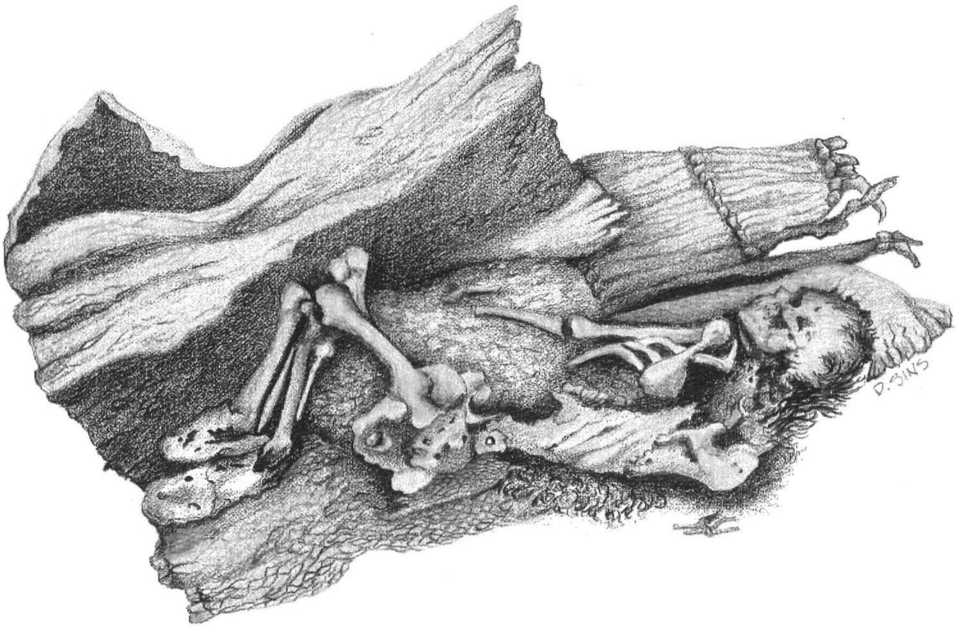
Nevada
Historical Society Quarterly



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NEVADA HISTORICAL SOCIETY QUARTERLY

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PATHOLOGY, TAPHONOMY, AND CRANIAL MORPHOMETRICS OF THE SPIRIT CAVE MUMMY

R. L. Jantz and Douglas W. Owsley

INTRODUCTION

The Spirit Cave Mummy was examined by scientists from the Smithsonian Institution and the University of Tennessee as part of a systematic survey of the human skeletal collection curated by the Nevada State Museum. The archaeological collection was inventoried to determine the number of individuals represented, completeness of each set of remains, and demographic information concerning age, sex, and population affiliation. Evidence of skeletal and dental pathology, taphonomic observations, and osteometric data including both cranial and postcranial measurements were recorded using a standardized format that allows comparison with historic and prehistoric groups from North America and other areas of the world. The data are a basis for documenting temporal trends and regional patterns in longevity, health, physical exertion and activity, robusticity and stature, and mortuary practices. The cranial measurements can be used to assess group identification and trace ancestral/descendent relationships through morphometric comparisons using multivariate, biological distance statistics. Craniofacial morphology is strongly determined by the genetic makeup of the individual, and groups that are closely related through common ancestry share similar features and dimensions.

This presentation highlights a few of the observations recorded for the Spirit Cave Mummy with primary emphasis placed on the craniometric data. Comparison

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to North American and world population data illustrates the application of modern databases to questions of morphometric affinity and population relationships.In order to demonstrate the potential of this approach, the analysis is advanced in greater detail than is normally the case through analyses that consider specific dimensions of the total craniofacial complex.

GENERAL DESCRIPTION AND TAPHONOMY

At the time of discovery, the body was positioned on the right side with the bones of the right arm flexed at the elbow and wrist such that the hand was placed under the chin. The left arm was extended and placed in front of the pelvis.Both legs were placed in a loosely flexed position. The flexure angle of the right femur was approximately 120 degrees relative to the pelvis and spinal column, and the angle at the knee was about 70 degrees.

The remains of this 40-to-44 year-old male comprised a complete skeleton with head hair, desiccated skin, and ligaments preserved in some areas, including dried articular cartilage on most of the joint surfaces. The bones of the face, the frontal bone, parietals, and the occipital squamous are partially covered with mummified skin and scalp tissue, although the posterior occipital and the base of the cranium are bare (Figure 1). Both eye orbits contain remnants of eye tissue and associated musculature. Patches of hair are present on the left frontal near the coronal suture, the left parietal, and the right side of the cranium. The hair is medium brown in

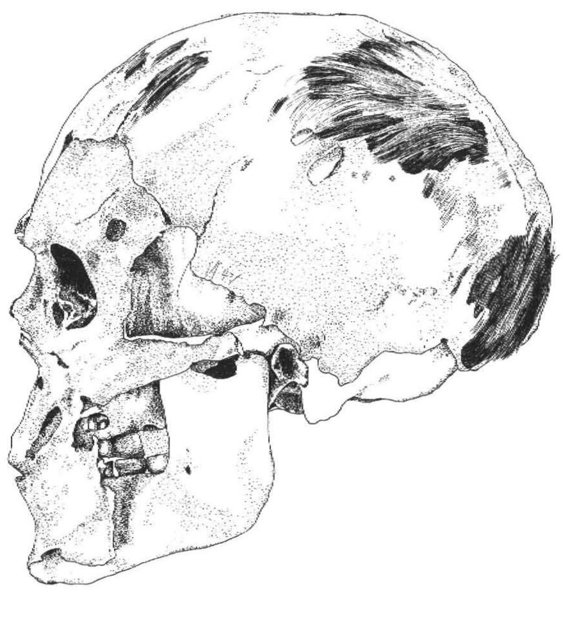

FIGURE 1. Lateral view of Spirit Cave skull showing morphological features and dessicated skin and hair. (*Drawing by S. Wallman*)

color with reddish tones (C. Lahren 1996), although at the time of recovery it was described as being darker prior to being exposed to the sun (Wheeler and Wheeler 1969). Some of the longer strands are 150 to 198 mm long, indicating that it was at least shoulder length. Some of the hair was cut angularly, which suggests that some type of blade was used to groom the hair (Lahren 1996). The mandible contains only small fragments of dried tissue.

Desiccated skin is present on the left scapula and ribs, and small patches are also present on the right ribs. The internal organs have decomposed although remnants of the large intestine and colon are present in the lower abdomen.

The postcranial skeleton is relatively gracile with only moderate development of the muscle attachments sites on the bones of the arms and legs. The cranial vault is long and narrow with a moderate vault height. The brow ridges are only moderately developed, and the frontal bone is long and curved. The height of the face is relatively short, lacks alveolar prognathism, and is fairly gracile, especially considering the large size of the skull. The nasal aperture has well defined inferior margins. The malars are not flared, but expand posteriorly, reaching their maximum width at the zygo-temporal suture.The palate is small and somewhat elongated.

BONE AND DENTAL PATHOLOGY

At the time of his death, this individual was recovering from an injury to the left temple that is evidenced by a circular impact site with radiating fractures extending superiorly and inferiorly away from the margin of the defect (Figure 2). This small indentation in the left, posterior frontal has a slightly darker color than the surrounding bone. The superior fracture travels superiorly along the coronal suture and crosses into the middle of the left parietal. This fracture has begun to unite along its inferior aspect on the frontal bone and where it crosses the coronal suture, although it was not completely healed at the time of death.

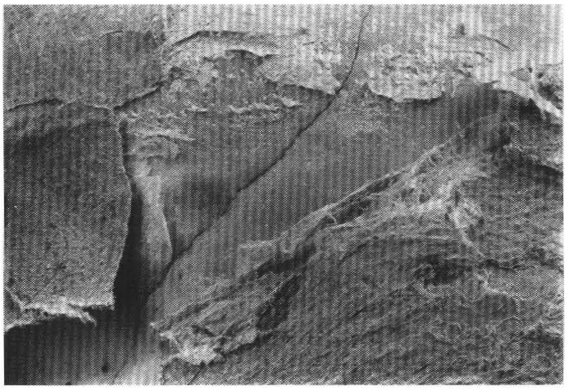

FIGURE 2. Close up view of the small impact indentation on the left frontal with radiating fractures.

Other injuries are evident in the bones of the right hand and the fifth lumbar vertebra. The fourth metacarpal has an old, healed fracture, and the right third metacarpal has a pronounced ridge on the palmar surface, which may be an old fracture line.

This individual has unilateral spondylolysis of the fifth lumbar vertebra with complete fracture of the left pars interarticularis (i.e., partial separation of the neural arch). There is slight bridging of the fracture on the inferior margin of the defect suggesting some degree of healing. From a posterior view the vertebral laminae are asymmetrical in their superior-inferior heights. At the midpoint of each lamina, the left side measures 13.6 mm; the right measures 16.8 mm. This asymmetry indicates a lack of development of the left side of the neural arch, which may be related to the timing of the fracture (i.e, occurring before the lamina was fully formed), or, conversely, the reduced size on the left side may be the reason for vulnerability to fracture of this side of the neural arch. The right side of the vertebra is normal, whereas the left transverse process shows sacralization, indicating another type of asymmetry in the development of this vertebra. Separate neural arches are often the result of fatigue fracture from stress on the lower vertebral column.

Another unusual anomaly of the spinal column is the presence of thirteen thoracic vertebrae, instead of the usual twelve. The thirteenth thoracic is lumbar-like in its morphology, and on the left side the transverse process is fused to the pedicle. The right side has a distinct, detachable, vestigial rib that measures 21 mm in length.

The spinal column shows changes due to minor arthritic degeneration. The first cervical vertebra (the atlas) has slight lipping around the margin of the facet for the dens process, and the corresponding dens process on the axis (C2) also displays slight lipping. The articular facets for the cervical vertebrae display slight cupping and lipping along with moderate porosity. Also, the vertebral bodies (i.e., the centra) of cervicals 3 through 7 show moderate lipping of the margins with slight porosity, particularly C3, C4, and C5. C5 has a small osteophyte that extends away from the inferior endplate for a distance of 4 mm and is 9 mm in width. Thoracic vertebrae 1 through 9 display slight lipping on the margins of the centra and on the articular facets. This condition on the centra is slightly more pronounced on the lower thoracics and thoracics 10-12 display slight to moderate levels of arthritic lipping of the centra and the facets. The articular facets of thoracic 10-12 display moderate lipping, but with no visible surface porosity.

A small Schmorl's node was present in the inferior endplate of the tenth thoracic vertebra (i.e., as evidenced by concavities resulting from herniation of disc material into the centrum). This shallow depression has an anteroposterior orientation and is linear in shape, measuring 2.5 mm in width by 8 mm in length. Similarly, the twelfth thoracic vertebra has small depressions in both the superior and inferior endplates of the centrum, and the first lumbar has a large Schmorl's node on its superior endplate. This depression is linear in shape with a transverse orientation across the endplate. The transverse measurement is 22 mm, the length is 5 mm, and the depth is 3 mm.

Three thoracic vertebrate (10-12) show slight anterior wedging of the centra, producing an insignificant amount of anterior curvature (i.e., kyphosis) of the spinal column at this location.

The lumbar vertebrae have slight lipping on the margins of the centra accompanied by slight porosity on the margins.The articular facets show no evidence of degeneration with the exception of the left inferior articular facet of L5, which shows remodelling due to the spondylolysis.

The left proximal radius and ulna have minor porosity and lipping of the joint surfaces, and the distal right femur was also scored for slight lipping.

The dentition exhibits moderately heavy wear due to attrition. The occlusal surface wear planes are flat for the anterior teeth, but have a lingual slope in the maxillary molars and a buccal slope in the mandibular molars. Especially heavy wear of the maxillary first molars has exposed the pulp chambers, resulting in active periapical abscessing at the time of death. The right mandibular first molar also had an active abscess that had spread to the second molar.

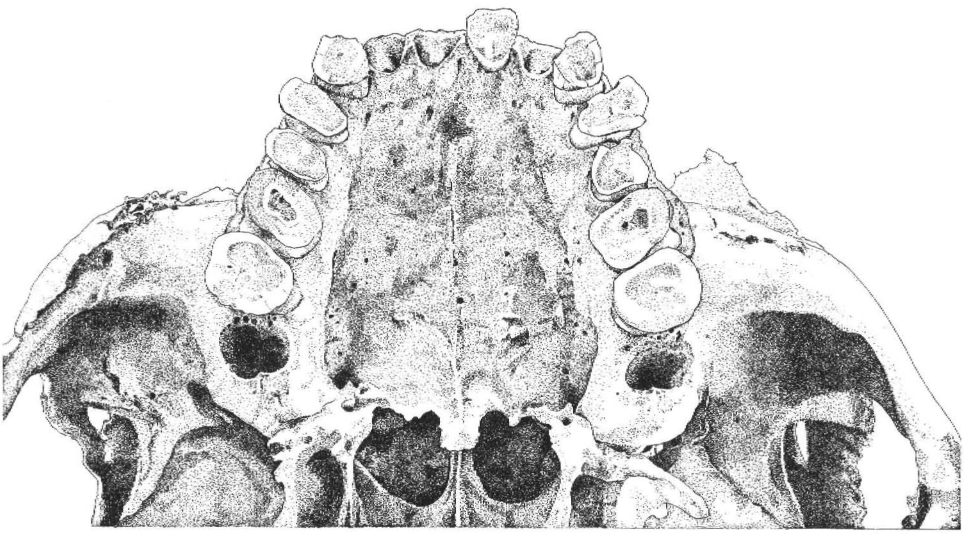

FIGURE 3. Maxillary dentition. (*Drawing by S. Wallmann, dedicated to Bob Elston*)

MORPHOMETRIC ANALYSIS OF THE CRANIUM

Analyses of Paleoamerican skeletal morphology have been based on the few existing dated remains (Steele and Powell 1992; Lahr 1995; Neves and Puciarelli

1991). Remains are often fragmentary and analyses are sometimes based on published measurements, which limits the number of measurements that can be included. For example, D. G. Steele and J. F. Powell's (1992) analysis of available North American crania was based on only eight measurements. Howells (1995) recently conducted a wide-ranging classification study of crania from many parts of the world, including a number of specimens representing early modern *Homo sapiens*. No Paleoamerican crania were included in Howells's sample. Morphometric studies of this type allow extraction of maximum information from individual specimens, and the Spirit Cave remains provide a case study that can used to illustrate this approach.

Samples

The data base consists of Howells's world-wide samples (Howells 1989) with the addition of several historic American Indian tribal samples from our data base. Table 1 presents the samples, sample sizes and region of the world from which each comes. Great Plains samples include the Blackfeet, Cheyenne, Crow, Sioux, Pawnee, and Historic Arikara (designatedHARIKARA in Table 1) from the Leavenworth archaeological site, and Cheyenne.We were able to assemble a small sample of Great Basin Numic speakers consisting of crania from the collections of the National Museum of Health and Medicine, the University of Utah, Brigham Young University, and other museum collections.

Table 1. List of world samples to which Spirit Cave Cranial dimensions were compared.

Group	N	Region	Source	Group	N	Region	Source
AINU	86	E Asia	Howells	HAINAN	83	E Asia	Howells
ANDAMAN	70	SE Asia	Howells	MOKAPU	100	Polynesia	Howells
ANYANG	42	E Asia	Howells	MORIORI	108	Polynesia	Howells
PARIKARA*	69	N America	Howells	N Japan	87	E Asia	Howells
HARIKARA	51	N America	Jantz/Owsley	NORSE	110	Europe	Howells
ATAYAL	47	E Asia	Howells	PAWNEE	27	N America	Jantz/Owsley
AUSTRALIA	101	SW Pacific	Howells	PERU	110	S America	Howells
BERG	109	Europe	Howells	PHILLIPIN	50	E Asia	Howells
BLACKFEET	66	N America	Jantz/Owlsey	S JAPAN	91	E Asia	Howells
BURIAT	109	Siberia	Howells	SANTA CRUZ	102	N America	Howells
BUSHMAN	90	S Africa	Howells	SIOUX	28	N America	Jantz/Owsley
CHEYENNE	22	N America	Howells	TASMANIA	87	SW Pacific	Howells
DOGON	99	W Africa	Howells	TEITA	83	E Africa	Howells
EASTER I	86	Polynesia	Howells	TOLAI	110	SW Pacific	Howells
EGYPT	111	N Africa	Howells	ZALAVAR	98	Europe	Howells
ESKIMO	108	Greenland	Howells	ZULU	101	S Africa	Howells
GUAM	57	Micronesia	Howells	NUMIC	22	N America	Jantz/Owsley

The American samples in Howells's database are from Santa Cruz Island, California; Peru; Eskimos from Greenland; and Protohistoric period Arikara (designated PARIKARA in Table 1) from the Sully site in South Dakota. Altogether, there are ten Amerindian samples among a total of thirty-four population samples.

Variable Selection

Howells's (1973, 1995) database contains sixty-one variables for most groups. Table 2 presents Howells's three letter abbreviations, along with a brief description of the measurement. Several analyses were conducted using various subsets of these measurements. These subsets were chosen to illustrate the relationships of the Spirit Cave individual to modern populations based on specific dimensions that have been defined through factor analyses of cranial measurements (Howells 1973; Key 1983). These studies have identified several complexes representing sets of dimensions that covary more strongly with each other than with other dimensions. The main cranial complexes are facial height, forwardness, prognathism, and vault breadth and height. Other important complexes include orbit horizontal profile, frontal flatness, upper facial breadth and midfacial size. These complexes were used as a guide to identify subsets of measurements incorporated into different analyses. These smaller analyses allow us to focus on relationships reflected by these cranial complexes, and to provide a metric description of the Spirit Cave male stated in terms of the patterns of variability seen in modern crania.

It was also necessary to exclude certain variables from all or most analyses. Excluded measurements include (1) those that could not be obtained from the Spirit Cave Mummy (because of adhering tissue it was not possible to obtain measurements to dacryon, asterion or the nasal region), (2) those possessing high interobserver variation (these consist of small measurements such as WNB, SSS [also excluded because of No. 1 above], IML, XML, MLS, GLS, and SOS, (3) measurements which mainly reflect robusticity, such as MDH, MDB and WMH, and (4) measurements whose primary purpose is the calculation of angles (FRF, PAF, and OCF).

Statistical Methods

Two analyses were run in parallel. In one, the raw measurements were used with sex differences in the reference samples removed by first centering on sex-specific means. In the other analysis, the raw variables were first converted to shape variables by dividing each by size. Size is defined as the geometric mean of all variables (Darroch and Mosimann 1985; Jungers, Falsetti, and Wall 1995). A size variable defined in this way removes isometric size. It differs from the approach taken by J. Kamminga and R. V. S. Wright (1988), who define size as the first principal component. Excluding the first principal component also removes some shape information. Unlike the first principal components, shape variables as de-

Table 2. Measurement Abbreviations and Descriptions. See Howells (1973;1989) for additional details.

Abr.	Description	Abr.	Description
GOL	glabello-occipital length	XML	maximum malar length
NOL	nasion-occipital length	MLS	malar subtense
BNL	basion-nasion length	WMH	minimum cheek height
BBH	basion-bregma height	SOS	supraorbital projection
XCB	maximum cranial breadth	GLS	glabella projection
XFB	maximum frontal breadth	STB	bistephanic breadth
ZYB	zygomatic breadth	FRC	frontal chord
AUB	biauricular breadth	FRS	frontal subtense
WCB	minimum cranial breadth	FRF	frontal fraction
ASB	biasterion breadth	PAC	parietal chord
BPL	basion-prosthion length	PAS	parietal subtense
NPH	nasion-prosthion height	PAF	parietal fraction
NLH	nasal height	OCC	occipital chord
JUB	bijugal breadth	OCS	occipital subtense
NLB	nasal breadth	OCF	occipital fraction
MAB	palate breadth	FOL	foramen magnum length
MDH	mastoid height	NAR	nasion radius
MDB	mastoid breadth	SSR	subspinale radius
OBH	orbital height	PRR	prosthion radius
OBB	orbital breadth	DKR	dacryon radius
DKB	interorbital breadth	ZOR	zygoorbit radius
NDS	Naso-dacryon subtense	FMR	frontomalar radius
WNB	simotic chord	EKR	ectoconchion radius
SIS	simotic subtense	ZMR	zygomaxillare radius
ZMB	bimaxillary breadth	AVR	M1 alveolar radius
SSS	zygomaxillary subtense	BRR	bregma radius
FMB	bifrontal breadth	VRR	vertex radius
NAS	nasio-frontal subtense	LAR	lambda radius
EKB	biorbital breadth	OSR	opisthion radius
DKS	dacryon subtense	BAR	basion radius
IML	inferior malar length		

fined here are not necessarily orthogonal to size. After carrying out the above operations, the following steps were taken: (1) Calculate Mahalanobis distances among the samples using principal components derived from the pooled within class covariance matrix. (2) Get principal coordinates from this matrix as described by Gower (1972). (3) Get distances of the Spirit Cave individual from each of the samples and calculate its principal coordinates. The distances of the Spirit Cave male from other groups can be used to assess which groups it most closely resembles and whether it falls within the range of variation of those groups. The principal coordinates allow a visual picture in reduced dimensions of its relationships on axes defined by the world samples.

The analyses including and excluding size generally yield similar results. Here we present the results which include size for the various cranial complex analyses, and the shape results for the general analysis.

RESULTS

Vault Profile

Vault profile measurements were selected to express the size and shape of the cranial vault in the sagittal plane. They express the complexes seen in vault height, frontal bone size and flatness, parietal size and profile, and cranial base flatness. There are twelve dimensions; six are radii from the transmeatal axis to various points on the vault, and six are chords and subtenses of the frontal, parietal and occipital. The Spirit Cave male classifies as Ainu on these twelve variables. Table 3 gives the four closest and the four most distant samples in the comparative database. The four closest populations are dominated by Asian/Pacific populations, but include the Zulu of Africa. The typicality probabilities show that the Spirit Cave male could easily be a member of any of these groups. The Bushman is the most distant population, but the next three are American Indians. The Spirit Cave male would be an atypical member of any of these populations.

Table 3. Distances, posterior and typicality probabilities of the four closest and four most distant populations based on sagittal vault dimensions.

	Four closest			Four most distant		
Group	D^2	Post	Typ		D^2	Typ
Ainu	10.31	0.47	0.59	Bushman	33.61	0.00
Moriori	12.14	0.19	0.43	Sioux	29.54	0.00
Zulu	13.55	0.10	0.34	Pawnee	26.06	0.01
N Japan	13.79	0.08	0.31	Harikara	25.76	0.01

Figure 4 shows the three-dimensional plot of the comparative samples (73 percent of dispersion) and the position of the Spirit Cave male. Its affinity to Ainu, the Pacific, and secondarily to East Asia, is evident in the plot. Table 4 gives the among structure coefficients which permit interpretation of the principal coordinate axes. The first axis reflects vault size with emphasis on height and posterior projection. The low American Indian scores on this axis reflect their low and relatively small vaults. Groups with high scores are Polynesians, and East Asians, including Ainu. The Spirit Cave male is clearly aligned with this last group of populations and not with American Indians. The second axis is primarily frontal curvature and an associated location of nasion. High scores reflect strongly curved frontal and posterior placement of nasion, low scores the reverse. Both American Indians and Polynesians exhibit flat frontals, as has been previously pointed out by Howells (1978). Unlike Indians, the Spirit Cave cranium does not have a flat frontal configuration. It is most similar to East Asian and Europeans in this regard. The third axis reflects frontal and parietal bone size and placement of nasion. High scores reflect large frontal and parietal and anterior placement of nasion. The Spirit Cave male has a high score most similar to certain Polynesians, Ainu and Zulu, but is in contrast to American Indians who score low.

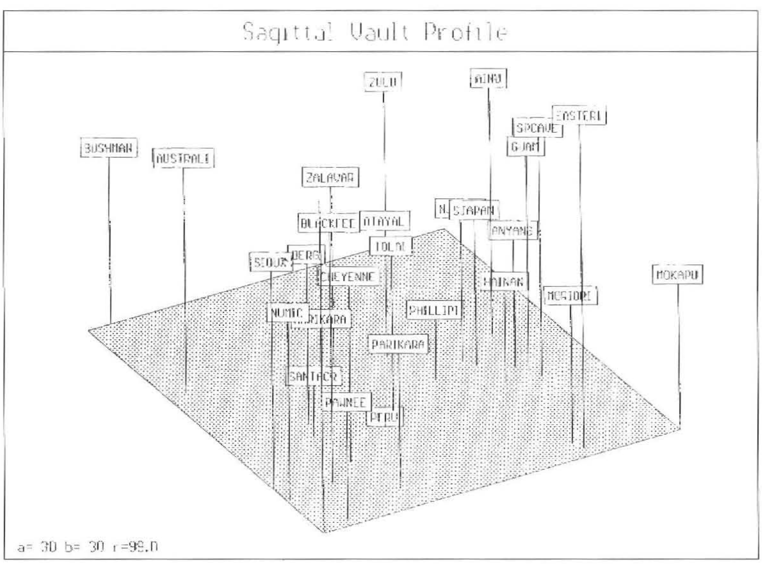

FIGURE 4. Three-dimensional plot showing the relationship of the Spirit Cave Male to world populations using sagittal vault variables.

Vault and Face Breadth

Vault and face breadth reflect the pattern of breadth variation. The variables are those which define vault breadth, upper facial breadth, and midfacial size. Table 5 shows the four closest and four most distant population samples in the

Table 4. Among Canonical Structure Coefficients for Vault Dimensions

	Can 1	Can 2	Can 3
FRC	0.372	-0.111	0.254
FRS	0.195	0.411	0.246
PAC	0.340	0.242	0.253
PAS	0.293	0.046	0.012
OCC	0.465	-0.172	-0.021
OCS	-0.345	-0.063	0.154
NAR	-0.013	-0.360	0.401
BRR	0.456	-0.221	0.147
VRR	0.499	-0.199	0.056
LAR	0.474	0.031	0.058
OSR	0.162	0.044	0.259
BAR	0.441	0.020	0.157

database. The Spirit Cave male is closest to Atayal in its pattern of breadths, but falls comfortably within the range of variation of Numic, Northern Japanese, and Zalavar.

Table 5. Distances, posterior and typicality probabilities of the four closest and four most distant populations based on vault and face breadths.

	Four closest			Four most distant		
Group	D^2	Post	Typ	Group	D^2	Typ
Atayal	8.23	0.46	0.69	Moriori	32.81	0.00
Numic	10.80	0.13	0.46	Andaman	27.85	0.00
N Japan	12.20	0.06	0.35	Buriat	26.82	0.01
Zalavar	12.48	0.05	0.33	Bushman	26.82	0.01

Figure 5 shows the three dimensional plot of the comparative samples and the position of the Spirit Cave male on these axes. Table 6 shows the canonical structure coefficients. The first axis is an expression of general breadth, with a contrast to nasal breadth. All Amerindians possess low scores resulting from their wide faces and vaults and narrow noses. The second axis expresses a contrast between face breadth, especially in the orbital region, and vault breadth. Indians score high on this axis by virtue of relatively wide faces. The Spirit Cave male is similar to American Indians on the first two axes. Axis three is orbit breadth, nasal and maxillary breadth, and vault breadth. The Spirit Cave male is low on this axis, falling below most Amerindians (exceptions are Numic and Cheyenne) and closer to many South Asian populations.

Table 6. Among Canonical Structure Coefficients for Vault and Face Breadths

	Can 1	Can 2	Can 3
XCB	-0.415	-0.316	0.238
XFB	-0.303	-0.357	0.247
ZYB	-0.556	0.227	0.198
AUB	-0.613	0.059	0.151
WCB	-0.521	-0.109	-0.072
NLB	0.240	0.086	0.308
MAB	-0.360	0.162	0.236
OBB	-0.232	0.277	0.405
ZMB	-0.493	0.228	-0.006
FMB	-0.174	0.363	0.315
EKB	-0.225	0.341	0.295

Facial Forwardness and Prognathism

These variables reflect variation in the facial forwardness and prognathism complexes, which express the forward projection of the face and maxilla. Table 7 shows the four closest and four most distant populations. The two closest are both European, but Norse has a much higher posterior probability than any other group. The typicality probability indicates that the Spirit Cave male is less typical than 89 percent of Norse crania and less typical than over 95 percent of the other three closest groups.

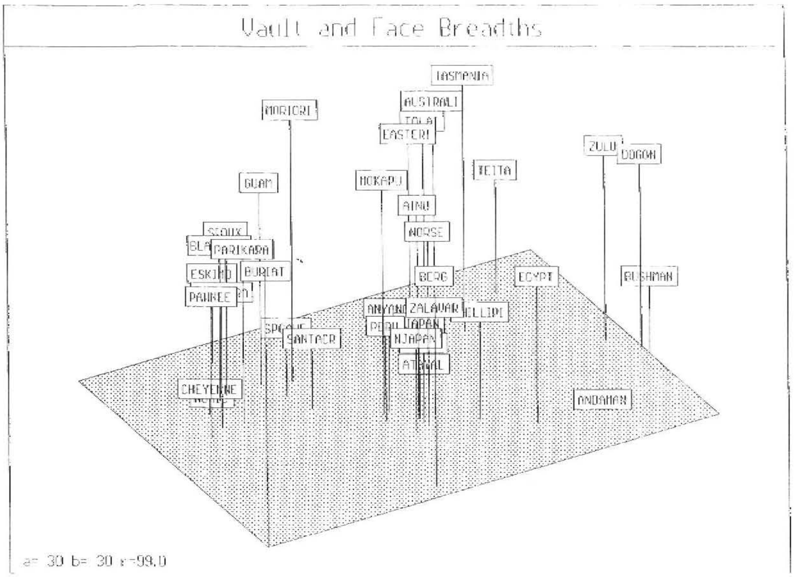

FIGURE 5. Three-dimensional plot showing relationship of the Spirit Cave male to world populations using vault and face-breadth variables

Table 7. Distances, posterior and typicality probabilities of the four closest and four most distant populations based on facial forwardness and prognathism dimensions.

	Four closest			Four most distant		
Group	D^2	Post	Typ	Group	D^2	Typ
Norse	18.10	0.78	0.11	Arikara	49.49	0.00
Zalavar	22.54	0.08	0.03	Andaman	48.12	0.00
Egypt	23.13	0.06	0.03	Eskimo	47.07	0.00
Bushman	25.02	0.02	0.02	Mokapu	45.62	0.00

Figure 6 shows the three-dimensional plot of the comparative samples and Spirit Cave, and Table 8 the canonical structure coefficients. The first axis is mainly prognathism and separates Southwest Pacific groups, the most prognathic, from East Asians, the least prognathic. The second axis reflects upper facial forwardness. Eskimos and Polynesians have high facial forwardness; Andaman Islanders have the least facial forwardness, although certain Amerindians (Peru and Santa Cruz) and certain Africans (Dogon and Bushman) also score low. The third axis, which is primarily cranial length, is the only one that systematically differentiates Amerindians from most other groups. Amerindians possess low scores, meaning they have short vaults. The Spirit Cave face's score on the first axis characterizes it as mildly prognathic, more like the Southwest Pacific than East Asia. On the second axis it exhibits little facial forwardness, less than that seen in most Amerindians. It is most differentiated on the third axis, where, because of its vault length, it scores high, along with Eskimo, Ainu, Australian, and Bushman.

Table 8. Among Canonical Structure Coefficients of Facial Forwardness/Prognathism

	Can 1	Can 2	Can 3
GOL	0.356	0.349	0.298
NOL	0.295	0.348	0.289
BNL	0.183	0.530	0.034
BPL	0.352	0.313	0.178
NAR	0.263	0.519	-0.051
SSR	0.435	0.385	-0.016
PRR	0.373	0.345	0.118
ZOR	0.164	0.525	0.156
FMR	0.115	0.572	-0.001
EKR	0.037	0.580	0.032
ZMR	0.204	0.486	0.185
AVR	0.390	0.365	0.118

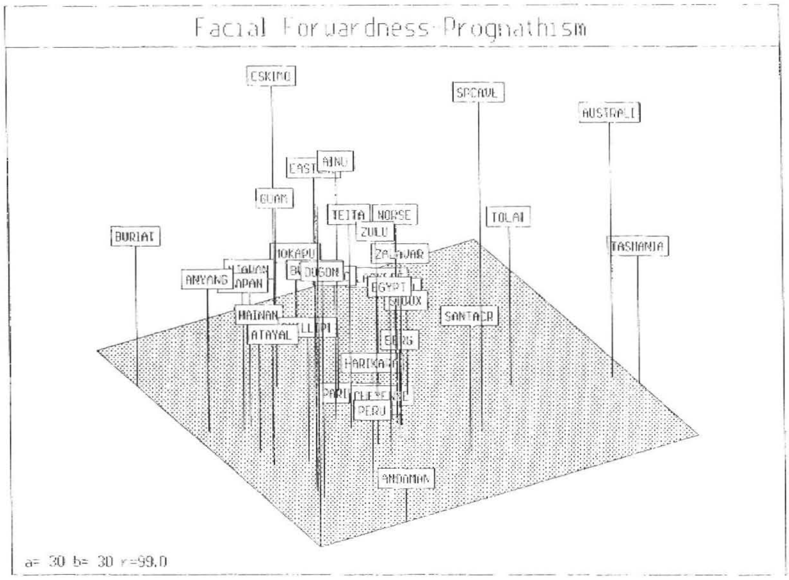

FIGURE 6. Three-dimensional plot showing relationship of the Spirit Cave male to world populations using prognathism and facial forwardness variables

Face Height, Breadth, and Projection

Face variables were selected to express variation seen in face height, face breadth, and facial projections. Face height appears on a separate factor in Howells's (1973) analysis. Face breadths are contained in his upper-face-breadth and midfacial-size factors. Facial projections are measured from various facial planes. T. L. Woo and G. M. Morant (1934) define four facial triangles designed to measure facial flatness and which exhibit marked variation among populations. Howells's measurements allow calculation of three of the four facial triangles, and Howells defined another. The dimensions defining these facial triangles appear in factor analyses as subnasal flatness, nasialia prominence and orbit horizontal profile, and interorbital prominence (Howells 1973; Key 1983). Unfortunately, because of inability to measure dacryon and the nasal bones on the Spirit Cave individual, we could use only two of the facial triangle variables, bifrontal breadth (FMB) and its subtense to nasion (NAS) and bimaxillary breadth (ZMB) and its subtense to subspinale (SSS). These will reflect orbit horizontal profile and subnasal flatness. Table 9 shows the four closest and four most distant populations. The Spirit Cave male clearly has a very strong European resemblance on the facial variables. The four most dissimilar populations are a mixture of the world's most morphologically extreme populations.

Figure 7 shows the position of the world samples and the Spirit Cave male on the first three principal coordinates, and Table 10 gives the structure coefficients for these axes. The first axis is an expression of general face breadth with a contrast

Table 9. Distances, posterior and typicality probabilities of the four closest and four most distant populations based on face height, breadth and projections.

	Four closest			Four most distant		
Group	D^2	Post	Typ	Group	D^2	Typ
Berg	13.77	0.34	0.32	Bushman	36.22	0.00
Norse	14.81	0.21	0.25	Tasmania	35.79	0.00
Zalavar	16.36	0.10	0.18	Andaman	32.81	0.00
Sioux	16.95	0.07	0.15	Buriat	30.59	0.00

to nose breadth. It reflects some of the same things seen on the first axis in the vault and face breadth analysis presented above. Amerindians have high scores reflecting their wide faces and narrow noses. On this axis the Spirit Cave individual aligns with populations of more moderate face breadth, such as Europeans, Polynesians and East Asians. The second axis reflects orbital width and orbit profile and subnasal flatness. The Spirit Cave face is distinguished from both the flat, broad-faced East Asian populations and from Southwest Pacific populations which have narrow, angular faces. Here it aligns with populations exhibiting only moderate orbit width and facial projections such as Europeans, Polynesians and Amerindians. The third axis reflects specifically orbit horizontal profile, and nasal and palate breadth. Here Spirit Cave has a high score, reflecting receding orbits and narrow nose and palate. This also places it close to Europeans and many American Indians.

Size Analysis

Size is often considered a nuisance variable to be eliminated if at all possible. Size has been included in the analyses presented here, but it is instructive to examine size alone. Separate size variables, as previously defined (Darroch and Mosimann 1985), were constructed for the face and vault. The size analysis was limited to males. Vault size is defined as the geometric mean of eleven vault dimensions, and face size as the geometric mean of ten face dimensions. Figure 8 shows the plot of vault size and face size of the comparative samples and the Spirit Cave male.

Table 10. Among Canonical Structure Coefficients face heights, breadth and projections

	Can 1	Can 2	Can 3
ZYB	.567	-.218	-.183
NPH	.604	-.057	-.080
NLH	.596	-.064	-.113
NLB	-.249	-.072	-.437
MAB	.357	-.204	-.362
OBH	.562	-.048	-.049
OBB	.265	-.402	-.164
ZMB	.551	.028	-.138
SSS	.038	-.492	.068
FMB	.183	-.408	-.101
NAS	.126	-.388	.422
EKB	.248	-.321	-.193

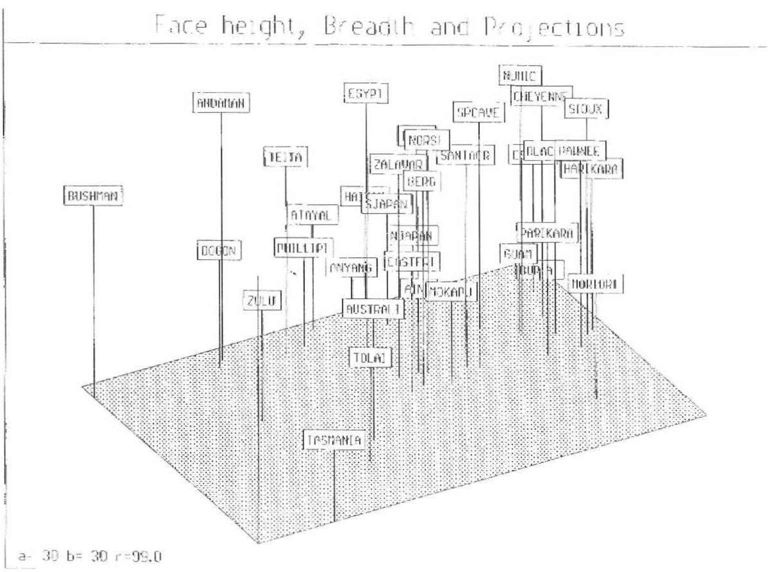

FIGURE 7. Three-dimensional plot showing relationship of the Spirit Cave male to world populations using face height, breadth, and projection variables.

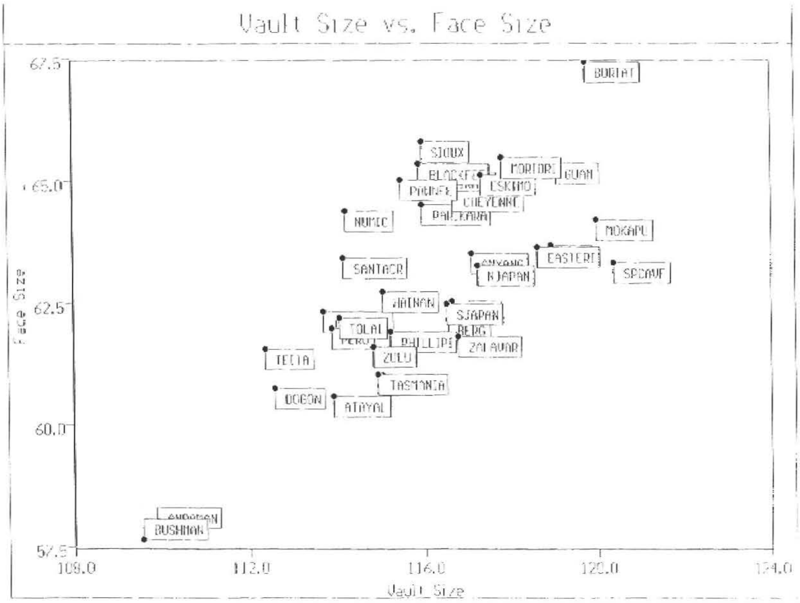

FIGURE 8. Plot of cranial vault and face size showing relationship of the Spirit Cave male to world male sample

There is a positive relationship between vault size and face size evident in the plot, but some independent variation as well. Amerindians can be characterized as possessing large faces and about average vaults. In contrast, the Spirit Cave individual has a large vault and an average sized face. Spirit Cave is most similar to Polynesian populations in vault and face size relationships.

General Analysis

The foregoing provides similarities of the Spirit Cave individual to world populations based on specific morphological complexes. The final stage in the analysis is to obtain an overall assessment. Table 11 gives the distances and the posterior probability of those distances of the Spirit Cave individual from all samples in the world data base, sorted from smallest to largest distance. There is a distinct pattern to be seen in these distances. Two of the three closest populations (Norse and Zalavar) are European. Ainu, the second closest, shares some of the morphometric features attributed to Europeans. In fourth and fifth position are two Amerindians, Blackfeet and Numic respectively. The next set, except for Egypt, consists of East or Southeast Asians. The posterior probabilities indicate that the only reasonable classifications are Norse, Ainu or Zalavar. However, the typicality probability for Norse is 0.00084, and all other populations are of course lower. Therefore the major conclusion is that the skull falls outside the range of variation of any modern population represented by currently available samples.

Table 11. Distances of Spirit Cave from all comparative samples, sorted from smallest to largest, and posterior probabilities.

NORSE	AINU	ZALAVAR	BLACKFEE	NUMIC	ATAYAL	EGYPT	HAINAN	NJAPAN
65.883	68.599	71.229	72.145	73.830	74.621	74.802	74.862	75.604
0.694	0.178	0.048	0.030	0.013	0.009	0.008	0.008	0.005
SJAPAN	ZULU	ANYANG	BERG	TEITA	CHEYENNE	MORIORI	PHILLIPI	DOGON
76.259	79.774	79.800	79.832	81.383	81.960	82.692	85.681	86.790
0.004	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
PERU	SANTACR	TOLAI	GUAM	ESKIMO	EASTERI	MOKAPU	39CO9	ARIKARA
87.242	87.407	87.510	88.066	89.561	91.803	92.071	92.657	93.484
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TASMANIA	AUSTRALI	PAWNEE	ANDAMAN	BUSHMAN	SIOUX	BURIAT		
94.054	96.880	96.943	97.416	99.088	110.437	115.464		
0.000	0.000	0.000	0.000	0.000	0.000	0.000		

DISCUSSION

The analysis has provided the basis for characterizing the Spirit Cave male's metric features, using the range of variation in modern *Homo sapiens* as the framework. The Spirit Cave specimen presents a mosaic of similarities and differences to the modern morphometric pattern, depending upon which craniofacial complex is used. For sagittal profile of the vault, it is most similar to Ainu, for vault and face breadths, to Atayal, for facial forwardness and prognathism to Norse, for the face variables to Europeans. In the general analysis, the vault profile, facial forwardness and prognathism components dominate, resulting in Norse and Ainu as the two populations to which Spirit Cave is most similar.

In the general analysis and most of the specific cranio-facial complex analyses, the Amerindian samples cluster rather tightly. The majority of Amerindian samples are from the Plains region, but Santa Cruz and even Peru are more similar to other Amerindians than to populations from other parts of the world. The Spirit Cave male does not show affinity to any Amerindian sample used here.

What should also be emphasized is that the Spirit Cave male falls outside the range of variation of all the samples used here. This is mainly due to its greater length; the parietal dimensions in particular contribute to Spirit Cave's uniqueness. We cannot conclude that the Spirit Cave individual falls outside the range of variation for modern Homo sapiens. The samples available, while extensive, do not begin to cover the range of variation present in modern Homo sapiens.

Hrdlicka's (1937) early contention that early Americans exhibit no difference from modern Indians may be responsible for much of the historical indifference accorded early American skeletons. The recent metric analyses have demonstrated that early American crania differ systematically from modern Amerindian crania. Compared to modern Indians, the Paleoamerican cranial vaults are longer and narrower, faces are shorter and narrower, and orbits are narrower and higher (Steele and Powell 1992). Steele and Powell (1992) have shown that their Paleoamerican sample fell outside the range of means defined by modern Amerindians. They conclude that Paleoamericans are more similar to South Asians and Europeans than they are to modern Indians.

In South America the differences may even be greater. Neves and Puciarelli (1991) place early South Americans nearest Australian Aboriginals and other populations of the Southwest Pacific. Even recent South Americans exhibit these relationships, which Lahr (1995) attributes to retention of robusticity rather than phylogenetic resemblance.

Our analysis of the Spirit Cave Mummy agrees with features attributed to early Americans in a number of respects, including long narrow, cranium, low face combined with high orbits, and narrow orbits. The Spirit Cave Mummy bears a number of similarities to European populations, as Steele and Powell (1992) observed in their sample. The South Asian similarity observed by Steele and Powell (1992) is weaker in the Spirit Cave individual, although the similarity to Ainu, which shares morphometric features with Polynesia (Brace and Hunt 1990), might be viewed in this way.

It is clear that any general extrapolations from our findings to peopling of the New World would be premature at this point. The findings are in line with some of the general ideas extracted from cranial analyses so far. It is fairly well established that the late Pleistocene populations of eastern Asia were not morphologically similar to the populations of the present who occupy the area. The Spirit Cave mummy's morphology shows little resemblance to any of the modern Mongoloids. It is also not very similar to any modern Amerindians, at least as they are represented by our samples. Even though modern North American Indians lack many of the features associated with modern East Asians, it is clear they have been influenced by recent dispersals. Lahr (1995) has argued that the early dispersal into East Asia consisted of people showing incipient Mongoloid features, such as facial flatness and a broad vault. It does not appear that the Spirit Cave mummy was drawn from a population exhibiting these incipient Mongoloid features. Our evidence would be more consistent with the proposition that the source population in Northeast Asia exhibited few of the features commonly associated with contemporary people of Northeast Asia.

The major problem facing synthesis of Paleoamerican craniometric variation concerns lack of comparable data. There has not yet been any systematic metric analysis of early American cranial or skeletal remains using a comprehensive set of variables. It is with this goal in mind that we are attempting to incorporate data from early Americans into our cranial data base. Application to the Spirit Cave skeletal remains has shown how informative such analyses can be.

BIBLIOGRAPHY

Brace, C. L., and K. D.Hunt

1990 A Nonracial Craniofacial Perspective on Human Variation: A(ustralia) to Z(uni). Am. J. Phys. Anthropol. 82:341-360.

Darroch, J. N., and J. E. Mosimann

1985 Canonical and Principal Components of Shape. Biometrika 72:241-252.

Gower, J. C.

1972 Measures of Taxonomic Distance and Their Analysis. In The As sessment of Population Affinities in Man. J. S. Weiner and J. Huizinga, eds. Clarenden Press, Oxford, pp. 1-24.

Howells, W. W.

1973 Cranial Variation in Man. Vol. 67. Papers of the Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, MA. 259 pages.

1978 Was the Skull of the Moriori Artificially Deformed? Arch. & Phys. Anthrop. in Oceania 13: 198-203.

1989 Skull Shapes and the Map. Papers of the Peabody Museum of Archaeology and Ethnology, Vol. 79. Harvard University, Cambridge, MA. 189 pages.

1995 Who's Who in Skulls. Papers of the Peabody Museum of Archae ology and Ethnology, Vol. 82. Harvard University., Cambridge, MA. 108 pages.

Hrdlicka, A.

1937 Early Man in America: What Have the Bones to Say? In Early Man. G. G. MacCurdy, ed. Lippencott, Co., London.

Jungers, W. L., A.B. Falsetti, and C. E. Wall

1995 Shape, Relative Size, and Size Adjustments in Morphometrics. Yearbook of Physical Anthropology 38:137-161.

Kamminga, J., and R. V. S. Wright

1988 The Upper Cave at Zhoukoudian and the Origins of the Mongoloids. J. Hum. Evol. 17:739-767.

Key, P. J.
1983 Craniometric Relationships Among Plains Indians. Vol. 34. Report of Investigations, The University of Tennesee, Department of An thropology, Knoxville, TN. 189 pages.

Lahr, M. M.
1995 Patterns of Modern Human Diversification: Implications for Amerindian Origins. Yearbook of Physical Anthropology 38:163-198.

Lahren, C.
1996 Letter to Dr. Douglas Owsley, dated Dec. 13, 1996

Neves, W. A. and H. M. Puciarelli
1991 Morphological Affinities of the First Americans: An Exploratory Analysis Based on Early South American Human Remains. J. Hum. Evol. 21:261-273.

Steele, D. G. and J. F. Powell
1992 Peopling of the Americas: Paleobiological Evidence. Hum. Biol. 64:303-336.

Wheeler, S.M. and Georgia N. Wheeler
1969 Cave Burials Near Fallon, Churchill County, Nevada. Miscellaneous Paper No. 3., pp 68-78. Nevada State Museum Anthropo logical Papers No. 14, Carson City.

Woo, T. L. and G. M. Morant
1934 A Biometric Study of the "Flatness" of the Facial Skeleton in Man. Biometrika 26:196 250.