4. Databases for Paleo-American Skeletal Biology Research

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This overview features a Smithsonian–University of Tennessee initiative to systematically document human skeletons from North America including Paleo-American remains. The goal is to gain anatomical and biomedical information through comprehensive examination and the application of modern biological and anthropological techniques. The database includes information on provenience, bone and dental inventories, demographics, skeletal and dental pathology, cranial and postcranial measurements, photographs and radiographs, and taphonomic observations. Specific examples illustrate the utility of this program to studies of the First Americans.

Introduction

Increasingly, osteological research is the key to improved understanding of past population structure, behavior, and adaptation. In terms of potential contributions to archaeology, history, and the biological sciences, human skeletons are remarkable archives of past events, activity patterns and evolutionary processes. No other resource provides so much information about genetic relationships, health, interaction (within and between groups), and sociocultural practices. The bioarchaeological approach to osteological research, with its emphasis on environmental and biocultural adaptation, population relationships, and demography, has become crucial to those basic archaeological objectives of understanding events and human experiences in antiquity.

Human bones and teeth provide unique archives of information. Deriving the maximum amount of information from these archives requires the expertise of a variety of disciplines: skeletal biology and forensic anthropology, archaeology, biochemistry, dental and medical sciences, and geosciences. Expert analyses discern patterns and trends in population demography, health, origins and migrations, patterns of gene flow, microevolutionary change, sociocultural interaction, activity patterns and life-style, subsistence and dietary reconstruction, and mortuary practices. These changes can be viewed through time and in different regions because investigative procedures and research designs have become more sophisticated. Advances in technology, analytical methods, and systematic approaches emphasize the development of computerized databases.

Yet, any database begins with analysis of one individual. The human skeleton, depending on its completeness and state of preservation, can tell us much about an individual: *sex* from characteristics of the pelvis and cranium; *ancestry* and population affiliation from craniofacial morphology; and *age* from the degree of union in long bone epiphyses and closure in cranial sutures, pubic symphysis and innominate auricular surface morphology, bone histology (osteon counting), dental wear, and degenerative bone disease. Evidence of osteological disease or trauma can suggest cause of death, provide insight into overall health (e.g., whether an individual suffered from iron deficiency anemia or infections), and even indicate limitations in mobility. The development of muscle, tendon, and ligament attachment sites and enthesophytes (projections or irregular ridges of ossification) at those sites can suggest handedness or biomechanical stress resulting from some habitual activity or occupation. Artificially induced modifications in human bone and teeth offer insight into sociocultural practices such as cranial deformation, surgical procedures, and repetitive activities.

Our work has added to these databases by intensively collecting osteological data for numerous groups from different time periods and geographical areas. We have developed and used a standardized recording format for dental and bone inventories, pathological conditions, and measurements of crania and postcrania. This approach maximizes the comparability of data and facilitates direct comparisons across samples. Data have been collected for well over 6,000 Euro-American, African-American, and Native American skeletons from North America. Our computerized database includes especially extensive records for the prehistoric and historic populations from the Great Plains and Great Basin. Paleo-American remains are extremely rare, but this database does include detailed information for several early Holocene and Paleo-American skeletons, including cases from Minnesota (e.g., Brown's Valley, Sauk Valley, and Pelican Rapids [Minnesota Woman]), Nevada (Spirit Cave, Wizards Beach, and the Grimes Shelter burials), and Nebraska (two crania).

Only the database developed by Steele and Powell (1992; 1994) has been compiled specifically for early-Holocene Paleo-American osteological and dental anthropological research. However, a few other data sets are directly applicable to this subject. These include the extensive series of dental discrete trait observations (e.g., dental cusp and root morphology) collected by Turner (1990) and craniometric data recorded by Howells (1989, 1996) and Brace et al. (1993). These morphological features are under strong genetic control and provide bases for establishing biological affinity and tracing population-historical relationships through time. Powell (1997) is developing a database for studying the dentitions of early-Holocene Paleo-Americans and early- and middle-Archaic groups (ca. 8,500–5,000 yr B.P.). Dental metric and discrete trait data for groups from around the Pacific Rim are also being incorporated. "The peopling of the Americas cannot be understood in the absence of knowledge about the biological affinities between Paleo-Americans and other prehistoric populations along the Pacific Rim. Dental variation is an important source of data for assessing these affinities" (Powell 1997).

Although our Great Basin and Plains database was initiated for studying Holocene populations of North America, its volume and breadth provide a structure that enables systematic analysis of early-Holocene Paleo-American remains, either individually or statistically within a comparative framework. A variety of questions can be addressed regarding such issues as mortuary practices, health and sociocultural interaction, and population relationships. The objective of this paper is to illustrate this potential with examples featuring different components of the database. The first two cases demonstrate how careful observation produces new information about ancient activities. The final example draws upon the craniometric database. This analysis uses population data from the Americas and other countries to address the question—Who were the First Americans?

Bone Inventories and Establishing the Number of Individuals

For each new case, our examination protocol begins with an inventory to determine the skeletal elements present. Bones and joint surfaces present are meticulously coded and can be grouped with similar data. Counts for related samples are used to determine frequencies of specific types of skeletal pathology relative to the number of bones observed. At a more general level, these inventories and associated taphonomic observations can define the number of individuals present in cases involving commingled remains. In this regard, our first example discusses information derived from the inventory of burned human remains found by Georgia Wheeler in 1940 in two twined hemp bags in Spirit Cave near Fallon, Nevada (Wheeler 1997). The bags looked very alike, although one had been placed inside a third, diamond-plaited bag made of split tules. While they had been brought to the Nevada State Museum (NSM) at the same time from the same cave, the museum had catalogued the bags and remains separately, but not sequentially. The curator wondered if the two bags really held two persons. It was difficult to tell as the remains were in so many pieces, and the pieces were so small. Of course, every museum wants to know how many individuals are in its collection. These remains were especially important because much later one of the bags had been dated to 9,040 ± 50 B.P. (Tuohy and Dansie 1997).

Paleo-American skeletons are rare enough that every bit of information that can be gleaned from the bones adds volumes to the database. Our research team methodically identified each piece, making precise notations (Figure 1). We cross-matched fragments from the two bags, and partially reassembled selected bones (e.g., the femora); and found many perfect fits (Figure 2). We concluded that the two bags contained the remains of one individual whose bones were separated in antiquity. Now the museum knows it has the skeleton of a young adult female, aged 18 to 22 years, who lived about the same time as the Spirit Cave male. We will now describe how we arrived at that identification.

At the outset of our study, we could see that both bags contained remains that exhibited the full range of colors related to heat intensity and burning. We noted brown and blackened bone that represents moderately extensive burning, and gray and white bone that indicates greater heat intensity and prolonged exposure to the fire. The more extensively burned gray/white pieces occur throughout the skeleton, but especially on the skull, upper and lower arm bones, diaphysis of the right fe-

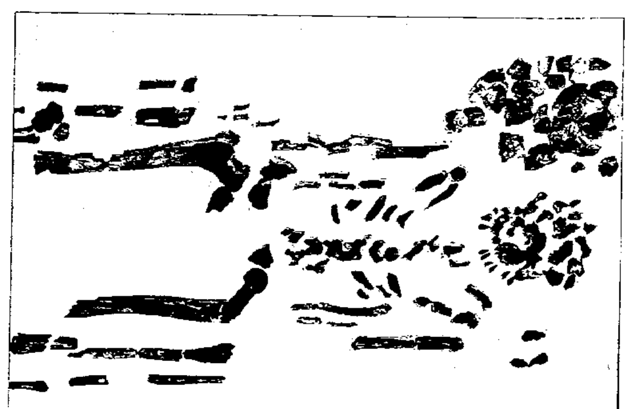


Figure 1. Anatomical placement of two related sets of burned bone fragments from Spirit Cave.

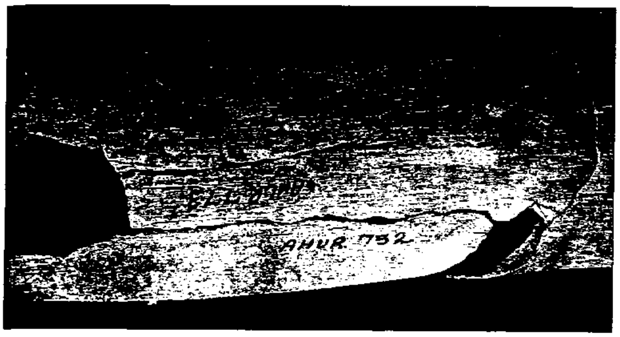


Figure 2.
A partially constructed femur diaphysis is reassembled from fragments contained in two separate containers (NSM catalog numbers AHUR 752 and AHUR 773).

mur, and the finger and foot phalanges and metatarsals. Light brown patches are evident on the femora and the neural arches of the lumbar vertebrae. These colors contrast with the proximal femora, which are darker and more consistent in color to charcoal. The difference results from the pelvic area being more protected from the fire, either by flesh, body position, and/or clothing. Some of the more calcined fragments have more fine mosaic cracks and transverse fractures indicative of burning flesh-covered bone.

The research team was able to use these color variations as a partial guide to reconstructing the skeleton. Obviously, attempting to reassemble long bones provided the best chance of finding matches of color and shape. Like a linear, monochromatic jigsaw puzzle, the fragments slowly came together. There were many perfect fits of bone fragments only centimeters in length. Innumerable fragments clearly belonged together but did not quite fit.

The skeleton was designated female, based on size. The complete left malar is small; the interorbital area is wide, with only slight development of the glabellar region.

Age was based on cranial suture closure, epiphyseal closure, and dental development and degree of wear. The cranial sutures are completely open, although the incisive suture appears to have closed. The proximal heads of the femora and the trochanters are fully united. The third molars are fully developed and erupted. The left second and third maxillary molars show no crown wear. Such observations represent small, but incremental, additions to the database.

Evidence of Traumatic Injuries

The same methodical attention to details allows the team to recognize cuts, fractures, and injuries to bone. Although precise statistics are far from being calculated, there is evidence for violence and small-scale warfare in prehistoric North America, even among hunting and gathering populations. In the northwestern United States, violent behavior can be traced as far back as the early-Archaic Paleo-American period. Examples include the projectile point embedded in the right innominate of the Washington state Kennewick skeleton (James Chatters, pers. comm. 1996) a the observation that the Spirit Cave male was recuperating from a head injury the time of his death (Jantz and Owsley 1997).

In this regard, our second illustration deals with recording evidence of the tra matic death of a male, probably of the early-Archaic Paleo-American period, ag 16 to 18 years, from the Grimes Burial Shelter in Nevada (Dansie 1997). The tea detected a V-shaped notch in the left second rib. This well-defined perimortem c is present on the inferior margin of the rib body (Figure 3). Not only does the c appear distinctly different from the animal puncture marks in other places, but least two pieces of embedded obsidian are visible in the cut. No reactive bone visible, indicating no healing occurred.

Figure 3.
Perimortem cut in a left second rib (AHUR 744).

The location of the defect indicates entry of a knife or projectile into the left side of the upper chest. The blade penetrated the second-third rib intercostal space damaging the inferior aspect of the left second rib. The maximum width of the cut measures 5.5 mm on the inferior margin, and it narrows rapidly into a linear cut measuring 1.2 mm across. The fracture margins indicate perimortem removal of the blade that compressed the internal fracture margins into the rib body and forced the external fracture margins outward, simultaneously breaking off and enlarging the fracture area. A second perimortem cut on that rib is represented by a V-shaped defect on the inferior margin that extends only 1.8 mm on the external surface and 2.4 mm on the internal surface. With the presence of two discrete fractures in the same rib, the team suggests that a knife was used.

This burial, according to S. M. Wheeler's site notes, was collected by guano hunters from a partially collapsed shelter also referred to as Cave #16 or the Grimes Burial Shelter (Wheeler 1939). They gave the remains to Margaret Wheat, who then gave them to Wheeler. When Wheeler accessioned the remains, a knife handle and diamond-plaited matting were associated with the remains. The matting has been dated to 9,470 ± 60 yr B.P. (Dansie 1997). Although not recognized at the time, two individuals were actually represented by these remains, a female (AHUR 743) aged 8.5 to 10.5 years (affectionately named the Paleokid), and the male (AHUR 744) described here.

The skeleton of the male is very incomplete, but the bones present are of good quality. The elements include a complete cervical and an upper thoracic vertebra, a partial left clavicle missing the acromial and sternal ends, a nearly complete left second rib, two incomplete right ribs, and a partial humeral head. At least seven well-defined postmortem punctures are evident on the humeral head. They penetrate the bone surface a minimum of 2 to 3 mm and were produced by a medium-sized carnivore such as a dog or coyote. Postmortem fractures of the ribs and clavicle may have resulted from burial disturbance by the guano hunters. However, some of the fracture margins appear older, although the source of this damage is unknown.

The individual's age is based on partial epiphyseal ring union on the vertebrae, and incomplete epiphyseal union of the humeral head. A sex of male is based on the size of the vertebrae and rib bodies relative to the age of the individual.

The Craniometric Database

W. W. Howells was probably the first to recognize the potential of linking large craniometric databases with electronic data processing for exploring relationships among skeletal populations. In the 1960s, Howells began to assemble a worldwide database, which ultimately included data from 28 samples, plus over 500 crania consisting of small samples, fossils, or other interesting specimens. Howells's database, which is now generally available (Howells 1996), has been used extensively by Howells (1973, 1989, 1995) and others.

Our database began with the systematic collection of cranial data from the Plains region (Jantz 1973; Lin 1973). In the early 1980s it was adapted to Howells's format (Key 1983). We have continued to add new cases. The rate of growth has intensified over the past several years with a concerted effort to obtain data from collections scheduled for repatriation. In the past several years, we have begun to add cranial data from the Great Basin, California and the Southwest, and to obtain metric data from specimens from the Paleo and Archaic periods from any location. These efforts have resulted in a cranial database containing, at the present time, about 2,000 individuals. Moreover, the database is fully compatible with Howells's, and the two can be merged when required. The structure and content of the database can be found in Key (1983) with an update in Jantz (1997).

In this example, we focus on Paleo-American crania to illustrate how the database can be used to address problems encountered in the study of fossil remains. Early American crania present the same set of problems encountered in the morphometric study of fossil remains generally. Van Vark (1995) recently outlined a number of them, but here we will address those relating to fragmentary material, small sample sizes, and an unknown number of populations.

Fragmentary Material

Fragmentary crania reduce the number of measurements available. Since multivariate procedures cannot normally deal with missing observations, it is necessary to construct a measurement set that is common to all crania included in an analysis. The principal advantage of using the battery of measurements defined by Howells (see Howells [1973] for definitions and Key [1983] for some additions) is the considerable redundancy it offers. Howells's original rationale was to provide a fine-grained quantification of cranial variation. As demonstrated by Howells (1973), each measurement quantifies some variation that is independent of all others. However, these dimensions define specific craniofacial complexes relating to vault breadth, face breadth, face height, and facial forwardness. Since a number of measurements contribute to each complex, it is usually possible to include dimensions that quantify each of the main morphological complexes. For example, vault height is quantified via basion-bregma height, bregma and vertex radius, and to some extent occipital chord. If basion is missing, as is often the case, vault height can still be quantified via bregma or vertex radius. The same reasoning applies to other complexes.

A solution to missing measurements (often employed to enhance sample size) is to predict missing dimensions from those available. That solution normally requires an estimate of the mean vector and covariance matrix, statistics that are unavailable in the case of isolated specimens.

Sample Sizes

Small sample sizes are an endemic problem in skeletal morphometrics when dealing with archaeological samples. Samples obtained from recent sites will normally present several or many crania, while nearly all Paleo-American crania consist of individual finds, widely scattered in time and space. Steele and Powell's (1992) synthesis of available Paleo-Americans lists 16 sites, 12 of which contain single individuals, three contain two individuals, and one site contains three individuals. Measurable crania included in their morphometric analysis are mainly confined to individual specimens.

So far the problem has been dealt with by pooling available specimens to create a Paleo sample. Steele and Powell's (1992) sample consists of crania from Minnesota, Texas, Colorado, and Arizona. That these specimens were all considered to date to ca. 8,500–10,000 yr B.P. may offer some justification for pooling; however, there has never been an attempt to assess the extent of homogeneity of a Paleo sample constructed in this way. The reason is, of course, that each is a sample of one, which makes it unsuitable for the usual statistical analyses. The fact is that the crania were sampled from an unknown number of populations, which brings us to the next problem.

Unknown Number of Populations

The contemporary Native North American population exhibits considerable genetic and metric differentiation. Cavalli-Sforza et al. (1994) give Fst estimates (a measure of variation among groups relative to the total variation) of 0.051 for Eskimo, Aleut, and Na-Dene, and 0.034 for North and Central America, excluding Eskimos. These values exceed those of most other comparable areas of the world. Metric analysis of recent living populations points to marked differentiation, patterned mainly along geographic lines (Jantz et al. 1992). Past and present cranial evidence points to substantial variation among earlier American populations (e.g., Neumann 1952), and even among populations of restricted regions such as the Plains (Key 1983). It is unrealistic to expect that variation was restricted during the Paleo period. It is essential to view the limited number of early American crania as representing diverse populations, and to use them to gain insight into this variation.

Statistical Approaches

The problems of small sample sizes and unknown numbers of populations are to some extent complementary. Two approaches have been employed to deal with these problems. The most common is to ascertain the relationship of an individual fossil cranium to known populations. This objective may be accomplished by calculating distances of a fossil cranium from large, usually recent samples. Howells's (1995) application is the most extensive, but included no early American crania. What one gains from such an analysis is a pattern of similarity or difference of a given skull in relation to modern groups, and an indication of whether the skull falls within the range of variation of modern populations (Albrecht 1992).

What cannot be learned from such an analysis is the relationship among fossil specimens, and whether they are likely to represent different populations. If we have only one specimen from each of several sites, it is not possible to employ the usual morphometric methods to assess relationships among sites and draw conclusions about which are similar. The principal limitation is that within-group covariance matrices are unavailable from individual specimens, and cannot be accurately estimated from small samples. The problem can be circumvented by using a covariance matrix obtained from samples external to the fossils. The question then becomes from which group(s) should the covariance matrix be obtained. Van Vark (1995) has used a world covariance matrix to obtain distances among fossil skulls. Ideally, the covariance matrix should be obtained from groups with population structure similar to the groups from which the fossil samples were drawn. Key and Jantz (1990) have used such an approach in a somewhat different context, that of ascertaining whether crania from a multicomponent site can be identified as belonging to different populations. In the case of fossil crania, the population structure is often unknown, or samples from populations with similar population structure are unavailable. Hence in the present analysis we use a world within-sample covariance matrix.

Application to Paleo-American Fossils

To date, we have been able to obtain our measurement set on four early-Holocene American crania that have good radiocarbon dates: Spirit Cave Mummy, Wizards Beach, Brown's Valley, and Pelican Rapids. The first two are Great Basin specimens housed at the Nevada State Museum. Both have dates in excess of 9,200 yr B.P. These crania were unavailable at the time Steele and Powell (1992) conducted their analysis of Paleo-American crania. Brown's Valley and Pelican Rapids, both from Minnesota, have recently been dated (Myster and O'Connell 1997). Brown's Valley, at ca. 8,900 yr B.P., is nearly as old as the Great Basin specimens; and Pelican Rapids, at 7,840 yr B.P., is slightly younger. Table 1 gives the measurements for these four crania. Wizards Beach is the only one on which a full set of measurements can be obtained. The Brown's Valley skull is the most incomplete. Lacking the base, measurements from basion are unavailable, as well as certain facial dimensions. Spirit Cave is complete, but certain measurements are unavailable due to adhering tissue. Pelican Rapids is nearly complete, lacking only measurements of the nasal bones. From Table 1 one can construct a measurement set consisting of enough dimensions to quantify cranial morphology in considerable detail.

The Mahalanobis distance of each skull from each of 34 recent world population samples was obtained. Table 2 presents the modern samples. Most (28) are from Howells's database, but since Howells's data contains only three American Indian samples, we have added six additional samples. Table 3 presents the distances and typicality probabilities of the 10 modern populations to which each fossil cranium is closest. These are sorted in order of increasing distance to aid in assessing similarity to modern groups. The typicality probabilities indicate whether a skull fits comfortably within the range of variation of a modern group.

The typicality probabilities show that all crania except Wizards Beach would be reluctant members of any modern group used here. Wizards Beach, on the other hand, fits comfortably within the range of variation of several modern groups. Its lowest distance is with Norse, but it fits almost as well in several American Indian groups and the Moriori, a Polynesian group. Spirit Cave is also most similar to Norse, but it would be less typical than 1.5 percent of Norse crania. Distances with other groups are substantially greater, so that it makes little sense to assess similarity to modern groups. The most striking results shown in Table 3 are the large distances of the Minnesota crania from any modern groups. The Pelican Rapids skull has slightly lower distances than Brown's Valley, but both are so distinct that they would be extremely improbable members of any modern group used here. All

Table 1. Measurements of four early American crania.

	Brown's Valley M	Pelican Rapids F	Wizards Beach M	Spirit Cave M
GOL*	193	179	187	195
NOL	189	177	185	191
BNL	—	95	101	104
BBH	—	126	135	138
XCB*	137	138	135	137
XFB*	116	111	115	116
ZYB	—	126	139	140
AUB*	133	124	126	129
WCB	—	0	76	79
ASB	111	114	105	—
BPL	—	92	95	98
NPH*	65	62	75	71
NLH*	50	48	55	50
JUB	119	108	119	120
NLB*	23	21	26	26
MAB	64	66	63	64
MDH	27	24	29	31
MDB	15	8	12	15
OBH*	34	34	35	34
OBB*	41	41	41	40
DKB*	23	19	23	25
NDS	19	15	12	—
WNB	—	—	8.6	—
SIS	—	—	2.5	—
ZMB	—	87	103	92
SSS	—	18	26	21
FMB*	96	92	101	100
NAS*	15	18	19	21
EKB*	95	92	102	101
DKS	10	11	12	—
IML	36	33	36	—

	Brown's Valley M	Pelican Rapids F	Wizards Beach M	Spirit Cave M
XML	50	47	46	—
MLS	9	10	8	—
WMH	20	23	25	26
SOS	8	4	5	—
GLS	6	2	3	—
STB	110	108	106	—
FRC*	114	105	108	114
FRS*	21	22	20	24
FRF	53	45	46	55
PAC*	111	109	110	120
PAS*	23	20	21	23
PAF	59	56	52	66
OCC	—	99	108	101
OCS	—	31	37	27
OCF	—	47	38	44
FOL	—	39	40	42
NAR*	103	94	94	99
SSR*	103	89	99	95
PRR*	107	97	102	101
DKR	88	83	82	—
ZOR*	86	77	80	85
FMR*	87	72	75	76
EKR*	79	69	69	70
ZMR*	77	69	73	71
AVR	83	75	80	79
BRR	124	120	119	125
VRR*	127	121	123	129
LAR	113	107	115	117
OSR	—	41	42	45
BAR	—	9	17	12

* used in analysis.

four crania agree in being most similar to European, Native American, Polynesian, or East Asian populations. No African, Australian, or Melanesian populations are represented among the most similar groups.

The relationships of the fossil to modern crania can be shown graphically by means of a principal coordinates plot, shown in Figure 4. The plot was constructed by putting the fossil crania into the analysis as if each represented a separate population sample. These two axes show 40 percent of the variation among all groups. The plot clearly reflects much of what could be observed in the distances; Wizards Beach is near modern populations, Spirit Cave is more removed, and the Minnesota specimens are the most distant. The morphometric basis of the Minnesota specimens' differentiation lies in their wide auricular breadths, flat frontal bones, narrow noses, and long, narrow vaults with long parietals.

Table 2. Modern reference samples with which early American crania were compared. All samples from Howells (1989) unless otherwise noted.

Group	Males	Females	Sampling location
Ainu	48	38	Hokkaido, Japan
Andaman	35	35	Andaman Islands
Anyang	42	—	South China
Arikara	42	27	South Dakota, USA
Atayal	29	18	Taiwan Aboriginals
Australia	52	49	South Australia
Berg	56	53	Austria
Blackfeet■	23	43	Montana, USA
Buriat	55	54	Western Siberia
Bushman	41	49	Southern Africa
Cheyenne■	17	5	Great Plains, USA
Dogon	47	52	Mali, Western Africa
Easter Island	49	37	Polynesia
Egypt	58	53	North Africa
Eskimo	53	55	Greenland
Guam	30	27	Micronesia
Hainan	45	38	South China
Mokapu	51	49	Polynesia
Moriori	51	49	Polynesia
North Japan	55	32	Hokkaido, Japan
Norse	55	55	Norway, Europe
Omaha▲	7	9	Eastern Nebraska, USA
Pawnee▲	10	17	Nebraska, USA
Peru	55	55	Peru, South America
Philippines	50	—	Philippine Islands
Ponca▲	10	9	Eastern Nebraska, USA
South Japan	50	41	North Kyushu
Santa Cruz	51	51	Santa Cruz Island, California, USA
Sioux▲	22	6	Great Plains, USA
Tasmania	45	42	Tasmania, Australia
Teita	33	50	Kenya, East Africa
Tolai	56	54	New Britain, Melanesia
Zalavar	53	45	Hungary, Europe
Zulu	55	46	South Africa

▲Described in Key (1983), with new additions.
■Jantz, unpublished

Relationships Among Fossils

Table 4 presents the Mahalanobis distances (D) between the four early American crania (lower diagonal), and the probability that the distance exceeds what would be expected if the two crania were drawn at random from the same population. The pattern of relationship is obvious. The two crania from Nevada and the two from Minnesota yield the two lowest distances; the largest distances are between Nevada and Minnesota specimens. Hence there is an apparent geographical patterning to be seen in the distances. Figure 5 shows a principal coordinate plot that brings out these relationships more clearly.

Table 3. Ten modern groups most similar to each early American cranium.

Wizards	Norse	Blackf	Santac	Sioux	Morior	Peru	Arikar	Zalava	Pawnee	Egypt
Dsqr	24.50	24.83	25.50	25.57	25.93	27.43	28.71	29.37	29.73	30.37
Typ	0.491	0.472	0.435	0.431	0.412	0.335	0.276	0.249	0.235	0.211
Spirit	Norse	Blackf	Ainu	Zalava	S Japa	Egypt	Sioux	Hainan	N Japa	Anyang
Dsqr	42.77	45.53	47.91	48.99	50.83	51.21	52.45	53.02	53.35	53.48
Typ	0.015	0.007	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001
Pelican	S Japa	Norse	Ainu	N Japa	Zalava	Ponca	Atayal	Mokapu	Sioux	Morior
Dsqr	58.66	60.16	60.61	61.70	62.50	62.87	62.87	62.98	63.46	63.46
Typ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brown's	Mokapu	Morior	Arikar	Easter	Peru	Santac	Pawnee	Norse	Ponca	Blackf
Dsqr	66.70	68.24	70.95	73.82	73.90	76.56	77.85	78.38	80.08	82.26
Typ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

The most critical question is whether the distances in Table 3 exceed those that would be found sampling a single population. For present purposes, the variation and covariation within a single population is defined as the average of the covariance matrices obtained from the 34 samples. This analysis will likely yield an overestimate of the variation to be found in the populations from which these crania were drawn, and hence an underestimate of the distance.

Defrise-Gussenhoven (1967) has shown that the expected distance of two individuals drawn randomly from a population is $\sqrt{2np-1}$, where n is the number of pairs, and p the number of measurements. This quantity will be normally distributed with a variance of 1 about the mean. In the present situation, the expected value for any pair of fossil crania is $\sqrt{2 \times 1 \times 25-1} = 7$. Hence in Table 4, any distance greater than seven would exceed the random expectation, and any distance greater than 8.65 (1.65 standard deviations above the mean) could be considered significant at the 0.05 level by a one-tailed test. The two lowest distances, Wizards

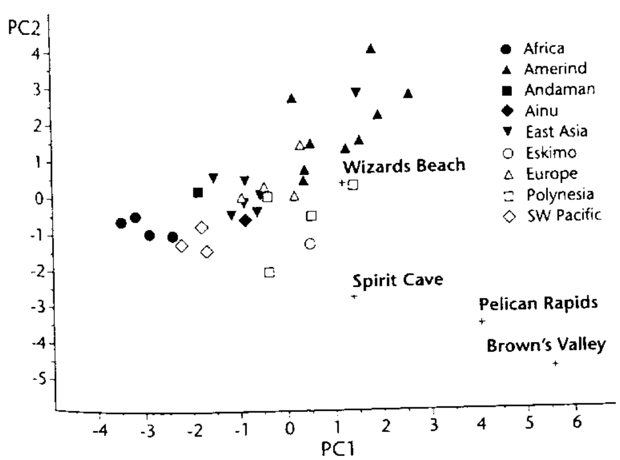


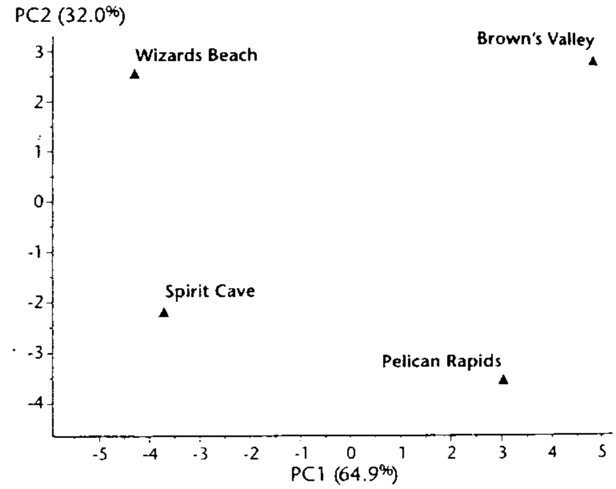
Figure 4.
Principal Coordinates plot of 34 world population samples and four well-dated early American fossils. The world populations are coded by general region; or in the case of Ainu, Eskimo, and Andaman, by specific ethnic group. The East Asian group includes one from Siberia, the Buriat.

Table 4. Mahalanobis distances between early American crania and probabilities that distances exceed sampling from a single population.

	Wizards Beach	Spirit Cave	Pelican Rapids	Brown's Valley
Wizards Beach	0.000	0.555	0.006	0.002
Spirit Cave	6.862	0.000	0.081	0.001
Pelican Rapids	9.542	8.402	0.000	0.295
Brown's Valley	9.847	10.008	7.539	0.000

Beach-Spirit Cave and Pelican Rapids–Brown's Valley, are easily within the range that could be expected from sampling a single population. Brown's Valley has a low probability of coming from the same population as Wizards Beach or Spirit Cave. Pelican Rapids is significantly different from Wizards Beach, but its probability with Spirit Cave is slightly above the customary 0.05 level, but still low.

Figure 5. Principal coordinates plot showing distances among four early American crania.



Conclusion: Databases for Paleo-American Research

Recent developments in Paleo-American research include marked advances in the bioarchaeology of the early-Holocene peoples of North America. New discoveries and accurate dating of previously unrecognized remains have contributed by adding to the small number of well-preserved and dated skeletons presently available. A few others undoubtedly exist in museum collections and need to be placed within correct temporal contexts by accelerator dating techniques. New discoveries and key specimens that were first studied decades ago are being reassessed using modern techniques within a systematic database approach facilitated by microcomputers. This presentation has illustrated a small part of the database that we have been developing for the past two decades. Our approach is comprehensive and includes careful inventory, taphonomic observations, evaluation of skeletal and dental pathology, and osteometrics. Craniometric analysis of four early-Holocene American specimens demonstrates the potential of this approach.

The results of the craniometric study bear on methodological applications to early-Holocene American skeletal remains and to issues regarding morphometric relationships of these paleo-Americans:

1. **The value of individual crania.** A single cranium has always been considered of limited value in morphometric analysis (e.g., Brothwell 1963); however, we have illustrated that the question of variation among early-Holocene American populations can in fact be addressed using individual crania. The potential of the approach outlined above will obviously be much greater when applied to a wider range of early-Holocene American crania. The approach is dependent upon systematic collection of data, both from early and recent populations, in order to develop an adequate comparative framework.
2. **Morphometric similarities to modern populations.** The similarities of the four crania examined here support previous results that indicate Americans of the early Holocene are not especially similar to recent American Indians. Only Wizards Beach falls easily within the range of variation of modern American Indians. Spirit Cave, as was demonstrated earlier (Jantz and Owsley 1997), falls outside the 98 percent range of all modern populations, while Brown's Valley and Pelican Rapids are even more atypical. Hrdlička's (1937) insistence that the Pelican Rapids skull fell within the range of variation of modern Sioux is not supported by morphometric analysis. The four crania do not present a consistent picture of similarity to any specific group of modern humans. Like Steele and Powell (1992), we observe a certain similarity to Europeans and South Asians. Neves and Puciarelli (1991) have observed similarity of early South Americans to Australians. We see no evidence for an African or Australian connection to early-Holocene Americans, but some resemblance to South Asians in the form of Polynesians can be seen in the data.
3. **The number of early-Holocene American populations.** Obviously four crania cannot be used as evidence to argue for any specific number of populations. However, that they appear to fall into two well-defined geographic groups agrees with our expectation that early American cranial morphometrics are patterned along geographic lines.

The morphometric analysis has revealed what can only be described as an unexpected finding, namely the similarity between Brown's Valley and Pelican Rapids. It is unexpected because the visual impression of these two crania is not one of great similarity. What they share metrically is a broad base, as shown in the auricular breadth, low vaults, flat frontals, and facial forwardness. It is likely that the age and sex difference is what contributes to the visual dissimilarity between the two crania. The morphometric similarity suggests the presence of a population in the Great Lakes area that exhibits these features. Decades ago Howells (1938) argued that the Torrington crania from Wyoming were morphologically similar to Pelican Rapids. The limited dates available for the Torrington site (Agogino and Galloway 1963) suggest that it may be late. If Howells's morphological assessment and the dating are correct, then a distinct population in the region has persisted for a long period of time. The morphometric distinctiveness of this population is sufficient to argue that it did not give rise to present Siouan or Algonquian populations inhabiting the region today.

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