



# Health and morbidity in ancient Chilean populations: Preliminary perspectives using subadult data

**Christine Elisabeth Boston**

The University of Western Ontario, Department of Anthropology

*Bioarchaeological studies have suggested a general trend whereby the health of past populations degraded as they transitioned from a nomadic, hunter-gatherer lifestyle to a sedentary, agricultural lifestyle. Ancient societies of northern Chile provide a unique perspective on this debate in that while the earliest societies relied on hunting and gathering they were at the same time sedentary. Furthermore, later agricultural Chilean societies had relatively balanced diets since they also relied on fishing. Thus, this study examined four skeletal markers of health on sixty-one subadults ranging from the Archaic (7000–1000 B.C.) to Late Horizon (A.D. 1476–1532) periods in order to prove the impact of subsistence strategies and social organization on individuals' health. These health markers were cribra orbitalia and porotic hyperostosis, trauma, dental pathological conditions, and infections. Despite the small sample size, this study gives a glimpse of childhood health conditions and morbidity patterns in northern Chile. The results showed no statistical differences of morbidity patterns between preagricultural and agricultural societies, a contradiction to previous assumptions about morbidity differences between preagricultural and agricultural societies.*

## Introduction

In the middle of the 20th century, archaeologists, physical anthropologists, and prehistorians began to question whether the health and lifestyles of societies may have changed as they transitioned from preagricultural to agricultural subsistence strategies. In 1982, Drs. Mark Cohen and George Armelagos brought together scholars at the “Impact on Human Health of the Neolithic Revolution” symposium in order to take an in-depth look at this question and provide possible answers based on studies of past human groups (Cohen and Armelagos 1984b). During this symposium, the researchers concluded that most populations suffered a decrease in health status as they moved from a hunter-gatherer subsistence strategy to an agricultural subsistence strategy as based on several factors, including a decline in nutritional intake and an increase in infection rates. This conclusion has

been generally accepted by scholars today and is considered valid across most if not all ancient and modern populations today (Ember and Ember 1999; Feder and Park 2007; Jurmain *et al.* 1997; Reinhard 1992; Walker 1985).

A reevaluation of this idea in the contexts of ancient Chilean populations from the north coast shows that this general trend may not hold true in this region as observations of the subadult sample discussed here do not agree with the findings of the Cohen and Armelagos (1984a) symposium. The results from analyses of subadult morbidity rates do not support previous research on adult populations from the area. This calls for a reevaluation of the conclusions reached by the Cohen and Armelagos symposium as they relate to the health statuses of past Chilean populations and the importance of sedentism in the preagriculture to agriculture transition. This

---

Author correspondence should be directed to [cboston2@uwo.ca](mailto:cboston2@uwo.ca) (Department of Anthropology, Social Sciences Centre, The University of Western Ontario, London, Ontario, Canada N6A 5C2)

*Nexus* is an annual graduate student publication of the McMaster University Department of Anthropology, Hamilton, Ontario, Canada. <http://digitalcommons.mcmaster.ca/nexus>

paper will delve deeper into the previous conclusions drawn from the symposium through the study of ancient Chilean samples in order to explain both these conclusions and the results from this study.

### Previous Research

In 1982, the symposium "Impact on Human Health of the Neolithic Revolution" was conducted in order to explore issues of health and well-being in ancient populations as they made the transition from a hunter-gatherer to an agricultural lifestyle. Previous to this symposium, the effects of agriculture on societies had been greatly debated and no definitive conclusions been reached on the subject (Cohen 1984). This symposium sought to remedy these debates by bringing together scholars who studied in different geographical regions of the world to answer questions related to health at the introduction of agriculture. Ancient populations from every habitable continent were surveyed using different techniques from both physical anthropology and archaeology, and the results of each study were presented at this symposium (see Cohen and Armelagos 1984a). The papers presented were later published in an edited volume by Cohen and Armelagos (1984b). Along with the papers from the symposium, the general trends and conclusions reached at the symposium were synthesized in order to answer questions related to the debates which initiated the symposium (Cohen and Armelagos 1984b). The general conclusions from this symposium showed that despite the apparent advantages of adopting an agricultural lifestyle (i.e. an increase in food supply), agricultural populations faced an increased risk of infections as well as a decline in nutritional intake due to restrictive diets (Cohen and Armelagos 1984b). These effects were due to the reliance on and consumption of a limited array of crops in comparison to the previous diverse diets consumed under the hunter-gatherer lifestyle. It was unclear, however, which group (hunter-gatherers or agriculturalists) had an increased tendency toward violence and accidental trauma based on all the studies examined at the symposium

(Cohen and Armelagos 1984b). It was also concluded that, overall, there was a decrease in the quality and length of life for individuals practicing agricultural lifestyles (Cohen and Armelagos 1984b).

There were two notable exceptions to the above conclusions. The studies by Lynette Norr (1984) and Jerome Rose *et al.* (1984) showed, in some cases, preagricultural, hunter-gatherer groups were less healthy than later agricultural groups. Norr (1984) focused her study on ancient Panamanian populations spanning 9,000 years and used archaeological analyses of faunal remains and stone tools as well as stable carbon and nitrogen isotopic studies. The conclusions of her study contradicted the general conclusions of the symposium, and she pointed out that a possible reason for this contradiction lay in the fact that the expected degradations to health would not occur if an agricultural diet was balanced and complimented with other food stuffs that replaced the missing nutrients (Norr 1984).

The other contradictory study conducted by Rose *et al.* (1984) focused on a comparison of pathological lesions manifested in the skeletal remains of individuals from the Mississippian and Caddoan cultures located in the southeastern United States. This study showed that there are several non-dietary factors such as poor sanitation, injury, parasitic invasions, and population concentrations which affect health and should be taken into consideration when comparing morbidity rates between preagricultural and agricultural groups (Rose *et al.* 1984). As such, changes in diet cannot be held solely responsible for changes in health when subsistence strategies change.

It is the goal of this paper to determine whether the conclusions reached at the Cohen and Armelagos symposium can be applied to ancient Chilean populations from the north coast. The sample used in this study included subadult (from birth to 17 years of age) individuals from both preagricultural and agricultural groups. The sample temporally spans a 7000 year period, showcasing the continued effects of agricultural change on populations.

A secondary goal of this paper is to reanalyze the conclusions reached by the Cohen and Armelagos symposium. In any field, re-evaluating past hypotheses and paradigms is necessary in order to further current research and to dismiss ideas which are no longer deemed applicable. Ancient Chilean populations give researchers an ideal opportunity to test whether the conclusions of the symposium are still valid or if further exceptions need to be described. It is hypothesized that the ancient Chilean populations surveyed here will provide another exception, and thereby provide greater insight regarding the diversity of health outcomes experienced by cultures who transitioned from one subsistence strategy to another.

## Background

### *Preagriculturalists*

The preagricultural sample consisted of 22 individuals and included members of the Chinchorro and Quiani cultural groups. The Chinchorro, who are best known for creating the world's oldest anthropogenic mummies, are an Archaic period preagricultural fishing group who resided in northern Chile and southern Peru (Arriaza 1995b; Aufderheide 2003; Guillén 2005; Rivera 1995; Standen and Arriaza 2000), although in this study only Chilean Chinchorro populations were sampled. They occupied this region from 7000-1000 B.C. (Arriaza 1995b; Aufderheide 2003; Costa-Junqueira *et al.* 2000; Guillén 2005; Rivera 1991; Rivera 1995; Standen *et al.* 2004; Sutter 1997). Archaeological evidence suggests they were a semi-sedentary population whose diet consisted mostly of marine resources, making up 80% of their diet (Arriaza 1995a). The high marine content of this diet resulted in the Chinchorro people having a high prevalence of parasitic invasions because marine foods were often raw or undercooked when consumed (Arriaza 1995a). This exposure to marine parasites is cited as having greatly affected their health and well being, leaving them nutrient deficient and resulting in iron-deficiency anemia.

The Quiani cultural period occurred during the Chinchorro occupation in Chile and is dated from 4220 to 3680 B.C. (Arriaza 1995b; Sutter

1997). Despite the overlap in time, the cultural materials associated with each group are distinctive enough to warrant a separation of the groups into two separate cultures (Arriaza 1995a). The Quiani culture was characterized as a group of marine foragers and hunters who experimented with horticultural practices (Arriaza 1995a; Cocilovo *et al.* 2005; Sutter 1997). Archaeological evidence suggests the Quiani were a completely sedentary group unlike their Chinchorro counterparts (Cocilovo *et al.* 2005; Rivera 1995).

### *Agriculturalists*

The agricultural sample consisted of 39 individuals from the Gentilar and Inka periods. The Gentilar culture dates from 1350 to 1476 and existed before and was contemporary with the Inka conquest of the region (Rivera 1991; Sutter 1997). The Gentilar people were a sedentary agricultural population which cultivated a variety of crops including maize, beans, and potatoes. The Gentilar also relied on fishing as a way to supplement their agricultural diet (Rivera 1991), which also put them at risk for parasitic invasions. The Gentilar culture is also characterized as having increased labor specialization, social stratification, and group tensions (Rivera 1991; Sutter 1997).

The Inka period of Chile is defined by the control of the region by the Inka of Peru from 1476 to 1532 (Rivera 1991; Sutter 1997). The Inka controlled the economics and political infrastructures of the region, exploiting the area in order to export goods such as copper, turquoise, and crops to other areas of the empire. The populations of this region relied on similar subsistence strategies as the Gentilar people did, so there was a reliance on both fishing and agriculture (Sutter 1997).

### *Expectations*

A similar study to the one presented in this paper was conducted by Dr. Marvin Allison (1984). Allison's study consisted of preagricultural groups from only Peru and agricultural groups from both Peru and Chile (Allison 1984), but his study did not include the populations examined here. Allison's study

concentrated on the soft tissue remains of mummified individuals from both Peru and Chile, and therefore did not closely focus on skeletal analyses due to the mummified condition of the remains used in his study. Allison primarily focused on a variety of pathological lesions in the soft tissue and employed skeletal analyses to determine rates of dental enamel hypoplasias, Harris lines, and stature (as based on measurements of the tibia) (Allison 1984). Allison conducted these skeletal analyses in order to determine stress during growth and development, which he attributed to poor diets. He did not, however, examine the skeletal remains more closely for caries, pathological lesions such as trauma or infections, occupational markers, etc., which could have yielded richer results for his study. He concluded from these populations that there was an increase in morbidity rates from preagricultural to agricultural groups, which is in line with the conclusions of the Cohen and Armelagos symposium (Allison 1984).

Based on the diets of the preagricultural groups for the Chilean sample used in this study, a different outcome could be hypothesized. Since the preagricultural groups had such a heavy reliance on marine resources, causing an imbalanced diet and a high rate of parasitic infections, an expectation that the agricultural individuals in this sample would be healthier than the individuals in the preagricultural sample are reasonable. This hypothesis goes against the previous and long since accepted conclusions first established during the Cohen and Armelagos symposium, and its testing will be further discussed here.

### Materials and Methods

The samples used for this study were observed at the Museo Arqueológico de San Miguel de Azapa in Chile in the summer of 2006. It includes 61 subadult individuals available for this study, with 22 individuals derived from the preagricultural sample and another 39 representing the agricultural sample. Subadults were examined because they are believed to be good proxies for the entire population given that children are more

sensitive to environmental and social changes, such as those resulting from shifting subsistence strategies. Subadults can, therefore, provide the maximum amount of information about a population and its changes in health when changes occur (Baxter 2005). Furthermore, childhood disease may not remain imprinted on the bones of adults as the bone constantly remodels during the growth process, so the use of subadult skeletons may provide a more accurate measure of childhood health statuses in comparison to the use of solely adult skeletal material (Baxter 2005).

This study focused on four skeletal markers of health which were chosen based on the previous studies in the Cohen and Armelagos (1984a) volume. The first marker of health was cribra orbitalia and porotic hyperostosis, which is associated with iron-deficiency anemia, which has been linked to poor quality diets, genetic disorders, and parasitic invasions (Aufderheide and Rodriguez-Martin 1998; Ortner 2003). Another marker was incidence of trauma, with both accidental and violence-related traumas being considered in both the Cohen and Armelagos papers (Cohen 1984) and this study. Also, dental pathological conditions and skeletal lesions related to infections were also considered. Dental pathological conditions such as abscesses and caries can be indicators of poor nutrition (Lukacs 1989 and 1992), while infections can be related to occupational hazards.

Using the SPSS 15.0 statistical program, the data collected from these samples were tested with both the G-test and the Fisher's Exact test. The G-test was employed to test the goodness of fit between frequencies of two populations and is considered more powerful than the Chi-square test when the sample sizes are less than 30 (Wonnacott and Wonnacott 1990). The Fisher's Exact test was also employed since some scholars have noted that the G-test gives inaccurate results for extremely small samples, which is the case for this study (Wonnacott and Wonnacott 1990). Both the G-test and Fisher's Exact test results will be presented.

Based on the information provided by Cohen and Armelagos (1984b), the hypotheses tested included:

- There was an expectation of an increase in the frequency of cribra orbitalia and porotic hyperostosis due to the correlation of anemia rates with maize dependence, meaning anemia rates should increase with the increased dependence on maize in agricultural diets. Maize is a poor source of iron and there is an association between maize diets and increased rates of porotic hyperostotic lesions as related to iron-deficiency anemia (Reinhard 1992; Tatala *et al.* 1998; Walker 1985);
- There was an expectation of a decrease in the frequency of trauma in children based on a previous study by Drs. Vivien Standen and Bernardo Arriaza (2000) which showed that the preagricultural Chinchorro people had an increased frequency of trauma due to accidents and interpersonal violence that can result from the scarcity of resources needed to survive. It was assumed that this same scarcity of resources would not exist in the agricultural sample since one of the advantages of agricultural subsistence strategies is an abundant and stable food supply (Cohen 1984). As well, agricultural subsistence strategies allow for food storage against poor harvests, which is not as easily done in hunter-gatherer subsistence strategies. As noted earlier, the Cohen and Armelagos papers had no conclusive data on trauma rates between preagricultural and agricultural groups;
- There was an expectation for an increase in the frequency of dental pathological conditions due to the increased consumption of carbohydrates; and
- Finally, there was an expectation of no change in the frequency of infections since Cohen and Armelagos (1984b) linked this with both sedentism and poor nutrition. Since both the preagricultural and agricultural groups were largely sedentary and had similar diets, it was expected that there would be no change.

**Table 1.** Summary of statistical analyses of the pathological conditions considered in this study

<i>Pathological conditions</i>	<i>Expectation</i>	<i>Observation</i>	<i>Statistical Significance</i>	
			<i>G-test</i>	<i>Fisher's exact test</i>
Cribra orbitalia and porotic hyperostosis	Increase	Increase	Marginal ( $P=.061$ )	No ( $P=.091$ )
Trauma	Decrease	Decrease	No ( $P=.150$ )	No ( $P=.361$ )
Dental pathology	Increase	Increase	Marginal ( $P=.068$ )	No ( $P=.138$ )
Infections	No change	Decrease	No ( $P=.270$ )	No ( $P=.293$ )

## Results

The null hypothesis was that there is no statistically significant difference in pathological lesion prevalence while considering preagricultural and agricultural groups. For the statistical tests, the statistical significance level was set at 5%. The null hypothesis would only be statistically significant (rejected) if the  $P$  value is at least as small or smaller than .05. A summary of these results is provided in Table 1.

For cribra orbitalia and porotic hyperostosis, there was an expectation of an increase in frequency, and the data showed an increase. However, this increase was marginally significant based on the G-test ( $P=.061$ ) and not significant for the Fisher's Exact test ( $P=.091$ ). For trauma, there was an expectation of a decrease in frequency, and the data showed a decrease. However, there was no statistical significance for either the G-test ( $P=.150$ ) or the Fisher's Exact test ( $P=.361$ ). For dental

pathological conditions, there was an expectation of an increase in frequency, and the data showed an increase. However, there was only a marginal statistical significance found with the G-test ( $P = .068$ ) and no statistical significance with the Fisher's Exact test ( $P = .138$ ). For infections, there was an expectation of no change, but there was a decrease in the frequency within the data. However, this was not statistically significant for either of the G-test ( $P = .270$ ) and the Fisher's Exact test ( $P = .293$ ).

### Discussion

It is noted that although the G-test may produce inaccurate results in sample sizes less than 30 (which was the case for the preagricultural sample), the G-test outcomes reported here did in fact agree with those of the Fisher's exact tests. The similarity of these statistical test results attest to their validity and utility for this study.

Explanations for why there was no statistical significance for these variables (cribra orbitalia and porotic hyperostosis; trauma; dental pathological conditions; and infections) could still be linked to sedentism as well as diet. Since both preagricultural and agricultural populations were sedentary, there was little to no change in lifestyle as time went on, only in diet, so both groups were possibly affected by the same pathogens. As for diet, the preagricultural sample had a very specialized diet concentrated on one type of food, marine, which possibly left the population nutritionally deficient (see Goodman and Armelagos 1985 and Lukacs 1992 for similar examples). With the introduction of agriculture came also the supplementation of marine resources, and it was this supplementation that may have increased the quality of diet for the populations during agricultural times as compared to the populations studied in the Cohen and Armelagos (1984a) papers. Dietary supplementation in conjunction with an agricultural diet will not lead to a decrease in overall nutrition, so the pathological effects of a nutritionally poor diet will not be present (Hodges 1987; Norr 1984; Starling and Stock

2007). The dietary differentiation between the preagricultural and agricultural groups might not have been as extreme as in other situations with other populations (see papers in Cohen and Armelagos 1984a), hence why there is no statistical significance or in some cases only a marginal significance, depending on the test to which one subscribes.

Also, it is known from previous studies on the Chinchorro that several individuals sampled did have evidence of parasitic lesions which were attributed to their marine fish diet (Arriaza 1995a). While there is no evidence at this time to show if the Quiani, Gentilar, and Inka populations used in this study also suffered from parasitic lesions, there is evidence that other Chilean and Peruvian populations from those periods did suffer from various parasitic lesions (Allison 1984). It may be assumed that the individuals in the Chilean sample may have also succumbed to similar parasitic lesions, especially since fish was still being consumed during these periods. The presence and effects of parasitic invasions in all of these populations could have been a contributing factor as to why these results came out not significantly different.

The explanations for why there is no statistical significance for trauma could be linked to the agricultural population being just as stressed as the preagricultural population, possibly due to the Inka rule or new stresses such as competition over land. There is archaeological evidence that shows that the Gentilar period was a time of group tensions (Rivera 1991; Sutter 1997), which may be attributable to why there is no statistical significance between the preagricultural and agricultural groups.

### Conclusion

These data do not definitively show statistically significant differences in morbidity rates between preagricultural and agricultural groups. This is only a preliminary exploration of the relationship between subsistence, diet, and health in ancient Chilean populations, and this research should be continued so as to include the adult data to see if these trends continue. One must also consider that because this study

focuses only on the osteological remains and not the soft tissue remains, which were unavailable for this study, only a portion of the data are available at this time.

While the reader should not accept these results uncritically, these results should not be dismissed as they contradict previous assumptions about health and morbidity in the northern Chilean region (Allison 1984). Further research on the adult data from this region needs to be conducted in order to test the validity of this research. If the adult data agree with the subadult data presented here, this could mean a reassessment of what is known about these populations in the past. If the adult data does not agree with the subadult data, this could mean that subadults cannot be used as

proxies in these populations as previously suggested by scholars. This study does suggest that all research on the matter of health and morbidity in ancient populations must be examined critically, and general conclusions cannot be applied to all populations.

#### Acknowledgements

Dr. Bernardo Arriaza & Staff at MASMA for allowing me access to the collections for this and my thesis research; Dr. Andrew Nelson for supervising me and aiding me in this research; Dr. Chris Ellis & Dr. Sohail Khan for aiding me in this research; the University of Western Ontario Faculty of Social Science for helping to fund my research; my family, in particular my father, for providing me with direction; and my friends for their endless support.

#### References

- Allison, Marvin. 1984. "Paleopathology in Peruvian and Chilean Populations." In *Paleopathology at the Origins of Agriculture*, edited by Mark Cohen and George Armelagos, 515-530. Orlando, FL: Academic Press.
- Arriaza, Bernardo. 1995a. *Beyond Death: The Chinchorro Mummies of Ancient Chile*. Washington, D.C.: Smithsonian Institution Press.
- Arriaza, Bernardo. 1995b. "Chinchorro Bioarchaeology: Chronology and Mummy Seriation." *Latin American Antiquity* 6: 35-55.
- Aufderheide, Arthur. 2003. *The Scientific Study of Mummies*. Cambridge: Cambridge University Press.
- Aufderheide, Arthur and Conrado Rodriguez-Martin. 1998. *Cambridge Encyclopedia of Human Paleopathology*. Cambridge: Cambridge University Press.
- Baxter, Joan. 2005. *The Archaeology of Childhood: Children, Gender and Material Culture*. Walnut Creek: Altamira Press.
- Cohen, Mark. 1984. "An Introduction to the Symposium." In *Paleopathology at the Origins of Agriculture*, edited by Mark Cohen and George Armelagos, 1-12. Orlando, FL: Academic Press.
- Cohen, Mark and George Armelagos. 1984a. *Paleopathology at the Origins of Agriculture*. Orlando, FL: Academic Press.
- Cohen, Mark and George Armelagos. 1984b. "Paleopathology at the Origins of Agriculture: Editors' Summary." In *Paleopathology at the Origins of Agriculture*, edited by Mark Cohen and George Armelagos, 585-602. Orlando, FL: Academic Press.
- Cocilovo, José, Héctor Varela, María Costa-Junqueira, and Silvia Valdano. 2005. "Los Pescadores Arcaicos de la Desembocadura del Río Loa (Norte de Chile): El Sitio Caleta Huelén 42." *Chungará* 37 : 5-19.
- Costa-Junqueira, María, Héctor Varela, José Cocilovo, Silvia Quevedo, Silvia Valdano. 2000. "Perfil Paleodemográfico de Morro de Arica, Una Población de Pescadores Arcaicos del Norte de Chile." *Boletín del Museo Nacional de Historia Natural Chile* 49: 215-235.
- Ember, Carol and Melvin Ember. 1999. *Anthropology*. Upper Saddle River, New Jersey: Prentice-Hall, Inc.
- Feder, Kenneth and Michael Park. 2007. *Human Antiquity: An Introduction to Physical Anthropology and Archaeology*. New York: McGraw-Hill.

- Guillén, Sonia. 2005. "Mummies, Cults, and Ancestors: The Chinchorro Mummies of the South Central Andes." In *Interacting with the Dead: Perspectives on Mortuary Archaeology for the New Millennium*, edited by Gordon Rakita, Jane Buikstra, Lane Beck, and Sloan Williams, 142-149. Gainesville, FL: University Press of Florida.
- Goodman, Alan and George Armelagos. 1985. "Factors Affecting the Distribution of Enamel Hypoplasias Within the Human Permanent Dentition." *American Journal of Physical Anthropology* 68: 479-493.
- Hodges, Denise. 1987. "Health and Agricultural Intensification in the Prehistoric Valley of Oaxaca, Mexico." *American Journal of Physical Anthropology* 73: 323-332.
- Jurmain, Robert, Harry Nelson, Lynn Kilgore, and Wenda Trevathan. 1997. *Introduction to Physical Anthropology*. Belmont, CA: Wadsworth Publishing.
- Lukacs, John. 1989. "Dental Paleopathology: Methods for Reconstructing Dietary Patterns." In *Reconstruction of Life from the Skeleton*, edited by Mehmet Iscan and Kenneth Kennedy, 281-286. New York; Alan R. Liss.
- Lukacs, John. 1992. "Dental Paleopathology and Agricultural Intensification in South Asia: New Evidence from Bronze Age Harappa." *American Journal of Physical Anthropology* 87: 133-150.
- Norr, Lynette. 1984. "Prehistoric Subsistence and Health Status of Coastal Peoples from the Panamanian Isthmus of Lower Central America." In *Paleopathology at the Origins of Agriculture*, edited by Mark Cohen and George Armelagos, 463-490. Orlando, FL: Academic Press.
- Ortner, Donald J. 2003. *Identification of Pathological Conditions in Human Skeletal Remains*. London: Academic Press.
- Reinhard, Karl. 1992. "Patterns of Diet, Parasitism, and Anemia in Prehistoric West North America." In *Diet, Demography, and Disease: Changing Perspectives on Anemia*, edited by Patricia Stuart-Macadam and Susan Kent, 219-260. Edison, NJ: Aldine Transaction.
- Rivera, Mario. 1991. "The Prehistory of Northern Chile: A Synthesis." *Journal of World Prehistory* 5: 1-47.
- Rivera, Mario. 1995. "The Preceramic Chinchorro Mummy Complex of Northern Chile: Context, Style, and Purpose." In *Tombs for the Living: Andean Mortuary Practices: A Symposium at Dumbarton Oaks: 12<sup>th</sup> and 13<sup>th</sup> October, 1991*, edited by Tom Dillehay, 43-78. Washington, D.C.: Harvard University Press.
- Rose, Jerome, Barbara A. Burnett, Michael S. Nassaney, and Mark W. Blauer. 1984. "Paleopathology and the Origins of Maize Agriculture in the Lower Mississippi Valley and the Caddoan Culture Areas." In *Paleopathology at the Origins of Agriculture*, edited by Mark Cohen and George Armelagos, 393-424. Orlando, FL: Academic Press.
- Standen, Vivien and Bernardo Arriaza. 2000. "Trauma in the Preceramic Coastal Populations of Northern Chile: Violence or Occupational Hazards?" *American Journal of Physical Anthropology* 112: 239-249.
- Standen, Vivien, Carlos Santoro, and Bernardo Arriaza. 2004. "Síntesis y Propuestas para el Período Arcaico en la Costa del Extremo Norte de Chile." *Chungará* 36: 201-212.
- Starling, Anne and Jay Stock. 2007. "Dental Indicators of Health and Stress in Early Egyptian and Nubian Agriculturalists: A Difficult Transition and Gradual Recovery." *American Journal of Physical Anthropology* 134: 520-528.
- Sutter, Richard. 1997. *Dental Variation and Biocultural Affinities Among Prehistoric Populations from the Coastal Valleys of Moquegua, Peru, and Azapa, Chile*. PhD diss., University of Missouri.
- Tatala, Simon, Ulf Svanberg, and Benedicta Mduma. 1998. "Low Dietary Iron Availability Is A Major Cause of Anemia: A Nutrition Survey in the Lindi District of Tanzania." *The American Journal of Clinical Nutrition* 68: 171-178.

Walker, Philip. 1985. "Anemia Among Prehistoric Indians of the American Southwest." In *Health and Disease in the Prehistoric Southwest*, edited by Charles Merbs and Robert Miller, 39-162. Tempe:

Arizona State University Anthropological Research Papers.

Wonnacott, Thomas and Ronald Wonnacott. 1990. *Introductory Statistics for Business and Economics*. Toronto: John Wiley and Sons.