

Ancient Health

Skeletal Indicators of Agricultural
and Economic Intensification

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Diet and Health in the Neolithic of the Wei and Middle Yellow River Basins, Northern China

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This chapter reports on trends in human health and morbidity in northern China during a time frame lasting from about 9,000 to 1,800 years ago. Our analysis is based on the frequencies of pertinent skeletal markers detected on the remains of individuals from collections excavated at sites dating to the Peiligang, Yangshao, Longshan, and Dynastic periods. The chronological position accorded each of the pertinent sites is based on interpretation of radiocarbon dates, stratigraphy, ceramic sequences, and, in the case of the Dynastic period material, on textual evidence (see Table 18.1).

Peiligang

Peiligang (circa 9000–7000 BP) is represented in this study by a skeletal series from Jiahu, in central Henan. At 5.5 hectares, Jiahu was a relatively large settlement for its time: a more typical size for Peiligang settlements was 1 to 2 hectares (Liu 2004: 74). Jiahu was partitioned into several residential clusters, each with a specially defined cemetery (Henan Institute 1989; Liu 2004: 126). The site is well known for its bone flutes (Zhang et al. 2004), inscriptions on tortoise shell (Xueqin et al. 2003), and a sequence of rice phytoliths and grains documenting the domestication of this important food plant (Chen et al. 1995a, 1995b).

Yangshao

The majority of the skeletal individuals examined for this study were collected at sites pertaining to Yangshao, a Neolithic culture group that dominated the region drained by the middle Yellow River. Yangshao is conventionally divided into Early, or Banpo (circa 6950–6000 BP), Middle, or Miaodigou (circa 6000–5500 BP), and Late, or Xiwang (circa 5500–5000 BP), although some local chronologies vary slightly from these ranges (Dai 1998; Zhang and Qiao 1992). Our Early Yangshao samples came from four sites in the central and

Table 18.1. Chronology and Location of the Pertinent Archaeological Sites

Occupation Site	Years BP County	Province	Cultural Phase	Interval ^a	Radiocarbon
					Age ^b
Jiahu	Wuyang	Henan	Peiligang	9000–7000	8220–7490
Banpo	Xi'an city	Shaanxi	Early Yangshao	6800–6300	6285–5170
Beiliu	Weinan	Shaanxi	Early Yangshao	6800–6200	6570–6210
Jiangzhai I	Lintong	Shaanxi	Early Yangshao	6900–6400	6180–5465
Jiangzhai II	Lintong	Shaanxi	Early Yangshao	6400–6000	5200–4590
Shijia	Weinan	Shaanxi	Early Yangshao	6300–6000	5200–4800
Guanjia	Luoyang	Henan	Middle Yangshao	6000–5500	
Xipo	Zhudingyuan	Henan	Middle Yangshao	6000–5500	
Meishan	Linru (Ruzhou)	Henan	Late Longshan	4500–4000	
Mengzhuang	Huixian	Henan	Late Longshan	4500–4000	
Kangjia	Lintong	Shaanxi	Han Dynasty	2200–1800	

^a The approximate time period of pertinent human occupation in calendar years ago based on calibrated radiocarbon dates, stratigraphy, ceramic sequences, and, where applicable, historical (textual) evidence, as reported in Liu (2004), Ma (2005), Henan Provincial Institute of Cultural Relics and Archaeology (2003), and XBM (1988).

^b The cumulative range of available uncalibrated dates in radiocarbon years at ± 2 standard deviations based on IA CASS 1991 and Zhang et al. 2004.

eastern parts of Shaanxi province: Banpo, Beiliu, Jiangzhai, and Shijia (Figure 18.1, Table 18.1).

Shijia is situated on the western bank of the Qiu River, twelve kilometers south of the Wei River, in eastern Shaanxi (Xi'an Banpo Museum 1978). The style of material culture excavated from the site suggests that it was occupied toward the end of the Early Yangshao (Gong 1988). Beiliu, located just one kilometer south of Shijia, is a multicomponent site, representing both the early and middle phases of the Early Yangshao.

Jiangzhai is located south of the Wei River, on the northern bank of the Linho River (Xi'an Banpo Museum 1988). Jiangzhai had a settled area of approximately five hectares, demarcated by a substantial ditch (Xi'an Banpo Museum 1988). The living community consisted of more than a hundred houses, which surrounded a central plaza encompassing circular structures interpreted as animal pens. There were two discrete areas of occupation, each representing a different time period: Jiangzhai I (earliest Yangshao) and Jiangzhai II. Burials from Jiangzhai I were distributed in a number of clusters outside the ditch (Xi'an Banpo Museum 1988). Jiangzhai II burials were found mainly in the central area of the site.

Middle Yangshao individuals examined for this study came from Xipo and Guanjia, both in western Henan. During Middle Yangshao, the overall number and size of settlements increased, the Yangshao sphere of influence expanded, and there was greater stylistic uniformity in material culture (Dai 1998; Ma

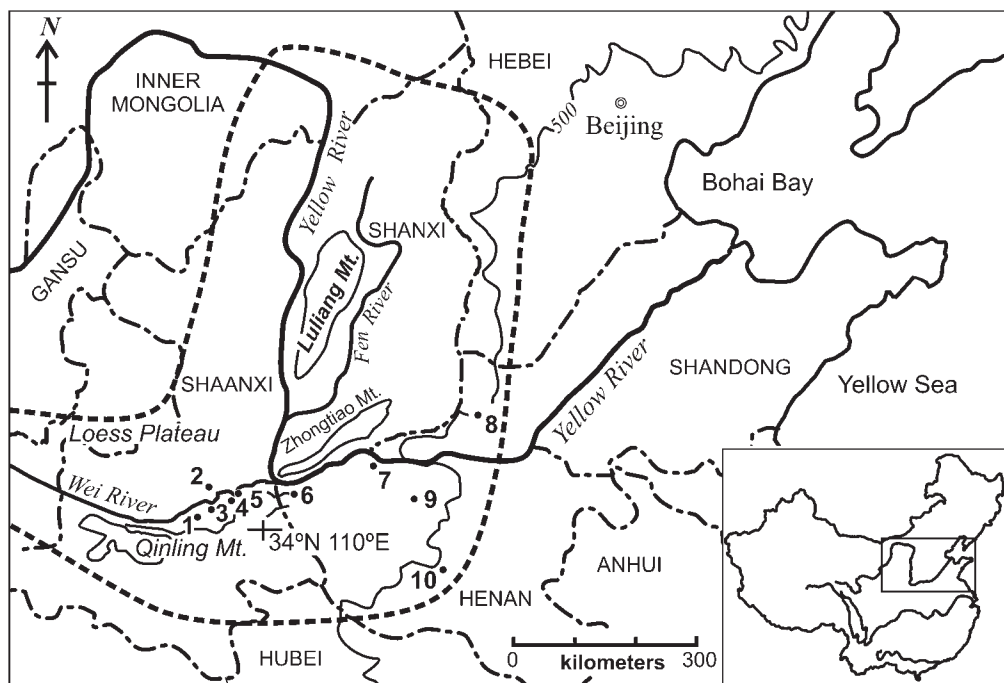


Figure 18.1. The study area. Dashed line marks approximate boundaries of the region of China in which Yangshao material culture has been recognized. 1, Banpo; 2, Kangjia; 3, Jiangzhai; 4, Beiliu; 5, Shijia; 6, Xipo; 7, Guanjia; 8, Mengzhuang; 9, Meishan; 10, Jiahu.

2003; Yan 1982b; Su 1999). The onset of social complexity was evidenced by construction of the earliest monumental edifices and development of a three-tier settlement-size hierarchy, along with marked inequality in the burial treatment of individuals (Ma 2003, 2005; Ma et al. 2006; Dai 1998; Yan 1982b; Su 1999).

Xipo is located in the upper Sha River valley, about three kilometers north of the Qinling Mountains, in the western corner of Henan (Ma 2005; Ma et al. 2005, 2006). Xipo may have been a regional center. It was a relatively large settlement (forty hectares), surrounded by a moat, and with an estimated population of 640–900 people (Ma 2003: 85). There was a three-level size hierarchy among the houses, as well as several larger labor-intensive structures; the biggest may have served as a gathering place for ritual or public functions (Ma 2003: 100). A cemetery outside the moat yielded 22 burials, all single interments. Associated grave goods indicate considerable differences in wealth or status.

Guanjia, the other Middle Yangshao site, was a smaller settlement (nine hectares). It is located along a narrow terrace on the south bank of the Yellow River, about seventy kilometers northeast of Mianchi (Fan 2000). The major occupation at Guanjia was contemporaneous with that at Xipo, but Peiligang and Early Dynastic remains are also present. Ditches demarcate the western and southern limits of the site, where it is not bounded by the Yellow River. Most of the burials uncovered had no associated artifacts (Fan 2000).

During Late Yangshao, an overall population increase in the middle valley was accompanied by the development of fortified towns with monumental public architecture (Liu 2004: 85–86). No Late Yangshao human remains were made available for this study.

Longshan

By about 5000 BP, the Yangshao cultural pattern had been succeeded by Longshan, marked by polished gray or black pottery, as well as a shift in settlement density and distribution. In much of the lowlands, population increased dramatically, while some of the adjacent uplands experienced a decline in population (Liu 2004: 27). Longshan burials are relatively rare, suggesting that some alternative postmortem treatment was being practiced. Longshan individuals examined for this study came from burials dating to approximately 4500–4000 BP at two sites in Henan: Mengzhuang and Meishan.

Meishan is located northwest of modern Ruzhou (Henan Institute 1991). Mengzhuang, in northern Henan, is on the north bank of the Wei River, near Huixian, in the southern foothills of the Taihang Mountains. It is a multicomponent site, with evidence for continuous occupation from the early Neolithic through the Dynastic period; only Longshan skeletons are considered here. During the Longshan period, the settlement was surrounded by walls 15.5 meters thick (Henan Institute 2003).

Dynastic Period

Han Dynasty individuals examined for this study came from Kangjia, in Shaanxi, north of the Wei River, dating to circa 2200–1800 BP (Liu 1994). Supplementary data are provided for burials from Kayue, in Qinghai province, west of our primary study area (Zhang and Han 1998), and a commingled Western Zhou collection (circa 3100–2850 BP) of uncertain provenience (Pechenkina et al. 2002). All three samples represent a time period characterized by further increase in human population density, as well as increasing social stratification.

Subsistence

Trace element and stable isotope analysis of human bones from Jiahu indicate that there was continuing use of wild resources and cultivated cereals throughout the Peiligang sequence (Hu 2002, Hu et al. 2006). The relatively high concentration of ^{15}N isotopes ($\delta^{15}\text{N}$ ranges from 7.21 to 10.46‰) indicates that the human diet at Jiahu also included a substantial proportion of animal products. Millet may have been a minor dietary constituent, as suggested by the $\delta^{13}\text{C}$ spacing between collagen and apatite. However, the low $\delta^{13}\text{C}$ of bone collagen (from -20.87 to -18.77‰) indicates a C3 based diet, thus suggesting rice as the staple cereal at Jiahu (Hu et al. 2006).

Alterations in subsistence practices in Shaanxi and Henan provinces during the Neolithic included increasing dependence on domesticated millet and pig husbandry (Yan 1992; Yuan and Flad 2002). Rice was grown, but in small quantities (Wei et al. 2001; Yan 1982a; Luoyang Museum 1981; An 1984). Wheat was apparently introduced into the area toward the end of the Longshan period (circa 4300 BP) (Crawford et al. 2005) and eventually replaced millet as the principal grain during the Dynastic period. Domesticated sheep and/or goats (*Ovis/Capra*) become evident during the later part of Longshan, sometime between about 4500 and 4000 BP (Zhou 1984; Liu 1994; Huang 1996; Yuan and Flad 2002). At least in western Shaanxi, fishing and foraging retained their importance throughout the Neolithic, to a far greater degree than in Henan (Yuan and Flad 2002).

Stable isotope analysis of fifteen human bone samples from the Yangshao sites of Jiangzhai and Shijia yielded carbon isotope values typical of farmers practicing C₄ agriculture (Pechenkina et al. 2005). Average collagen carbon isotope values ($\delta^{13}\text{C}$ ‰) for Jiangzhai I were -9.3‰ ($n=2$), -10.5‰ ($n=3$) for Jiangzhai II, and -10.0‰ ($n=9$) for Shijia, suggesting that millet constituted 75–85 percent of the diet (Pechenkina et al. 2005). Nitrogen isotope values ($\delta^{15}\text{N}$ ‰) were highest for Jiangzhai I (9.01‰) and lower for samples from the more recent occupations at Jiangzhai II (8.63‰) and Shijia (8.10‰), suggesting some reduction in the consumption of animal products through time. A single specimen of human bone from the Banpo series had more negative ^{13}C and somewhat higher ^{15}N values (-15.00‰ and 9.05‰, respectively), indicating a greater proportion of wild foods in the diet of that individual.

Although no stable isotope estimates are available for human bone dating to Middle Yangshao, analysis of pig and dog bones from Xipo indicates that millet contributed up to 90 percent of their diet (Pechenkina et al. 2005). It seems likely that humans from Xipo also depended on millet for their subsistence. Further intensification of millet agriculture during the Longshan period is also

Table 18.2. Dietary Composition of Commonly Grown Cereals

	Cal.	Prot. (g)	Carb. (g)	Iron (mg)	B1 Thiamin (mg)	B2 Riboflavin (mg)	B3 Niacin (mg)	C Ascorbic Acid (mg)	Protein Score (%) ^a
<i>RDA</i>				48–59	10–18	1.4–1.8	1.1–1.5	14–20	40–60
Cereal									
Barley	327	10.5	71.8	6	0.31	0.1	5.2	0	62 [Ly]
Buckwheat	336	10.3	73.8	3	0.36	0.18	2	0	89 [Le]
Maize	306	9.1	71.7	2.8	0.29	0.11	2.1	0	63 [Ly]
Millet									
<i>Setaria</i> sp.	341	9.5	74.7	5.5	0.43	0.12	2.2	0	34 [Ly]
<i>Panicum</i> sp.	326	12.7	66.5	3.5	0.4	0.1	4	0	41 [Ly]
<i>Sorghum</i> sp.	342	10	72.7	3.8	0.33	0.18	3.9	0	37–48 [Ly]
Rice	341	5.8	73.4	1.4	0.33	0.06	5.6	0	60–77 [Ly]
Rye	334	12.8	70.4	3.0	0.47	0.20	1.7	0	82 [Th]
Wheat	332	11.6	72.1	3.3	0.37	0.12	4.6	0	57 [Ly]

Source: FAO 1972.

Note: Dietary composition is based on 100 grams of edible portion. Cal. = dietary calories;

Prot. = protein; Carb. = carbohydrates; Le = leucine; Ly = lysine; Th = threonine.

^a Protein score is based on presence of essential amino acids, listed in brackets.

^b RDA is given as grams or milligrams, as indicated.

suggested by stable isotope analysis of human bone from Shaanxi (Cai and Qui 1984).

Dietary deficiencies associated with reliance on specific cereals have been observed in a number of studies (for example, Cohen and Armelagos 1984; Larsen 1995; Papathanasiou 2005); these can also be predicted from the inadequate nutrient content of such foods (Food and Agriculture Organization 1972; Drake 1989; Table 18.2). Most cereals lack vitamin C and are low in niacin (B₃). Among the most niacin-deficient cereals are *Setaria* millet, buckwheat, rice, and maize. Although millets have a relatively high iron content, absorption of nonheme iron from plant sources is very inefficient and is further impeded by the lack of vitamin C (Hallberg and Hulthén 2000).

With the exception of rye and buckwheat, almost all cereals contain minimal levels of largely incomplete protein. Millets are among the poorest sources of protein; they are particularly deficient in lysine, the lack of which can lead to a number of physiological disorders, including anemia, anorexia, growth arrest, weight loss, and low protein turnover, as well as collagen and myosin structural anomalies (Harper et al. 1970; Gietzen 1993; Cree and Schalch 1985; Astrom and Decken 1983).

Oral Health

The Peiligang skeletal series from Jiahu, although substantial, is practically devoid of teeth, except for three fragmentary maxillae and two mandibles; most teeth were lost postmortem. A number of conditions, including abscesses—one of them penetrating a paranasal sinus—the loss of alveolar height, and the obliteration of dental sockets, all suggest persistent oral infections and relatively early tooth loss. Of forty available disassociated teeth, five had carious lesions.

There is marked variation in all indicators of oral health among individuals from the Yangshao sites. In Early Yangshao collections from Shaanxi, frequencies of carious lesions were generally low, varying from 6 percent for Jiangzhai II to 29 percent for Beiliu (Table 18.3). All caries detected were on molars and premolars. The lesions were usually small, affecting only one surface of a single tooth, without resulting in abscesses. The average number of carious lesions per adult dentition was consistently less than one, varying from 0.25 to 0.57 (Table 18.4). The elevated frequency of caries in dentitions from Beiliu probably stems from the advanced age of all individuals in that sample.

Table 18.3. Frequencies of Individuals with Specific Pathological Conditions Reflecting Oral Health

Site	Post. Caries f. [N] ^a	Ant. Caries f. [N]	Root Caries f. [N]	Abscess f. [N]	AMTL f. [N]	Calculus Accretion f. [N]
<i>Yangshao</i>						
Beiliu	.29 [7]	.00 [3]	.00 [3]	.00 [7]	1.00 [7]	.43 [7]
Jiangzhai I	.15 [13]	.00 [11]	.00 [11]	.09 [11]	.17 [13]	.77 [13]
Jiangzhai II	.06 [17]	.00 [20]	.00 [20]	.00 [20]	.12 [17]	.35 [17]
Shijia	.21 [28]	.00 [21]	.00 [21]	.04 [21]	.61 [28]	.46 [28]
Guanjia	.75 [24]	.25 [24]	.13 [24]	.38 [24]	.46 [24]	.62 [21]
Xipo	.79 [19]	.17 [18]	.11 [19]	.47 [19]	.63 [19]	.42 [19]
<i>Longshan</i>						
Meishan	.71 [7]	.40 [5]	.43 [7]	.29 [7]	.29 [7]	.57 [7]
Mengzhuang	.50 [6]	.00 [5]	.00 [5]	.00 [5]	.00 [5]	.83 [6]
<i>Dynastic</i>						
Kangjia	.62 [13]	.30 [10]	.30 [10]	.31 [13]	.77 [13]	.23 [13]
Western Zhou	.04 [23]	.00 [23]	.00 [23]	.00 [23]	.17 [23]	.00 [23] ^a
Kayue ^b	.33 [12]	--	--	.25 [12]	.33 [12]	.16 [12]

Note: *N* = number of dental sets examined; *f.* = frequency of incidence; Post. = posterior teeth (molars and premolars); Ant. = anterior teeth (incisors and canines); AMTL = antemortem tooth loss.

^a Absence of calculus accretions is probably the consequence of overall poor preservation.

^b Based on Zhang 1993.

Table 18.4. Number of Pathological Conditions per Adult Dentition

Site	Caries Count [N]	Root Abscess Count [N]	Antemortem Tooth Loss Count [N]	Calculus Accretion Count [N]
<i>Yangshao</i>				
Beiliu	0.57 [7]	0.00 [3]	6.43 [7]	0.00 [7]
Jiangzhai I	0.46 [13]	0.00 [11]	1.38 [13]	0.00 [11]
Jiangzhai II	0.29 [17]	0.00 [20]	0.76 [17]	0.00 [20]
Shijia	0.25 [28]	0.05 [21]	0.71 [21]	0.00 [21]
Guanjia	3.04 [24]	0.83 [24]	2.38 [24]	0.38 [24]
Xipo	2.10 [19]	1.00 [19]	4.79 [19]	0.47 [19]
<i>Longshan</i>				
Meishan	3.14 [7]	0.57 [5]	1.14 [7]	0.29 [7]
Mengzhuang	0.83 [6]	0.40 [5]	0.00 [5]	0.00 [5]
<i>Dynastic</i>				
Kangjia	3.23 [13]	0.30 [10]	0.30 [10]	0.31 [13]
Western Zhou	0.65 [23]	0.00 [23]	0.00 [23]	0.00 [23]

Note: N = number of dental sets examined.

The dental health of individuals from the Middle Yangshao sites of Guan-jia and Xipo was considerably worse. Large multiple caries were frequent on anterior as well as posterior teeth (for the latter, 75 percent and 79 percent of individuals, respectively, with at least one carious lesion) and were often associated with abscesses. Antemortem tooth loss was high (Figure 18.2, B).

Poor oral health is also evident in collections from the Longshan site of Meishan, as well as the Dynastic period series from Kangjia (Figure 18.2, A; Tables 18.3–18.4). However, Longshan dentitions from Mengzhuang were affected by caries to a considerably lesser degree than those from contemporary Meishan. The commingled Western Zhou collection shows very low frequencies of both caries and abscesses.

Rapid dental wear was typical of individuals from both the Early and Middle Yangshao periods, although there was considerable variation within sample groups. The teeth of older individuals were frequently worn to below the cemento-enamel junction and there was traumatic pulp exposure, a degree of tooth wear that may reflect the use of teeth as tools. Enamel chipping was also common. Lingual surface attrition of the maxillary anterior teeth (LSAMAT) was found on Jiangzhai dentitions (Pechenkina et al. 2002). On individuals from Xipo and Jiahu, some mandibular incisors were worn to a greater degree than molars and premolars (Figure 18.2, C–D).

Mandibular and maxillary tori and exostoses were present in all of the Yangshao skeletal collections, but with considerable variation in frequency. These conditions were more common at Early Yangshao sites, Jiangzhai and Shijia, than at those of Middle Yangshao, Guan-jia and Xipo (Table 18.5). The

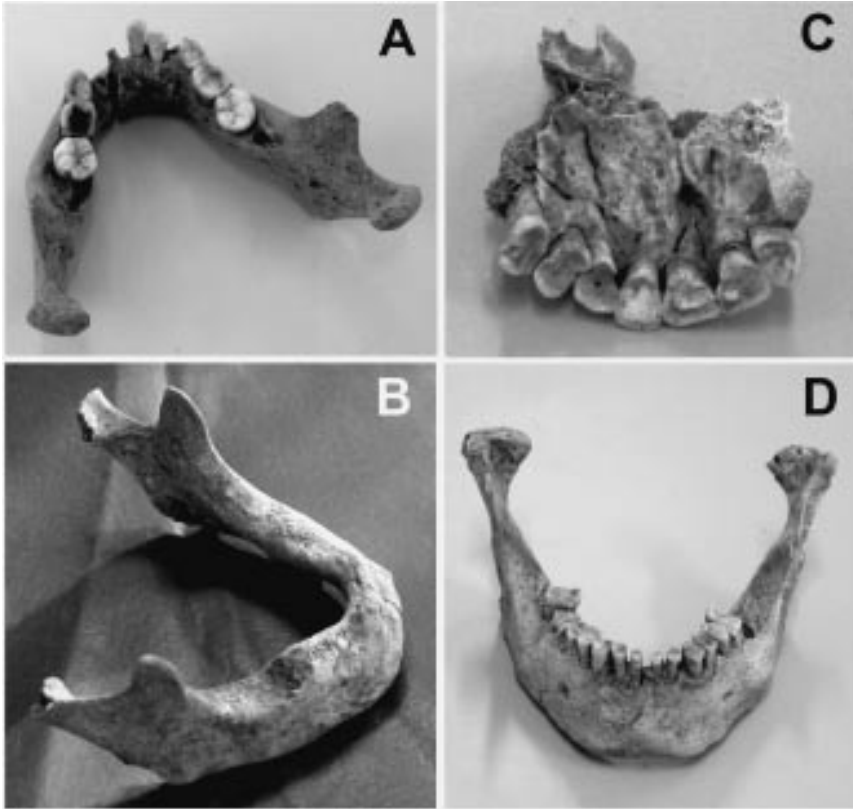


Figure 18.2. Oral health during the Chinese Neolithic. *A*, carious lesion on a deciduous molar (Meishan MT20); *B*, an edentulous mandible (Guanjia M26); *C*, lingual attrition of the anterior teeth (Xipo M14); *D*, severe anterior wear and osteoarthritis of the temporomandibular joint (Xipo M21).

frequency of exostoses on the mandible and maxilla was particularly high on dental sets from Shijia (28 percent for mandibular tori; 54 percent for maxillary exostosis). The frequency of mandibular tori for the Shijia sample is comparable to that observed for other populations from East Asia (Dodo and Ishida 1987; Kerdpon and Sirirungrojying 1999) but lower than that reported for circumpolar populations (Zubov 1973; Steffensen 1969; Dodo and Ishida 1987).

Osteoarthritis of the temporomandibular joint was common in all of the collections studied, except for those of the Dynastic period. The highest frequencies of degenerative lesions on the TMJ were observed for Xipo and Beiliu dentitions (82 percent and 67 percent, respectively). The preponderance of temporomandibular disorders in these collections can be linked to antemor-

Table 18.5. Frequencies of Mandibular and Maxillar Torii and Exostoses and Osteoarthritis of the TMJ

Site	Mandibular Torus f. [N]	Maxillar Exostosis f. [N]	Temporomandibular Disorders f. [N]
<i>Yangshao</i>			
Beiliu	.17 [6]	.50 [6]	.67 [6]
Jiangzhai I	.00 [5]	.07 [15]	.25 [4]
Jiangzhai II	.15 [13]	.47 [17]	.13 [16]
Shijia	.28 [34]	.54 [35]	.52 [33]
Guanjia	.09 [22]	.10 [20]	.18 [22]
Xipo	.19 [16]	.12 [17]	.82 [17]
Longshan			
Meishan	.00 [5]	.00 [6]	.60 [5]
Mengzhuang	.00 [5]	.40 [5]	.17 [6]
Dynastic			
Kangjia	.00 [9]	.00 [10]	.22 [9]
Western Zhou	.00 [23]	.00 [15]	.22 [23]
Kayue ^a	--	.16 [12]	--

Note: N = number of observable elements; f. = frequency of affected elements.

^a Based on Zhang 1993.

tem tooth loss and/or stresses related to use of the anterior teeth as tools (Figure 18.2, D; Table 18.5).

Oral health data are available from the literature for a few other ancient Chinese skeletal collections (for example, Zhang and Han 1998; Zhang 1993). Six Late Neolithic skulls from Yuchisi, in Anhui province, north of the Huai River, which date to approximately 4800–4500 BP (Zhang and Han 1998; Wang 1998), evidenced no carious lesions, a state of oral health similar to that of the Jiangzhai and Shijia Early Yangshao populations. However, antemortem tooth loss was high at Yuchisi, with three out of six dentitions missing several teeth. Occlusal wear was concave and mild to moderate, reflecting diets dominated by cereals (Smith 1984). Both rice and millet phytoliths have been recovered at the site (Wang 1998).

Twelve adult skulls also showing poor dental health stem from a site of the Shang Dynasty–era Kayue culture, in Lijishan County, Qinghai (Zhang 1993). Antemortem tooth loss was frequent, with four of the twelve skulls missing at least one tooth. Large cavities with multiple root abscesses on the labial sides were present on the alveoli of three of the female skulls.

Nonspecific Indicators of Stress

Table 18.6 summarizes the occurrence of nonspecific indicators of stress in all of the skeletal collections utilized in this study. There are large differences in

Table 18.6. Nonspecific Indicators of Physiological Stress

Age Category/ Site	Porosity of Cranial Vault f. [N]	Moderate/ Severe PH f. [N]	Cribral Orbitalia f. [N]	Sphenoid Porosity f. [N]	Linear Enamel Hypoplasia f. [N]
<i>Peiligang adult</i>					
Jiahu	0.46 [37]	0.19 [37]	0.25 [28]	--	--
<i>Yangshao adult</i>					
Beiliu	0.00 [6]	0.00 [6]	0.00 [6]	0.00 [5]	--
Jiangzhai I	0.11 [9]	0.00 [9]	0.33 [9]	0.11 [9]	0.57 [14]
Jiangzhai II	0.16 [19]	0.00 [19]	0.11 [19]	0.05 [19]	0.27 [11]
Shijia	0.23 [39]	0.08 [39]	0.03 [38]	0.15 [39]	0.09 [22]
Guanjia	0.33 [21]	0.14 [21]	0.10 [20]	0.00 [4]	0.76 [17]
Xipo	0.30 [17]	0.12 [17]	0.06 [16]	0.00 [11]	0.33 [12]
<i>Yangshao nonadult</i>					
Jiangzhai	0.00 [6]	0.00 [6]	0.17 [6]	0.20 [5]	--
Shijia	0.14 [7]	0.00 [7]	0.20 [5]	0.00 [5]	--
Guanjia	0.25 [4]	0.25 [4]	0.25 [4]	--	1.00 [3]
<i>Longshan</i>					
Meishan adults	0.83 [6]	0.50 [6]	0.50 [6]	--	0.60 [5]
Meishan juv.	0.00 [7]	0.00 [7]	0.43 [7]	--	0.33 [3]
Mengzhuang	0.14 [7]	0.14 [7]	0.40 [5]	--	1.00 [4]
<i>Dynastic adult</i>					
Kangjia	0.56 [9]	0.33 [9]	0.44 [9]	0.00 [9]	0.80 [10]
Western Zhou	0.44 [18]	0.22 [18]	0.56 [18]	0.00 [18]	--

Note: N = number of observable elements; f. = frequency of affected elements.

the prevalence of nonspecific indicators of stress. Because the number of individuals is relatively small and many are fragmentary, these differences could be an artifact of sampling error. Nevertheless, certain noticeable trends are suggestive.

We distinguish simple porosity of the cranial vault from porotic hyperostosis (PH) or macroporosity with clear hyperostosis. Porous lesions of the parietal, frontal, and occipital bones can result from many different conditions, including scurvy, osteoporosis, and inflammation, and are sometimes pseudopathological (Grupe 1995; Wapler et al. 2004; Ortner et al. 1999). Porotic hyperostosis or macroporosity of the cranial vault associated with diploe expansion, as well as hyperostosis of the orbital roof or cribra orbitalia (CO), both may suggest chronic anemia during early childhood (Ortner and Putschar 1985; Stuart-Macadam 1987a,b, 1989). Porous lesions below the temporal lines on the parietal and sphenoid bones probably indicate scurvy (Ortner et al. 1999; Ortner et al. 2001; Brickley and Ives 2006). The fragmentary nature of Neolithic Chinese osteological collections limits confident diagnosis as to the source or sources of these lesions.

Porous lesions were common on the crania from Henan, including the Peiligang collection from Jiahu (PH evident on 19 percent of the crania), as well as the Middle Yangshao collections from Xipo (12 percent) and Guanjia (14 percent).

Despite heavy reliance on millet at Jiangzhai and Shijia, as indicated by stable isotope values for human bone, surprisingly low frequencies of porotic hyperostosis were found on adult skulls (PH at Jiangzhai was 0 percent; for Shijia, 8 percent). The frequency and severity of CO and PH were considerably greater in our tiny samples from the subsequent Longshan, Western Zhou, and Han periods (PH for Meishan adults was 50 percent; for the Western Zhou collection, 22 percent; for Kangjia, 33 percent; CO frequencies were even higher). The Longshan collection from Mengzhuang had a modest PH frequency (14 percent) but a high frequency of CO (40 percent).

Linear enamel hypoplasia (LEH) was common in all of the collections, with the exception of that from Shijia (9 percent). The highest frequencies of LEH were found on the Mengzhuang, Kangjia, and Guanjia adult dentitions (100 percent, 80 percent, and 76 percent, respectively), as well as among Guanjia nonadults (100 percent). No clear temporal or other trend in such frequencies was detected.

Adult stature, as estimated from long bone lengths, varied substantially among the collections (Table 18.7). The greatest average statures recorded for both sexes were from the early Peiligang collection made at Jiahu (173.7 centimeters for males and 164.5 centimeters for females). Jiahu males appear to have been remarkably tall, even by comparison with modern Chinese males. The average height of 20-year-old males in northern China in 2001 was reported as 171.8 centimeters (Lei et al. 2006). Estimated average statures for all of the Yangshao collections are lower. Longshan and Dynastic period individuals were even smaller.

Sexual dimorphism (the difference between male and female stature, divided by average stature) also showed considerable variation among the collections examined (Table 18.7). The highest degree of sexual dimorphism was found for samples from sites evidencing the heaviest reliance on cooked cereals: Xipo, Meishan, and Kangjia.

Systemic Infection

Few studies have addressed the prevalence of infectious diseases in ancient China. Suzuki and colleagues (2005) examined Bronze Age skeletal collections ($N=181$) from three sites of the Kayue culture (circa 3000–1500 BP) in Qinghai. Periosteal lesions predominantly affected the tibiae and were observed on the long bones of fifteen individuals. Two postcranial skeletons had lesions typical

Table 18.7. Femur Length and Estimated Stature from Chinese Neolithic Samples

Site	Femur Length (mm)		Estimated Stature (cm) ^a		
	Males [N]	Females [N]	Males	Females	Sexual Dimorphism
<i>Early Neolithic</i>					
Jiahu	470.31±17.4 [32]	428.09±33.8 [21]	173.69	64.49	2.72
Yangshao					
Beiliu	448.00±27.3 [4]	408.84±20.1 [4]	168.89	160.50	2.55
Jiangzhai I	455.87±19.4 [4]	427.85±19.9 [5]	170.58	164.53	1.81
Jiangzhai II	450.73±17.9 [7]	416.90±11.3 [6]	169.46	162.26	2.17
Shijia	447.71±26.0 [14]	410.08±16.5 [10]	169.26	161.11	2.47
Guanjia	440.60±10.9 [5]	413.44±20.7 [9]	167.30	161.46	1.78
Xipo	448.98±24.5 [11]	398.65±23.3 [5]	169.10	158.28	3.31
Longshan					
Meishan	441.8±15.1 [5]	389.6±31.0 [3]	167.56	156.33	3.47
Mengzhuang ^b	438.9±29.2 [9]	418.5±15.0 [4]	166.93	162.55	1.33
<i>Dynastic</i>					
Kangjia	433.4±18.8 [9]	366.8±14.8 [4]	165.76	155.74	3.12
Western Zhou	437.0±18.3 [8]	397.1±24.6 [6]	166.52	157.94	2.64

^a Stature estimates are based on formulas for Mongoloid males from Trotter and Gleser 1958.

^b Based on Henan Institute 2003: 546.

of treponemal infection, but no cranial involvement was detected (Suzuki et al. 2005).

Mycobacterial DNA was identified by polymerase chain reaction (PCR) in three of fifteen human skeletons recovered from tombs excavated in Xinjiang-Uigur province in northern China, dating to the Cheshi-Quianguo period, about two thousand years ago. No macroscopic skeletal lesions suggesting tuberculosis were found (Fusegawa et al. 2003). Furthermore, the primers used in the procedure were specific not only for *Mycobacterium tuberculosis* but also for *M. bovis* (Eisenach et al. 1990) and for *M. microti*, which typically infects rodents. Thus, it is not clear whether the DNA found actually was derived from a human-specific strain of *Mycobacterium*.

We found little evidence of chronic systemic infection on the Yangshao skeletons. Periosteal bone formation was associated exclusively with traumatic injury. One subadult skeleton (a 12–14-year-old) from Shijia presented inflammatory lesions on the distal diaphyses of both femora. A radiograph (Figure 18.3, A) revealed pathological subperiosteal and endosteal changes in both femora suggestive of chronic infection. On the same radiograph, transverse lines above the distal epiphyseal plate might reflect multiple growth arrest episodes related to chronic infection.

One Late Longshan skeleton (Meishan M7) had an angular deformity of the spine, resulting from virtually complete resorption of the ninth thoracic vertebral body and partial resorption of the eighth (Figure 18.3, B and C). These

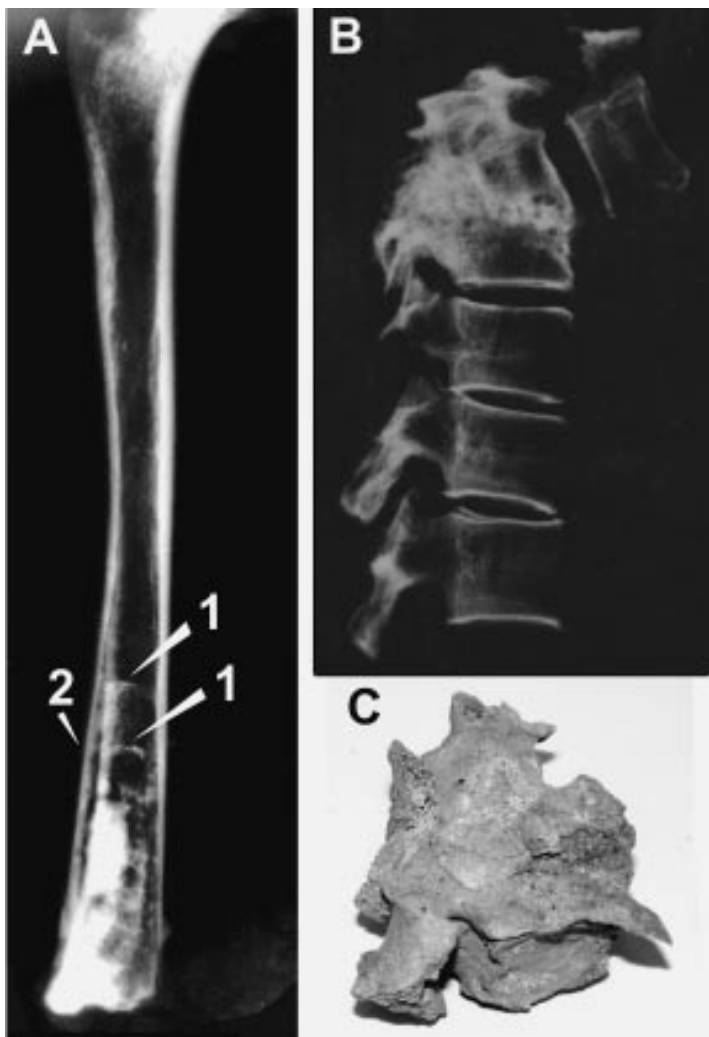


Figure 18.3. Systemic infection in northern China during the Neolithic. *A*, right femur of a 12–14-year-old child (Shijia M43:27): 1, growth arrest lines; 2, raised cortices on the distal portion of the femoral diaphyses. *B* and *C*, resorptive lesions on the thoracic vertebrae of Meishan M7; possible tuberculosis spondyloarthropathy.

lesions are consistent with tuberculous spondyloarthropathy, or Pott's disease (Ortner and Putschar 1985). Bone tuberculosis might also have been the cause of a solitary focus of circumscribed macroporosity on the left parietal of the same individual. No other skeletal elements were affected. These findings represent what may be the earliest documented case of bone tuberculosis from East Asia. However, molecular analysis would be needed to exclude other in-

fectious diseases such as brucellosis and blastomycosis as possible causes of those lesions and the associated trauma (Aufderheide and Rodriguez-Martin 1998).

A Han Dynasty adult skeleton from Kangjia had circumscribed periosteal lesions on the long bones, appearing as nodules 3–4 centimeters in diameter on the distal metaphyses and the distal portion of the diaphyses of both tibiae, or as lobules on the proximal metaphyses of the tibiae, fibulae, and femora. Lesions were found on both anterior and posterior surfaces of the leg bones but were especially prominent on the entheses, along the popliteal line, on the medial malleoli, on the gluteal tuberosities of both femora, and along the interosseus crests of the fibulae. Lobular bone formation was also observed on both humeri around the deltoid tuberosities and distal metaphyses. The circumscribed form of these lesions suggests that there were numerous ulcers in the soft tissues overlying the affected bone. These ulcers could have resulted from either a systemic infection or diabetes in an advanced stage.

Traumatic Injury and Violence

A high frequency of cranial trauma was evident from the samples recovered at three of the Yangshao sites in Shaanxi: Jiangzhai (27.6 percent), Shijia (18.9 percent), and Beiliu (16.6 percent, one out of six skulls). Many of these traumatic injuries apparently reflect interpersonal violence (Pechenkina 2002, see also Jackes 2004 for detailed discussion of the Jiangzhai fractures).

One skull (M18) from Beiliu, a probable male, had perimortem cut marks on the forehead that could have resulted from scalping (Figure 18.4, A). A perimortem depression fracture of the frontal bone on a female skull from Jiangzhai could have been produced by a rounded stone or club (Figure 18.4, B). A Jiangzhai male (M112:13) had a healed compression fracture of the left zygomatic (Figure 18.4, C), which could have resulted from a blow delivered using a blunt instrument held in the right hand by an opponent directly facing the victim. Large areas of bone depression, surrounded by oppositional bone and macroporosity, were found on the parietals of a Jiangzhai male (M202:36A) and a Shijia probable female (M28:19). These depressions likely represent healed and remodeled blunt fractures, similar to the perimortem compression fractures described above. There was also a healed and remodeled infraction of the frontal bone on a male skull (M27:29) from Shijia (Figure 18.4, D).

Postcranial bones are underrepresented in the Jiangzhai and Shijia collections. One Jiangzhai male (M150) had a dislocated fracture of the left ulna, which could have been a parrying injury, but also might have resulted from a fall (Lovell 1997). A female from Beiliu (M10) had healed fractures on the distal portion of the left radius and ulna that very likely resulted from extending

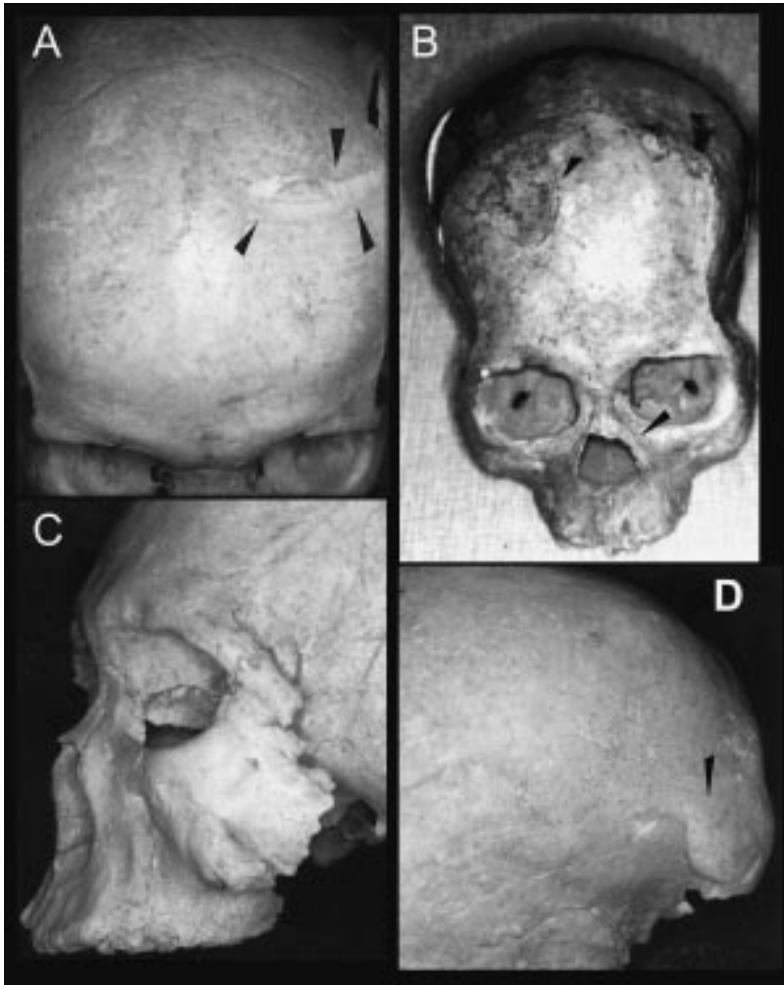


Figure 18.4. Traumatic injuries on Yangshao crania from China. *A*, cut marks on a skull from the Beiliu site (M18); *B*, perimortem depression fracture and a healed fracture of the nasal bones of a skull from Jiangzhai; *C*, healed direct compression fracture of the left zygomatic of a male skull from Jiangzhai (M112:13); *D*, a healed infraction, surrounded by excessive porosity in a skeleton from Jiangzhai (M202:36A).

the arm while falling. A female from Shijia (M28:31) had a fracture of the left femur at midshaft. This injury showed evidence of healing, yet no union took place between the two parts of the diaphyses. Substantial bone loss occurred, as the cortical material was only 2–3 millimeters thick, indicating that the limb had gone unused for a period of time before death. Healed fractures were likewise found on two humeri and two clavicles belonging to other Yangshao individuals.

Cranial traumas were less common in the Middle Yangshao collections than in those from Early Yangshao. Only one of the twenty-one Guanjia skulls had a possible perimortem injury. Postcranial fractures were found on the remains of two individuals from the same site: one of the humerus midshaft (M2) and the other of the femoral diaphysis (M13). Both were dislocated, but well healed and remodeled, suggesting that each of the affected individuals survived for an extended period of time after being injured.

Although no skulls from Xipo show evidence of traumatic injury, two individuals had fractures of the ribs and four of eighteen had healed fractures of the ulna. One individual (M4) had fractured both the left and the right ulna, while another (M2) had fractured and dislocated both radius and ulna at midshaft. These postcranial fractures affected male skeletons exclusively.

No cranial fractures were detected on the remains of any Longshan individual examined; small sample sizes and/or sampling error may skew our interpretation toward an apparent lack of interpersonal violence for this period.

Summary

The human skeletal collections examined for the study reported here were recovered from sites in a geographic area encompassing approximately one thousand square kilometers and ranging in time from about 9000 to 2000 BP.

Interpretation of health status for the Peiligang community at Jiahu is complicated by the fragmentary condition of the surviving human remains. Estimated average adult stature for these individuals was the greatest of all among the sample series considered. However, physiological stress, as indexed by high frequencies of porotic hyperostosis and cribra orbitalia, was greater at Jiahu than at the Early Yangshao sites of Jiangzhai and Shijia, although about the same as was evident for the Middle Yangshao collections from western Henan. The limited number of available maxillar and mandibular fragments from Jiahu suggest poor oral health, typical of people reliant on a carbohydrate-rich diet.

Overall, the lowest frequencies of anemia indicators, carious lesions, and tooth loss were found in the Early Yangshao collections. In comparison with individuals from Jiangzhai and Shijia, Middle Yangshao specimens evidenced poor oral health and a higher frequency of physiological stress markers. It is not clear whether these differences reflect a temporal change in subsistence and pathogenic loads, were related to environmental differences and subsistence variation, or are the result of some combination of the above factors. Faunal assemblages at Early Yangshao sites in Shaanxi suggest heavy reliance on wild animals for food (Yuan and Flad 2002). Conversely, domestic pig bones con-

stituted 80–85 percent of the Middle Yangshao Xipo faunal assemblage (Ma 2003).

On the basis of the results of this study, we suggest that there was an overall deterioration in community health after about five thousand years ago for many northern Chinese populations. Frequencies of porotic hyperostosis and cribra orbitalia were especially high at the Longshan site of Meishan, where average adult stature was less than at the Yangshao sites. A possible tubercular spine among this collection might be evidence for the introduction of a new pathogen into the area, although it could more simply reflect lower individual resistance related to physiological stress. The Longshan population at Mengzhuang does not seem to have been affected by dietary deficiencies to the same degree as the Longshan population at contemporaneous Meishan. However, human skeletons from Mengzhuang exhibit frequencies of stress markers comparable to those for the Yangshao individuals from Xipo and Guanxia.

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