

SHORT PAPER

Drought-Related Changes in Two Hunter–Gatherer California Populations

Elizabeth Weiss¹

Environmental Dynamics Program, University of Arkansas, Fayetteville, Arkansas 72701

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Skeletal remains from two California cemeteries bracketing a severe drought that began around 1200 yr B.P. are analyzed to determine drought-related quality of life changes in Native Americans. Cemetery 1 predates the drought at 2895 ± 160 yr B.P. to 1845 ± 90 yr B.P. and Cemetery 2 dates it at 1100 ± 90 yr B.P. to 1220 ± 200 yr B.P. Quality of life was assessed through femoral computerized tomography scan measures of cortical thickness, age at adult death, and pathology/trauma frequency. After controlling for age and sex differences, changes from Cemetery 1 to Cemetery 2 showed decreases in cortical thickness and age at death and increases in pathology and trauma frequency. © 2002 University of Washington.

INTRODUCTION

Droughts can have major impacts on human populations. For example, droughts in the Sahel during the 1970s and 1980s caused tens of thousands of people to die (Holmes *et al.*, 1997). Anthropologists have begun to take notice of the negative effects that droughts may have had on prehistoric populations (Owsley, 1991; Walker, 1991–1992; Lambert, 1993; Oliver-Smith, 1996; Ivanhoe, 1995; Jones *et al.*, 1999). Jones *et al.* (1999), for instance, demonstrated that a drought lasting from about 1200 to 600 yr B.P. negatively affected population size, trade, and level of violence in preagricultural populations in four regions of North America, including the San Joaquin Valley in California. Evidence of this drought came from tree rings, packrat middens, and fossils, and decreases in quality of life were documented by reduction in site size and bead and other artifact manufacturing, and by increments in pathologies and traumas (Stine, 1994; Jones *et al.*, 1999). However, Jones *et al.* (1999) and others (e.g., Bettinger, 1999) acknowledged that other factors could have accounted for the apparent patterns and that biology, culture, location, and subsistence patterns have to be better controlled before drought can be definitively accepted as the causal factor for the documented changes.

The present study provides a site-specific test of the hypothesis that drought negatively affects prehistoric populations, holding constant biology, culture, and mode of subsistence. Skeletal remains from two cemeteries at CA-SJO-91 from the San Joaquin Valley in California were examined. The dates of those cemeteries bracket a medieval California drought that began in California circa 1400 yr B.P. but that is best documented between 1200 and 600 yr B.P. (Stine, 1994; Jones *et al.*, 1999). As such this study reduces the uncertainty about the drought hypothesis.

Site CA-SJO-91 was discovered in April 1970 while Interstate Highway 5 was under construction. Many of the burials contained artifacts enabling behavioral and cultural reconstruction of the populations. The excavation yielded 161 individuals from two cemeteries (Hague, 1977; Wait *et al.*, 1994). Although the excavation at CA-SJO-91 was a salvage site, most of the skeletal remains were in good condition. The most abundant remains were lower limbs and pelvises, allowing individuals to be sexed and aged.

The site is located in a region of California ethnographically attributed to the Northern Valley Yokuts. Hague (1977) determined that Cemeteries 1 and 2 represent an early habitation by Yokuts, or Native Americans directly ancestral to the Yokuts. Artifacts, such as clay frogs, beads, and hunting implements, were found that show cultural similarity and continuity of the two cemeteries. Further evidence for the relatedness of the two populations comes from the similarity of their acorn caches and mortar-and-pestle artifacts. There was no evidence of agriculture present at either time period and at both time periods a large variety of flora and fauna existed that the Yokuts could have used for food. The staple food for both populations was acorns, which came from oak trees on the surrounding grassy plains (Seldomridge, 1976).

Cemetery 1 dates from 2895 ± 160 to 1845 ± 90 B.P. and Cemetery 2 from 1100 ± 90 to 1220 ± 200 yr B.P. (Table 1; GX-4529; Schulz and Johnson, 1980). ¹⁴C techniques were used to date 15 features of the CA-SJO-91 site containing baked clay, rock, bone, charcoal, and burnt acorns (Schulz and Johnson, 1980). Confirmatory dating came from an independent examination of the morphology of the beads (Wait *et al.*, 1994). Finally,

¹ Mailing address: E-mail: eweiss@anthrosciences.com. 1265 Richmond Street, Suite 1710, London, Ontario N6A 3M1, Canada.

TABLE 1
¹⁴C Analysis Results for CA-SJO-91

Individual	Material	Cemetery	Age, ¹⁴ C yr B.P.
Burial-32	bone	1	1845 ± 90
Below feet of burial-32	charcoal	1	2560 ± 100
Burial-78	bone	1	2985 ± 160
Burial-86	bone	1	2200 ± 160
Burial-100	bone	2	1100 ± 90
Burial-106	bone	2	1220 ± 200
Burial-127	bone	2	1220 ± 200

a third dating technique, using obsidian sourcing and hydration of several projectile points, confirmed the validity of the dates from the radiocarbon and bead morphology (Wait *et al.*, 1994).

METHODS

In the present study, three indices of quality of life were used to examine the effects of the drought: decreased cortical thickness, decreased life span, and increased pathology and trauma frequency. Cortical bone thickness is a good indicator of quality of life because it is continually deposited throughout the life of an individual and reflects changes in nutrition (Owlsley, 1991). Average age at time of death is another often-used quality of life indicator (Cohen, 1989). An older age at death signifies adequate nutrition and care for the elderly. Infant remains are excluded in this comparison so that average age at time of death reflects a shift in life span rather than an abundance of infant births and deaths. Some anthropologists, however, contend that infant mortality should be an expected outcome of resource scarcity caused by droughts. Pathologies and traumas constitute a third quality of life indicator. Droughts typically lead to scarce resources, which in turn leads to increased fighting for them.

For 64 of 98 individuals, computer tomography (CT) was used to obtain femoral midshaft cross-sections (Weiss, 1998). CT scans were available for 53 individuals from Cemetery 1 (predrought cemetery) and for 11 individuals from Cemetery 2 (drought cemetery). For each cross-section, six measurements were made (in cm) from the end of the medullary cavity to the end of the cortical bone and means calculated to obtain a cortical thickness value (Dewey *et al.*, 1969). Data on age, pathologies, and traumas were collected for 69 individuals from Cemetery 1 and 29 individuals from Cemetery 2.

Analyses of covariance were used to control for age and sex differences in cortical thickness and pathology/trauma frequency and to test for the significance of the differences between the two cemeteries. Only sex was controlled for in the analysis of the age at death variable. Controlling for sex and age is important because females have lower values for cortical thickness than do males, because cortical bone thins with age, because

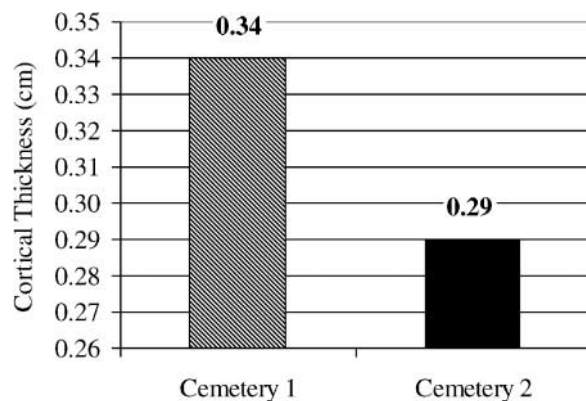


FIG. 1. Differences in cortical thickness (cm) by cemetery. Bars show means.

females live longer than males, and because elderly individuals more frequently have pathologies or traumas than do young individuals.

RESULTS

Analyses of covariance (controlling for age and sex) revealed that Cemetery 1 (the nondrought cemetery) had greater cortical thickness, older ages at death, and fewer pathologies and traumas than Cemetery 2 (the drought cemetery). An interaction effect was noted: measures of female cortical thickness and age at death (but not pathology or trauma frequency) decreased more than did those for males.

Individuals in Cemetery 1 had significantly thicker cortical bone than did those in Cemetery 2 (Means = 0.34, 0.29 cm; SDs = 0.05, 0.09; $F = 4.37$; $p = 0.05$) (Fig. 1). Furthermore, females from Cemetery 1 had higher cortical thickness values than did females from Cemetery 2 (Means = 0.32, 0.26 cm;

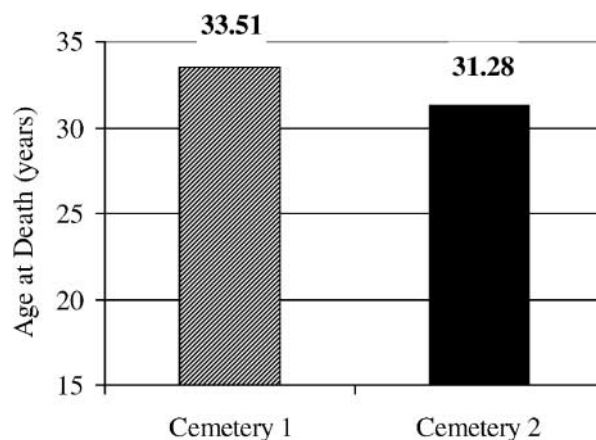


FIG. 2. Differences in age at death (years) by cemetery with y-axis starting at the youngest age in the sample. Bars show means.

TABLE 2
Summary of Significant Findings

Property	Paired Group Differences		
	Cemetery	Sex	Age
Cortical thickness	Cemetery 1 > Cemetery 2	Females: Cemetery 1 > Cemetery 2	Elderly: Cemetery 1 > Cemetery 2; Young Adults: Cemetery 1 > Cemetery 2
Age at death	Cemetery 1 > Cemetery 2	Females: Cemetery 1 > Cemetery 2	—
Pathology/trauma frequency	Cemetery 1 > Cemetery 2	—	—

SDs = 0.06, 0.04; $F = 10.77$; $p = 0.01$). The elderly from Cemetery 1 had thicker cortical bone than did those from Cemetery 2 (Means = 0.32; 0.23 cm; SDs = 0.04; 0.08; $F = 7.74$; $p = 0.01$). Finally, young adults from Cemetery 1 had thicker cortical bone than did those from Cemetery 2 (Means = 0.36, 0.25 cm; SDs = 0.05, 0.07; $F = 11.27$; $p = 0.01$).

Individuals in Cemetery 1 lived longer than those in Cemetery 2, although the difference was significant only when controlling for sex (Means = 33.51, 31.28; SDs = 12.02, 10.68; $F = 3.03$; $p = 0.03$) (Fig. 2). Males from Cemetery 1 actually died earlier than did males from Cemetery 2, but this result was not significant (Means = 30.75, 31.47; SDs = 9.92, 11.93; $F = 0.06$; $p = 0.81$). The female life span, however, was significantly longer in Cemetery 1 than it was in Cemetery 2 (Means = 39.04, 30.93; SDs = 14.05, 8.79; $F = 3.05$; $p = 0.09$).

The pathology/trauma frequency of Cemetery 1 was also significantly lower than that of Cemetery 2 ($F = 7.79$, $p = 0.01$). In Cemetery 1, 33 of 69 individuals (48%) had pathologies, traumas, or both. In Cemetery 2, 18 of 29 individuals (62%) had pathologies, traumas, or both. Table 2 provides a summary of the results.

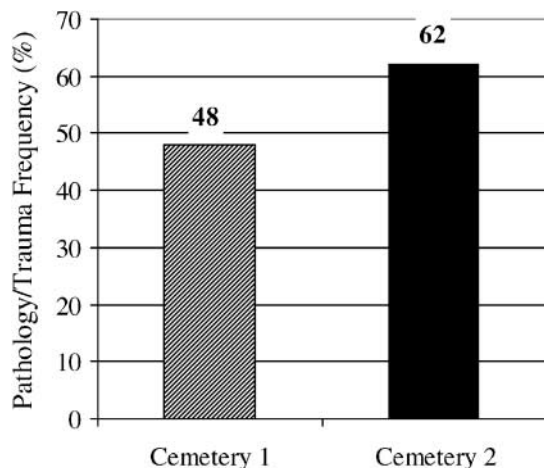


FIG. 3. Differences in the frequency of pathologies and traumas by cemetery. Bars show frequencies.

CONCLUSION

The present study adds support to the hypothesis that droughts negatively affected prehistoric Californian Native Americans. Two cemetery populations from the same site, were compared one that preceded the drought and one during it, thus controlling for several factors such as location, subsistence pattern, biology, and culture. The drought population (Cemetery 2) had thinner cortical bone, a lower life span, and more traumas and pathologies than did the predrought population (Cemetery 1). Although, problems, such as small sample size, make this study less than definitive, these results dovetail with those from other studies (Ivanhoe, 1995; Jones *et al.*, 1999; Lambert, 1993; Walker, 1991–1992).

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