Quaternary International xxx (2015) 1–14

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

A bioarchaeological study of osteoarthritis among populations of northern China and Mongolia during the Bronze Age to Iron Age transition to nomadic pastoralism

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ARTICLE INFO

Article history:
Available online xxx

Keywords:
Degenerative joint disease
Pastoral
Nomad
Activity
Inner Asia

ABSTRACT

This paper examines data on joint disease among archaeological populations of several sites within northern China and Mongolia to test hypotheses about cultural uniformity among pastoralists and potential changes in the levels and types of activities during the Bronze Age to early Iron Age transition from mixed economies to mounted pastoralism. Despite continuing debate on the etiology of osteoarthritis, there is general consensus that joint use is an important contributor to joint disease. The vertebrae and major limb joints (shoulder, elbow, wrist/hand, hip, knee, and ankle/foot) of adult samples from these two periods were analyzed for prevalence and patterns of joint disease with respect to sex, age, time period, and location. There were only two joint regions with a significant difference between males and females: at the elbow, where males had a higher prevalence, and at the hip, where it was higher among females. The findings indicated a positive relationship between age and osteoarthritis, and that the spine was one of the most affected areas, along with the elbow and knee. Between the two time periods, while not at the level of significance, there was a pattern of higher prevalence of osteoarthritis in the vertebrae and upper limb joints among the Iron Age sample, while the Bronze Age sample had higher rates within the lower limb joints. These findings suggest different mechanical stresses between the two periods, perhaps associated with changes from mobility by foot in the Bronze Age to increased mounted mobility during the Iron Age, including mounted warfare. However, when comparing the individual sites within the two periods and within geographic regions, there was no distinct pattern, as there was much variation within both the Bronze Age and the Iron Age sites, as well as within regions. These varied results among sites and regions suggest that were was no uniform pastoral way of life or movement that imprinted clear patterns of osteoarthritis among pastoral samples. Instead, these data suggest that varied activities, movements, and perhaps mixed economic practices and workload among the sexes may have been characteristic among the "pastoral" groups of the Inner Asian steppe.

1. Introduction

Joint disease, which can cause pain and functional disability, is one of the most commonly identified pathological lesions in archaeological human remains (Bridges, 1992) and has been rising in prevalence among modern populations. Clinical data from the Global Burden of Disease 2010 study show that osteoarthritis is the most common joint disease (Storheim and Zwart, 2014), with hip and knee osteoarthritis as one of the highest contributors (ranked 11th) to global disability (Cross et al., 2014). Diseases of the joint have been referred to as osteoarthritis, osteoarthrosis, and degenerative joint disease, with no universally accepted term (Salter, 2002). For the purposes of this paper, "osteoarthritis" is used as it is the more frequently preferred term (Weiss and Jurmain, 2007). The progressive disorder typically occurs in the most movable joints in the body, the synovial (diarthroidal) joints, and involves the focal loss of articular cartilage that exposes bone surfaces and may result in bone lesions of the joint and joint margins (Ortner, 2003). The bone changes include proliferative bone remodeling at joint margins (osteophytes, or "lipping"), erosion (porosity), and eburnation (polishing from bone-to-bone contact) of subchondral bone (Aufderheide and Rodríguez-Martín, 1998).

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http://dx.doi.org/10.1016/j.quaint.2015.07.072
1040-6182/

Numerous studies of joint disease among ancient skeletal populations have been done to reconstruct activity patterns in the past (e.g., see Jurmain et al., 2012 for review). Often such studies have focused on repetitive mechanical loading as a major contributor to osteoarthritis and have attempted to distinguish patterns of osteoarthritis within subsistence regimes and as indicators of activity levels and sexual division of labor (e.g., Merbs, 1983; Walker and Hollimon, 1989; Bridges, 1992; Molleson, 2000; Molnar et al., 2011). Others have cautioned against directly applying osteoarthritis as indicators of occupation and specific tasks, however, noting the complex etiology of the disease (Jurmain, 1991, 1999; Weiss and Jurmain, 2007; Jurmain et al., 2012), with multifactorial contributing factors such as aging, genetic predisposition, sex, weight, age of onset of intensive activity, trauma, and disease (Kellgren and Lawrence, 1958; Felson et al., 1987; Anderson and Felson, 1988; Felson et al., 1988; Spector et al., 1996; Abramson and Attur, 2009).

Despite the debate on the specific causes of osteoarthritis, there is general consensus that joint use, i.e., movement, is an important contributor to joint disease (Ortner, 2003; Waldron, 2009, p. 28). Many osteological studies have underscored that with careful attention to potentially confounding factors and critical evaluation of results, there is value in studying how physical activity and mechanical strain may influence joint disease (Ortner, 1968; Jurmain, 1977; Pickering, 1984; Bridges, 1991; Lovell, 1994; Lieverse et al., 2007; Klaus et al., 2009; Machicek, 2011; Schrader, 2012; Watkins, 2012; Woo and Sciulli, 2013). The genetic predisposition for joint disease is difficult to tease out in ancient samples, but osteoarthritis patterns within local assemblages may be evaluated in conjunction with genetic research, if available. While such a genetic study is not the focus here, the age and sex of individuals can be determined skeletally, as can the potential for secondary joint disease resulting from trauma or disease, and though it is difficult to estimate body weight in skeletal samples, obesity is less likely to have occurred in prehistoric samples (Eaton et al., 1988; Booth et al., 2002). Moreover, the association between joint disease and mechanical stress has been supported in many studies (see Larsen, 2015, pp. 179–180 for review). Thus, when controlling for age and sex and excluding cases of pathological osteoarthritis, the distribution of joint disease within individuals and within populations can be used to make inferences about habitual movements and levels of intense activity among ancient groups, if not the specific activity themselves. This study examines the prevalence and pattern of osteoarthritis among a relatively unstudied group, ancient pastoralists, specifically samples from northern China and Mongolia (Fig. 1), in order to reconstruct their activity profiles and also to shed light on the potential differences among community members with different roles such as between males and females and younger and older adults, thus contributing to contextual interpretations of pastoral lifeways.

Many studies on joint disease among archaeological skeletal collections of different subsistence strategies have been conducted, focused primarily upon hunter–gatherer and agricultural groups. These studies have attempted to distinguish patterns within these distinct economic regimes (e.g., Pickering, 1984; Walker and Hollimon, 1989; Bridges, 1991; Holliman, 1992; Lovell, 1994; Larsen, 1995; Molleson, 2000; Klaus et al., 2009; Woo and Sciulli, 2013; Lieverse et al., 2015, in press). Yet there remains a dearth of osteoarthritis research on ancient pastoral populations, with just a few studies on well-known groups such as the Arikara of the American Plains and the Avars, Scythians, and Xiongnu of the Eurasian steppe (Bradtmiller, 1983 as cited in; Bridges, 1992; Marcsik et al., 2001; Wentz and de Grummond, 2009; Machicek and Beach, 2013). Pastoralism is a subsistence regime that involves animal herding and mobility as a means to maximize exploitation of the natural pasture in otherwise marginal environments. In particular, nomadic pastoralism is an economic specialization where mobile groups migrate with their animals to exploit extensive, but seasonal grasslands (Barfield, 1993) and is an effective way to convert low quality plant resources into portable high quality goods (Crawford and Leonard, 2002).

Pastoralism has often been essentialized as a rather uniform lifestyle, yet pastoral communities are varied, with a continuum in the degree of mobility, including transhumance, agropastoralism, and nomadic pastoralism, as well as diversity in the roles of individuals within these communities (Frachetti, 2012). This paper uses data on joint disease among pastoralists of Inner Asia to test hypotheses about potential changes in pastoral activities and the associated effects on joints during the Bronze Age to early Iron Age transition from mixed economies to the adoption of mounted pastoralism. A multiscalar approach is used to examine osteoarthritis patterns of various demographic groups, communities/sites, regions, and the two time periods.

1.1. Pastoralism in Inner Asia

Pastoralists occupied the “Inner Asian frontier” (Lattimore, 1940), the eastern portion of the vast Eurasian steppe region, as early as the Bronze Age, developing alongside agricultural societies within China. Climatic changes to colder and drier conditions during the early half of the first millennium BC may have made pastoral nomadism more economically feasible in the steppe region of the northeast (Shishlina and Hiebert, 1998, also see paleoclimate data review in; Linduff et al., 2002). Data also support this climate shift in the northwest and Central Asia, where there was aridification of the region by 4000 cal. BP (An et al., 2012), concomitant with changes to archaeological assemblages that suggest a decline in agriculture (An et al., 2005). Thus, adoption of the nomadic pastoral pattern in the Inner Asian steppe may be seen as an effective adaptive strategy to changing environmental conditions (Barfield, 1993). Frachetti (2002) has also argued that the shift toward increasing mobile herding in the eastern steppe during the Bronze Age may be seen as a political strategy by groups to maximize their social power (e.g., control of conduits of trade and transport of resources) within a region of increasing sociopolitical interaction and complexity. Among Inner Asian pastoralists, while sheep are the most economically important livestock, horses also provide dietary resources, and more significantly, aid in mobility, transportation of goods, and in military strikes (Barfield, 1989, 1993). Horses and horseback riding are intimately linked with changes in social complexity among Inner Asian pastoralists.

The chronology of this region is not well understood, as the developments within societies varied across different swaths of the steppe, and it is particularly less well-defined in Mongolia. This paper follows the chronology proposed by Hanks (2010) with the Bronze Age at ca. 3500–1200 BC, followed by a broad transition from the late Bronze Age to early Iron Age from 1200 to 300 BC. Some of the earliest archaeological evidence of horse domestication is found in western Asia by 3700 BC among early Bronze Age cultures (Anthony, 2007). Mobile herding was adopted during the transitional phase of late Bronze to early Iron Age, with possible continuation of regional variation in subsistence regimes among many groups, ranging from hunting and gathering and fishing to small-scale agriculture (Honeychurch and Amartuvshin, 2006; Murphy et al., 2013). Mounted warfare developed by the Iron Age in the second half of the first millennium BC (Di Cosmo, 2002), which spread eastward to the Mongolian steppe by the fourth century BC (Volkov, 1995; Shui, 2002; Mair, 2003). With the development of mounted pastoralism among steppe groups, neighboring northern Chinese states similarly adopted use of a cavalry to counter strong nomadic tribes such as the Xiongnu.

Please cite this article in press as: Eng, J.T., A bioarchaeological study of osteoarthritis among populations of northern China and Mongolia during the Bronze Age to Iron Age transition to nomadic pastoralism, Quaternary International (2015), http://dx.doi.org/10.1016/j.quaint.2015.07.072