The Arthritic Toll of Warfare, Farming, and Pastoralism among Populations of China and Mongolia in the Zhou Dynasty/Xiongnu Period

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Abstract
Marked social changes occurred in East Asia during the first millennium BC, especially in the latter half. China experienced not only the Zhou dynasty’s fragmentation into contentious states but also the emergence of innovations in iron technology. In the northern steppe frontier, nomadic pastoral cultures arose and one of the strongest confederacies to emerge were the Xiongnu, who posed a threat to Chinese states. Bioarchaeological analysis of arthritic patterns in skeletal collections from sites in China and Mongolia dating to this turbulent time offer insight into the toll of changing subsistence strategies and increased warfare.

Sites & Historical Context
China: An era of continual civil wars between hegemonic states punctuated the Eastern Zhou period (1045-256 BC) of China, and warfare centered around the destruction of the enemy.1 The state of Zhao (403-222 BC) was one of the last strong northern frontier states (Fig 1a). The finds from Zhao-era sites in Heilengjiang County, in the modern province of Inner Mongolia, derive from two cemeteries (“HT-HX”) of military soldiers (Fig 1b). These burials offer evidence of military life during a time of intensified warfare that shifted toward massed infantry, professional soldiers, and the use of cavalry pioneered by the Zhao to deal with nomadic warriors.2-4

A second site in central China offers a view of a non-military population from Henan province, which served as a buffer zone between more powerful states during this time.5 The Chenjiagu cemetery (here referred to as “Henan,” Fig. 1b) practiced farming during a time when iron technology and the use of oxen-drawn maile were more efficient.4 Their lifestyle contrasts with individuals from other sites studied here who were directly and continuously engaged in warring (Tab. 1).

Mongolia: Roughly contemporaneous to these two populations were horse-riding cultures that had spread eastward to the northern steppe frontier. Tensions between agrarian Chinese states and nomads occupying the neighboring northern steppe became increasingly evident as Chinese states entered defensive Great Walls along the north to separate the states like Zhao from warlike nomads.1 A constant threat on these northern borders were the Xiongnu (Fig. 1c), a confederation of nomadic tribes from the Ordos steppe region of Mongolia, who eventually formed a nomadic empire (209 BC-AD 155). Burials of Xiongnu samples analyzed here include those from multiple sites located throughout Mongolia (Fig. 1c).

Degenerative Joint Disease
Arthritis is a product of many factors, including degenerative changes to the joint from functional (mecchanical) stress, which can manifest skeletally as bone growth and/or bone destruction. Despite debate on the etiology of specific causes of degenerative joint disease (DJD), there is general agreement that joint use is an important contributor to osteoarthritis.5 The distribution of arthritic changes in the skeleton is likely to vary between societies and with different roles (e.g., gendered, specialist) within a society.6 Thus, patterns of DJD can help reveal what, if any real differences exist among the populations studied here, both within the groups and between their groups. Specifically, as tested in this study, these differences may be correlated with:

- Different modes of subsistence: agriculture in China vs. nomadic pastoralism in Mongolia
- Different occupations & activities: mounted warriors vs. soldiers of China vs. farmers
- Sexual division of labor within each population

Potential Biases: Sex & Age
Males outnumbered females in three sites, though the sex difference between the sites is not significant (χ²=1.3, p=0.52, Fig. 2). The over-representation of males is marked in the Xiongnu sample with 63% males and 34% females, close to the level of significance (χ²=3.2, p=0.07). Similarly, there are more males (66% M vs. 34% F, with the rest of indeterminant sex) in the Henan sample (χ²=5.6, p=0.06). The sex ratio is also not significantly different in the Henan sample (χ²=5.9, p>0.5).

Age: A second potential source of bias is in the age composition within each sample, as joint disease is often slowly progressive.7 With individuals of advanced ages more likely to show arthritic changes. Samples were examined with respect to three broad age categories of Young Adults (VA=16-30), Middle Adults (MA=30-45), and Older Adults (OA=45+), as well as a category of adults for whom an age category could not be assigned (A). The HT-HX sample was comprised of many commingled remains, most lacking associated pelvis or cranium, so many were not aged into specific categories and instead placed in the general “Adult” category though were likely in the range of middle adult ages since this was a military population. Also, the few that did have their ages determined were young adults. There are some differences in age categories present for the Xiongnu and Henan samples (Fig. 4).

Results
Results were obtained with respect to the frequencies of joint disease within each age category. As expected, there were generally higher frequencies among the older age groups. Here we limit the discussion to the comparison of results from the total population across the sites (Fig. 5, Tab. 2).

Joints Observed
- Vertebrae: 1) OA = osteoarthritis of vertebral facets, 2) osteophytosis, or lipping of margins
- Shoulder: glenoid fossa of scapula, humeral head
- Elbow: distal humeral epiphysis, radial head, ulna
- Wrist/hand (combined since limited foot bones): distal radius & ulna, carpals, hand bones
- Hip: acetabulum, femoral head
- Knee: distal femur, patella, proximal tibia
- Ankle/foot (combined since limited foot bones): distal tibia & Ibula, tarsi, foot bones

If an individual had any of the bones of a joint (with a complete joint surface), that person was scored for presence of DJD (Fig. 2). Evidence of DJD on any joint surface (either left or right) was sufficient to count the joint as affected. Recommendations for differential diagnosis of DJD were followed, where erosion (“polishing” is a diagnostic criterion, and in the absence of this, at least two of the following: osteophytes (joint margin new bone growth), deformity of joint surface, porosity, and new bone growth on joint surface.8

Statistical Results
Chi-square tests were used to analyze inter-site differences, while Fisher’s Exact tests were used to determine which among the three had significantly different frequencies and to compare demographic differences between the sexes of each site.

Inter-site total population: HT-HX often had significantly higher frequencies of joint disease, but the pattern differed with respect to the joint location and with the comparative population (Tab. 3). For vertebral osteoarthropathy, HT-HX had a greater frequency than the other two samples (p=0.01). However, HT-HX had higher rates than that of Henan in DJD of the shoulder (p=0.02) and wrist/hand (p=0.02). In the lower limb, HT-HX had greater rates of DJD in the knee (p=0.01) and ankle/foot (p=0.03) compared to Xiongnu, which did better in rates of DJD in the hip compared to HT-HX (p=0.04).

Discussion & Conclusion
During this turbulent period, the soldier sample from HT-HX seems to have suffered the most joint disease, likely related to occupational activities such as repeated drills and training, as well as actual combat. Compared to another “active warrior” population of the nomadic pastoral Xiongnu, the HT-HX group suffered from more back problems, as well as knee and foot joint disease, while the Xiongnu sample had more hip disease, which may be expected since the Xiongnu were mounted warriors while the HT-HX sample may have been composed of mostly foot soldiers. Though not at the same level of significance, Xiongnu females also had higher rates of hip DJD than the females of the other two sample populations, possibly indicative of their participation in horse riding.

The agricultural sample from Henan had a lower DJD rate compared to both of the other two groups, a finding that may be related to lower rates of DJD in soldiers of China vs. farmers. Furthermore, the Xiongnu sample still had high rates of DJD despite its higher representation of younger age groups.

Within each population, gendered activities seem possible as males generally had higher DJD rates than females in the same joint.

Within each population, gendered activities seem possible as males generally had higher DJD rates than females in the same joint. Differences in DJD rates between males and females of the other two sample populations, possibly indicating their participation in horse riding. The agricultural sample from Henan had a lower DJD rate, particularly among women.

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References:

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