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ORIGINAL PAPER

Impact of Subsistence on Demographic Patterns in Bronze Age to Early Iron Age in Northern China

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Abstract
Demography is the study of human population dynamics including deaths, births, and migrations. Statistical analysis can help researchers understand paleodemographic patterns of health, mortality, and morbidity among ancient populations. Generally speaking, population is affected by both the natural environment and social conditions. This research is based on six archaeological cemetery sites located in Heilongjiang, Inner Mongolia, and Shanxi Provinces in northern China, temporally spanning from the Bronze Age to the early Iron Age (about 1000 BC–200 BC). This study demonstrates how subsistence patterns influence the population in the north of ancient China. The results show that the mortality rate of the population groups that relied on animal husbandry peaks much earlier than among the agricultural groups; the estimated life expectancy of members of the agricultural economy group is longer than that of those in the animal husbandry group; and the animal husbandry group shows a relatively larger sex imbalance.

Keywords Bronze age China · Iron age China · Paleodemography · Subsistence

1 Introduction

Paleodemographic research based on human skeletal remains can help us explore changing relationships between population dynamics, the natural environment, and the social conditions in different archeological cultures or populations across different time periods and geographic regions or environmental zones, or between different modes of subsistence. Through the study of sex ratio, peak age of death, and life-span, we can estimate the ancient inhabitants' living conditions (Nagaoka et al. 2013; White 2014; Espinoza and Morfin 2015; Walter and DeWitte 2017). Furthermore, it aids a better understanding of local funeral customs, ancient people's views of life and death, and other archaeological topics. At present, the use of demographic studies in Chinese archaeological research mainly focuses on descriptions of a single site and not comparative analysis among different ancient inhabitant groups. The purpose of this study is to combine methods of physical anthropology and demography in order to provide interpretations of the interrelations between population and subsistence patterns by analyzing human skeletons from different cemeteries. As population dynamics can be influenced by many factors, in order to control for the variable of chronological change, we here have chosen cemeteries in northern China from the same period, namely the Bronze Age to Early Iron Age.

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2 Material and methods

The demographic data used in this study were collected from six archaeological sites in northern China, temporally spanning from the Bronze Age to the early Iron Age (about 1000 BC–200 BC), including Pingyang 平洋 cemetery (Heilongjiang 1990) in Heilongjiang 黑龙江 Province, Jinggouzi 井沟子 cemetery (Jilin 2004) and Xindianzi 新店子 cemetery (Zhang et al. 2008) in Inner Mongolia 内蒙古, and Shangma 上马 cemetery (Shangma 1990), Siqi 虎祁 cemetery

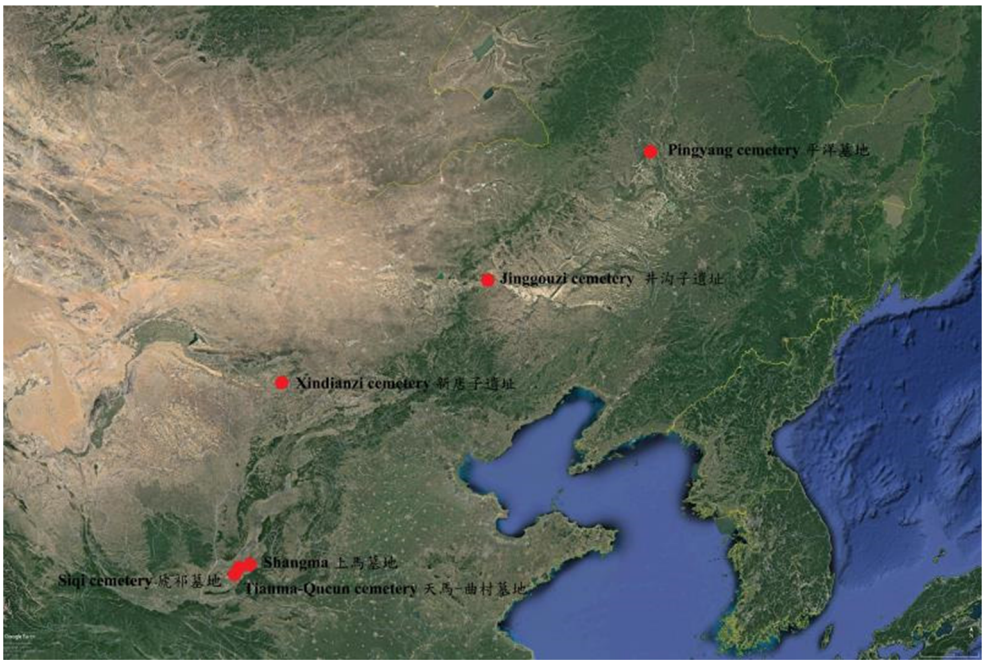

Fig. 1 Map showing the locations of the six Bronze Age through early Iron Age cemetery sites studied

(Wang 2014), and Tianma-Qucun 天马- 村 cemetery (Pan 2000) in Shanxi 山西 Province (Fig. 1).

2.1 The Pingyang site

The Pingyang site is located in the southwest of Heilongjiang Province, and is comprised of the Zhuanchang 砖厂and Zhandou 战斗 cemeteries. The original field archaeologists dated the site from the Bronze Age to the early Iron Age (Heilongjiang 1990), while some other scholars think the end date of the site might date as late as the Hanshu 汉书 Period II Culture, around 200 BC (Pan and Lin 2002). From analysis of archaeological materials such as unearthed tools, weapons, and animal bones, it has been speculated that the ancient local populations mainly relied on animal husbandry, together with fishing and hunting (Heilongjiang 1990). Because of the limited preservation conditions of the human skeletal remains from the Zhandou site, data are only analyzed here from the Zhuanchang cemetery. A total of 97 tombs were excavated, and the minimum number of individuals (MNI) is 298. Of these, 237 individuals were identified to a sex group, with 135 males and 102 females. The identification rate is 79.53%, and the sex ratio is 1.32:1 (Pan 1990).

2.2 The Jinggouzi site

The Jinggouzi site is located in eastern Inner Mongolia and includes two cemetery groups (east and west) (Jilin 2004). Through analysis of tomb construction patterns and burial objects, this site has been dated from the Bronze Age to the early Iron Age (from the early Spring and Autumn period to the Warring States period) (Jilin 2004). A high content of $\delta^{15}N$ in bones suggests a relative heavy reliance on an animal protein-based diet (Zhang et al. 2008). Animal bones and artifacts made from bones and clam shells found in these tombs demonstrate a subsistence strategy based on animal husbandry together with fishing and hunting (Chen 2007). A total of 150 individuals were excavated from the Jinggouzi cemetery, and 67 individuals were identified to a sex group, including 40 males and 27 females. The identification rate is 44.67%, and the sex ratio is 1.5:1 (Zhu and Liu 2014).

Table 1 Comparison of mortality rates from the six cemetery groups in this study (unit: %)

Cemetery	Minor (0–14)	Adolescent (15–23)	Young Adult (24–35)	Middle Adult (36–55)	Elderly (56-)
Pingyang	16.6	18.3	9.7	32.5	3.4
Jinggouzi	45.7	25.0	25.0	4.3	0.0
Xindianzi	9.3	16.3	30.2	27.9	0.0
Shangma	2.3	14.3	20.4	49.6	11.8
Siqi	6.9	13.1	36.9	23.1	0.6
Qucun	5.5	16.6	27.3	40.3	2.9

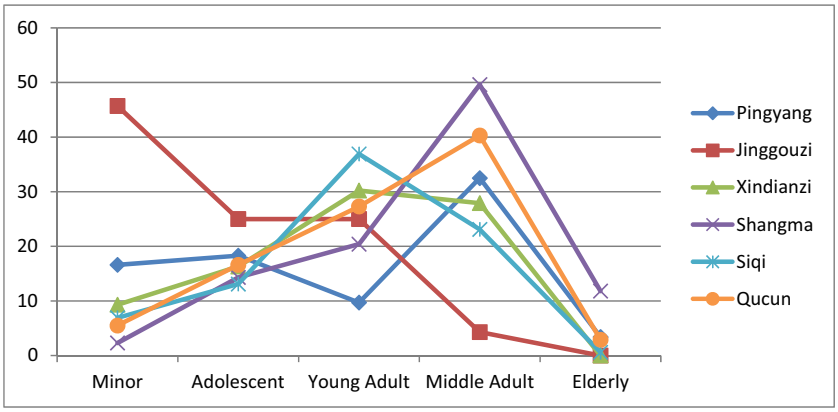

Fig. 2 Trend lines of age-specific mortality rates for the six cemetery groups in this study (y-axis: % of total)

2.3 The Xindianzi cemetery

The Xindianzi cemetery, located in central Inner Mongolia (Zhang 2005), dates to the early Iron Age (from the middle Spring and Autumn period to the Warring States period) (Xindianzi 2009). Isotopic analysis of cow, horse, and sheep bones provides evidence for well-developed animal husbandry (Zhang 2005). Of the 43 human individuals excavated from this cemetery, 38 individuals were identified to a sex group, with 26 males and 12 females. The identification rate is 88.37%, and the sex ratio is 2.2:1 (Zhang et al. 2008).

2.4 The Shangma cemetery

The Shangma cemetery is located in the southern area of Houma, Shanxi Province. Burial objects indicate that the site dates to the Bronze Age (Western Zhou to early Warring States periods) (Shangma 1990). Within the 1373 tombs excavated, 1059 individuals were found in this cemetery. Of this total, 1034 individuals were identified to a sex group, with 548 males and 486 females. The sex ratio is 1.1:1 (Pan 1994).

2.5 The Siqi cemetery

Located in southwestern Houma, Shanxi Province, the Siqi cemetery has been dated to the Iron Age (from the Warring States period to the Han Dynasty) based on sacrificial pits. From the excavated 173 tombs, 160 individuals were identified. 133 individuals were identified to a sex group, including 64 males and 69 females. The identification rate is 83.13%, and the sex ratio is 0.93:1 (Wang 2014).

2.6 The Tianma-Qucun cemetery

The Tianma-Qucun cemetery is located in southern Shanxi Province. Burial goods date the site to the Bronze Age and early Iron Age (from the Western Zhou to the Spring and Autumn period). From the 625 tombs excavated, 524 individuals were recovered. Those identifiable to a sex category include 251 males and 220 females. The sex ratio is 1.14:1 (Pan 2000).

Based on the geographic locations and subsistence patterns, these six cemeteries can be classified into two groups:

1. Those with a predominantly animal husbandry based subsistence strategy: Pingyang cemetery, Jinggouzi cemetery, and Xindianzi cemetery, all of which are located in northeastern China.

2. Those with a predominantly agriculturally based subsistence strategy: Shangma cemetery, Siqi

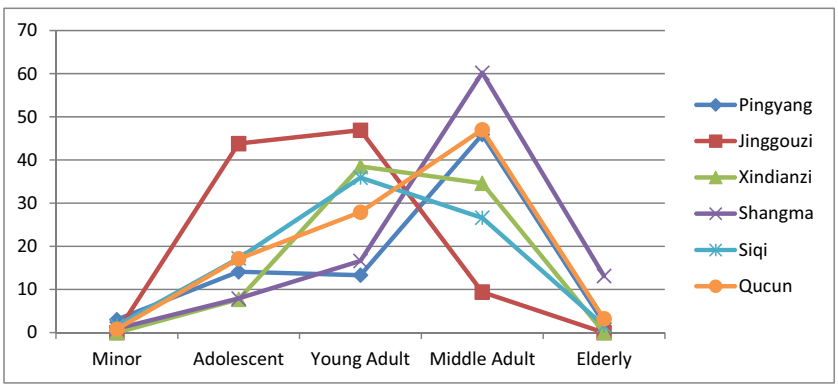

Fig. 3 Trend lines of age-specific mortality rates for males from the six cemetery groups in this study (y-axis: % of total)

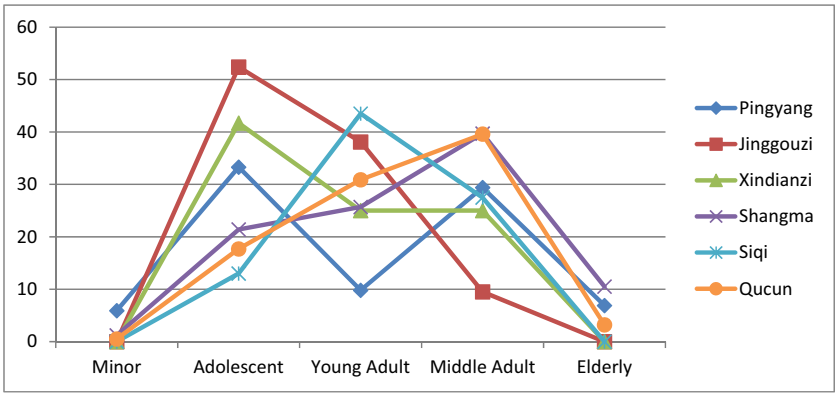

Fig. 4 Trend lines of age-specific mortality rates for females from the six cemetery groups in this study (y-axis: % of total)

cemetery, and Tianma-Qucun cemetery, all located in Shanxi Province.

All of the samples mentioned above were identified to sex and age estimations using the standards established by Wu et al. (1984) and Shang (1985). The age range is divided here into minors (0–14 years old), adolescents (15–23 years old), young adults (24–35 years old), middle adults (36–55 years old), and elderly (56 years old and up), as is commonly done in the Chinese anthropological research tradition.

3 Results and discussion

3.1 Mortality rates

Statistical analysis of age-specific mortality rates is an important method in paleodemographic research. It can be used to study the age-at-death distribution in a group and allows for comparative analysis between groups. The mortality rate in each age group is the number of individuals within that age group divided by total number of individuals.

It can be seen from Table 1 and Fig. 2 that the animal husbandry group (the Pingyang, Jinggouzi, and Xindianzi cemeteries) shows a higher mortality rate in the minor age group. Also, the mortality peak for the Xindianzi and Siqi groups is young adulthood, which is earlier than the other groups. In order to explain this phenomenon, we compared mortality rates among males and females separately (Figs. 3 and 4). Because the sex of minors cannot be easily determined, the mortality rate of minors by sex could not be determined.

Figure 3 shows that the male mortality rate peaked in young adulthood in the Jinggouzi, Xindianzi, and Siqi groups, which may contribute to the advanced peak for age at death at the population level. Considering evidence of skeletal trauma (e.g., a bronze arrowhead embedded in a pelvis in the Jinggouzi cemetery) and the historical-geographical context (e.g., the Siqi cemetery is located at the boundary of the Wei 魏 and Qin 秦 states during the Warring States period [Fan et al. 2002]), warfare could be a reasonably assumed causal factor to explain the increased mortality among young people. On the other hand, the male inhabitants of the animal husbandry group died at a younger age compared to those in the agriculture group. This may be the result of a comparatively more stable agricultural economy making it possible for the residents to live a longer life.

Figure 4 illustrates the female mortality rates among the different cemetery groups. Females in the Jinggouzi, Xindianzi, and Pingyang cemetery groups that mainly subsisted on animal husbandry died in adolescence, earlier than the agriculture groups. The living conditions for groups depending on animal husbandry might have been harder than those of agricultural groups. Additionally, it is possible that poor medical conditions contributed to a larger number of young women dying in childbirth or postpartum.

Table 2 Comparison of estimated life expectancies among four population groups analyzed in this study (unit: years). Siqi and Xindianzi are not included as data are lacking in the original reports

Cemetery	Male	Female	Total
Pingyang	36.89	32.16	32.54
Jinggouzi	26.41	27.26	16.54
Shangma	41.72	36.57	39.09
Qucun	35.49	35.25	34.19

3.2 Estimated life expectancy

Life expectancy is a statistical measure of how long a person is expected to live. It is also an important reference index for evaluating the level of people's health. An abridged life table is commonly used to estimate ancient people's life expectancy. Archaeological research on life expectancy assumes a static population pattern in which all individuals are, for statistical purposes, treated as being born at the same time, and people are classified by their age of death.

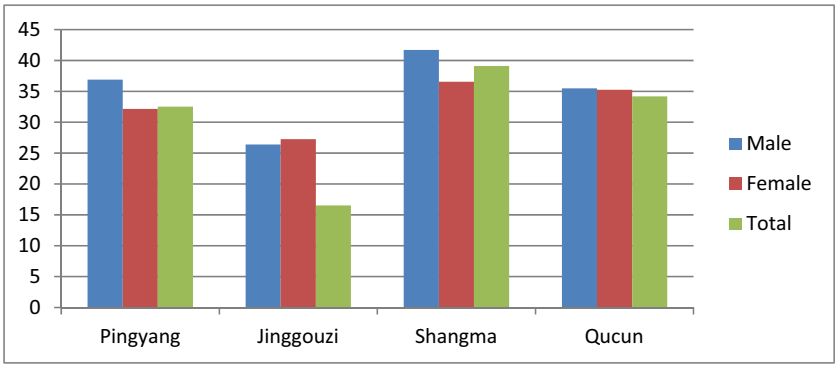

Fig. 5 Bar chart of estimated life expectancies among four population groups analyzed in this study. Siqi and Xindianzi are not included as data are lacking in the original reports

Table 2 and Fig. 5 illustrate that members of the agriculture groups (Shangma and Qucun) have a longer estimated life expectancy than those in the animal husbandry group (Pingyang and Jinggouzi), and the differences in male estimated life expectancy may be the main reason. Assuming those who died outside the community were brought back and buried in the community cemetery, these may be due to the differences in the division of labor between male and female and in lifestyle under different subsistence strategies (e.g., in the animal husbandry group, males might need to go out to pasture or hunt, which may put them in danger). We also note that the inability to estimate sex in the minor group may result in underestimation of life expectancies.

3.3 Sex ratio

Sex ratio is a way to study population sex structure. From a biological perspective, the sex ratio of a human population should be close to 1:1.

As is shown in Table 3, the animal husbandry group (Pingyang, Jinggouzi, and Xindianzi) show a relatively imbalanced sex ratio, with more males than females. The reason for this is unclear; however, it is possible that this is the result of natural environmental and social factors. A social factor could include female infanticide, for example, if, because of needs within an animal husbandry environment, or for hunting and warfare, more men were needed to maintain production and carry out required tasks (e.g., according to historical records, only men were allowed to join in warfare) (see Zhao 2005; Gu 2010).

Table 3 Comparison of sex ratios among the six population groups analyzed in this study

	Pingyang	Jinggouzi	Xindianzi	Shangma	Siqi	Qucun
Sex ratio	1.32:1	1.5:1	2.2:1	1.1:1	0.93:1	1.14:1

4 Conclusion

In conclusion, subsistence strategy has significant influence on demographic patterns in northern China during the Bronze Age to early Iron Age. The mortality rate of the population groups that relied on animal husbandry peaks during young adulthood. This is much earlier than among the agricultural groups (where the peak is during middle adulthood). This difference may be explained by warfare, poor natural environment, and unstable food resources, but these factors need to be further tested archaeologically. For the male populations, risk-taking behaviors may additionally count for the difference in the life expectancy between inhabitants who subsisted on animal husbandry and hunting and those who depended on farming. For females, the living conditions in animal husbandry communities may have been harder than those in agriculture communities. A lack of medical care may have led to a large number of young women's death in childbirth or postpartum, which could also result in a higher death rate in the minors group.

The estimated life expectancy of members of the agricultural economy group is longer than that of those in the animal husbandry group. The difference between the whole populations is mainly accounted for by differences between male average estimated life expectancy. Meanwhile, the animal husbandry group shows a relatively larger sex imbalance—the proportion of males is much larger than the proportion of females. Further study is needed to understand the specific social and cultural contexts in order to extrapolate possible explanations for the existing sex imbalance.

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