**QUEEN'S
UNIVERSITY
BELFAST**

A Bioarchaeological Study of Xiongnu Expansion in Iron Age Tuva, South Siberia

Murphy, E. M. (2012). A Bioarchaeological Study of Xiongnu Expansion in Iron Age Tuva, South Siberia. In D. C. W. Hartley, D. G. B. Yazicioğlu, & D. A. T. Smith (Eds.), *The Archaeology of Power and Politics in Eurasia: Regimes and Revolutions* (pp. 240-261). Cambridge University Press.

Published in:

The Archaeology of Power and Politics in Eurasia: Regimes and Revolutions

Queen's University Belfast - Research Portal:

[Link to publication record in Queen's University Belfast Research Portal](#)

General rights

Copyright for the publications made accessible via the Queen's University Belfast Research Portal is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The Research Portal is Queen's institutional repository that provides access to Queen's research output. Every effort has been made to ensure that content in the Research Portal does not infringe any person's rights, or applicable UK laws. If you discover content in the Research Portal that you believe breaches copyright or violates any law, please contact openaccess@qub.ac.uk.

THE ARCHAEOLOGY OF POWER AND POLITICS IN EURASIA

Regimes and Revolutions

EDITED BY
CHARLES W. HARTLEY, G. BIKE YAZICIOĞLU
AND ADAM T. SMITH

CAMBRIDGE

CAMBRIDGE UNIVERSITY PRESS

Cambridge, New York, Melbourne, Madrid, Cape Town,
Singapore, São Paulo, Delhi, Mexico City

Cambridge University Press

32 Avenue of the Americas, New York, NY 10013-2473, USA

www.cambridge.org

Information on this title: www.cambridge.org/9781107016521

© Cambridge University Press 2012

This publication is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without the written
permission of Cambridge University Press.

First published 2012

Printed in the United States of America

A catalog record for this publication is available from the British Library.

Library of Congress Cataloging in Publication data

University of Chicago Conference on Eurasian Archaeology (3rd : 2008)

The archaeology of Power and Politics in Eurasia : regimes and revolutions / [edited by]

Charles W. Hartley, G. Bike Yazıcıoğlu, Adam T. Smith.

p. cm.

Papers originally presented at the Third University of Chicago Conference on
Eurasian Archaeology, May 1-3, 2008.

Includes bibliographical references and index.

ISBN 978-1-107-01652-1

1. Social archaeology – Eurasia – Congresses. 2. Excavations
(Archaeology) – Eurasia – Congresses. 3. Eurasia – Civilization – Congresses.
4. Eurasia – Antiquities – Congresses. I. Hartley, Charles W. II. Yazıcıoğlu,
G. Bike, 1979– III. Smith, Adam T. IV. Title.

DS328.U55 2008

950–dc23 2011039457

ISBN 978-1-107-01652-1 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs
for external or third-party Internet Web sites referred to in this publication and does not
guarantee that any content on such Web sites is, or will remain, accurate or appropriate.

A BIOARCHAEOLOGICAL STUDY OF XIONGNU EXPANSION IN IRON AGE TUVA, SOUTH SIBERIA

Eileen M. Murphy

One of the aims of this volume is to demonstrate the heterodoxy of approaches apparent in Eurasian archaeology and to facilitate communication between the different approaches. A further objective is to upend traditional approaches to the study of politics in Eurasia through the application of a variety of new analytical tools. As such, the purpose of this chapter is to see if a bioarchaeological approach has the potential to make a contribution to archaeological studies of political change within a protohistoric Eurasian context. The health status of two skeletal population groups from the cemetery of Aymyrlyg, Tuva, South Siberia – one of which is considered to have included at least some members of a population that originally subjugated the other – will be examined to see if it is possible to identify differences in levels of physiological stress that might be related to this sociopolitical process that would undoubtedly have impacted on all segments of the social world. Although it may not be immediately apparent, it is hoped to demonstrate that a bioarchaeological approach can shed light on the impact of a regime on a political landscape and that such an approach has the potential to clearly demonstrate how political forces can transform past Eurasian societies (see Marshall, this volume).

This study is the first attempt to test if a bioarchaeological approach can be used as a possible means of identifying societal disruption within southern Siberia, and it is restricted to adult individuals. Similar studies on historical populations have demonstrated the validity of this approach when bioarchaeological data is integrated in an appropriate manner with archaeological and textual information (e.g., Perry 2007). If care is taken to understand the

potential limitations of the different datasets their integration can “provide an evocative historical bioarchaeological narrative” (Perry 2007: 487).

Bioarchaeological research is a valuable methodology for studying the impact that large-scale sociopolitical, environmental, and economic processes may have had on the health and well-being of archaeological populations (Perry 2007: 486). Steckel and Rose (2002b: 3) have stated that health is not only an important factor in the quality of life but is also closely related to “demographic, social, economic, and political change and with the outcomes of wars and other conflicts.” According to the World Health Organisation (2006), health may be defined as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” Anthropological studies of war-torn populations have demonstrated a reduced state of well-being among the civilians caught up in such conflicts. The indirect negative impacts of conflicts are largely due to a combination of population displacement and factors associated with a deterioration of the social environment. Both of these situations have been associated with a notable degradation in the state of civilian health. A further impact of conflict is a decline in psychosocial well-being, which can have a long-term effect on a population (Meddings 2001: 11–12). Bioarchaeological studies have demonstrated the generally negative impact on health that periods of social disruption can have on colonized indigenous populations such as the Maya of Mesoamerica (Storey, Marquez Morfin, Smith 2002) or the Aborigines of Central Australia (Littleton 2005). Many colonizations involve a degree of military force that can further contribute to the deterioration of an indigenous population’s health status. Sixteenth-century Spanish explorations of the Florida Gulf Coast, for example, are known to have involved military action. The indigenous Gule tribe suffered a notable deterioration in health and general quality of life during the colonial period, and the combination of factors at play led to their eventual extinction as a tribe (Larsen et al. 1992).

A substantial body of literature exists on the evidence for physiological stress in past skeletal populations (e.g., Cohen and Armelagos 1984; Steckel and Rose 2002a). This is not surprising because biological stress is a central factor in the study of the health of past human societies. Goodman and colleagues, in their model of the factors largely responsible for physiological stress, have emphasized the key role that the environment plays – in providing resources for survival but also concomitant stressors. Cultural systems can help buffer a society against stressors, but some stressors – including warfare and social disruption – can also be culturally induced. Depending on host resistance factors, the stressors can then cause physiological disruption or stress to the skeleton that is manifested in disruption to growth and the development of disease and can ultimately result in death.

The impact of physiological stress can have serious negative consequences on a population, and can result in a decreased level of health, a reduced ability to undertake work, a suppressed reproductive capacity, and general sociocultural disruption (Goodman 1991; Goodman and Armelagos 1988; Goodman, Lallo et al. 1984; Goodman, Thomas et al. 1988). It has been clearly demonstrated that psychological stress can also have a negative impact on physiological processes, including growth and health status (see Bush 1991 for discussion).

ARCHAEOLOGICAL BACKGROUND

This study involves an examination of two population groups from the cemetery complex of Aymyrlyg, Tuva, in southern Siberia. The Scythian-period burials at Aymyrlyg, deriving from the Uyk Culture, are considered to predominantly date to between the third and second centuries BC (Mandelshtam 1992: 185). The second group of burials originate from the Hunno-Sarmatian-period Shurmak Culture and are largely thought to date to between the third century BC and the second century AD (Stambulnik 1983: 34).

The most characteristic subterranean burial structure used in Uyk Culture funerary monuments was the rectangular log house tomb. Invariably, the number of individuals buried within an Aymyrlyg log house tomb was considerable, with as many as fifteen skeletons being recovered from individual examples (Figure 12.1). Stone cists were also used during this time – the majority of which were small, with room only for the burial of a single individual, most often a child (Mandelshtam 1983: 33). Two components of the Scythian Triad – characteristic weapons and artifacts decorated with the Animal Style of artwork – were well represented among Aymyrlyg's Uyk Culture grave goods (Mandelshtam 1983: 28–32). Differences in the wealth and possibly the social standing of the tribal family units are considered to be apparent in the burials of the Uyk Culture, with relatively rich and poor graves ascribed on the basis of the accompanying grave goods. There were no extreme differences in the wealth of these units, however, and this has been interpreted by Russian academics as evidence that society was generally egalitarian (Mandelshtam 1992: 194).

The majority of Shurmak Culture burials at Aymyrlyg comprised a single individual. Burial in a composite wooden coffin or, less frequently, in a log or a wooden block was characteristic, although some fourteen variations in the plan of the inner grave were apparent (Figure 12.2). In addition, each of the basic burial formats showed a great variation in detail. It has been observed that the Shurmak Culture burials at Aymyrlyg differed considerably from

Figure 12.1. Drawing of Uyk Culture Log House Tomb VI.6

those of the site's Uyk Culture, as well as from those of other Hunno-Sarmatian-period burial sites in Tuva, such as Kokel (Stambulnik 1983: 34). The principal differences were the diversity of funerary rites associated with the bodies and the extensive variety of features in the subterranean sections of the tombs. Some of the burials were considered to display a combination of features typical of both the Uyk Culture and the Shurmak Culture. These traits have been considered as evidence for the existence of an unstable society in the early stages of its development. As such, the excavators concluded that the Hunno-Sarmatian-period cemetery at Aymyrlyg had existed at a time when the Uyk Culture was ending and the Shurmak Culture was commencing – a chronological border considered to have occurred around the third and second centuries BC (Mandelshtam and Stambulnik 1992: 196).

It was during these centuries that several significant social changes are believed to have occurred among the nomadic tribes of the steppes. In the west, the Scythians were succeeded by the Sarmatians, while in the east, the Xiongnu, who are often presumed to be the prehistoric ancestors of the later Huns, emerged as a strong nomadic power. As a result, this period in the history of the steppe nomads is referred to as the Hunno-Sarmatian period (Zadneprovskiy 1994: 457). Owing to their rising prosperity from pastoralism, the development of an iron industry, and their military prowess, the

Figure 12.2. Drawing of a Shurmak Culture adult buried in a wooden coffin in a context of unknown context

Figure 12.3. Map showing the supposed extent of the Xiongnu Empire in the first century BC

twenty-four Xiongnu tribes dramatically increased in strength, resulting in the emergence of the powerful Xiongnu Empire (Ishjants 1994: 153). According to historical sources, the Xiongnu initially engaged in a lengthy struggle against other nomadic tribes, particularly the Wusun and the Yuezhi, as well as with the Chinese (Litvinsky and Guang-da 1996: 29; see Chang this volume), and for several centuries the Xiongnu Empire acted as a rival power to the Han Empire of China (Turbat 2006: 22). At its greatest extent the nomad empire is thought to have stretched from Korea to the Altai, and from the border of China to Transbaikalia (Phillips 1965: 112). At the end of the third and the beginning of the second century BC the populations of Tuva, the Transbaikalia area, the Minusinsk Basin, and the Altai are all considered to have experienced the impact of Xiongnu military expansion (Figure 12.3; Davidova 1996: 159).

The Chinese sources recount that in 201 BC the *chanyu* Modun conquered the country of Dinlin, which was located in the Minusinsk Basin on the Yenisei River. The Dinlin are considered to have been part of the Tagar Culture and are mentioned in the written sources as being among the acquired "possessions" of the Huns (Mannai-Ool 1970: 107; Sulimirski

1970: 112). It is generally believed that the Hunnish tribes would also have established rule to the south of the Tagar Culture, which, by this time, would have also included the region of Tuva. Archaeological data has been used to support this theory, but it also indicates there was not an immediate transformation from the preceding Uyuk Culture of the Scythian period. It has been postulated, therefore, that the new culture developed as a result of a complicated and prolonged process that occurred in a climate of rapid political change that involved the movement into Tuva of new groups of people (Mandelstam and Stambulnik 1992: 196). The population of Tuva is thought to have established greater ethnic links to the Minusinsk Basin during this time, and in the first century BC part of the population of Tuva and the Gianguny tribe, which had been forced out of northwestern Mongolia by the Huns, is believed to have moved to the Minusinsk Basin and formed the basis of the Tashtyk Culture (Mannai-Ool 1970: 107).

The Scythian-period Uyuk Culture in Tuva does not appear to have totally disappeared from the archaeological record, however, and a large proportion of its characteristics – its funerary monuments, burial rituals, and grave goods – seems to have been assimilated into the new Shurmak Culture (Mannai-Ool 1970: 108). Mandelstam and Stambulnik (1992: 205) have postulated that the social structure of the Hunno-Sarmatian-period Shurmak Culture in Tuva was characterized by the destruction of the system of communal relationships. They considered that the temporary submission of Tuva to the Xiongnu State and the introduction of new ethnic groups into the region at this time enabled this process to occur. One might therefore envisage a regime where the Xiongnu immigrants were in control of the political aspects of life. If this theory is accepted then it is probable that all levels of society would have been affected by these events. It has also been argued that the traditional social structure of the Uyuk Culture underwent a transition during the development of the Shurmak Culture, and that this transition is reflected in the relative infrequency with which collective burials occurred during this time (Mandelstam and Stambulnik 1992: 205). In addition, the differences between rich burials and poor burials were considered to be more apparent in the burials of the Shurmak Culture than had been the case for the Uyuk Culture, with the richest burials of the later culture containing large numbers of objects made from precious metals. The occurrence of large kurgans that covered a number of individual interments, however, has been interpreted as evidence that tribal structure was still strong (Mandelstam and Stambulnik 1992: 205).

As stated earlier, Mandelstam and Stambulnik (1992: 196) were of the opinion that the change from the Uyuk Culture to the Shurmak Culture involved the movement of new groups of people into Tuva. A detailed

craniometric and osteometric analysis was undertaken on a number of individuals from Aymyrlyg (Bogdanova and Radzjun 1991). The findings indicated that the Uyuk Culture individuals at Aymyrlyg displayed more European characteristics than did the Shurmak Culture individuals, who displayed more pronounced Asian features. In addition, differences in the degree of Asian and European admixture were evident between Shurmak Culture individuals buried in ground pits and those buried in stone cists. This finding was interpreted as evidence that the population burying their dead at Aymyrlyg during the Hunno-Sarmatian period was heterogeneous, comprising both individuals of the preceding Uyuk Culture and those of the more recently arrived Shurmak Culture (Bogdanova and Radzjun 1991). It must also be considered possible that some of the individuals of the later group may have been born as a result of intermarriage between members of the Uyuk Culture and the early Shurmak Culture incomers.

RESEARCH ASSUMPTIONS

When the historical, archaeological, and biometric data is taken into consideration, it would appear valid to suggest that the Shurmak Culture had developed as a consequence of the movement of groups from the Xiongnu Empire into Tuva. Both the Uyuk and Shurmak Cultures were seminomadic pastoralists who would have undertaken cyclic migration with fixed routes and set winter campsites (Vainshtein 1980: 52, 96). Chinese historical documentation such as the *Shiji*, emphasizes the mobility of the tribes of the Xiongnu, and it is no leap of faith to imagine they would have had the capability of traveling northward into Tuva. These texts also indicate the Xiongnu tribes were renowned for their military capability. When the *chanyu* Modun reorganized the Xiongnu army in 209 BC he replaced the heavily armed horse riders with light cavalry armed with long composite bows, resulting in the creation of a military force with much greater maneuverability (Ishjamts 1994: 163). The historical sources indicate that women and children had fighting capability (Ishjamts 1994: 164), but male warriors appear to have dominated (Watson 1961: 155–156). Indeed, one can imagine that it was groups of young male warriors, acting on the orders of the *chanyu*, who were largely responsible for the expansion of the Xiongnu Empire. As Anthony (1990: 898) observes, "It might be hypothesized that among societies in which male statuses and roles were largely determined by success in war, and in which young males therefore actively sought opportunities for conflict, the cumulative effects of sustained glory-seeking raiding might lead to significant outward migration."

Modern conflicts have demonstrated the myriad difficulties that humans can face in wartime situations, from food shortages and water pollution to physical and mental trauma at both individual and population levels (e.g., Pearce and Rush 1999). Bush (1991: 17–18) has succinctly summed up the underlying logic behind the biocultural approach to studying past human health: "Health cannot be considered in a vacuum because the human organism is receptive to environmental influences, physical, cultural and societal; the socio-cultural system can have a powerful impact upon the individual, producing psychological stress which can be manifested physically." As such, the objective of the current study is to compare the frequencies for a number of childhood physiological stress indicators, nonspecific infectious lesions, fractures, and weapon injuries among the adults of the two population groups from Aymyrlyg. It is anticipated that the Shurmak Culture, which exhibits archaeological features hinting at the existence of an unstable society brought about by the Xiongnu expansion, should display higher frequencies of these lesions and injuries than the apparently more stable preceding Uyuk Culture group.

MATERIALS AND METHODS

Because the study represents the first attempt to test the hypothesis that the Shurmak Culture individuals at Aymyrlyg should display signs of poorer health and less well-being as a consequence of the social disruption alluded to in both the archaeological and historical records, it was decided to focus specifically on the substantial corpus of adult skeletons from the cemetery complex. Previous research has demonstrated that physiological stress indicators are also present among the nonadults from the Aymyrlyg populations (Murphy 1998, 2008), and it is intended to undertake a detailed statistical comparative study of the health status of the nonadults at a later date. A total of 413 individuals from the Uyuk Culture and 148 individuals from the Shurmak Culture were included in the palaeodemographic analysis. A further 17 Uyuk Culture individuals of known sex but uncertain age were also included in the palaeopathological examination. The skeletons were of varying states of completeness and preservation, and in many instances only the skull was present (see Murphy 1998). The Shurmak Culture individuals were generally more complete than their Uyuk Culture counterparts. This is evident from the fact that only approximately one-third of the expected numbers of femora were present for the earlier culture, whereas more than 80 percent of Shurmak Culture femora were present (see Table 12.2). The majority of the physiological stress indicators – cribra orbitalia, porotic hyperostosis, and dental enamel hypoplasia – were largely indicative of childhood stress and the individuals

included in the current study are those who would have survived these early stresses. The levels of tibial periostitis, fractured bones, and weapon injuries should provide some indication of adult health and well-being.

AGE AND SEX

Sex was determined on the basis of a morphological analysis of the pelvis and skull following the recommendations of Ferembach, Schwidetzky, and Stloukal (1980) and Buikstra and Ubelaker (1994). Estimates of adult ages at death were largely determined from an examination of the morphology of the pubic symphysis (Brooks and Suchey 1990) and the auricular surface (Lovejoy et al. 1985). In cases where the pelvis was not present, age at death was determined on the basis of the state of dental attrition (Brothwell 1981: 71).

INDICATIONS OF PHYSIOLOGICAL STRESS

Wood et al. (1992) have provided much for palaeopathologists to consider through their assertion that less healthy individuals die younger and that those healthier individuals who live for a longer period of time have a greater chance of developing palaeopathological lesions. To avoid being misled by an osteological paradox it is necessary to combine palaeopathological and palaeodemographical data with contextual information (Steckel and Rose 2002c: 586). The physiological stressors included in the current study were cribra orbitalia, dental enamel hypoplasia, tibial periostitis, and stature. All lesions were observed macroscopically and were generally recorded following the methods advocated by Buikstra and Ubelaker (1994) and Steckel and Rose (2002b).

Cribra orbitalia is the term used to refer to generally symmetrical lesions, with the morphology of small perforations of varying size and density, apparent in the cortical bone of the superior aspects of the orbit. The occurrence of lesions of similar morphology in the skull vault is referred to as *porotic hyperostosis* (Stuart-Macadam 1991: 101). The lesions have traditionally been interpreted as an indicator of iron-deficiency anemia acquired during childhood (e.g., Stuart-Macadam 1985). A recent study by Walker and colleagues (2009) has demonstrated that neither lesion can be physiologically caused by iron-deficiency anemia. They have suggested that porotic hyperostosis is due to hemolytic and megaloblastic anemias that most commonly arise from deficiencies of vitamin B₁₂ and vitamin B₉ (folic acid) (Walker et al. 2009, 114). They indicate that the situation concerning cribra orbitalia is less clear-cut and that those lesions may have been caused by a multitude of conditions, which include chronic infections and deficiencies of vitamins B₁₂, C, and D (Walker et al. 2009, 115, 119). They propose that

a combination of poor diet, lack of hygiene, infectious diseases, and cultural practices associated with pregnancy and breastfeeding might explain the high levels of these lesions in many past populations (Walker et al. 2009: fig. 4). The degree of severity and extent of the surface affected were recorded (cf. Stuart-Macadam 1991: 109).

Dental enamel hypoplasia is one of the most common developmental defects of the tooth enamel, and it arises as a consequence of ameloblast disturbance during enamel matrix production. The most common form of hypoplasia is Linear Enamel Hypoplasia in which the defect has the appearance of a groove, although the defect may also take the form of a sharp line, or appear as a band of pit-type defects (Hillson 1996: 166–167). Once a hypoplastic defect has occurred in the enamel it cannot be removed because enamel does not have the ability to remodel. Consequently, a hypoplastic defect on a permanent tooth acts as a memory to an incident of physiological stress that affected the ameloblast activity during childhood (Dobney and Goodman 1991: 81; Goodman and Armelagos 1988: 936; Goodman and Martin 2002: 23). It is possible to differentiate between hypoplasias due to systemic stresses and those caused by nonsystemic factors such as localized trauma. The former situations can arise as a consequence of nutritional deficiencies and many childhood illnesses (Roberts and Manchester 1995: 58). Enamel hypoplastic defects were recorded on the basis of the methodology advocated by Goodman, Armelagos, and Rose (1980: 519). The position of the lesions on the permanent teeth was recorded using a thimble-tipped sliding calliper as the distance between the center of the defect to the cemento-enamel junction. Individuals with fewer than four teeth preserved, with extensive attrition, or for whom the enamel had been subject to post-mortem destruction were classed as unobservable and excluded from the analysis. The third molars were also excluded from the study inasmuch as they are considered to be too variable in the time of development (Goodman et al. 1980: 518). The severity of the hypoplastic lesions was categorized on the basis of the grading system by Brothwell (1981: 156).

Reactive new bone formation (periostitis) can occur as a result of inflammation in specific and nonspecific infectious processes; it can arise as a result of direct trauma (Ortner 2003: 106), or it can occur as a consequence of other disease processes that cause physiological stress (Ribot and Roberts 1996: 70). Nonspecific pathological bone changes are virtually identical to one another and result from infection by a variety of pyogenic bacteria, including staphylococci, streptococci, pneumococci, and the typhoid bacillus. In the modern world, *Staphylococcus aureus* is responsible for more than 75 percent of cases of infection (Finch and Ball 1991: 208). The palaeopathological changes can involve the development of pits, striations, and

plaques of bone formation (Ortner 2003: 206–27). Following the guidelines of Lovell (2000: 237), the extent and location of the lesions were recorded, as was their state of healing (see Goodman and Martin 2002: 34). The tibia is considered to be the bone most sensitive to the development of periostitis, probably as a consequence of its close proximity to the skin and its propensity for attaining frequent minor injuries (Goodman and Martin 2002: 34–35). As a result, only the tibia was included in the present study.

Growth is controlled by a mixture of environmental and genetic factors (although see Goodman 1991: 33–35 for discussion). Stunting of growth can arise as a consequence of both nutritional deficiency and infectious disease processes (Pinhasi 2008: 365), and studies of living populations have demonstrated a clear relationship between physiological stress and stature (Larsen 1997: 14). The research of Trotter and Gleser (1958: 121) has indicated significant differences between the relationship of stature to bone length among Europeans, Asians, and blacks. They considered the differences significant enough to warrant the development of different regression equations for each of the three major races. Because the population groups from Aymyrylg are believed to be of mixed European and Asian extraction (Bogdanova and Radzjun 1991: 60), the estimation of stature is problematic. Feldesman and Fountain (1996) have demonstrated how the application of inappropriate stature equations has the potential to over- or underestimate living stature. As a consequence of the problematic nature of stature determination for the potentially mixed-race Aymyrylg population groups, the maximum length of the femur was used as a means of assessing growth (cf. Buzon and Judd 2008: 95).

TRAUMA

A detailed account of the evidence for trauma at Aymyrylg has already been published (Murphy 2003). As such, the discussion of trauma here will be restricted to a statistical analysis of the overall prevalences of fractures and weapon injuries among the two population groups. As will be seen, the data included in Table 12.2 represents the number of individuals who displayed one or more fractured bones and the number of individuals who displayed one or more types of weapon injury. These included injuries caused by blades, chekan axes, and arrowheads, as well as cases of decapitation and scalping.

STATISTICS

Kolmogorov-Smirnov two-sample tests were applied to the age and sex distributions. Chi-squared Goodness of Fit tests were used to compare

sex distributions, classified according to the four age categories, for both cultures. The *Z*-test was used to compare the proportions of cribra orbitalia, porotic hyperostosis, dental enamel hypoplasia, tibial periostitis, fractured bones, and weapon injuries apparent in the two populations. This method was favored over chi-squared tests as it can determine if a proportion is significantly greater or less than another proportion, whereas a chi-squared test can only determine if an observed proportion is significantly different from an expected proportion (Sheskin 2004: 511). In any cases where the sample size was less than five, a Fisher's Exact test was applied. An ANOVA test was applied to the logarithms of the mean left and right male and female femoral lengths from the two cultures.

RESULTS

AGE AND SEX DETERMINATION

A total of 413 adults of known age and sex from the Uyük Culture were included in the study, and the sex ratio of males ($n = 224$) to females ($n = 189$) was 1.2:1. The Shurmak population group comprised some 148 adults of determinable age and sex, with a sex ratio of males ($n = 69$) to females ($n = 79$) of 0.9:1. In a normal population, a sex ratio of 1:1 is expected (Waldron 1994: 23) and as the sex ratio of both population groups at Aymyrlyg does not deviate markedly from the norm it is probable that the sexes are realistically represented in these groups. Details of the age and sex distribution for the Aymyrlyg population groups are provided in Table 12.1.

A Kolmogorov-Smirnov test indicated that there was no significant difference between the age distribution of each culture ($P = 0.211$). The majority of individuals in both groups had died at an age of 25–34 years (ca. 40%), followed in frequency by those who had died at 35–44 years (ca. 30–35%), and those who had died at an age of 17–24 years (ca. 20–25%). Very small numbers of older adults were present (ca. 5–10%). Chi-square Goodness of Fit tests revealed no significant difference in sex distribution between the two cultures for the 17–24 years ($\chi^2 = 2.723$; $P = 0.099$); 25–34 years ($\chi^2 = 0.956$; $P = 0.328$), and 45+ years ($\chi^2 = 1.986$; $P = 0.159$) age categories. A significant difference was, however, detected for the 35–44 years ($\chi^2 = 42.065$; $P = 0.000$) group in which the frequency of Shurmak males was significantly lower than expected, and the frequency of Shurmak females significantly higher than expected.

Table 12.1. Age and sex profiles of the adults from Aymyrlyg ($n = 561$); percentages provided in parentheses

	17–24		25–34		35–44		45+		Total	
	Uyük	Shurmak	Uyük	Shurmak	Uyük	Shurmak	Uyük	Shurmak	Uyük	Shurmak
Male	39 (17)	15 (22)	95 (43)	32 (46)	72 (32)	16 (23)	18 (8)	6 (9)	224 (54)	69 (47)
Female	55 (29)	15 (19)	66 (35)	26 (33)	49 (26)	34 (43)	19 (10)	4 (5)	189 (46)	79 (53)
Total	94 (23)	30 (20)	161 (39)	58 (39)	121 (29)	50 (34)	37 (9)	10 (7)	413	148

Table 12.2. Prevalence of stress indicators, trauma, and average femoral length; percentages provided in parentheses

	Uyük Culture			Shurmak Culture		
	Male	Female	Total	Male	Female	Total
Cribra orbitalia	78/354 (22)	50/339 (15)	128/693 (18)	33/114 (29)	31/114 (27)	64/228 (28)
Porotic hyperostosis	21/180 (12)	7/169 (4)	28/349 (8)	13/53 (24)	5/57 (9)	18/110 (16)
Enamel hypoplasia	35/134 (26)	27/89 (30)	62/223 (28)	19/44 (43)	20/48 (42)	39/92 (42)
Tibial periostitis	7/170 (4)	2/156 (1)	9 (3)	4/126 (3)	4/147 (3)	8/273 (3)
Fractures	27/231 (12)	8/199 (4)	35/430 (8)	17/69 (25)	10/79 (13)	27/148 (18)
Weapon injuries	12/231 (5)	1/199 (1)	13/430 (3)	13/69 (19)	5/79 (6)	18/148 (12)
Femur length (cm)	45.16 (161)	41.17 (154)		44.33 (113)	40.62 (137)	

INDICATIONS OF PHYSIOLOGICAL STRESS

All 430 Uyük Culture individuals of known sex were included in the palaeopathological analysis – these comprised 231 males and 199 females – and all 148 Shurmak Culture adults discussed earlier were also included in this analysis (Table 12.2; Figure 12.4). The prevalence of cribra orbitalia in the observable orbits of the Uyük Culture was 18%, and the lesion occurred with a frequency of 28% among the observable orbits of the Shurmak Culture. A *Z*-test indicated that the proportion of cribra orbitalia in the Uyük Culture population was significantly lower than for the Shurmak Culture ($Z = -3.10$; $P = 0.001$). Porotic hyperostosis occurred among Uyük Culture adult cranial vaults with a frequency of 8%, whereas it had a prevalence of 16% for cranial vaults from the Shurmak Culture adults. A

Figure 12.4. Graph comparing the prevalence of physiological stress indicators and trauma in the Uyük and Shurmak Culture population groups

Z-test indicated that the proportion of porotic hyperostosis in the Uyük Culture population was significantly lower than for the Shurmak Culture ($Z = -2.54$; $P = 0.006$). Dental enamel hypoplasia occurred among Uyük Culture adult dentitions with a prevalence of 28%, whereas the dentitions of Shurmak Culture adults displayed hypoplastic lesions with a frequency of 42%. A Z-test indicated that the proportion of dental enamel hypoplasia in the Uyük Culture population was significantly lower than for the Shurmak Culture ($Z = -2.52$; $P = 0.006$).

New bone formation on the tibiae occurred with a markedly low frequency of 3% in both population groups. A Z-test indicated that there was no statistical significance in the proportions of tibial periostitis apparent in the two cultures ($Z = -0.12$; $P = 0.450$). The frequency of adults with one or more fractured bones among the Uyük Culture population was 8%, whereas their Shurmak Culture counterparts had a frequency of 18%. A Z-test indicated that the proportion of individuals with one or more fractured bones in the Uyük Culture population was significantly lower than for the Shurmak Culture ($Z = 3.43$; $P = 0.000$). The prevalence of weapon injuries among the Uyük Culture was only 3%, whereas 12% of Shurmak Culture adults displayed evidence for one or more weapon injuries. A Z-test indicated that the proportion of individuals with weapon injuries in the Uyük Culture population was significantly lower than for the Shurmak Culture ($Z = -4.26$; $P = 0.000$). A further Z-test revealed that Uyük Culture males were significantly more likely to have weapon injuries than were Uyük Culture females

($Z = 2.83$; $P = 0.003$), whereas Shurmak Culture males were also significantly more likely to display weapon trauma than were their female counterparts ($Z = 2.32$; $P = 0.010$). In the former case, a Fisher's Exact test was applied as one of the sample sizes was less than five.

Uyük Culture males had a mean femoral length of 45.16 cm, and the mean femoral length for females was 41.17 cm. Shurmak Culture males and females had mean femoral lengths of 44.33 cm and 40.62 cm, respectively. An ANOVA test, undertaken on the logarithms of the mean left and right male and female femoral lengths of the two cultures, found that the mean lengths of the male and female Uyük Culture femora were significantly higher than those of their Shurmak Culture counterparts ($F = 10.83$; $P = 0.001$).

DISCUSSION

The demographic profiles of the Uyük Culture and the Shurmak Culture were broadly similar in terms of overall age distribution and sex ratio. The only significant difference apparent was detected for the 35–44 years group in which the frequency of Shurmak males was significantly lower than expected, whereas the frequency of Shurmak females was significantly higher than expected. The frequency of Shurmak Culture males dying at the age of 25–34 years was relatively high (46%) compared to female deaths at this age (33%). The trend would appear to be indicating that Shurmak Culture males were more likely to die at an age of 25–34 years (46%), whereas Shurmak Culture females had a better chance of survival until 35–44 years (43%). A similar trend was not evident for the Uyük Culture, and both sexes in this group appear to have followed a similar demographic profile, with relatively similar proportions of males and females dying within each age category. It can therefore be suggested that the Shurmak Culture lifestyle was less conducive to males reaching longevity than their female counterparts.

As discussed earlier, the Shurmak Culture is believed to have developed as part of the expansion of the Xiongnu Empire. The historical accounts imply that Xiongnu society largely centered on military prowess, particularly of males (Watson 1961: 155–156; Ishjamts 1994: 164). It is possible that male involvement in warfaring activities made them more susceptible than females to dying at a younger age. Perhaps the Shurmak Culture experienced greater social unrest or was a generally more warfaring society than its predecessor. It needs to be remembered at this point that not all injuries will leave their traces on the skeleton and that many soft tissue injuries remain invisible to palaeopathologists.

The results of the statistical analysis demonstrate clear differences in the health status of the Uruk Culture when compared to the Shurmak Culture. Although all of the individuals included in the study had survived until adulthood, the levels of cribra orbitalia, porotic hyperostosis, and dental enamel hypoplasia suggest that Shurmak Culture children were significantly more susceptible to physiological stress than their Uruk Culture counterparts. In addition, Shurmak Culture adults appear to have been significantly more susceptible to acquiring both fractured bones and weapon injuries, and they were significantly shorter than members of the Uruk Culture. Tibial periostitis was the only indicator where significant differences between the two cultural groups were not apparent, and this type of lesion occurred very infrequently among both populations.

The chapter started with a research assumption that anticipated that the Uruk Culture group would display evidence for a higher standard of health than the Shurmak Culture population because of social disruption, and the results certainly appear to support this proposition. So how do the findings correlate with the scenario that the Shurmak Culture was at least a partially new, unstable cultural group brought about as a result of Xiongnu expansion? As discussed earlier the historical, archaeological, and biometric evidence suggests that the Shurmak Culture developed as a result of the physical movement of new people into Tuva. We must therefore imagine the scenario wherein the original population of Tuva, who might be considered to be the nonpolitical actors, and the new Xiongnu population, the political actors, were living together under the auspices of the Shurmak Culture. It is inevitable that this situation would have placed stress on both the native and migrant groups. Initially, at least, the native group would probably have been subjugated by the Xiongnu incomers, whereas the latter would presumably have had to survive within a potentially hostile environment. Without further detailed biometric and perhaps DNA studies, however, it is impossible to identify the actual proportions of people from the original and new populations buried at Aymyrlyg. It is impossible to know, for example, whether the Xiongnu group wholly or largely was comprised of male warriors (cf. Anthony 1990: 898) who then intermarried with Uruk Culture females to produce many of the members of the Shurmak Culture population buried at Aymyrlyg. The archaeologists who excavated the cemetery complex believed the Shurmak Culture burials to display numerous features that were derived from the preceding Uruk Culture. Significantly, they observed that the Shurmak Culture burials at Aymyrlyg were notably different from those discovered in other broadly contemporary burial grounds, such as Kokel (Stambulnik 1983: 34). This might provide a clue as to what impact the Xiongnu expansion

had on the people who buried their dead at Aymyrlyg. One can envisage a situation rather similar to the development of Hiberno-Norse populations in the coastal areas of southern Ireland during the tenth century AD. Waves of Viking attacks from the late eighth century AD onward gradually resulted in the establishment of a number of new settlements at places such as Dublin, where the Vikings might overwinter. The Norwegian Vikings in these new settlements, however, soon realized there was profit to be made through trading with the native Irish. As a consequence, these Norse Vikings gradually became assimilated into Irish society as a result of intermarriage with members of the local population, and they also became Christians. This did not mean that they adopted a peaceful lifestyle, however, and for the next two hundred years they were intricately involved in the politics and warfare of Ireland, often fighting alongside their Irish neighbors against other Irish kingdoms (Donnelly 1997: 62). If a similar situation had been responsible for the creation of the Shurmak Culture burials at Aymyrlyg, then the increase in physiological stress apparent among this later population group may have been a response to the overall social disruption brought about by the Xiongnu expansion rather than to a full-scale conquest. The cultures of the indigenous population and the migrant groups may have blended, but it is still possible that the introduction and development of a new social system would have resulted in increased psychological and physiological stress.

In their discussion of the various stressors that impacted on colonial and later twentieth-century Andean populations, Goodman and colleagues (1988: 187–191) discuss how, in addition to environmental stressors, the poorer members of such societies are subject to stresses brought on by socioeconomic changes. This section of the population has a low standard of living and is required to work harder to gain access to a smaller share of the food. The long-term effect of this situation is that the poor are more susceptible to disease and ill health and their children are smaller than those of their wealthier counterparts. This political-economic perspective on stress may prove informative when trying to interpret the differences in prevalence of stress indicators between the Uruk and Shurmak Cultures. Following this approach it is envisaged that a dominant group gains control over the productivity of others. By doing this they are limiting the adaptive capability of the subordinate group, which in turn increases stress on this group and can result in a lower standard of health (cf. Goodman et al. 1988: 191). Anthropological studies have also demonstrated, however, that life-change situations that involve migration genuinely cause physiological stress to the migrant groups (see Goodman et al. 1988: 175, for discussion). As such, regardless of the composition of the Shurmak Culture population in terms

of the proportions of indigenous and incoming people, it is very probable that its development was a highly stressful time for both native and newcomer alike.

The statistically significant greater proportions of cribra orbitalia, porotic hyperostosis, and dental enamel hypoplasia among the Shurmak Culture individuals would tend to suggest that, certainly, when the adults included in this study were children, they had been subject to a greater level of physiological stress than their predecessors. The archaeological, ethnographic, and historical information indicates that both populations were principally pastoralists. The products obtained from agricultural and hunting and gathering activities probably supplemented the diet of meat and milk products from the pastoralist economy (Vainshtein 1980: 52, 59–61). As such, provided there was an adequate supply of such products, it is unlikely that these lesions would have been caused by dietary inadequacy. If there had been a period of conflict in Tuva, however, it is possible that the new social system of the Shurmak Culture, which appears to have been more hierarchial (Mandelshtam and Stambulnik 1992: 205), may have meant that certain members of this newly constituted population group had more limited access to adequate food resources than during the preceding Uyk Culture. A study of living individuals born during the famine of 1959–1961 in China, for example, revealed significant elevations in dental enamel hypoplasia formation among teeth developed during the famine compared to those developed in nonfamine circumstances (Zhou and Corrucini 1998). Thus it can be suggested that the statistically significant increase in dental enamel hypoplasia among members of the Shurmak Culture relative to members of the Uyk Culture is an indication of a deterioration of child health that may have been related to social disruption possibly caused during the period of Xiongnu expansion.

The paucity of tibial periostitis among both populations is interesting, but it can be interpreted in a number of ways. If we consider the evidence for cribra orbitalia, porotic hyperostosis, and dental enamel hypoplasia as largely a reflection of childhood physiological stress, and tibial periostitis to be an indicator of adult health, then the low prevalence of the latter condition may be a reflection of better health among adults than children. Alternatively, it is often the case that death can ensue quite rapidly in the aftermath of microbial attack as part of an acute infectious disease. In such cases, the individual would have died too quickly for osseous changes to have occurred (Larsen 1997: 64). It is possible that the seminomadic lifestyle was not conducive to the development of infectious lesions, although both population

groups have produced definite and possible cases of tuberculosis (Murphy 1998; Murphy et al. 2009; Taylor et al. 2007).

The Uyk Culture males and females had significantly longer femoral lengths than their Shurmak Culture counterparts. Krogman and Işcan (1986: 302–351) have demonstrated that the maximum length of the femur is related to living stature more closely than the maximum length of any of the other long bones. The research of Steckel (1995) has shown that a person's stature is directly related to the quality of their diet and to their disease history, although the latter is of less importance. It appears to be the case that individuals with an adequate diet attain their genetic growth potential, whereas this is not the case for those individuals with a poor diet. A variety of studies have demonstrated that stature has a tendency to increase with economic and nutritional improvement and that, conversely, a decline in stature will ensue during times of hardship and deprivation (Larsen 1997: 14). The discussion of stature is complicated, however, by the suggestion of the movement into Tuva of an increasingly Asian population at the formation of the Shurmak Culture. Recent genetic studies have clearly demonstrated that adult height is substantially influenced by hereditary factors (e.g., Lettre et al. 2008). Research has indicated that there are significant statistical differences in the mean femur length/stature of the three main geographical "races"—Asian, white, and black (Feldesman and Fountain 1996). It is feasible that the movement of an Asian people into Tuva could have contributed to the shorter femoral lengths apparent for the Shurmak Culture individuals, perhaps following intermarriage with the more European populations of the Scythian-period Uyk Culture.

Trauma largely arises as a consequence of violent encounters with the environment or with other humans (Merbs 1989: 161). Statistical analysis revealed the Shurmak Culture to have a significantly higher number of individuals with fractured bones and weapon injuries than the Uyk Culture. Further detail about specific fracture and weapon injury prevalences can be found in Murphy (2003), but it is clear that the forces that impacted on the later group made them more susceptible to a broad range of injuries, as well as to conflict-related death. Within the scenario that the Shurmak Culture had developed as a result of the militaristic expansion of the Xiongnu, this finding is not unexpected. In addition, in both groups a significantly higher number of males than females displayed weapon injuries. The historical sources for both the Scythian-period Uyk Culture and the Hunno-Sarmatian-period Shurmak Culture indicate that warfare was largely, but not exclusively, a male preoccupation (Sélincourt and Burn 1972: 291, 307–308; Watson 1961: 155).

CONCLUSIONS

The results of this survey would tend to suggest a decline in health status between individuals of the Uyük Culture and the succeeding Shurmak Culture. The increased prevalences of cribra orbitalia, porotic hyperostosis, and dental enamel hypoplasia are an indication that, as children, members of the latter group were more susceptible than members of the preceding group to physiological stress. A decrease in average femoral lengths between the groups may indicate that external circumstances were having a negative impact on the stature of the Shurmak Culture individuals. The possibility of the movement of an Asian population into Tuva as a result of Xiongnu expansion, however, may also have had an impact on population height. The higher number of individuals with fractured bones and weapon injuries in the Shurmak Culture population is a further indicator of the poorer quality of life of the latter group. The palaeopathological differences highlighted between the two populations buried at Aymyrlyg are compatible with the documentary and archaeological evidence that indicates that the populations of Tuva and other neighboring regions experienced the military force of the Xiongnu Empire at the end of the third and the beginning of the second century BC (Davidova 1996: 159). It is envisaged that the movement of new people, in whatever quantity, into the region as part of a militaristic expansion would have potentially caused significant stress to both the incoming and the native groups. The archaeological evidence for a blending of the two cultures is suggestive of intermarriage between the migrant and native populations. It is therefore possible that the deterioration in health status and quality of life may have been largely due to social disruption rather than to a full-scale militaristic colonization of the region by new people. Although radiocarbon dating of the burials at Aymyrlyg and further research on the material culture have the potential to provide more information on the relationship of the burials to Xiongnu expansion, this study has clearly demonstrated that the health status and the quality of life deteriorated among the people burying their dead in the cemetery as time progressed. Further bioarchaeological research on the nonadult individuals from the Uyük and Shurmak Cultures buried at Aymyrlyg should help elucidate additional information about the health status of these two population groups. In addition, multivariate analyses of metric and nonmetric traits might provide more information concerning the nature of the population change that appears to have occurred with the onset of the Shurmak Culture. Palaeopathological analysis of other southern Siberian prehistoric and protohistoric populations is certainly needed in order that the findings from Aymyrlyg can be placed into a broader context that will enable a greater

understanding of the health status and quality of life of the region's past populations. It is hoped that bioarchaeological methods will in the future be viewed as a valuable approach for elucidating the impact of sociopolitical changes on the past populations of Eurasia.

ACKNOWLEDGMENTS

I would like to thank Maureen Marshall for inviting me to participate in the Third University of Chicago Conference on Eurasian Archaeology. I am very grateful to the late Professor Ilyia Gokhman and to Professor Yuri Chistov, Kunstkamera Museum, Saint Petersburg, for enabling me to analyze the Aymyrlyg collection. Thanks are due to Libby Mulqueeny of the School of Geography, Archaeology and Palaeoecology, Queen's University Belfast, for preparing Figures 12.1–12.3, and to Dr. Colm Donnelly, of the aforementioned school, for his comments on the text.