HEALTH STATUS AND LIFESTYLE IN EARLY NEOLITHIC AND IRON AGE TAIWAN

Michael Pietrusewsky*, Adam Lauer*, Cheng-hwa Tsang**

*Department of Anthropology, University of Hawaii at Manoa, Honolulu
**Institute of History and Philology, Academia Sinica, Taipei

Pacific Island Archaeology in the 21st Century: Relevance and Engagement, Koror, Republic of Palau, July 1-3, 2009
Introduction

Intensive archaeological excavations, which have been on going since the year 2000, at the Tainan Science-Based Industrial Park located in Tainan County, southern Taiwan, are providing a wealth of information on Taiwan’s prehistoric past (Tsang, 2005).
Tainan Excavations

Thus far, more than 50 sites, covered by 7-8 meters of overlying sediments and spanning a time period from 5000 to a few hundred years before present, have been identified in the Industrial Park (Tsang, 2005).
Tapenkeng Culture

Several of the sites are associated with the earliest Neolithic culture of Taiwan, the Tapenkeng culture, well known for its cord-marked and incised pottery (Chang, 1969, Tsang, 2005).
Tainan Burials

In addition to a rich record of cultural and faunal remains from these sites, human skeletal remains of approximately 2,000 individuals have been recovered.
Nankuanli East Site

The focus of this paper is a limited number of skeletons from one of the earliest Neolithic sites from Tainan Industrial Park, the Nankuanli East site. The major subsistence base of this cultural horizon included hunting, fishing and the collection of shellfish, as well as early farming involving the cultivation of rice, foxtail millet, root, and fruit crops (Tsang, 2005; Bellwood, 2006).
Shisanhang Site

Comparisons are made with previously examined skeletons from an Iron Age site located in northern Taiwan, the Shisanhang site (Pietrusewsky and Tsang, 2003). Although gathering and hunting remain important activities, the inhabitants of this Iron Age site also subsisted on cereal crops such as rice, made iron tools, and engaged in long-distance trade (Tsang, 2000).
Transition to Agriculture

Although there are exceptions, most notably Southeast Asia (e.g., see Pietrusewsky and Douglas, 2002 and Douglas and Pietrusewsky, 2007), previous bioarchaeological research has reported a negative impact on human health following the transition to intensified agriculture (e.g., Cohen and Armelagos, 1984; Larsen, 2006; Steckel and Rose, 2002; Cohen and Crane-Kramer, 2007). Generally, researchers have reported higher frequencies of indicators of stress such as enamel hypoplasia and cribra orbitalia as well as indicators of dental health in response to malnutrition, infectious diseases, and changes in diet following the transition to agriculture.
Objectives

In this study, using general and well as specific indicators of physiological stress (Goodman et al, 1984), we examine health, diet, and lifestyle of the inhabitants living during the early Neolithic and later Iron Age periods of Taiwan. Broader comparisons with skeletal series located outside Taiwan are also made.

Although our sample size is small, this is one of the very first studies of the skeletons from Nankuanli East and the Tainan Science-Based Industrial Park.
Hypotheses

- Sex differences in NKLE caries & dental indicators
- Increase systematic stress & dental indicators in Iron Age skeletons compared to Early Neolithic
- Less advanced dental attrition in Iron Age than in Early Neolithic

Specifically, we examine three hypotheses in this paper:

One, because of differences in diet, females are expected to demonstrate greater prevalence of caries and related dental health indicator than males.

Two, commensurate with changes in subsistence economies, it is predicted that frequencies of systematic stress and certain indicators of dental health will increase in later Iron Age Taiwan compared to the earliest Neolithic communities in Taiwan.

Three, following the general trend that agricultural societies use their teeth and jaws less vigorously than hunter-gatherer and foraging societies, we expect less advanced dental attrition in the Iron-Age skeletal series compared to the early Neolithic series from Taiwan.
Nankuanli East Site

The skeletons from the Nankuanli East site, as well as other sites within the Science-based Industrial complex, appeared to be exceptionally complete and well preserved at the time of their excavation and when they were first examined in the storage facility.

However, the excavation methods used to remove the skeletons *en-bloc*, created unforeseeable challenges to our study.
Excavation Methods

Once we began our study of these remains last summer, it soon became apparent that it was nearly impossible to free these remains from the preserving materials used in the field.
Because of this unfortunate situation, we decided to concentrate our efforts on the skulls and teeth.
Nankuanli East: Early Neolithic

- 14 adult males
- 9 adult females
- 17: 20-35 yrs.
- 6: 35-50 yrs.

Nankuanli East Site

A month of very intensive laboratory cleaning and reconstruction by a 6 member team, resulted in the examination of 14 adult male and 9 adult female skulls and teeth. 17 of the adults died as young adults (20-35) and 6 died between 35-50 years of age.
### Shisanhang Iron Age Series

<table>
<thead>
<tr>
<th>Age/Sex</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young adult</td>
<td>13</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Middle-aged</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>8</td>
<td>23</td>
</tr>
</tbody>
</table>

### Shisanhang (SSH) Site (1500-1000 years BP)

An equal number of the best preserved and most complete adult skeletons from the Shisanhang site were used in this study. The data were recorded by me during a previous visit to Academia Sinica in 2000 (Pietrusewsky and Tsang, 2003).
## Comparative Skeletal Series

The skeletal series from Southeast Asia and East Asia used in the comparisons are shown here.

<table>
<thead>
<tr>
<th>Skeletal Series</th>
<th>Location</th>
<th>Dates (years BP)</th>
<th>References for Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Da But</td>
<td>Vietnam</td>
<td>5500 to 6000</td>
<td>Oxenham et al. (2002, 2006)</td>
</tr>
<tr>
<td>Nankuanli East</td>
<td>Southwestern Taiwan</td>
<td>c. 5000</td>
<td>Tsang (2005)</td>
</tr>
<tr>
<td>Middle to Final Jomon</td>
<td>Japan</td>
<td>5000 - 2300</td>
<td>Temple (2007a,b)</td>
</tr>
<tr>
<td>Khok Phanom Di</td>
<td>Central Thailand</td>
<td>4000 - 3500</td>
<td>Taylor (1999)</td>
</tr>
<tr>
<td>Anyang</td>
<td>Northern China</td>
<td>3100</td>
<td>Li (1977)</td>
</tr>
<tr>
<td>Yayoi</td>
<td>Japan</td>
<td>2500 - 1700</td>
<td>Temple and Larsen (2007)</td>
</tr>
<tr>
<td>Shisanhang</td>
<td>Northwestern Taiwan</td>
<td>1500-1000</td>
<td>Tsang (2000)</td>
</tr>
<tr>
<td>Atayal</td>
<td>Taiwan Aborigines</td>
<td>modern</td>
<td>Howells (1989)</td>
</tr>
</tbody>
</table>
Methods

The methods used to determine age-at-death, sex, and to record linear enamel hypoplasia and the dental health indicators follow previous work reported in the Ban Chiang monograph (Pietrusewsky and Douglas, 2002).
Dental Enamel Hypoplasia and Dental Pathology

Observations of dental enamel hypoplasia and dental pathologies were recorded on a per tooth or per tooth socket basis.
Tooth Ablation

Tooth ablation, in this case most likely a rite of puberty, was observed in all of the adult Nankuanli East individuals examined in this study. With a single exception, the pattern observed was the intentional removal of both maxillary lateral incisors and canines well before the time of death. Loss of teeth due to tooth ablation is not included in our frequencies of antemortem tooth loss.
Linear Enamel Hypoplasia (LEH)

Linear enamel hypoplasia are bands of decreased enamel thickness that provide a nearly indelible indicator of stress during tooth crown formation that occurs in infancy and childhood. These defects are associated with acute forms of stress including infection, inadequate nutrition, and weanling diarrhea.

Although not statistically significant, a higher frequency of linear enamel hypoplasia is observed in males than in females. Given that the frequencies are relatively high suggests significant infant and childhood stress was experienced by both sexes during the early Neolithic.
Antemortem Tooth Loss (AMTL)

Antemortem tooth loss, or loss of teeth during an individual lifetime, is attributable to a variety of causes including, most notably, dental caries, periodontal disease, and alveolar defects.

The overall frequency of antemortem tooth loss in the Nankuanli East series is extremely low. No significant difference was observed in the average frequencies of antemortem tooth loss for males and females.
Dental Caries

Dental caries results from a disease process that involves an acid demineralization of enamel and dentine caused by fermentation of carbohydrates by bacteria, a process initiated particularly in the presence of sugars. Without intervention it results in the complete destruction and loss of the affected tooth during the individual’s lifetime.

The overall frequency of carious lesions in the Nankuanli East teeth, again, is a very low, with no significant sex difference observed.
Alveolar Defects

The frequency of alveolar defects, or alveolar bone loss concentrated around the apex of the tooth roots originating from infections of dental pulp, is extremely low in the Nankuanli East series, no significant differences were observed between males and females.
Alveolar Resorption

The overall frequency of advanced levels of alveolar resorption, a condition associated with periodontal disease, in this series is relatively low. Once again, no significant difference was found for the male and females frequencies of this type of resorption.
**Dental Calculus**

The overall frequency of advanced dental calculus, or mineralized dental plaque, one of the most common dental diseases observed in the living as well as in skeletal series, is relatively low. A significantly higher frequency of calculus was observed in females compared to males. Oral hygiene, diet, and systemic stress affect the levels and location of dental calculus.
Dental Attrition

Finally, the overall incidence of advanced dental attrition, tooth wear that exposes the pulp cavity is relatively low in these remains. A higher, but not statistically significant, frequency of advanced dental attrition is observed in males when compared to females.
Linear Enamel Hypoplasia

Although the frequency of linear enamel hypoplasia in adult males and females from Nankuanli East is high, the difference between sexes is not significant.
Dental Pathology in NKLE

Dental Health of Nankuanli East Series

Overall, the dental health of the Nankuanli East skeletons is relatively good. The frequencies of antemortem tooth loss, dental caries, alveolar defect, dental calculus, and alveolar resorption are relatively low for this early Neolithic series. With the exception of dental calculus, which is greater in females, there are no significant sex differences in the frequencies of oral-dental health indicators recorded for this series.

There is little support for the first hypothesis that expects higher frequencies of dental caries and related dental indicators of health in females than males due to differences in diet.
Early Neolithic and Iron Age Taiwan Comparisons

Comparisons between the early Neolithic series from Nankuanli East and the Iron Age Shisanhang series reveal few differences.

The higher frequency of dental enamel hypoplasia observed in the Nankuanli East series is not statistically significant suggesting similar levels of childhood stress in the early Neolithic and later Iron Age Taiwan.
Dental Pathology in Early Neolithic/Iron Age Taiwan
Likewise, identical or lower frequencies of antemortem tooth loss, dental caries, and alveolar defects were observed in both series though none of the differences is significant. These results, therefore, fail to confirm the second hypothesis that subsistence economies of Iron Age Taiwan should be associated with an increase in systematic stress and dental health.
Alveolar Resorption and Dental Calculus in NKLE and SSH

However, significantly higher frequencies of alveolar resorption and dental calculus were observed in the Shisanhang series compared to Nankuanli East. These results confirm a generally accepted decline in health associated with the transition from early Neolithic to later Iron Age Taiwan.
Attrition

As expected, significantly lower levels of advanced attrition were observed in the Iron Age series from Taiwan compared to the early Neolithic series suggesting a more abrasive diet for these early Neolithic than in the later Iron age inhabitants of Taiwan.

Perhaps even more remarkable than these mostly minor differences, which may be attributable to difference in diet and oral hygiene, is the overall similarity in dental health between the earliest Neolithic and later Iron Age skeletons from Taiwan.
Linear Enamel Hypoplasia (LEH)

Finally, a few comparisons are made with skeletal series from outside Taiwan. A comparably high, but not significant, frequency of linear enamel hypoplasia is observed in the Middle to Final Jomon series from Japan. Jomon subsistence included foraging, hunting and fishing, as well as plant cultivation.
Antemortem Tooth Loss
The prevalence of antemortem tooth loss for the Taiwan series are among the lowest reported.
Alveolar Defects

The prevalence of alveolar defects for the Taiwan series is among the lowest reported in these comparisons.
Dental Caries

Likewise, caries prevalence is very low in the Early Neolithic and later Iron Age Taiwan series.

The series having similarly low frequencies of these three indicators include the Neolithic and Metal age series from Vietnam which have been described as foragers and agriculturalists (Oxenham et al., 2002, 2006) whose subsistence base included marine resources, not unlike the early Neolithic and later Iron Age skeletal series from Taiwan.

Again, although lower rates of dental caries have been associated with rice-dominated agricultural communities, the unusually low frequencies of dental infections observed in the Taiwan series may also reflect a non-agricultural economy, or an economy that included a subsistence diet that was low in starches and sugars. As demonstrated elsewhere, reliance on marine resources may be responsible for the generally good dental health of the prehistoric inhabitants of Taiwan.
**Dental Attrition**

The level of advanced dental attrition observed in the Nankuanli East series is most similar to skeletal series from Thailand. Differences in diet and food preparation techniques have been suggested for these higher levels of dental wear.
CONCLUSIONS

Except for dental calculus there are no significant differences in the frequencies of childhood stress and dental health indicators for males and females in the earliest Neolithic skeletons from Taiwan.

With the exception of dental calculus and alveolar resorption observed in the later Iron Age series, there are few differences in the prevalence LEH and dental health in the early Neolithic and later Iron Age skeletons from Taiwan. This conclusion is similar to previous studies in neighboring Southeast Asia that have demonstrated that the transition from foraging subsistence to farming is not necessarily associated with a decline in health as observed in other regions of the world.

As expected, lower levels of advanced dental attrition were observed in the Iron Age series from Taiwan.

Broader comparisons reveal that the dental health in the prehistoric skeletons from Taiwan was generally good.

The higher than expected frequency of linear enamel hypoplasia reported for the early Neolithic inhabitants of Taiwan warrants further investigation.
ACKNOWLEDGEMENTS

- Kuang-ti Li
- Academia Sinica, Taiwan
- I-Ping Chan, Yu-hsuan Tseng, Ivy Yeh, Albert Liu, Hsiu-Man Lin
- National Research Council of Taiwan
- International Archaeological Research Institute, Inc., Honolulu
References Cited


Tsang CH. 2000. Recent advances in the iron age archaeology of Taiwan. Indo-Prehistory Association Bulletin 20:153-158.