test used to provide information about which craniofacial measurements were affected by artificial cranial deformation was multiple linear regression. The strategy was to determine the extent of linear dependence of each of the basic 15 measurements on the two deformation variables FDR and ODR. The results of the regression analysis are given in Table 27.

The linear regression test revealed three of the same craniofacial measurements (maximum breadth, bizygomatic breadth, and external alveolar breadth) to be most highly dependent upon deformation among the males. Maximum length also appeared to be significantly affected by deformation.

The two measurements which seemed to be most affected by deformation among the females were maximum breadth and nasal height. Strangely, nasal height broke with the emerging pattern by not being directly related to the breadth of the skull.

Unreliable results can be obtained from linear regression when the independent variables used are highly correlated (Nie et al. 1975). The variables FDR and ODR have correlation coefficients of 0.5870 in the male sample and 0.5470 in the females, which, though large, do not appear large enough to cause problems.

TABLE 27

PERCENT OF VARIATION IN CRANIOFACIAL MEASUREMENTS DUE TO DEFORMATION AS DETERMINED BY MULTIPLE LINEAR REGRESSION

Measurement	Males %	F-value	Females %	F-value
1. Max. lgt.	33.8	4.85*	12.6	1.37
2. Max. brdth.	46.7	8.33**	93.7	142.75**
3. Bas.-breg.	4.6	0.46	12.2	1.32
4. Endo.-nas.	1.4	0.14	14.8	1.65
5. Endo.-alv. pt.	17.1	1.86	5.2	0.47
6. Min. front. brdth.	15.6	1.66	0.8	0.08
7. Bizygomatic brdth.	38.1	4.93*	4.2	0.39
8. Na.-alv. pt.	7.1	0.69	16.9	1.73
9. Ext. alv. lgt.	5.2	0.49	6.9	0.59
10. Ext. alv. brdth.	40.4	6.10**	3.8	0.32
11. Nasal ht.	3.8	0.36	52.6	9.06**
12. Nasal brdth.	4.5	0.42	1.0	0.00
13. Biorbital brdth.	8.7	0.00	21.4	2.18
14. Ba.-po.ht.	9.5	0.95	7.9	0.82
15. Aur. ht.	5.1	0.00	15.5	1.65

*Significant at 0.05 level

**Significant at 0.01 level

$R^2 \times 100 = \%$

Summary of the three tests. Evidence that maximum breadth, bizygomatic breadth, and external alveolar breadth were deformation dependent was gathered in each of the three tests; thus, it seems safe to conclude that these breadth measurements were all changed by artificial cranial deformation as practiced by the Caddo. Each of the three tests produced evidence that maximum breadth was closely related to deformation; in fact, maximum breadth was identified in both males and females in each of the tests. It stands alone as the most affected measurement.

On the other hand, basion-bregma, endobasion-nasion, nasion-alveolar point, external alveolar length, nasal breadth, and basion-porion height showed little evidence of being deformation related.

There was evidence that maximum length, endobasion-alveolar point, minimum frontal breadth, nasal height, biorbital breadth, and auricular height were affected by deformation. However, none of these appeared significantly in all three tests nor did any one of them appear in both sexes in a single test. Conclusions were difficult to draw concerning these six measurements.

Comparison with other studies. Several researchers have made attempts to determine the effect of deformation upon craniofacial measurements. Giles and Bleibtreu (1963) noted that cranial length, breadth, and height were affected by deformation while facial measurements were not. Their study involved a series of crania from the southwest. They did not discuss the type of deformation occurring on the skulls used in their study. However, Neumann (1942) mentioned lambdoid deformation in connection with the Indians from Chaco Canyon, and Rogers (1975) attributed most of the deformation in the southwest to unintentional deformation of the occipital bone. Leigh (1937:272) noted that in some skulls with extreme occipital flattening there was a broadening effect on the posterior part of the mandible. Leigh (1937) also noted that extreme fronto-occipital deformation definitely influenced palate form. Rogers (1975) used several indices in his study of fronto-occipital and annular deformation from the southwest and Peru. He concluded that no significant changes in the facial structure resulted from the degree of deformation typical of the Pueblo populations. Similarly, the Peruvian skulls deformed in the fronto-occipital manner were not significantly different from undeformed crania. There were marked differences with regard to four indices in the Peruvian annular deformed series, however. The differences were as follows: (1) Internal Palatal Index was larger in the deformed specimens which indicated a wide palate in relation to length, (2) Mean Orbital Index increased in the deformed group which suggested more rounded orbits, (3) Upper Facial Index increased in the deformed series which indicated a widening of the face in comparison to height, and (4) Gnathic Index increased in the deformed crania which suggested a protrusion of the lower portion of the face with reference to a vertical facial plane.

Measurements Selected for Population Distance Study

It was clear from the previous analyses that maximum breadth, bizygomatic breadth, and external alveolar breadth should not be entered as variables used to measure the biological distance of the Kaufman-Williams group from other Amerindians. On the other hand, basion-bregma, endobasion-nasion, nasion-alveolar point, external alveolar length, nasal breadth, and basion-porion height seemed to be independent of cranial deformation. Decisions on the remaining six measurements were difficult. However, some of the comparative data by Maples (1962) and Westbury (1978) did not include data on nasal breadth, basion-porion height, and auricular height; hence these were automatically discarded. Also discarded, though mostly on intuitive grounds, were maximum length and nasal height. Nasal height decreased in both sexes going from the moderate to extreme classes and appeared somewhat affected by deformation in females in the last two tests.

Two breadth measurements, minimum frontal breadth and biorbital breadth, were retained mainly because of the desire to have some breadth variables entered into the distance formula. Minimum frontal breadth showed a relation to deformation only in the males in two of the three tests. The biorbital breadth variable appeared moderately related to deformation in two tests though only in one sex each time.

In conclusion, the following seven measurements were retained for the Penrose distance calculation: (a) basion-bregma,

(b) endobasion-nasion, (c) endobasion-alveolar point, (d) minimum frontal breadth, (e) nasion-alveolar point, (f) external alveolar length and (g) biorbital breadth.

Penrose Size and Shape Biological Distance Study

The means for the males and females for the seven measurements in the six populations for which a pairwise distance was computed are summarized in Table 28. The common standard deviation for each character is given in the second column of Table 28; they were calculated as described in Chapter 3. Surprisingly large distance coefficients resulted between the Sanders sample and each of the other five sites among the males and between the Fulton group and each of the other five female groups. Because of the large distance coefficients which resulted from these two groups they have been deleted in the matrix presentation of the pairwise Penrose Size and Shape Coefficient shown in Table 29.

From data supplied by Rao, Penrose calculated his coefficient in 20 Indian populations using 8 characters. These 190 coefficients averaged 4.01 (Penrose 1954). The average for the males from Table 29 is 2.743 (SD = 1.259) while for females the mean is 2.721 (SD = 1.900). Although the eight characters measured by Rao were not the same as the seven used in this study, it is comforting to know that the coefficients are in the same range.

Generally speaking the Cooper material appears morphologically more distant from the other populations; although in the females

TABLE 28

MEANS AND COMMON STANDARD DEVIATIONS FOR SEVEN MEASUREMENTS (Male Values at Top and Female Values at Bottom)

Measurement	Common Standard Deviation	Kaufman-Williams	Fulton	Sanders	Saint Helena	Arikara	Cooper
3. Bas.-breg.	4.858	137.23	141.30	151.00	136.86	134.34	140.30
		(22)	(2)	(1)	(21)	(32)	(3)
	4.799	132.00	129.00	131.00	130.23	129.41	132.30
		(23)	(1)	(1)	(13)	(34)	(3)
4. Endo.-nas.	4.900	102.27	104.30	104.00	103.76	104.06	104.60
		(22)	(8)	(8)	(21)	(32)	(3)
	3.590	97.87	100.00	99.20	96.46	99.41	101.70
		(23)	(1)	(12)	(13)	(34)	(2)
5. Endo.-alv. pt.	5.776	101.57	101.80	104.80	101.29	100.91	101.20
		(21)	(4)	(5)	(21)	(32)	(3)
	4.612	98.48	82.00	98.50	98.62	97.68	98.50
		(21)	(1)	(11)	(13)	(34)	(2)
6. Min. front. brdth.	4.139	92.87	95.40	92.50	95.40	93.63	93.50
		(23)	(13)	(13)	(20)	(32)	(5)
	4.183	89.62	92.30	86.60	92.69	91.24	87.40
		(26)	(17)	(17)	(13)	(34)	(3)
8. Nas.-alv. pt.	3.878	70.68	75.00	75.20	74.62	73.91	71.50
		(22)	(3)	(9)	(21)	(32)	(2)
	4.104	68.00	77.00	70.68	68.00	70.59	71.00
		(22)	(1)	(14)	(13)	(34)	(1)

TABLE 28 (continued)

Measurement	Common Standard Deviation	Kaufman-Williams	Fulton	Sanders	Saint Helena	Arikara	Cooper
9. Ext. alv. lgt.	3.867	55.41 (22)	53.20 (6)	55.80 (10)	55.75 (20)	55.31 (32)	57.50 (2)
	2.803	54.24 (21)	55.00 (3)	53.80 (13)	52.92 (12)	53.03 (34)	54.80 (2)
13. Biorbital brdth.	3.582	98.86 (21)	101.70 (3)	102.90 (10)	101.58 (19)	99.59 (32)	104.50 (2)
	3.125	95.25 (20)	97.00 (2)	95.50 (13)	97.00 (13)	95.29 (34)	94.00 (1)

TABLE 29

PENROSE SIZE AND SHAPE DISTANCE BETWEEN SAMPLE PAIRS

	Males				
	Kaufman-Williams	Fulton	Saint Helena	Arikara	Cooper
Kaufman-Williams	0.000				
Fulton	3.207	0.000			
Saint Helena	1.828	1.729	0.000		
Arikara	1.549	3.278	0.650	0.000	
Cooper	3.127	4.166	3.227	4.664	0.000

	Females				
	Kaufman-Williams	Sanders	Saint Helena	Arikara	Cooper
Kaufman-Williams	0.000				
Sanders	1.546	0.000			
Saint Helena	1.761	4.546	0.000		
Arikara	1.589	1.876	2.037	0.000	
Cooper	2.626	1.087	7.379	2.766	0.000

Cooper and Sanders are close. In the male samples, the Kaufman-Williams collection differs most from the Fulton and Cooper; among the females, the Kaufman-Williams and Cooper distance is also large.

The coefficient seems to place the Kaufman-Williams, Arikara, and Saint Helena morphologically close, but it is difficult to judge since the distance coefficient has no direction.

The breakdown of the Penrose coefficient into its size and shape components is given in Table 30. The main contributor to the total coefficient in every case is the shape component; the size component of the total distance is negligible.

The Penrose Size and Shape Distance shown in Table 30 is plotted on principal coordinates in Figures 11 (males) and 12 (females). The reduction to two principal components provides a fairly accurate two-dimensional picture of the intergroup distances because together these two components account for 82.4% and 91.8% of the variance in the original distances in males and females, respectively.

The most notable aspect of the principal coordinate plots is the relatively large distance of the Cooper sample from all the others, especially in the male group.

Generally speaking, the distance analysis neither supports nor denies the hypothesized common ancestor of the Arikara and Caddo. Theoretically the Arikara evolved from this common ancestor through the Saint Helena group while the Kaufman-Williams population evolved through a population similar to the Cooper and Sanders. However, the arrows drawn through the graphs in Figures 11 and 12 from Cooper or Sanders to Kaufman-Williams and from Saint Helena to Arikara do not extrapolate to a common beginning. This is particularly true in

TABLE 30

BREAKDOWN OF PENROSE COEFFICIENT INTO SIZE AND SHAPE COMPONENTS
(Size, Shape)

	Males				
	Kaufman-Williams	Fulton	Saint Helena	Arikara	Cooper
Kaufman-Williams	0.000				
Fulton	0.654, 2.554	0.000			
Saint Helena	0.428, 1.400	0.024, 1.706	0.000		
Arikara	0.044, 1.505	0.359, 2.919	0.198, 0.452	0.000	
Cooper	0.654, 2.473	0.000, 4.166	0.024, 3.203	0.359, 4.305	0.000

	Females				
	Kaufman-Williams	Sanders	Saint Helena	Arikara	Cooper
Kaufman-Williams	0.000				
Sanders	0.000, 1.546	0.000			
Saint Helena	0.001, 1.760	0.000, 4.545	0.000		
Arikara	0.005, 1.583	0.004, 1.873	0.003, 2.035	0.000	
Cooper	0.078, 2.548	0.071, 1.016	0.066, 7.313	0.042, 2.723	0.000

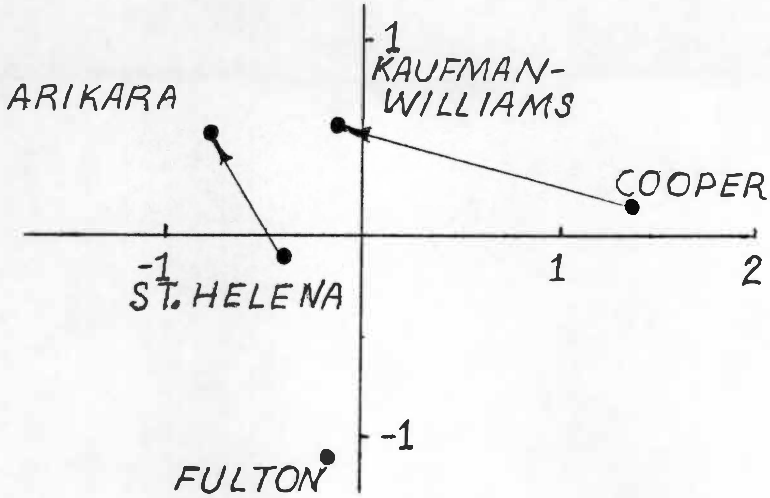


Figure 11. Male Distances Represented on the First Two Principal Coordinates.

The horizontal axis explains 47.8% of the intersample variation; the vertical axis explains 34.6%.

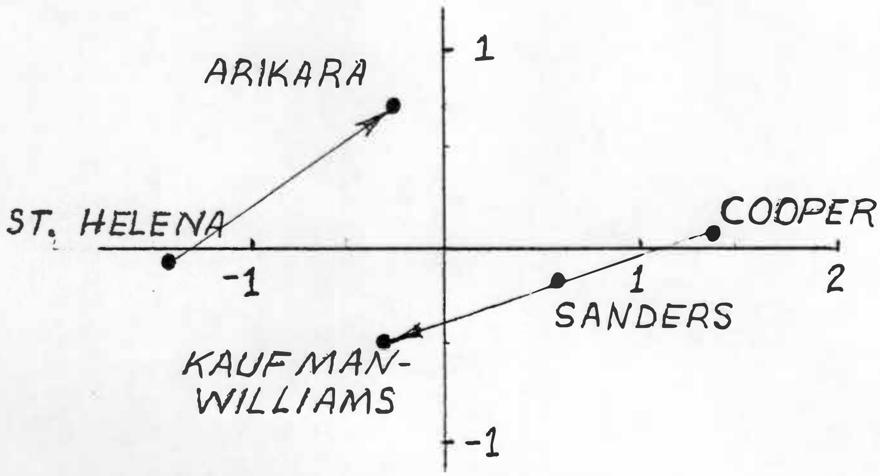


Figure 12. Female Distances Represented on the First Two Principal Coordinates.

The horizontal axis explains 76.7% of the intersample variation; the vertical axis explains 15.1%.

the female group where the lines are almost oppositely directed. The small sample sizes and variability in sample size from one measurement to another in the Sanders, Fulton, and Cooper samples have probably distorted the findings.

If the Cooper, Fulton, and Sanders groups are ignored, the first principal coordinate places the male populations in the expected order, Saint Helena between the Kaufman-Williams and the Arikara. The first principal coordinate in the females placed the Arikara and Kaufman-Williams together with Saint Helena removed.

CHAPTER 7

ANALYSIS OF THE NON-METRICAL DATA

The analysis of the non-metrical data was concerned with interpopulation variability since comparative information was not available for the populations used in the metrical analysis. Several of the traits which were observed did not occur at all in the Kaufman-Williams population; therefore, these traits have been dropped from further consideration and do not appear in the tables. Two variants of the arrangement of the sutures in the pterion region were not observed. These were: (a) K and (b) frontotemporal articulation. None of the individuals studied had a metopic suture or a bregmatic bone. Only one occurrence of a double condylar facet and one Inca bone were observed.

Discrete trait differences were analyzed in three ways: (a) sex differences, (b) bilateral differences, and (c) deformation class differences. The data are presented in each table in terms of total number of occurrences for a particular trait followed by the total number of observations made. This ratio then appears in percent form. Some variation occurred in the number scored because of the impossibility of observing particular traits due to breakage or suture obliteration.

Sex Differences in Non-metrical Traits

Table 31 presents the sex differences which occurred among the non-metric traits. Even though there are evident differences in trait frequencies, these differences did not prove statistically significant under a chi-square test using a 0.05 level of significance.

This disagrees with the findings of Sublette (1966), Corruccini (1974) and Jantz (1970) who found several discrete traits which showed significant sex differences. However, Carpenter (1976) found nonsignificant differences between the sexes. Berry and Berry (1967) also found no significant sex difference in the frequency of discrete traits; however, they tested the average differences between males and females rather than making a trait by trait comparison.

One factor is perhaps worth noting. Corruccini (1976:289) stated that skulls ". . . with ossicles at lambda and asterion (are) uniformly larger than the skulls without extra ossicles." Both of these traits were found more frequently in male skulls which are presumed to generally be somewhat larger than female skulls.

Bilateral Incidence of Non-metrical Traits

The bilateral occurrence of the discrete traits is shown in Table 32. Again none of the observed differences were significant at the 0.05 level. Furthermore, no definite patterns emerged regarding the prevalence of a given trait on a particular side when the sexes were compared; quite often the highest incidence of a trait occurred

TABLE 31

SEX DIFFERENCES IN NON-METRICAL TRAITS

Trait	Males (26) No.	%	Females (28) No.	%
Supraorbital foramen or notch	46/47	97.87	53/55	96.36
Sutures into infraorbital foramen	14/44	31.82	15/45	33.33
Sutures in region of pterion				
wide H	19/52	36.54	25/56	44.64
narrow H	7/52	13.45	7/56	12.50
X	2/26	7.69	--	0.00
epiteric	4/52	7.69	7/56	12.50
Ossicle at lambda	7/24	29.17	5/27	18.52
Lambdoid ossicle	22/48	45.83	21/52	40.38
Ossicle at asterion	15/46	32.61	8/54	14.81
Parietal notch bone	6/44	13.64	8/52	15.38
Coronal ossicle	2/42	4.76	--	0.00
Parietal foramen	24/52	46.15	20/54	37.04
Sagittal ossicle	3/20	15.00	2/22	9.09
Dehisiences of tympanic	2/52	3.85	7/54	12.96
Mastoid foramen exsutural	6/52	11.54	3/51	5.88
Pharangeal fossa	4/22	18.18	--	0.00
Ear exostoses	4/52	7.69	2/54	3.70
Palatine torus	1/25	4.00	2/24	8.33
Mandibular torus	2/52	3.85	8/56	14.29
Mylohyoid bridge	2/52	3.85	2/56	3.57
Accessory mental foramen	1/26	3.85	1/28	3.57

TABLE 32

BILATERAL INCIDENCE OF NON-METRICAL TRAITS IN KAUFMAN-WILLIAMS POPULATION

	Males (26)				Females (28)				Subadults (9)			
Trait	R No.	%	L No.	%	R No.	%	L No.	%	R No.	%	L No.	%
Supraorbital foramen or notch	23/23	100.00	23/24	95.83	27/28	96.43	26/27	96.30	7/7	100.00	7/7	100.00
Sutures into infraorbital foramina	5/21	23.81	9/23	39.13	7/22	31.82	8/23	34.78	2/6	33.33	2/5	40.00
Sutures in region of pterion												
wide H	9/26	34.62	10/26	38.46	12/28	42.86	13/28	46.43	2/9	22.22	1/9	11.11
narrow H	5/26	19.23	2/26	7.69	3/28	10.71	4/28	14.29	1/9	11.11	--	0.00
X	--	0.00	2/26	7.69	--	0.00	--	0.00	--	0.00		0.00
epiteric	3/26	11.54	1/26	3.85	5/28	17.86	2/28	7.14	--	0.00	3/9	33.33
Ossicle at Lambda	7/24	29.17			5/27	19.00			3/7	42.86		
Inca bone	--	0.00			--	0.00			1/7	14.29		
Lambdoid ossicle	12/25	48.00	10/23	43.48	9/26	34.62	12/26	46.15	5/7	71.43	5/7	71.43
Ossicle at asterion	10/22	45.45	5/24	20.83	5/27	18.52	3/27	11.11	2/5	40.00	3/7	42.86
Parietal notch bone	2/22	9.09	4/22	18.18	4/26	15.38	4/26	15.38	1/6	16.67	2/6	33.33

TABLE 32 (continued)

	Males (26)				Females (28)				Subadults (9)			
Trait	R No.	%	L No.	%	R No.	%	L No.	%	R No.	%	L No.	%
Coronal ossicle	1/21	4.76	1/21	4.76	--	0.00	--	0.00	--	0.00	--	0.00
Parietal foramen	11/26	42.31	13/26	50.00	13/27	48.15	7/27	25.93	3/7	42.86	1/7	14.29
Sagittal ossicle	3/20	15.00			2/22	9.09			1/6	16.67		
Dehisiences of tympanic	1/26	3.85	1/26	3.85	4/27	14.81	3/27	11.11	4/7	57.14	6/7	85.71
Mastoid foramen exsutural	3/26	11.54	3/26	11.54	1/25	4.00	2.26	7.69	--	0.00	--	0.00
Pharangeal fossa	4/22	18.18			--	0.00			--	0.00		
Ear exostoses	2/26	7.69	2/26	7.69	1/27	3.70	1/27	3.70	--	0.00	--	0.00
Palatine torus	1/25	4.00			2/24	8.33			--	0.00		
Mandibular torus	1/26	3.85	1/26	3.85	4/28	14.29	4/28	14.29	--	0.00	--	0.00
Mylohyoid bridge	1/26	3.85	1/26	3.85	1/28	3.57	1/28	3.57	1/9	11.11	1/9	11.11
Accessory mental foramen	1/26	3.85	--	0.00	--	0.00	1/28	3.57	--	0.00	--	0.00

on one side in males and on the other side in the females. Of the discrete trait observations included in Table 32, a slight preference for the right side was displayed in males while there was a slight preference for the left side in females. These findings were contrary to those of Trinkaus (1978) who did find significant bilateral differences in his study.

Deformation Class Differences in Non-metrical Traits

The incidence of discrete traits in the two deformation classes is shown in Table 33. The chi-square test of significance once again suggested that none of the differences were significant at the 0.05 level. However, several trends were noted in both the male and female groups which suggest that deformation affected the frequency of non-metric traits to some degree. The following traits occurred more frequently in the moderately deformed group in both sexes: (a) supraorbital foramina, (b) sutures into infra-orbital foramina, (c) epiteric bone, (d) ossicle at asterion, (e) parietal notch bone, (f) pharangeal fossa, and (g) mylohyoid bridge. Conversely, several traits occurred in higher frequency among the extremely deformed males and females. These include: (a) wide H suture at pterion, (b) narrow H suture at pterion, (c) ossicle at lambda, (d) lambdoid ossicle, (e) dehisiences of the tympanic, (f) palatine torus, (g) mandibular torus, and (h) accessory mental foramina.

It seems unlikely that traits such as the mylohoid bridge or accessory mental foramina were affected by deformation. However,

TABLE 33

TRAIT FREQUENCY BY DEFORMATION CLASS

Trait	Males (22)				Females (22)			
	Moderate (7)		Extreme (15)		Moderate (9)		Extreme (13)	
	No.	%	No.	%	No.	%	No.	%
Supraorbital foramen or notch	14/14	100.00	28/30	93.33	18/18	100.00	23/26	88.46
Sutures into infraorbital foramen	4/14	28.57	8/30	26.67	8/18	44.44	5/26	19.23
Sutures in region of pterion								
wide H	5/14	35.71	13/30	43.33	8/18	44.44	14/26	53.85
narrow H	1/14	7.14	4/30	13.33	1/18	5.56	4/26	15.38
X	--	0.00	1/30	3.33	--	0.00	--	0.00
epiteric	1/14	7.14	2/30	6.67	3/18	16.67	4/26	15.38
Ossicle at lambda	1/7	14.29	7/15	46.67	1/9	11.11	3/13	23.08
Lambdoid ossicle	6/14	42.86	14/30	46.67	5/18	27.78	11/26	42.31
Ossicle at asterion	5/14	35.71	8/30	26.67	3/18	16.67	3/26	11.54
Parietal notch bone	2/14	14.29	4/30	13.33	4/18	22.22	3/26	11.54
Coronal ossicle	2/7	28.57	--	0.00	--	0.00	--	0.00
Parietal foramen	8/14	57.14	14/30	46.67	6/18	33.33	9/26	34.62

TABLE 33 (continued)

Trait	Males (22)				Females (22)			
	Moderate (7)		Extreme (15)		Moderate (9)		Extreme (13)	
	No.	%	No.	%	No.	%	No.	%
Sagittal ossicle	--	0-00	3/15	20.00	1/9	11.11	1/13	7.69
Dehisiences of tympanic	--	0.00	2/30	6.67	2/18	11.11	5/26	19.23
Mastoid foramen exsutural	1/14	7.14	5/30	16.67	1/18	5.56	--	0.00
Pharangeal fossa	3/7	42.86	1/15	6.67	1/9	11.11	--	0.00
Ear exostoses	--	0.00	2/30	6.67	--	0.00	--	0.00
Palatine torus	--	0.00	1/15	6.67	--	0.00	1/13	7.69
Mandibular torus	--	0.00	2/30	6.67	--	0.00	6/26	23.08
Mylohyoid bridge	1/14	7.14	--	0.00	2/18	11.11	--	0.00
Accessory mental foramina	--	0.00	1/30	3.33	--	0.00	1/26	3.85

several of the sutural bone variations probably do reflect the stresses of deformation. Dorsey (1897) reported that among Kwakiutl crania the frequency of wormian bones increased as the skull became more elongated through deformation. He also noted that deformation pressures created a disturbance in the normal time of closure of the sutures. In particular he noted the early closure of the coronal suture among the Kwakiutl. Even though no records were kept concerning suture obliteration the author feels that early closure was also prevalent among the Kaufman-Williams crania since it was often impossible to determine the type of suture arrangement at pterion even though the skulls were not broken.

Other researchers who have examined deformed crania have also noted high frequencies of wormian bones (Hooten 1930; Bennett 1965). On the other hand, Bass (1964) and Jantz (1970) working with essentially undeformed Arikara crania noted wormian bone frequencies in the range of 25-35%. Bennett (1965) studied the relationship between basi-occiput length and the presence of wormian bones. He noted that in most cases where wormian bones are present that some form of physical stress is also evident. He says,

> It can be produced by any number of factors which influence head shape in general, such as artificial deformation, basi-occiput length, or pathological conditions such as hydrocephaly. The variable expressivity of wormian bones, as well as their formation, appears to be due to the type and amount of stress placed on the lambdoid suture during late fetal and early post-natal periods of bone growth (Bennett 1965:259).

Thus, the higher frequency of occurrence of both the ossicle at lambda and lambdoid ossicles in the extremely deformed group is probably related to the stresses of deformation.

Summary

The discrete trait analysis based upon sex, bilateral, and deformation differences produced no significant differences in any of the traits when analyzed in any of the three ways. However, the increased frequency of lambdoid ossicles and the ossicle at lambda in the extremely deformed crania suggests that the stresses produced by deformation do affect the presence of wormian bones to some extent.

CHAPTER 8

SUMMARY AND CONCLUSIONS

The primary purpose of this study was to provide a detailed biological analysis of the skeletal remains from the Kaufman-Williams site in order to expand our knowledge about the prehistoric Caddo. A further analysis then attempted to relate the skeletal material from this site to skeletal samples from other Caddoan sites and from sites associated with other members of the Caddoan Linguistic Family. Descriptive, metrical, and non-metrical data were considered in analyzing the Kaufman-Williams material. Establishment of intergroup relationships involved consideration of only the metrical data. The results can be summarized as follows.

Descriptive Data

a. Seventy-five skeletons were recovered during the Kaufman-Williams excavations; there were 28 females, 26 males and 21 subadults.

b. Twenty-eight percent of the deaths occurred among subadults. The highest death rate for males occurred between 30.0 and 34.9 years of age. The females had two periods of high death rate--one between 30.0 and 34.9 years of age and the other between 45.0 and 49.9.

c. Congenital defects, which caused no apparent disability, occurred quite frequently in the Kaufman-Williams sample; these were noted most often in the vertebral column.

d. Degenerative arthritis was a commonly noted condition among the older individuals.

e. Dental caries and abscesses occurred frequently.

f. Single extended burials were the most frequently encountered type at Kaufman-Williams.

g. All of the graves but nine contained burial offerings; usually the grave goods were placed around the head and shoulders.

h. Pottery was the most frequently included artifact; it was more often found in quantity with the females.

i. There were some differences in the types of tools associated with the males and females.

j. Parallelo-fronto-occipital deformation was the most common type of deformation at Kaufman-Williams.

Metrical Data

a. Cluster analysis of the skulls based upon the two ratios (Frontal Deformation Ratio, FDR, and Occipital Deformation Ratio, ODR) provided good agreement with the subjective evaluation regarding the degree of deformation.

b. Several craniofacial measurements were found to be affected by deformation; these most commonly involved breadth measurements.

c. The Penrose distance calculation placed the Cooper material generally more distant from the other populations; however, among the females Cooper and Sanders were close.

d. The Penrose coefficient placed the Kaufman-Williams, Arikara, and Saint Helena morphologically close.

e. The most notable aspect of the principal coordinate analysis of the Penrose distance matrix was the relatively large distance of the Cooper sample from all of the other groups, especially among the males.

f. The distance analysis neither supported nor denied the hypothesized common ancestor of the Caddo and Arikara.

Non-metrical Data

a. No significant differences were noted in discrete trait frequencies between the sexes.

b. Bilateral differences in non-metrical trait frequencies were not significant.

c. No significant differences were noted in the frequency of discrete traits in the two deformation classes; however, there were several traits which occurred in higher frequencies in both sexes in either the moderate or extreme deformation classes. These consistencies suggest a trend influenced by the amount of deformation.

Many of the usual problems encountered in the analysis of skeletal samples have surfaced in this study. First is the difficulty of obtaining suitable comparative material. In the Caddoan area several factors have contributed to the paucity of comparative material. Many of the skeletal collections are in fragmentary condition due to the vagaries of preservation or collection. Also, much of the collected material has never been reported upon or has been treated rather cursorily as part of a larger archaeological report. Furthermore, there has been an apparent de-emphasis upon studies of this type at some schools in the Caddoan area. Wesolowsky and Malina, in their analysis of the skeletal material from the Harris County Boys School site, state,

> Aside from the stature reconstruction, traditional osteometric approaches were not used in this study since there is a growing realization in physical anthropology that understanding of the significance of data derived from such techniques is markedly deficient (Aten et al 1976:80).

A few pages later, they ironically complain of ". . . the near total lack of comparative data" (Aten et al 1976:85). Coupled with the above complication is the reluctance of some schools and researchers to release their raw data. Certainly all research in physical anthropology could move forward more expeditiously if there were more cooperation.

Another problem that is often encountered in studies of skeletal material is cranial deformation. Howells (1973), in a discussion of the use of cranially deformed skulls in multivariate studies, stated, ". . . if post-mortem pressure, or artificial deformation, has clearly changed the shape of a whole region of the skull from its normal character, it should be discarded" (Howells 1973:34). This is generally true in biological distance studies; however, failure to measure or to report intentionally deformed crania at all because they are deformed (Buikstra and Fowler 1976:86; Butler 1969:118) drastically limits the amount of biological data that is available about certain groups. Instead such crania should be measured, and the particular measurements affected by deformation should be determined. Once this is done, biological distance comparisons between deformed and undeformed groups can validly be made. After all, cranial deformation was a common practice among many prehistoric groups. Ignoring it will not make it go away. The only hope in circumventing the interpretative problems it poses is to understand its effect on both metric measurements and discrete traits.

The utilization of the Frontal Deformation Ratio (FDR) and the Occipital Deformation Ratio (ODR) is a start toward quantifying deformation. Other approaches might also be developed. However, any attempt to determine which measurements are affected by deformation will be more successful if sample sizes are large and if a good collection of undeformed crania from the same population is available for comparison.

One further comment is perhaps pertinent. Many more biological studies involving the Caddo Indians are needed. Present studies are so limited that the biological relationships between the three Caddo Confederacies or the relationships between the earlier Gibson and later Fulton Aspects cannot be clearly ascertained. Furthermore, comparisons of the Caddo with other groups in the Texas-Oklahoma area have apparently not been attempted. When these comparisons have been made, it is likely that the more farflung biological relationships among the various members of the Caddoan Linguistic Family will be easier to understand. Hopefully, this study is a step toward our better understanding of the biological variability occurring among one segment of the prehistoric Amerindians.

LIST OF REFERENCES

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Adair, James
1775 The history of the American Indians. New Edition (1930) Ed. by Samuel Colle Williams. The Watagua Press, Johnson City, Tennessee.

Aegerter, Ernest and John A. Kirkpatrick
1963 Orthopedic diseases. W. B. Saunders Co., Philadelphia, Pennsylvania.

Allison, M. J. and E. Gerszten
1977 Paleopathology in Peruvian mummies. Department of Pathology, Medical College of Virginia, Virginia Commonwealth University, Richmond, Virginia.

Anderson, J. E.
1962 The Human Skeleton. Department of Northern Affairs and National Resources, Ottawa, Canada.

Aten, Lawrence E., Charles K. Chandler, Al B. Wesolowsky, and Robert M. Malina
1976 Excavations at the Harris County Boys' School Cemetery. Texas Archaeological Society, Dallas, Texas.

Bailet, H. and E. E. Hunt, Jr.
1964 The sexing of children's skeletons from teeth alone and its genetic implications. American Journal of Physical Anthropology 22:171-173.

Bass, William M.
1964 The variation in physical types of the prehistoric Plains Indians. Memoir I. Plains Anthropologist 9:65-145.

1971 Human Osteology. Missouri Archaeological Society, University of Missouri, Columbia, Missouri.

n.d. Measurements on Plains Indians.

Bass, William M., David R. Evans, and Richard L. Jantz
1971 The Leavenworth Site Cemetery: Archaeology and Physical Anthropology. University of Kansas Publications in Anthropology 2. Lawrence, Kansas.

Bell, Robert E.
1953 The Scott site, Le Flore County, Oklahoma. American Antiquity 18:314-331.

Bell, Robert E.
1961 Relationships between the Caddoan area and the Plains. Bulletin Texas Archaeological Society 31:53-73.

Bell, Robert E. and David A. Baerreis
1951 A survey of Oklahoma archaeology. Bulletin Texas Archaeological and Paleontological Society 22:7-100.

Bennett, Kenneth A.
1961 Artificial cranial deformation among the Caddo Indians. The Texas Journal of Science 13:377-390.

1965 The etiology and genetics of wormian bones. American Journal of Physical Anthropology 23:255-260.

Berry, A. C. and R. J. Berry
1967 Epigenetic variation in the human cranium. Journal of Anatomy 101:361-379.

Berry, R. J.
1968 The biology of non-metrical variation in mice and men. In: The Skeletal Biology of Earlier Human Populations, Ed. by D. R. Brothwell. Symposia of the Society for the Study of Human Biology, Vol. 8, Pergamon Press, New York, New York.

Bezdek, J. C.
1973 Fuzzy Mathematics in Pattern Classification. Ph.D. Dissertation. Cornell University, Ithaca, New York.

1974 Numerical taxonomy with fuzzy sets. Journal of Mathematical Biology 1:57-71.

Black, Thomas K.
1978 A new method for assessing the sex of fragmentary skeletal remains: femoral shaft circumference. American Journal of Physical Anthropology 48:227-231.

Blair, W. Frank
1950 The biotic provinces of Texas. The Texas Journal of Science 2:93-117.

Bolton, Herbert Eugene
1908 The native tribes about the east Texas missions. Texas Historical Association Quarterly 11:249-276.

Brothwell, Don R.
1965 Digging Up Bones. British Museum, London, England.

Brothwell, D. R. and A. T. Sandison
1967 Diseases in Antiquity. Charles C. Thomas, Springfield, Illinois.

Brown, J. A., Robert F. Bell, and Don G. Wyckoff
1978 Caddoan settlement patterns in the Arkansas River drainage. In: Mississippian Settlement Patterns. Ed. by Bruce D. Smith. Academic Press, New York, New York.

Brown, K. M.
1975 The Tigert site: An early Caddoan archaeological site in the Hart Creek Drainage, Northeast Texas. The Texas Journal of Science 26:229-247.

Brues, Alice M.
1957 Skeletal material from the Nagle site. Bulletin Oklahoma Anthropological Society 5:101-106.

1958 Skeletal material from the Horton site. Bulletin Oklahoma Anthropological Society 6:27-32.

1959 Skeletal material from the Morris site (CK-39). Bulletin Oklahoma Anthropological Society 7:63-70.

Buikstra, Jane
1976 Hopewell in the Lower Illinois Valley. Northwestern University Archaeological Program Scientific Papers #2, Evanston, Illinois.

Buikstra, Jane and D. Fowler
1975 An osteological study of the human skeletan material from the Bentsen-Clark site. In: The Bentsen-Clark site, Red River County, Texas: A Preliminary Report. Ed. by L. Banks and J. Winters. Texas Archaeological Society, Dallas, Texas.

Bushnell, David I.
1922 Villages of the Algonquian, Siouan, and Caddoan Tribes West of the Mississippi. Bureau American Ethnology Bulletin 77:182-185.

Butler, Barbara H.
1969 Analysis of the human skeletal remains. In: Archaeological Investigations at the Sam Kaufman site, Red River County, Texas. Ed. by S. Alan Skinner, R. King Harris, and Keith M. Anderson. Southern Methodist University Contributions in Anthropology #5, Dallas, Texas.

Carpenter, James C.
1976 A comparative study of metric and non-metric traits in a series of modern crania. American Journal of Physical Anthropology 45:337-344.

Cheverud, James M., Jane E. Buikstra and Elizabeth Twichell
1979 Relationships between non-metric skeletal traits and cranial size and shape. American Journal of Physical Anthropology 50:191-198.

Coleman, William H.
1969 Sex differences in the growth of the human bony pelvis. American Journal of Physical Anthropology 31:125-152.

Colquitt, Walter T. and C. H. Webb
1940 Dental diseases in an aboriginal group. Tri-State Medical Journal. Jan. 2414-2417.

Corruccini, Robert S.
1974 An examination of the meaning of cranial discrete traits for human skeletal biological studies. American Journal of Physical Anthropology 40:425-446.

1976 The interaction between nonmetric and metric cranial variation. American Journal of Physical Anthropology 44:285-294.

Davis, E. Mott
1961a Proceedings of the Fifth Conference on Caddoan Archaeology. Bulletin Texas Archaeological Society 31:75-143.

1961b The Caddoan Area: an introduction to the symposium. Bulletin of the Texas Archaeological Society 31:3-10.

1970 Archaeological and historical assessment of the Red River Basin in Texas. In: Archaeological and Historical Resources of the Red River Basin. Ed. by Hester A. Davis. Arkansas Archaeological Survey Research Series #1, University of Arkansas Museum, Fayetteville, Arkansas.

Davis, Hester A. (ed.)
1970 Archaeological and historical resources of the Red River Basin. Arkansas Archaeological Survey Research Series #1, University of Arkansas Museum, University of Arkansas, Fayetteville, Arkansas.

Dembo, A. and J. Imbelloni
1938 Deformaciones intencionales de cuerpo humano de caracter etnico. Biblioteca del Americanista Moderno. José Anesi, Buenas Aires, Argentina.

De Villiers, Hertha
1968 The Skull of the South African Negro. Witwatersrand University Press, Johannesburg, South Africa.

Dickinson, S. D.
1941 Certain vessels from the Clements place, an historic Caddo site. Bulletin Texas Archaeological and Paleontological Society 13:117-132.

Ditch, L. E. and J. C. Rose
1972 A multivariate dental sexing technique. American Journal of Physical Anthropology 37:61-64.

Dorsey, George A.
1897 Wormian bones in artificially deformed Kwakiutl Crania. American Anthropologist 10:169-182.

1905 Traditions of the Caddo. Carnegie Institution of Washington, Washington, D.C.

Dreizen, Samuel, Catherine Currie, Ellen Jo Gilley, and Tom D. Spies
1953 The effect of nutritive failure on the growth patterns of white children in Alabama. Child Development 24:189-202.

Dreizen, Samuel, Charles N. Spirakis, and Robert E. Stone
1964 Chronic undernutrition and postnatal ossification. American Journal of Diseases of Children 108:44-52.

Dunn, J. C.
1974 A fuzzy relative of the ISODATA Process and its use in detecting compact well-separated clusters. Journal of Cybernetics 3:32-57.

Dupertius, C. W. and J. A. Hadden
1951 On the reconstruction of stature from long bones. American Journal of Physical Anthropology 9:150-154.

Dwight, Thomas
1905 The size of the articular surfaces of the long bones as characteristics of sex. An anthropological study. American Journal of Anatomy 4:19-31.

Ford, James A.
1936 Analysis of Indian Village Site Collections from Louisiana and Mississippi. Department of Conservation, Louisiana Geological Survey, Anthropological Study #2, New Orleans, Louisiana.

Genoves, Santiago C.
1967 Proportionality of long bones and their relation to stature among Mesoamericans. American Journal of Physical Anthropology 26:67-78.

Gilbert, B. Miles
1973 Misapplication to females of the standard for aging the male Os pubis. American Journal of Physical Anthropology 38:39-40.

Gilbert, B. Miles and Thomas W. McKern
1973 A method for aging the female Os pubis. American Journal of Physical Anthropology 38:31-38.

Giles, Eugene and Hermann K. Bleibtreu
1961 Cranial evidence in archaeological reconstruction: a trial of multivariate techniques for the Southwest. American Anthropologist 63:48-61.

Gill, George W.
1971 The prehistoric inhabitants of northern coastal Nayarit: skeletal analysis and description of burials. Ph.D. Dissertation. University of Kansas, Lawrence, Kansas.

1977 Manifestations of a conceptual artistic ideal within a prehistoric culture. American Antiquity 42:101-110.

Gindhart, Patricia S.
1969 The frequency of appearance of transverse lines in the tibia in relation to childhood illnesses. American Journal of Physical Anthropology 31:17-22.

Glover, William B.
1935 A history of the Caddo Indians. The Louisiana Historical Quarterly 18:872-946.

Goldschmidt, Walter R.
1935 A report on the archaeology of Titus County in east Texas. Bulletin Texas Archaeological and Paleontological Society 7:89-99.

Goldstein, M. S.
1940 Cranial deformation among Texas Indians. American Journal of Physical Anthropology 27:312-313.

1948 Dentition of Indian crania from Texas. American Journal of Physical Anthropology 6:63-84.

1957 Skeletal pathology of early Indians in Texas. American Journal of Physical Anthropology 15:299-307.

Gottlieb, Karen
1978 Artificial cranial deformation and the increased complexity of the lambdoid suture. American Journal of Physical Anthropology 48:213-214.

Gower, J. C.
1972 Measures of taxonomic distance and their analysis. In: The Assessment of Population Affinities in Man. Ed. by J. S. Weiner and J. Huizinga. Clarendon Press, Oxford, England.

Gray, Margery P. and William S. Laughlin
1960 Blood groups of Caddoan Indians of Oklahoma. American Journal of Human Genetics 12:86-94.

Green, Richard F., Judy M. Suchey, and D. V. Gokhale
1979 The statistical treatment of correlated bilateral traits in the analysis of cranial material. American Journal of Physical Anthropology 50:629-634.

Gregg, John B. and Robert N. McGrew
1970 Hrdlicka revisited (external auditory canal exostoses). American Journal of Physical Anthropology 33:37-40.

Gregory H. F.
1963 Skull deformation: an Indian beauty mark. Louisiana Studies 2:52-53.

Greulich, William W.
1951 The growth and development status of Guamanian School children in 1947. American Journal of Physical Anthropology 9:55-70.

1957 A comparison of the physical growth and development of American-born and native Japanese children. American Journal of Physical Anthropology 15:489-515.

Greulich, William W.
1958 Growth of children of the same race under different environmental conditions. Science 127:515-516.

Griffin, James B.
1961 Relationships between the Caddoan area and the Mississippi Valley. Bulletin Texas Archaeological Society 31:27-37.

Griffith, William Joyce
1954 The Hasinai Indians of East Texas as seen by Europeans, 1687-1772. Middle American Research Institute, Tulane University, New Orleans, Louisiana.

Hanihara, Kazuro and Takao Suzuki
1978 Estimation of age from the pubic symphysis by means of multiple regression analysis. American Journal of Physical Anthropology 48:233-240.

Harris, R. K.
1945 Bone implement burial, Collins County, Texas. Bulletin Texas Archaeological and Paleontological Society 16:84-88.

Harris, R. K.
1953 The Sam Kaufman site, Red River County, Texas. Bulletin of the Texas Archaeological Society 24:43-68.

Harris, R. K., Inus Marie Harris, Jay C. Blaine, and Jerrylee Blaine
1965 A preliminary archaeological and documentary study of the Womack site, Lamar County, Texas. Bulletin Texas Archaeological and Paleontological Society 36:287-363.

Harris, R. K. and Mr. and Mrs. John Perkins
1954 Burials 12, 13, 14, and 15 the Sam Kaufman site 19B3-2. The Record. Dallas Archaeological Society, Dallas, Texas.

Harris, R. K. and Lester Wilson
1956 Burial 17, the Sam Kaufman site, 19B3-2. The Record. Dallas Archaeological Society, Dallas, Texas.

Hatcher, Mattie A. (Translator)
1927 Descriptions of the Tejas or Asinai Indians, 1691-1722. Fray Isidro Felis De Espinosa on the Asinai and their allies. The Southwestern Historical Quarterly 31:150-180.

Hiernaux, J.
1964 The measuring of morphological differences between populations for a set of variables. Yearbook of Physical Anthropology 12:127-135.

Hoffman, Michael P.
1969 Prehistoric developments in southwestern Arkansas. Bulletin of the Arkansas Archaeological Society 10:36-49.

Holt, C. Adams
1978 A re-examination of parturition scars on the human female pelvis. American Journal of Physical Anthropology 49:91-94.

Hooten, Ernest A.
1930 The Indians of Pecos Pueblo. Yale University Press, New Haven, Connecticut.

Howells, W. W.
1973 Cranial Variation in Man. Peabody Museum of Archaeology and Ethnology. Harvard University, Cambridge, Mass.

1978 Was the skull of the Moriori actually deformed? Archaeology and Physical Anthropology in Oceania 13:198-203.

Hrdlicka, Ales
1909 Report on an additional collection of skeletal remains from Arkansas and Louisiana. Journal of the Academy of Natural Science of Philadelphia 14:171-249.

1924 Catalog of human crania in the United States National Museum Collections. Proceedings United States National Museum 63:1-51.

1927 Catalog of human crania in the United States National Museum Collections. Proceedings of the United States National Museum 69:1-127.

1935 Ear exostoses. Smithsonian Miscellaneous Collections 93:1-100.

1940 Catalog of human crania in the United States National Museum Collections: Indians of the Gulf States. Proceedings of the United States National Museum 87:315-464.

Hrdlicka, Ales
1952 Practical Anthropometry. Fourth Edition ed. by T. D. Stewart. The Wistar Institute of Anatomy and Biology, Philadelphia, Pennsylvania.

Huff, M. E.
1960 Burial 18, the Sam Coffman site. The Record. Dallas Archaeological Society, Dallas, Texas.

Hughes, Jack T.
1974 Prehistory of the Caddoan-Speaking tribes. In: American Indian Ethnohistory. Plains Indians. Ed. by David A. Horr. Garland Publishing Inc., New York, New York.

Hunt, E. E., Jr. and I. Gleiser
1955 The estimation of age and sex of preadolescent children from bones and teeth. American Journal of Physical Anthropology 13:479-487.

Hurme, V. O.
1948 Standards of variation in the eruption of the first six permanent teeth. Child Development 19:213-231.

Imrie, J. A. and G. M. Wyburn
1958 Assessment of age, sex, and height from immature human bones. British Medical Journal 1:128-131.

Jackson, A. T.
1933 Indian pipes of east Texas. Bulletin Texas Archaeological and Paleontological Society 5:69-86.

1934 Types of east Texas pottery. Bulletin Texas Archaeological and Paleontological Society 6:38-57.

1935 Ornaments of east Texas Indians. Bulletin Texas Archaeological and Paleontological Society 7:11-29.

1938 Fire in east Texas burial rites. Bulletin of the Texas Archaeological and Paleontological Society 10:77-113.

Jantz, Richard L.
1970 Change and Variation in Skeletal Populations of Arikara Indians. Ph.D. Dissertation. Anthropology Department, University of Kansas, Lawrence, Kansas.

1972 Cranial variation and microevolution in Arikara skeletal populations. Plains Anthropologist 17:20-35.

Jantz, Richard L.
1973 Microevolutionary change in Arikara crania: a multivariate analysis. American Journal of Physical Anthropology 38:15-26.

1977 Craniometric relationships of Plains populations: historical and evolutionary implications. Plains Anthropologist 22:162-176.

Jantz, Richard L., Douglas W. Owsley, and P. Willey
1978 Craniometric relationships of Central Plains populations. In: The Central Plains Tradition: Internal Development and External Relationships. Ed. by Donald J. Blakeslee. University of Iowa, Iowa City, Iowa.

Jelks, Edward B.
1961 Relationships between the Caddoan area and Texas. Bulletin Texas Archaeological Society 31:65-70.

Johnson, Leroy
1962 The Yarbrough and Miller sites of northeastern Texas, with a preliminary definition of the La Harpe Aspect. Bulletin of the Texas Archaeological Society 32:141-284.

Johnston, Francis Edward
1961 Sequence of epiphyseal union in a prehistoric Kentucky population from Indian Knoll. Human Biology 33:66-81.

1962 Growth of the long bones of infants and young children at Indian Knoll. American Journal of Physical Anthropology 20:249-254.

Keen, J. A.
1950 A study of the difference between male and female skulls. American Journal of Physical Anthropology 8:65-79.

Keith, Kenneth D.
1973 Paleostomatology at the Moore site (Lf-31), Le Flores County, Oklahoma. Bulletin Oklahoma Anthropological Society 22:149-157.

Kelley, Marc
1978 Phenice's visual sexing technique for the Os Pubis: A Critique. American Journal of Physical Anthropology 48:121-122.

1979 Parturition and pelvic changes. American Journal of Physical Anthropology 51:541-545.

Kerley, Ellis
1970 Estimation of skeletal age: after about age 30. In: Personal Identification in Mass Disaster. Ed. by T. D. Stewart. National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Key, J. A. and H. E. Cornwell
1942 Fractures, Dislocations and Sprains. C. V. Mosby, St. Louis, Missouri.

Krause, Richard A.
1969 Correlation of phases in Central Plains prehistory. Plains Anthropologist 14:82-96.

Krieger, Alex D.
1946 Culture Complexes and Chronology in Northern Texas. The University of Texas Publication #4640, Austin, Texas.

1947a The eastward extension of Puebloan datings toward cultures of the Mississippi Valley. American Antiquity 12:141-148.

1947b The first symposium on the Caddoan archaeological area. American Antiquity 12:198-207.

Krogman, W. M.
1962 The Human Skeleton in Forensic Medicine. Charles C. Thomas, Springfield, Illinois.

Kronfeld, Rudolf
1954 Development and calcification of the human deciduous and permanent dentition. In: Basic Readings on the Identification of the Human Skeleton. Ed. by T. D. Stewart and M. Trotter. Wenner-Gren Foundation for Anthropological Research, New York, New York.

Lange, Charles H.
1954 A report on data pertaining to the Caddo Treaty of July 1, 1835: The historical and anthropological background and aftermath. In: American Indian Ethnohistory Plains Indians. Ed. by David Agee Horr. Garland Publishing Co., New York, New York.

Lanier, Raymond R.
1954 Some factors to be considered in the study of lumbosacral fusion. American Journal of Physical Anthropology 12:363-371.

Lawton, Sherman P.
1956 A burial in McCurtain County, Oklahoma. Bulletin Texas Archaeological Society 27:185-194.

Leigh, R. Wood
1937 Dental morphology and pathology of Pre-Spanish Peru. American Journal of Physical Anthropology 22:267-296.

Lemley, Harry J.
1936 Discoveries indicating a pre-Caddo culture on Red River in Arkansas. Bulletin Texas Archaeological and Paleontological Society 8:25-55.

Lesser, Alexander and Gene Weltfish
1932 Composition of the Caddoan linguistic stock. Smithsonian Miscellaneous Collections 87:1-15.

Lester, Charles W. and Harry L. Shapiro
1968 Vertebral arch defects in the lumbar vertebrae of prehistoric American Eskimos. American Journal of Physical Antrhopology 28:43-48.

MacCurdy, George Grant
1923 Human skeletal remains from the highlands of Peru. American Journal of Physical Anthropology 6:217-330.

Mahalanobis, P. C.
1936 On the generalized distance in statistics. Proceedings of the National Institute of Science, India 2:49-55.

Maples, William R.
1962 A morphological comparison of skeletal material from Sanders Focus and from Fulton Aspect. Unpublished M.A. Thesis. University of Texas, Austin, Texas.

Maresh, Marion M.
1955 Linear growth of long bones of extremities from infancy through adolescence. American Journal of Diseases of Children 89:725-743.

Marquis, A.
1974 A Guide to America's Indians. University of Oklahoma Press, Norman, Oklahoma.

McHenry, Henry M. and Peter D. Schulz
1976 The association between Harris Lines and enamel hypoplasia in prehistoric California Indians. American Journal of Physical Anthropology 44:507-512.

McKern, Thomas W.
1957 Estimation of skeletal age from combined maturational activity. American Journal of Physical Anthropology 15:399-408.

McKern, Thomas W.
1970 Estimation of skeletal age: from puberty to about 30 years of age. In: Personal Identification in Mass Disasters. Ed. by T. D. Stewart. National Museum of Natural History, Smithsonian Institution, Washington,D.C.

McKern, Thomas W. and T. D. Stewart
1957 Skeletal Age Changes in Young American Males, Analyzed from the Standpoint of Identification. Technical Report EP-45. Headquarters Quartermaster Research and Development Command, Natick, Massachusetts.

McNeill, R. William and George N. Newton
1965 Cranial base morphology in association with intentional cranial vault deformation. American Journal of Physical Anthropology 23:241-254.

Merchant, Virginia L. and Douglas H. Ubelaker
1977 Skeletal growth of the protohistoric Arikara. American Journal of Physical Anthropology 46:61-72.

Miles, A. E.
1963 The dentition in the assessment of individual age in skeletal material. In: Dental Anthropology. Ed. by Don R. Brothwell. Pergamon Press, New York, New York.

Mooney, James
1928 The aboriginal population of America north of Mexico. Smithsonian Miscellaneous Collections 80:1-40.

Moore, Clarence B.
1912 Some aboriginal sites on Red River. Journal of the Academy of Natural Sciences of Philadelphia 14:481-643.

Morant, G. M.
1927 A study of the Australian and Tasmanian skulls, based on previously published measurements. Biometrika. 19:417-440.

Morse, Dan
1978 Ancient Disease in the Midwest. Illinois State Museum, Springfield, Illinois.

Moss, Melvin L.
1958 The pathogenesis of artificial cranial deformation. American Journal of Physical Anthropology 16:269-286.

Navey, Liane
1975 Human skeletal remains from the east fork of the Trinity River. In: Archaeological Investigations at Lake Lavon 1974. Ed. by Mark J. Lynott. Southern Methodist University, Dallas, Texas.

Neuman, Robert W.
1974 Historical locations of certain Caddoan tribes. In: American Indian Ethnohistory. Plains Indians. Ed. by David Agee Horr. Garland Publishing Co., New York, New York.

Neumann, Georg K.
1942 Types of artificial cranial deformation in the eastern United States. American Antiquity 7:306-310.

1952 Archaeology and race in the American Indian. In: Archaeology of the Eastern United States. Ed. by James B. Griffin. University of Chicago Press, Chicago, Illinois.

Neumann, Georg K. and Cheryl G. Waldman
1968 Regression formulae for the reconstruction of the stature of Hopewellian and Middle Mississippi Amerindian populations. Proceedings Indiana Academy of Sciences 77:98-101.

Newcomb, W. W.
1960 Indian Tribes of Texas. Bulletin Texas Archaeological Society 29:1-34.

1969 The Indians of Texas from Prehistoric to Modern Times. University of Texas Press, Austin, Texas.

Newell, H. Perry and Alex D. Krieger
1949 The George C. Davis site, Cherokee County, Texas. Memoirs of the Society for American Archaeology 5:3-255.

Nie, Norman H., G. Hadlai Hull, Jean G. Jenkins, Karin Steinbrenner, and Dale H. Bent
1975 Statistical Package for the Social Sciences (second edition) McGraw-Hill Book Co., New York, New York.

Oliver, George
1969 Practical Anthropology. Charles C. Thomas, Springfield, Illinois.

Orr, Kenneth G.
1946 The archaeological situation at Spiro, Oklahoma: a preliminary report. American Antiquity 11:228-256.

1952 Survey of Caddoan area archaeology. In: Archaeology of the Eastern United States. Ed. by James B. Griffin University of Chicago Press, Chicago, Illinois.

Ossenberg, Nancy
1970 The influence of artificial cranial deformation on discontinuous morphological traits. American Journal of Physical Anthropology 33:357-372.

1974 Origins and relationships of Woodland peoples: the evidence of cranial morphology. In: Aspects of Upper Great Lakes Anthropology. Ed. by Elden Johnson. Minnesota Historical Society, St. Paul, Minnesota.

1976 Within and between race distances in population studies based on discrete traits of the human skull. American Journal of Physical Anthropology 45:701-716.

1977 Congruence of distance matrices based on cranial discrete traits, cranial measurements, and linguistic-geographic criteria in five Alaskan populations. American Journal of Physical Anthropology 47:93-98.

Owsley, Douglas W.
1975 A Demographic Analysis of Skeletons from the Larson Site (39WW2) Walworth County, South Dakota. Unpublished M.A. Thesis. University of Tennessee, Knoxville, Tennsssee.

Pearce, J. E.
1932 The archaeology of east Texas. American Anthropologist 34:670-687.

Pearson, K.
1926 On the coefficient of racial likeness. Biometrika 18:105-117.

Penrose, L. S.
1954 Distance, size, and shape. Annals of Eugenics 18:337-343.

Perino, Gregory
1979 Personal communication, March.

Perkins, John
1955 Burial 16, the Sam Kaufman site, 19B3-2. The Record. Dallas Archaeological Society, Dallas, Texas.

Phenice, T. W.
1969 A newly developed visual method of sexing the Os Pubis. American Journal of Physical Anthropology 30:297-302.

Powell, Mary Lucas
1977 Prehistoric ritual skull burials at the Crenshaw site 3MI6, southwest Arkansas. Bulletin Texas Archaeological Society 48:111-118.

Pucciarelli, Hector Mario
1974 The influence of experimental deformation on neurocranial wormian bones in rats. American Journal of Physical Anthropology 41:29-38.

1978 The influence of experimental deformation on craniofacial development in rats. American Journal of Physical Anthropology 48:455-461.

Rahman, N. A.
1962 On the sampling distribution of the studentized Penrose measure of distance. Annals of Human Genetics 26:97-106.

Reynolds, E. L.
1945 The bony pelvic girdle in early infancy. American Journal of Physical Anthropology 3:321-354.

1947 The bony pelvis in prepubertal childhood. American Journal of Physical Anthropology 5:165-200.

Rightmire, G. P.
1969 On the computation of Mahalonobis' Generalized Distance (D^2). American Journal of Physical Anthropology 30:157-160.

Roche, Maurice B. and George G. Rowe
1952 The incidence of separate neural arch and coincident bone variations. Journal of Bone and Joint Surgery 34A:491-494.

Rogers, Spencer
1975 Artificial Deformation of the Head. San Diego Museum Papers No. 8. San Diego Museum of Man, San Diego, California.

Romero, Javier
1970 Dental mutilation, trephination and cranial deformation. In: Physical Anthropology. Ed. by T. Dale Stewart. Handbook of Middle American Indians. University of Texas Press, Austin, Texas.

Schmidt, Dwight
1980 Personal communication, February.

Schour, I. and M. Massler
1941 The development of the human dentition. Journal of the American Dental Association 28:1153-1160.

1944 Chart--Development of the Human Dentition. Second edition. American Dental Association, Chicago, Illinois.

Scurlock, J. Dan
1962 The Culpepper site, a late Fulton Aspect site in northeastern Texas. Bulletin of the Texas Archaeological Society 32:285-316.

1965 The Kadohadacho Indians: A correlation of archaeological and documentary data. M.A. Thesis. University of Texas, Austin, Texas.

Shapiro, H. L.
1928 A correction for artificial deformation of skulls. Anthropological Papers, American Museum of Natural History 30:1-38.

Singh, Indera P. and M. K. Bhasin
1968 Anthropometry. Bharti Bhawan (Regd.), Delhi, India.

Skinner, S. Alan, R. King Harris, and Keith M. Anderson
1969 Archaeological Investigations at the Sam Kaufman Site, Red River County, Texas. Southern Methodist University Contributions in Anthropology #5, Dallas, Texas.

Smith, Ralph A.
1958 Account of the journey of Bernard de la Harpe: Discovery made by him of several nations situated in the west. The Southwestern Historical Quarterly 62:75-86, 371-385, 525-541.

Sneath, Peter H. A., and Robert R. Sokal
1973 Numerical Taxonomy. Freeman and Company, San Francisco, California.

Snodgrass, Richard M.
1951 Toward measurement of the face in space and time. Dental Digest, October 448-451.

Snow, Charles E.
1948 Indian Knoll Skeletons of site OH2 Ohio County, Kentucky. The University of Kentucky Reports in Anthropology 4:377-554.

Steinbock, R. Ted
1976 Paleopathological Diagnosis and Interpretation Charles C. Thomas, Springfield, Illinois.

Stevenson, Paul H.
1924 Age order of epiphyseal union in man. American Journal of Physical Anthropology 7:53-93.

Stewart, T.D.
1931 Incidence of separate neural arch in the lumbar vertebrae of Eskimos. American Journal of Physical Anthropology 16:51-62.

1940 Some historical implications of physical anthropology in North America. Smithsonian Miscellaneous Collections 100:15-50.

1953 The age incidence of neural arch defects in Alaskan natives, considered from the standpoint of etiology. Journal of Bone and Joint Surgery 35A:937-950.

1956 Examination of the possibility that certain skeletal characters predispose to defects in the lumbar neural arches. Clinical Orthopedics 8:44-60.

1957 Distortion of the pubic symphyseal surface in females and its effect on age determination. American Journal of Physical Anthropology 15:9-18.

1958 The rate of development of osteoarthritis in identification. The Leech 28:144-151.

1969 The effects of pathology on skeletal populations. American Journal of Physical Anthropology 30:443-450

1970 Identification of the scars of parturition in the skeletal remains of females. In: Personal Identification of Mass Disasters. Ed. by T. D. Stewart. National Museum of Natural History, Smithsonian Institution, Washington, D.C.

1973 The People of America. Charles Scribner's Sons, New York, New York.

1979a Essentials of Forensic Anthropology. Charles C. Thomas, Springfield, Illinois.

1979b Patterning of skeletal pathologies and epidemiology. In: The First Americans: Origins, Affinities and Adaptations. Ed. by William S. Laughlin and Albert B. Harper. Gustav Fischer, New York, New York.

Story, Dee Ann
1978 Some comments on anthropological studies concerning the Caddo. In: Texas Archaeology. Ed. by Kurt D. House. Southern Methodist University Press, Dallas, Texas.

Sublette, Audrey J.
1966 Seneca Physical Type and Change Through Time. Unpublished Ph.D. Dissertation. State University of New York, Buffalo, New York.

Suchey, Judy Myers, Dean V. Wiseley, Richard F. Green and Thomas T. Noguchi
1979 Analysis of dorsal pitting in the Os Pubis in an extensive sample of modern American females. American Journal of Physical Anthropology 51:517-539.

Suhm, D. A. and A. Krieger
1954 An introductory handbook of Texas Archaeology. Bulletin Texas Archaeological Society 25.

Sullivan, Louis R.
1925 The frequency and distribution of some anatomical variations in American crania. Anthropological Papers of the Museum of Natural History 23:207-257.

Swanton, John R.
1911 Indian tribes of the lower Mississippi valley and adjacent coast of the Gulf of Mexico. Bulletin Bureau American Ethnology 43:1-386.

1931 The Caddo social organization and its possible historical significance. Journal of the Washington Academy of Sciences 21:203-206.

1942 Source material on the history and ethnology of the Caddo Indians. Bulletin Bureau American Ethnology 132:1-308.

1946 The Indians of the southeastern United States. Bulletin Bureau American Ethnology 137.

1952 The Indian tribes of North America. Bulletin Bureau American Ethnology 145:299-307.

Tanner, Helen Hornbeck
1972 The territory of the Caddo Tribe of Oklahoma. In: American Indian Ethnohistory. Plains Indians. Ed. by Davis Agee Horr. Garland Publishing Co., Inc., New York, New York.

Terry, Glenn C.
1979 Personal communication, November

Thieme, Fred P. and William J. Schull
1957 Sex determination from the skeleton. Human Biology 29:242-273.

Tobias, Phillip V.
1972 Growth and stature in South African populations. In: Human Biology of Environmental Change. Ed. by D. J. M. Vorster. International Book Publishers, London, England.

Todd, T. Wingate
1920 Age changes in the pubic bone. American Journal of Physical Anthropology 3:285-343.

Todd, T. Wingate and D. W. Lyon, Jr.
1924 Endrocranial suture closure its progress and age relationship. American Journal of Physical Anthropology 2:325-384.

Trinkaus, Erik
1978 Bilateral asymmetry of human skeletal non-metric traits. American Journal of Physical Anthropology 49:315-318.

Trotter, Mildred
1970 Estimation of stature from intact long limb bones. In: Personal Identification in Mass Disasters. Ed. by T. D. Stewart. National Museum of Natural History. Smithsonian Institution, Washington, D.C.

Trotter, Mildred and Goldine C. Gleser
1952 Estimation of stature from long bones of American Whites and Negroes. American Journal of Physical Anthropology 10:463-514.

1958 A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. American Journal of Physical Anthropology 16:79-123.

Ubelaker, Douglas H.
1974 Reconstruction of Demographic Profiles from Ossuary Skeletal Samples. Smithsonian Contributions to Anthropology 18. Smithsonian Institution Press, Washington, D.C.

1978 Human Skeletal Remains. Aldine, Chicago, Illinois.

Van Vark, G. N.
1970 Some Statistical Procedures for the Investigation of Prehistoric Human Skeletal Material. Doctoral Dissertation. Rijksuniversiteit te Groningen.

Walker, Winslow M.
1935 A Caddo burial site at Natchitoches, Louisiana. Smithsonian Miscellaneous Collections 94 #14:1-22.

Washburn, Sherwood
1948 Sex differences in the pubic bone. American Journal of Physical Anthropology 6:199-207.

Weaver, David S.
1979 Application of the likelihood ratio test to age estimation using the infant and child temporal bone. American Journal of Physical Anthropology 50:263-269.

Webb, Clarence H.
1940 House types among the Caddo. Bulletin Texas Archaeological and Paleontological Society 12:49-75.

1945 A second historic Caddo site at Natchitoches, Louisiana. Bulletin Texas Archaeological and Paleontological Society 16:52-83.

1959 The Belcher Mound, a stratified Caddoan site in Caddo Parish, Louisiana. Memoirs of the Society for American Archaeology 16:1-212.

1960 A review of the northeast Texas archaeology. Bulletin Texas Archaeological Society 29:35-62.

1961 Relationships between the Caddoan and Central Louisiana culture sequences. Bulletin Texas Archaeological Society 31:11-21.

Webb, Clarence H. and Monroe Dodd
1939 Bone 'gorget' from a Caddoan mound burial. American Antiquity 4:265-268.

Webb, Clarence H. and Hiram F. Gregory
1978 The Caddo Indians of Louisiana. Archaeological Survey and Antiquities Commission, Baton Rouge, Louisiana.

Webb, Clarence H. and Ralph McKinney
1975 Mounds Plantation (16CD12), Caddo Parish, Louisiana. Louisiana Archaeology 2:39-127.

Wells, C.
1967 A new approach to paleopathology: Harris Lines. In: Diseases in Antiquity. Ed. by D. Brothwell and A. T. Sandison. Charles C. Thomas, Springfield, Illinois.

Westbury, Marilyn S.
1978 Osteological analysis. In: Archaeological Research at Proposed Cooper Lake, Northeast Texas, 1974-1975. Ed. by Karen Doehner and Richard E. Larson. Southern Methodist University, Dallas, Texas.

White, Patsy
1970 Investigation of the cemetery at the Gee's Landing Site, 3DR17. Bulletin of the Arkansas Archaeological Society 11:1-20.

Wilder, Harris H.
1920 A Laboratory Manual of Anthropometry. P. Blaiston's Sons and Co., Philadelphia, Pennsylvania.

Williams, Stephen
1955 The aboriginal location of the Kadohadacho and related Indian tribes. In: American Indian Ethnohistory. Plains Indians. Ed. by David A. Horr. Garland Publishing Co., New York, New York.

Willis, Theodore A.
1931. The separate neural arch. Journal of Bone and Joint Surgery 13:709-721.

Woodall, J. Ned
1969 Archaeological excavations in the Toledo Bend Reservoir, 1966. Southern Methodist University Contributions in Anthropology #3, Dallas, Texas.

Wood-Jones, F.
1931 The non-metric morphological characters of the skull as criteria for racial diagnosis. Journal of Anatomy 65:179-195.

Wycoff, Don G.
1970 Archaeological and historical assessment of the Red River Basin in Oklahoma. In: Archaeological and Historical Resources of the Red River Basin. Ed. by Hester A. Davis. Arkansas Archaeological Survey Publications on Archaeology, Research Series #1, University of Arkansas Museum, Fayetteville, Arkansas.

Wycoff, Don G.
1971 The Caddoan cultural area: an archaeological perspective. In: American Indian Ethnohistory. Plains Indians. Ed. by David A. Horr. Garland Publishing Co., New York, New York.

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