Reconstructing Diet, Health and Activity Patterns in Early Nomadic Pastoralist Communities of Inner Asia

by

Michelle L. Machicek

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Abstract

From the distant past until the present day, the archetypal image of the vast steppe lands of Inner Asia has been represented by populations practicing various forms of nomadic pastoralism as their predominant means of subsistence and way of life. While existing research in this region has focussed on questions pertaining to empire formations and interactions, as well as social and political complexity, a more developed understanding of diet, health, and activity patterns has yet to be established.

Towards this end, the broad aim of this dissertation entails the reconstruction of diet, health and activity in discrete populations which inhabited this region from c. 1500 BCE to CE 600. These objectives have been addressed through a comprehensive research programme involving osteological and chemical analyses of human skeletal remains, derived from archaeological sites located throughout modern-day southern Siberia, Mongolia, Inner Mongolia, Xinjiang and Kyrgyzstan. Additional skeletal samples dating from c. CE 1200 to 1300 and a late historic sample from c. CE 1700 to 1900 have been included to provide a comparative framework for the earlier material under study.

This dissertation aimed to challenge assumptions, which often presuppose a predominantly mobile pastoralist lifestyle for many of these populations, by providing indirect and direct evidence for dietary habits and evidence for workload and activity patterns. Long-term dietary intake was investigated through the analysis of stable carbon and nitrogen isotopes on both human skeletal remains and associated archaeological faunal material. Diet has also been assessed through a comprehensive study of dental pathology and dental wear analysis. Health and nutrition has been assessed through the study of dental pathology, linear enamel hypoplasia, and degenerative joint disease. Workload and activity patterns have been addressed through the combined analysis of musculo-skeletal stress markers and degenerative joint disease.

The key results of this dissertation indicate dietary variation and similarities in distinct communities which are related to food procurement strategies carried out at local group levels. The results of the isotopic and dental pathology analyses indicate dietary variation in discrete groups which may have been labelled under the same terms historically and archaeologically, but based on these findings did not necessarily engage in identical subsistence regimes. In addition, the results of the isotopic analyses reflect the influence of the inhabitation of arid environments on $\delta^{15}N$ isotopic signatures and reinforce the need for contextualising isotopic results within local environmental settings. The analysis of degenerative joint disease, coupled with musculo-skeletal stress marker recording has provided an indication of variation in workload and health between discrete groups. Based on these results workload variation and activity patterns have been found to be relatable to local food production activities and social circumstances of particular groups. Finally, the combined analyses presented in this dissertation have provided a firm basis for reconstructing past life-ways of these populations by presenting a more thorough understanding of diet, health and group activities. In addition, this assessment provides a foundation for future research in these areas, which will continue to contribute to our knowledge of the ancient communities of this region.

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I know that my achievement is quite ordinary, I am not the only man to seek his fortune far from home, and certainly I am not the first. Still, there are times I am bewildered by each mile I have travelled, each meal I have eaten, each person I have known, each room in which I have slept. As ordinary as it all appears, there are times when it is beyond my imagination.

- Jhumpa Lahiri [Interpreter of Maladies]

Throughout the course of this research and during the years of my academic endeavours, there have been numerous people who have contributed in many ways towards helping me to achieve my goals. While it is impossible to name everyone here, I am nonetheless appreciative of everyone who has supported me along the way.

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Chapter One
Introduction

The human species has always had to cope with its environment. The ability to adapt and contend with the world around us is an innate biological skill as well as a testament to our cultural innovation and complexity. The central component of this research concerns the issue of how prehistoric populations responded in physiologically detectable ways to their inhabitation of diverse geographical areas, to their utilisation of differing subsistence strategies and to the effects of socio-cultural processes. This will allow us to more fully understand the nature of human responses more broadly speaking to adverse environments, dietary composition and habitual stresses. The nomadic pastoralist communities of Inner Asia serve as a remarkable example of the ability to adapt, cope and thrive in a multitude of cultural and environmental circumstances and therefore provide the main focus for this research. This dissertation addresses these concerns through the examination of human skeletal remains derived from populations who inhabited the vast Inner Asian steppe-lands spanning the time frame from approximately 1500 BC to AD 1300.

At various points throughout the Bronze Age (c. 2000 to 500 BC) and Early Iron Age (c. 600 to 300 BC), different forms of nomadic pastoralism became the predominant mode of subsistence throughout the Eurasian steppes. However, it is still unclear as to exactly when and why this development occurred (Barnes 1993; Anthony 2007). Various studies have proposed the possibility of climate change as an influencing factor, suggesting that increasing aridity may have prompted a move towards more mobile pastoralist economies that were better able to utilise marginal or unstable environments (discussed in Yablonsky 1995; Shishlina and Hiebert 1998). However, if climate change did play a significant role, this has yet to be clearly established. Other possible influences include increasing cultural contact between sedentary and mobile groups, human migration, technological innovations, and the development of horse-riding (Barnes 1993; Cavalli-Sforza 1996; Levine 1999; Anthony 2007).

Much of the earlier scholarship of this region largely focussed on the relationship between what has been termed the 'steppe and the sown', the world of the nomadic pastoralist communities and settled agriculturalists. The focus on this dichotomy would subsequently shape the nature of academic discourse in the region from its earliest beginnings (i.e. Peake and Fleure 1928). While now it is well-recognised that there was undoubtedly complex interrelationships with neighbouring agriculturalist communities, various mobile pastoralist groups living in differing environments, would have engaged in this interaction to a greater or lesser extent than others (Khazanov 1994; 2001). Furthermore, the motivations and circumstances in which these interactions took place are little understood at present. It is recognised that in anthropological discourse there is often the need for generalisations to be made in order to drive theory and enable widespread comparisons to be undertaken. However, this study aims to readdress many of the statements made concerning subsistence activities in the Inner Asian steppes by examining various populations within their respective local settings. This will not only allow for a greater understanding of the interactive processes that took place between sedentary and mobile communities but also within and between discrete nomadic pastoralist groups.

There are a number of archaeological and anthropological debates concerning the degree of reliance of nomadic pastoralists on external resources, such as agricultural and aquatic food products to supplement primarily meat and dairy-based diets. Essentially, there are two major anthropological positions regarding the reliance of nomadic pastoralists on neighbouring sedentary communities for agricultural products. These two theories have been described as the 'greedy' and 'needy' models (Di Cosmo 1994). The 'greedy' model suggests that aggressive behaviour carried out by nomadic groups, such as the documented raids on the northern frontier of the Han Empire, were undertaken to obtain valuable and desired commodities which included grain. The 'needy' model relies on ethnographic evidence to demonstrate that nomadic pastoralist communities typically do not exist in isolation from their sedentary neighbours, and that pastoralists engage in trade and exchange to supplement and extend their available dietary resources (Khazanov 1994; Salzman 2004). Support for proposed dietary regimes and subsistence strategies are most often based on *indirect* dietary evidence obtained from historical accounts, archaeological faunal remains, palaeobotanical evidence and ethnographic analogies. To date, there have been relatively few comprehensive and comparative studies that have examined human skeletal remains in order to determine the diets of prehistoric nomadic or semi-nomadic groups in this region. Therfore, the extent to which these groups were utilising grain, fish and other supplementary food sources to meet their dietary needs has yet to be clearly established. In addition, it should also be pointed out that these two models more appropriately concern the periods when nomadic pastoralism was already well-established in this region. It is possible that very different social factors influenced these communities during the earliest transitional phases (e.g. the Late Bronze and Early Iron Ages) that encompassed the adoption of mobile herding as a standard way of life. Current suggestions, based on research from north and central Mongolia, propose that this early phase was characterised by a transition from hunting-gathering to herding-hunting-gathering, at least at these locales (Honeychurch and Amartuvshin 2007; 2010; Wright 2006; Wright et al. 2007). In other regions, such as in the oases of Kyrgyzstan, Turkmenistan and Xinjiang, and in the western reaches of the Eurasian steppes, there is evidence for the adoption of mobile herding by previously sedentary agriculturalist communities (Watson 1971; Shishlina and Hiebert 1998). Proposed factors which could have influenced this development are those mentioned above and include such possibilities as changing climate, cultural and technological innovations and increasing mobility brought about through the widespread adoption of horse-riding (Renfrew 1999; Cavalli-Sforza 1996; Shishlina and Hiebert 1998; van Geel et al. 2004; Anthony 2007).

1.1 Aims and Objectives

The major objective of this dissertation was to employ multiple lines of evidence to provide a more thorough understanding of the populations that inhabited the study region. More specifically, this investigation aimed to provide a more comprehensive picture of dietary regimes, group health and activity/workload patterns. These objectives were addressed through a combination of osteological and chemical analyses of human skeletal remains and by the examination of associated archaeological contextual information and ancient historical accounts.

Osteological analyses consisted of an assessment of dental pathological conditions and dental macro-wear, as well as a comprehensive study of degenerative joint disease and musculo-skeletal stress markers. Observations based on chemical information were obtained through a comprehensive programme of stable carbon and nitrogen isotopic analyses of human and faunal archaeological material excavated from discrete sites located within the modern-day borders of Mongolia. The majority of the skeletal samples included in this dissertation were excavated from Late Bronze Age (c. 1000 to 400 BC) and Iron Age (c. 600 BC to AD 100) burials. Additional samples from Medieval and early-modern historical contexts were also included to allow for both diachronic and broader geographic comparisons to be made. Furthermore, this dissertation is comprised of three distinct sections that do not in each case examine the same skeletal material, culture group or time period. These sections are divided into dental pathology analysis, stable isotope analysis and musculo-skeletal stress marker and degenerative joint disease analysis. Details pertaining to each skeletal sample utilised for the respective analyses are provided in the relevant subsequent chapters.

The major objectives of this study were as follows:

1) To reconstruct dietary habits of communities living in distinct environmental settings using osteological analyses. These analyses included the recording of common dental pathological conditions and macro-wear patterns. Dietary habits based on dental pathology were

then compared both within and between samples based on sex and time period. This provided a further measure for understanding dietary variation at local levels and more broadly speaking by providing a macro-regional and multi-temporal view of resource exploitation practices.

2) To reconstruct long-term dietary intake from stable carbon and nitrogen isotopic analyses carried out on human and faunal archaeological remains from Mongolia. This area of assessment allowed for comparisons to be made which addressed dietary composition both within and between sample populations from two major site locations in Mongolia. Results were also compared from two smaller groups from Mongolia. Further comparisons were made based on sex and time period within the respective sample groups. This area of consideration has provided a starting point for assessing change and continuity in dietary regimes over time in this region and has provided a further measure for determining degree of variation and/or similarities based on age and sex in these populations.

3) To reconstruct group health, workload and activity patterns from osteological analyses. These analyses included the examination of dental pathology and stress indicators on dentition and crania and degenerative joint disease and musculo-skeletal stress markers on post-cranial material. Comparisons were made between and within samples in order to reconstruct health and activity patterns based on sex and age. Further comparisons were made to assess possible variation between communities that were thought to have engaged in divergent subsistence regimes.

1.2 General Considerations: Reconstructing Diet and Health from Human Skeletal Remains

This dissertation aimed to challenge assumptions which often presuppose a predominantly mobile pastoralist lifestyle for many of these populations by providing indirect and direct evidence for dietary habits. As mentioned above, long-term dietary intake was investigated through the analysis of stable carbon and nitrogen isotopes from both human skeletal remains and associated archaeological faunal material. Dietary habits and group health was investigated through a comprehensive study of dental pathology and dental macro-wear analysis. This was implemented by recording the occurrence and severity of pathological conditions including ante-mortem tooth loss, caries, abscesses, and periodontal disease (Hillson 1979; 1996; 2000; Roberts and Manchester 2005). Health and nutrition was also assessed through the examination of linear enamel hypoplasia and degenerative joint disease. In addition, variation and similarities in degree of workload and activity patterns were explored through a comprehensive examination of musculo-skeletal stress markers and degenerative joint disease.

The investigation of health from the examination of human skeletal remains is complicated by difficulties associated with what has been described as the '*osteological paradox*' (Wood et al. 1992). This quandary is based on the suggestion that it may be the case that individuals who survived long enough for disease to be manifested on the skeleton actually represent the most resilient members of the population in question, as weaker individuals would not have survived to that point (Ortner 1991; Wood et al. 1992). Thus arguably, group health may be difficult, if not impossible to properly assess solely from skeletal material. While it is important that these cautions are kept in mind, it is generally recognised that it is still possible to examine many aspects of health in prehistoric societies, particularly when multiple lines of evidence are employed (Ortner 1991; Wood et al. 1992; Goodman 1993; Steckel and Rose 2002; Wright and Yoder 2003).

There are numerous reasons why the study of diet in prehistoric populations is an integral component to understanding past human society as a whole. The human species utilises and manipulates food in ways that extend far beyond what is necessary for basic nutritional needs (Cohen 1987). Human groups intentionally alter landscapes and environments for the sole purpose of implementing various subsistence regimes and through the action of food 'processing' (i.e. exploiting food-stuffs for nutritional or cultural purposes) change food into *diet* (Schutkowski 2008: 142). Furthermore, as Schutkowski (2008: 141) points out, humans differ from other organisms in that they, 'uniquely combine two aspects of eating, by sharing with all other organisms of their habitats the task of consuming food for nutritional requirement, while at the same time using food, or rather culturally acquired dietary habits, as a signifier of individual group, or even national preferences and identities'.

While the manner in which a society obtains or produces its food does not wholly define who they are, it undeniably plays an integral part in the way in which they are identified and assessed within modern anthropological discourse. There are a number of ways in which dietary composition of an individual or group can be inferred from osteological analyses and those which are the focus of this study have been mentioned above. Archaeological faunal assemblages and palaeobotanical evidence from the study region have proven to be informative with regards to dietary choices made by these groups. These sources serve as additional lines of evidence which contribute to the overall reconstruction of dietary intake in these populations. Furthermore, an individual's age, sex and workload are all factors which contribute to the extent to which his or her diet is an adequate or appropriate source of energy and nutrition (Dennell 1979). Additional concerns and considerations pertaining to health, workload and activity as well as palaeodietary reconstruction are discussed in subsequent chapters of this study.

1.3 Geography and Environmental Settings of the Study Region

Throughout the Eurasian steppes and inclusive of northern and western China there are numerous geographical designations applied to discrete areas within this region. These designations are often used divergently by scholars and can have a multitude of meanings. Additionally, within this expansive area there exists a significant range of environmental diversity. Descriptions are provided below to clarify the geographical definitions that are used throughout this work and to describe the complex ecological settings of this region. A macro-regional view of the study region is provided in Figure 1.1 below.

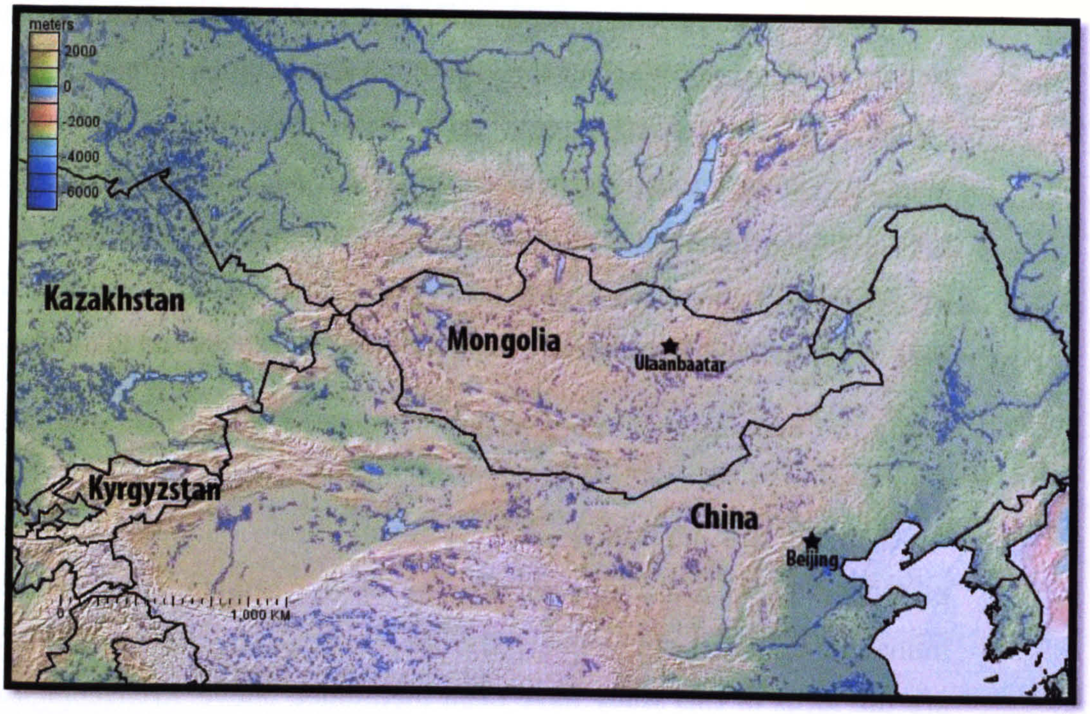


Figure 1.1 Macro-regional view of the study area. All base maps in this dissertation, unless otherwise indicated, were created from http://www.geomapapp.org.

The locales from which the samples included in this dissertation are derived are situated within the geographic region variously referred to as *Eurasia*, *Central Asia*, and *Inner Asia*. Eurasia as it is used throughout this study refers to the vast region of grassland and forest-steppe stretching from the Danube River in the west to the Manchurian Plain in the east and comprising territory north of the Black and Caspian Seas, the Hindu Kush and Kopet Dag Mountain ranges and including Inner Mongolia. This area is situated within the modern-day countries of Russia, Ukraine, Kazakhstan, Kyrgyzstan, Turkestan, Tajikistan, Uzbekistan, Mongolia, and portions of northern and western China. Central Asia is defined here as the landmass stretching from the Caspian Sea and Ural Mountains in the west, to the Ordos Plateau in the east, which is bordered to the south by the Hindu Kush and Kopet Dag mountain ranges and the forests and tundra of central and northern Siberia. Inner Asia is defined as comprising the eastern reaches of Central Asia and including southern Siberia, Manchuria, Mongolia, Inner Mongolia, Xinjiang and Tibet (Lattimore 1940).

The majority of the samples included in this dissertation are from archaeological contexts situated within the modern-day borders of Mongolia, south-central Siberia and the Gorny (High) Altai region of Siberia. Mongolia itself can be roughly divided into three horizontal environmental zones. The northern portion of the country primarily consists of grassland steppe and *Taiga* pine forests that also characterise the landscape of south-central Siberia. A number of large lakes, such as Lake Khovsgol and Lake Baikal and the major river systems of the Selenge and Egiin Gol are situated within this area. However, despite the presence of these natural resources, this is still a relatively arid and unstable environment with a fragile ecology that cannot naturally support intensive agriculture (Humphrey and Sneath 1999).The northern zone also incorporates the Khentii Mountain range to the east of Ulaanbaatar and the Altai Mountains in the west. The central section of the country is dominated by vast expanses of steppe grasslands especially the Dornod Steppe in the east of the country and is bounded by the Khangai and Altai Mountains in its western portion. The south of the country is a particularly arid environment that is comprised of sparse grassy steppes as well as sand and rock deserts. The Gobi Desert is the prominent feature in the very south of the country, but it should be noted that *Gobi* in Mongolian denotes an arid region with insufficient vegetation to support an abundance of flora and fauna. Hence areas outside the Gobi Desert proper are sometimes referred to as *Gobi* in Mongolia as well.

Additional skeletal samples are from sites located in modern-day Xinjiang and Kyrgyzstan. These sites differ somewhat from those of Mongolia and south-central Siberia in that they are situated within regions which have been characterised, at least since the Bronze Age, by interactions between oasis farmers and mobile herders (Gryaznov 1957; Shishlina and Hiebert 1998). Xinjiang is the westernmost territory in China and one of the most landlocked places on earth. This region is comprised of the Tarim Basin and Taklamakan Desert. The Taklamakan is bounded by the Kunlun Mountains to the south and the Pamir and Tian Shan mountain ranges to the west and north respectively. This is an arid environment characterised by extreme and rapidly fluctuating temperatures. In spite of its aridity, oases in this region have traditionally been areas of low intensity cultivation. The modern-day country of Kyrgyzstan is also a mountainous and landlocked area of Central Asia. A significant portion of the country is comprised of the Tian Shan Mountains and the remainder consists of valleys, river drainages, and basins. The climate varies regionally with the south-western portion of the country reaching temperatures as high as 40°C while the northern parts are more temperate. Vegetation consists primarily of grasslands and birch and pine trees. Extremes both in ecology and temperatures are most prominent in the Tian Shan mountain range where the climate can vary from arid at low altitudes to glacial at the highest. Modern herders practice high-to-low altitude pastoralism and it is likely that prehistoric herders adapted in similar ways to the many ecological zones in this area. The majority of the modern-day inhabitants of the country reside in the Fergana Valley, a lush region able to support a diversity of flora and fauna due to the two major rivers that unite in the Valley, the Naryn and Kara Darya. Many modern-day inhabitants in this area practice agriculture for their primary means of subsistence. However, even though agriculture is widely practiced here currently, many years of Soviet restructuring of the economy and the application of modern irrigation techniques have contributed to this development.

1.4 Terminology and Definitions

A number of terms and designations have been used throughout this dissertation to describe various attributes of the societies under investigation and the skeletal samples utilised for this research. In order to explain terms which may be problematic or have multiple meanings, definitions relating to environment, subsistence, and biological terminology are discussed below. In addition, these definitions are provided to clarify any ambiguities that may exist between disciplines when employing these particular terms.

Environment

Environment as it is used throughout this work can encompass the complete setting in which human beings are situated; this can be both the ecological setting, as well as the social and cultural milieu. This study does not advocate theories of *environmental determinism* but rather aims to highlight the different types of environmental circumstances that can affect individuals on both biological and cultural levels (Schutkowski 2008).

Hunter-gathering

This is a subsistence strategy that typically involves the direct procurement of food and resources from the natural environment with little or no reliance on animal domestication. Populations supported by foraging activities are typically small and the nature of the local environment often dictates people's mobility. Foragers adopt mobility as an adaptive strategy to an unstable or seasonally fluctuating resource base in an effort to minimise risk (Ross 1987; Veth 2006). Hence, in arid environments hunter-gatherers are usually relatively mobile due to resource scarcity, thus necessitating foraging across a greater area, whereas in areas where there are abundant resources, foragers may adopt more sedentary life-ways (Ross 1987). However, the annual range covered by a group of hunter-gatherers is rarely correlated with the total amount of territory exploited by individuals in their lifetimes, which is significant due to the fact that individuals within the same group may have a very different foraging radius (Thacker 2006). Variation in mobility among hunter-gatherer groups appears to be contingent on hunting vs. collecting strategies, what resources are being exploited (as well as by whom), and the climate of the local environment (Ross 1987; Kelly 1992; Binford 2001).

Pastoralism

Pastoralism is a subsistence strategy that relies primarily on animal husbandry. This does not however, rule out other forms of food procurement to supplement diet in conjunction with herding. Pastoralists benefit both primarily from the animals they raise and the secondary products provided by those animals, such as milk, cheese, and hides. Pastoralists can employ varying degrees of mobility, but when mobility is extensive and/or frequent the term *nomadic* pastoralism is used to distinguish between highly mobile and more sedentary populations. Throughout this dissertation the terms *mobile pastoralist* and *nomadic pastoralist* are used interchangeably. Pastoralist groups can incorporate a range of mobility strategies depending on the species and composition of their herds as well as the ecology and climate of the region they inhabit (Barfield 1993; Salzman 2004). Herds often require short distance movement coupled with seasonal migration over varying distances. High altitude herders, for example, typically practice seasonal migration from highland to lowland pastures. What sets pastoral mobility apart from other subsistence strategies is that migration is intended to maximise the health of the herds and only indirectly benefits the health of the population. Hence pastoral mobility aims to find adequate pasture and water for the herds rather than for the population, while also minimising conflict between other herders who are competing for the same resources (Chang 2006).

Agriculture

Agriculture is a subsistence strategy in which the majority of food production is based on the cultivation of crops. It should be recognised however that agriculturalists can also rely by varying degrees on animal husbandry. Cultivation is typically a labour intensive and highly specialised subsistence strategy which necessitates sedentism by at least a portion of the population (Jochim 1981). Even though agricultural populations are tied to the land they cultivate, the food surplus and labour specialisation that often results, can allow portions of the population to travel great distances (Ibid).

Mixed Subsistence

Mixed subsistence, or mixed economy, is a type of subsistence that incorporates two or more food procurement strategies. Most societies do in fact practice a mixed subsistence and exclusive exploitation of one strategy is relatively rare. Agriculturalists, for example, often raise animals in conjunction with farming. Similarly, pastoralists may engage in small plot farming during specific times of the year. It is recognised that none of these subsistence strategies represent ideal or exclusive resource procurement activities, but are rather essentialised categories that identify the primary mode of production or resource extraction.

Adaptation

The term adaptation denotes the ability of human beings to cope and contend with the environment around them. Adaptation as it is used in a biological sense denotes an organism's (human's in this case) ability to modify itself in order to be fit for and survive in the environment in which it exists.

Physiological Response

Physiology itself refers to the study of living organisms; plant, animal or human. *Physiological response* in this case indicates the automatic untrained reaction of the human body to various outside stimuli.

Stress

Stress as it is used throughout this study denotes the physiological stress which a person's body may be subjected to as a result of outside environmental circumstances. In the context of this dissertation, these circumstances can be related to health, diet, nutrition and socio-cultural conditions which all have the potential to affect the human body various ways.

1.5 Structure of the Dissertation

This dissertation begins with an introduction to the study area and outlines the primary aims and objectives of the analyses to be carried out. Geographic demarcations and descriptions of the study region are provided and problematic terminology is discussed and defined.

Chapter Two provides chronological information and a background discussion of the archaeological sites and contexts that are relevant to this dissertation. The results of a series of radiocarbon dates carried out for this study are provided, along with a brief discussion of chronological concerns. Background information from several early historical sources is also provided in this chapter. Archaeological contextual information and discussions pertaining to burial rites associated with the skeletal samples utilised in this study are also included.

Chapter Three provides a brief discussion of sample concerns and considerations. In addition, this chapter includes the standard osteological methods that were employed for age and sex estimation of the skeletal material.

Chapter Four concerns the reconstruction of past dietary habits and group health based on dental pathology and dental macro-wear analysis. This chapter includes comparative information pertaining to past research in dietary analysis from populations both within the study region and from studies of populations further abroad. Data obtained and analysed from the skeletal samples is provided in this chapter along with the results and discussion of this area of assessment.

Chapter Five consists of a detailed study of stable carbon and nitrogen isotopic analyses applied to human and faunal material from sites located in several distinct regions of Mongolia. A brief discussion of isotopic studies of neighbouring populations is provided, as well as a discussion of the methods and limitations of dietary reconstruction based on these analyses. Following this, the methods, results and discussion of the isotopic study carried out for this dissertation are provided in detail.

Chapter Six examines general health, workload and activity patterns within and between three discrete samples from the study region. A brief discussion of the difficulties encountered when inferring habitual activities from human skeletal material is also included in this section. The materials and methods used to carry out this aspect of study are provided along with the results and discussion of the analysis.

Chapter Seven includes a brief summary and conclusion of the dissertation as a whole and discusses how the objectives of this research programme have been met. The effectiveness of various methods and limitations encountered through the course of this research are also considered. Finally, potential directions for future research and the overall conclusions of this investigation are discussed.

Chapter Two
Background Information

The skeletal samples included in this study are from archaeological contexts associated with several culture-historical groups and temporal horizons of the study region. The two major sample groups are from Pazyryk and Xiongnu burials. Additional samples are from Bronze Age, Han Dynasty, Early Medieval and Mongol Period burial contexts. The following sections in this chapter discuss historical background, chronology, archaeological context and information pertaining to the funerary traditions of the populations under investigation. The location of each sample utilised in this study is provided in Figure 2.1.

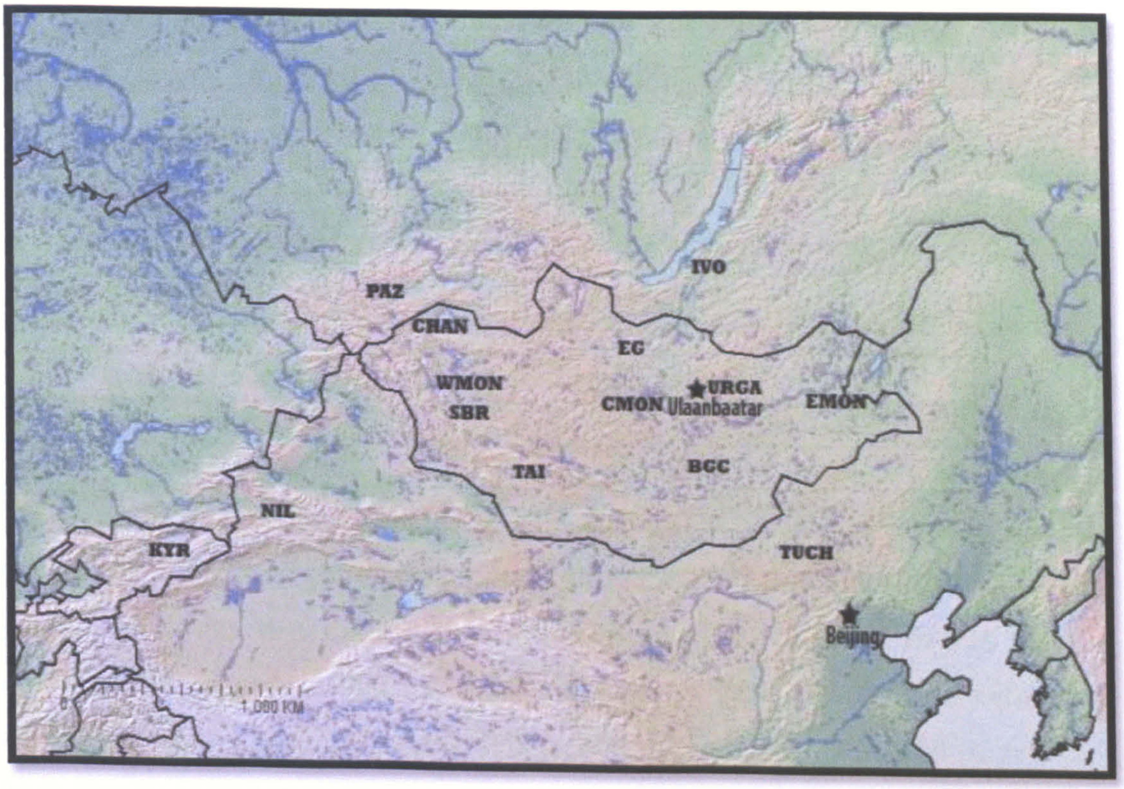


Figure 2.1 Locations of all samples included in this dissertation. WMON= Western Mongolia, TAI= Taishar, BGC= Baga Gazaryn Chuluu, CHAN= Chandman Ulangom, PAZ= Pazyryk (multi-sites), IVO= Ivolga, SBR= Shombuuzin belcher, CMON= Central Mongolia (multi-sites), EG= Egiin Gol, NIL= Nileke, TUCH= Tuchengzi, KYR= Kyrgyzstan (multi-sites), EMON= Eastern Mongolia, URGA=Urga (surface collection).

2.1 Chronology and Radiocarbon Dates

A number of measures were relied upon to be certain of the chronology of the skeletal samples included in this study. Temporal designations have been based on radiocarbon dates, published and unpublished reports and archaeological contextual information. Scholars working in this region often employ culture-historical names to designate a particular group of individuals (e.g. *Scythian* or *Xiongnu*) and this can be problematic at times (Hanks 2002). These designations are often based on a combination of ancient historical texts and similarities in archaeological material culture and funerary customs for a particular group. Throughout this work, several of these cultural designations are regularly used. However, this usage is not meant to imply any ethnic or biological association between or within groups of people but rather to designate a time frame and associated archaeological context with a particular sample group. In addition, temporal designations based on technological chronology (e.g. Bronze Age, Iron Age) are also employed throughout this dissertation. Tables 2.1 and 2.2 below indicate the major chronological divisions of the study region.

Table 2.1 Major chronological divisions for the study region.

Basic Chronology for the Study Region	
Neolithic	c. 8000 - 2000 BC
Bronze Age	c. 2000 - 500 BC
Iron Age	c. 500 BC - AD 500
Medieval	c. AD 500 - 1400

Table 2.2 Major culture-historical temporal designations for the study region.

Major Culture-Historical Temporal Designations	
Siberia/Mongolia	
Bronze Age (khirigsuur)	c. 1500 – 800 BC
Late Bronze Age/Early Iron Age (slab burial)	c. 1000 – 400 BC
Early Iron Age/ Pazyryk	c.600 – 300 BC
Xiongnu	c. 300 BC – AD 100
Turkic	c. AD 600 – 800
Uighur	c. AD 900 – 1000
Khitan	c. AD 1000 – 1100
Mongol	AD 1200 – 1400
Historic-Manchu/Buddhist	AD 1600 – 1900
Kyrgyzstan	
Saka/Wusun	c. 600 – 100 BC
Great Migration Period (Hunnu)	c. AD 200 – 400
Turkic	c. AD 500 – 900
Uighur (Kyrgyz)	c. AD 800 – 900
China	
Shang	1500 – 1000 BC
Zhou	1000 – 221 BC
Warring States	475 – 221 BC
Qin	221 – 207 BC
Han	206 BC– AD 220
Liao	AD 907 – 1125
Yuan	AD 1279 – 1368

There is, of course, much debate among scholars concerning chronology and absolute dates and in some regions material culture may appear somewhat earlier or later than in others (for discussions see Hall 1997; Mallory et al. 2002 and Chang et al. 2003). The designations provided here are intended only as a general guide for this dissertation, although several additional details must mentioned. The chronology for Saka and Wusun (also *Usun*) is sometimes designated as two periods, Saka (c. 750 to 300 BC) and Wusun (c. 300 BC to AD 200) (Rosen et al. 2000). The designations for Bronze Age Mongolia 'khirigsuur' and 'slab burial' in Table 2.2 refer to archaeological burial features found throughout Mongolia and southern Siberia that are referred to by these names and are roughly dated to the respective periods indicated. Several temporal designations for Kyrgyzstan differ somewhat from those used for sites in Mongolia, although they share the same name. These are specifically the Turkic and Uighur Periods. Also note that Uighur Period is also called Kyrgyz Period in Kyrgyzstan. Another potential area of confusion is that the 'Great Migration Period' which is also called the 'Hunnu' Period in Kyrgyzstan is not meant to directly correlate with the Mongolian term for the Xiongnu (*Khunnu*). The Great Migration Period or Hunnu (sometimes also *Hunnic*) Period in Kyrgyzstan begins later than the Xiongnu Period. The term 'Great Migration Period' is also, in itself, problematic. There is a great deal of diversity in the archaeological record during this period in Central Asia, but this is not necessarily attributable solely to migration or the movement of peoples at this time. Migration is invoked in the first place largely to accommodate the claim that the Xiongnu were moving across Central Asia at this time. This label obscures other factors that may be contributing to the diversity evident in the archaeology of the region. Hence the samples from Kyrgyzstan included in this dissertation that date to this period are not to be interpreted as representative of people 'in flux' or dislodged by the migration of the Xiongnu, nor the Xiongnu 'people' themselves. A total of 521 individuals were assessed for this dissertation. These individuals were derived from a wide range of archaeological contexts and time periods. Table 2.3 provides the number of individuals from each site location and the number of individuals associated with each respective time period from each site. Chapter Three, Table 3.2 pg. 49 indicates the samples utilised for each analysis that comprise the subsequent analytical chapters of this dissertation. Samples designated as 'multi-small sites' were grouped together from individual burials or burial clusters located in close proximity to one another to form a sample. The Burial Context column in Table 2.3 indicates the major culture of burial type associated with each sample. In some cases burials were distinctive from the major monument types or 'cultures' associated with the majority of the samples and thus only a designation of the time period is provided.

Table 2.3 Sites, date ranges and number of individuals from each sample. ID=Sample ID used throughout the dissertation.

Site/Location	ID	Approximate Date Ranges	Burial Context	Num. of Individs.
Western Mongolia (multi-small sites)	WMON	c. 2900-1260 BC	Khirigsuur/ Kurgan	14
Taishar, Ulaan Boom, Gobi-Altai, Mongolia	TAI	c. 1500 – 800 BC	Khirigsuur/ Kurgan	8
Baga Gazaryn Chuluu, Dundgobi, Mongolia	BGC	c. 2000-500 BC	BA	2
		c. 1000 – 400 BC	Slab burial	6
		c. 300 BC-AD 200	Xiongnu	22
		c. AD 600 – 800	Early Med. (Turkic)	1
		c. AD 1200-1400	Mongol	7
Chandman, Ulangom, North-West Mongolia	CHAN	c. 700- 400 BC	EIA	23
Gorny-Altai, (multi-small sites) Siberia	PAZ	c. 700-300 BC	Pazyryk	67
Ivolga, South-Central Siberia	IVO	c. 300 BC-AD 200	Xiongnu	30
Shombuuzin belcher, Khovd, Western Mongolia	SBR	c. 300 BC-AD 200	Xiongnu	4
Central Mongolia (multi-small sites)	CMON	c. 300 BC-AD 200	Xiongnu	20
Egiin Gol, North-Central Mongolia	EG	c. 1000 – 400 BC	Slab burial	5
		c. 300 BC-AD 200	Xiongnu	42
		c. AD 600 – 800	Early Med. (Turkic)	1
		c. AD 1200-1400	Mongol	1
Nileke, Xinjiang	NIL	c. 500- 221 BC	Kurgan	39
Tuchengzi, Inner Mongolia	TUCH	c. 475 BC-AD 220	Shaft tomb (Han)	53
Issyk-kul and Tian Shan, (multi-small sites) Kyrgyzstan	KYR	c. AD 300-500	Early Med. Kurgan	26
Eastern Mongolia (multi-small sites)	EMON	c. AD 1200-1400	Mongol	21
Urga, Central Mongolia (Ulaanbaatar)	URGA	c. AD 1700-1900	Surface collection	129
Total				**521**

For this study, a series of radiocarbon dates was obtained for a total of eighteen individuals excavated from burial contexts from Mongolia and Kyrgyzstan. This was undertaken in order to establish dates for several individuals that were interred in one context, where there was no additional archaeological evidence to indicate a possible date and in some cases, where there was no contextual information available. All radiocarbon dating analysis was carried out at the Scottish Universities Environmental Research (SUERC) Radiocarbon Dating Facility, East Kilbride, Scotland. Twelve ^{14}C dates were obtained for individuals from Mongolia from the site of Baga Gazaryn Chuluu (BGC), indicated in Figure 2.1. Table 2.4 indicates these results and the corresponding excavation identification numbers associated with each burial.

Table 2.4 ^{14}C results for twelve individuals from Baga Gazaryn Chuluu (BGC), Mongolia.

Laboratory ID	Excavation ID	Radiocarbon Age BP	Culture/Historic Designation
SUERC-27242	BGC EX 05.04	2120 ±30	Xiongnu
SUERC-27246	BGC EX 07.01	2745 ±30	Late Bronze/Early Iron Age
SUERC-27247	BGC EX 07.07	2340 ±30	Late Bronze/Early Iron Age
SUERC-27248	BGC EX08.02	2075 ±30	Xiongnu
SUERC-27249	BGC EX 08.04a	1770 ±30	Xiongnu
SUERC-27250	BGC EX 08.04b	2080 ±30	Xiongnu
SUERC-27251	BGC EX 08.06	2040 ±30	Xiongnu
SUERC-27252	BGC EX 08.08	1960 ±30	Xiongnu
SUERC-27256	BGC EX 08.17	2750 ±30	Late Bronze/Early Iron Age
SUERC-27257	BGC EX 08.21	3050 ±30	Bronze Age
SUERC-27853	BGC EX 08.22	725 ±30	Mongol
SUERC-27852	BGC EX 08.25	2175 ±30	Late Early Iron Age/Early Xiongnu

Table 2.5 indicates the radiocarbon dates obtained for individuals from six separate sites in Kyrgyzstan. This data series is admittedly limited, however as there are currently few dates available from Kyrgyzstan, they are meant to provide a basis for further dating programmes. In addition, it should be pointed out that some of these sites are multi-period and these results are not meant to act as a guide for the entire cemetery. However, they do provide a guide for the skeletal samples which were studied from Kyrgyzstan and are included in the dental pathology assessment of this dissertation (Chapter Four). Figure 2.2

below provides the location of each site from which the dated skeletal material is derived.

Table 2.5 ^{14}C results for six individuals from selected sites in Kyrgyzstan.

Laboratory ID	Excavation ID	Radiocarbon Age BP	Culture/Historic Designation
SUERC-27843	Japuruk kurgan 2	1660 ±30	Early Medieval
SUERC-27844	Uch kurbu kurgan 6	1800 ±30	Early Medieval
SUERC-27848	Chet keltevek kurgan 4	1575 ±30	Early Medieval
SUERC-27849	Cutuu balak kurgan 34	1670 ±30	Early Medieval
SUERC-27850	Bish-tash-koroo kurgan 7a	1515 ±30	Early Medieval
SUERC-27851	Baskya I kurgan 10	2295 ±30	Saka/Wusun

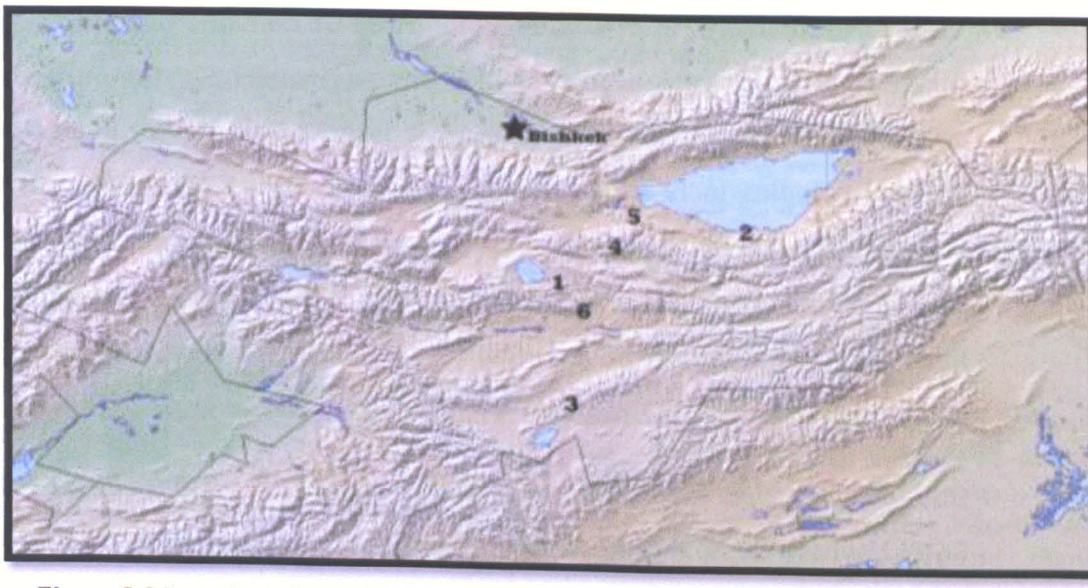


Figure 2.2 Location of sites in Kyrgyzstan where ^{14}C dates are from. 1 Japuruk, 2 Uch kurbu, 3 Chet keltevek, 4 Cutuu balak, 5 Bish-tash-koroo, 6 Baskya I.

2.2 Background Information from Historical Texts

The archetypal representation of the later prehistoric populations of the Eurasian steppes is characterised by groups of mounted warriors and 'tribes' moving across the landscape with their herds, with no fixed dwellings, in search of pasture and water. This image has been perpetuated by the vivid and colourful accounts found in both ancient and more recent historical texts that describe various culture groups of the region. The following excerpts are from texts describing Iron Age populations of the region and later historic accounts of the Mongols.

Some of the most well-known of these descriptions are found in the remarkable tales of the Scythians, which are presented in Herodotus' *Histories* (c. 440 BC). A portion of the *Histories* is devoted to detailed accounts of the belief systems and customs of the Scythians and the geography of the lands they inhabited. The term *Scythian* itself is problematic and has been used by researchers at various times to denote specific ethnicity, particular material-culture styles and Eurasian nomads in general (discussed in Hanks 2002). Herodotus' *Histories* also refer to different types of Scythians, from *Royal Scythians* to *agricultural Scythians* and even to Scythians who live beyond the geographical boundaries he had already demarcated. Therefore, it is not always clear when this term is used to exclusively refer to a specific group of nomadic pastoralists or as an inclusive term for various groups of Eurasian peoples. For the purposes of this discussion however, this complication is largely immaterial. Even though the skeletal samples included in this dissertation are not from classical Scythian contexts, the excerpts provided here provide an insight into what Herodotus saw as characteristic of nomadic culture and life-ways. The passages included here are a selection of those which discuss funerary customs and where diet and transhumance is mentioned.

One of the earliest references to nomadic life-ways in the *Histories* is found in Book I, where comparisons are made between another 'tribe', the *Massagetae*, and the Scythians:

> In their dress and way of living the Massagetae are like the Scythians. Some ride, some do not-for they use both infantry and cavalry. They have archers and spearmen and are accustomed to carry the 'sagaris', or battle axe. The only metals they use are gold and bronze: bronze for spearheads, arrow-points, and battle-axe, and gold for headgear, belts and girdles. Similarly they give their horses bronze breastplates, and use gold about the bridle, bit, and cheek-pieces...
>
> They have only one way of determining the appropriate time to die, namely this: when a man is very old, all his relatives give a party and include him in a general sacrifice of cattle; then they boil the flesh and eat it. This they consider to be the best sort of death. Those who die of disease are not eaten but buried, and it is held a misfortune not to have lived long enough to be sacrificed. ***They have no agriculture, but live on meat and fish,*** of which there is an abundant supply in the Araxes. ***They are milk-drinkers.*** The only god they worship is the sun, to which they sacrifice horses: the idea behind this is to offer the swiftest of mortal creatures to the swiftest of gods. (Hdt. I.215-16 *emphasis by author*).

The majority of the descriptions of the Scythians are presented in Book IV, which also recounts the campaign of the Persian ruler Darius I (550-486 BCE) into the lands inhabited and ruled by the Scythians. In this Book, Herodotus also discusses the geography of the region as well as cultural practices, religious beliefs and battle tactics. The following excerpt recounts a message sent by Idanthyrsus, the Scythian king, to Darius:

> I have never run from any man in fear; and I am not doing so now from you. There is, for me, nothing unusual in what I have been doing: it is precisely the sort of life I always lead, even in times of peace. If you want to know why I will not fight, I will tell you: ***in our country there are no towns and no cultivated land***; fear of losing which, or seeing it ravaged, might indeed provoke us to hasty battle. If, however, you are determined upon bloodshed with the least possible delay, one thing there is for which we will fight-the tombs of our forefathers. Find these tombs, and try to wreck them, and you will soon know whether or not we are willing to stand up to you (Hdt. IV.127 *emphasis by author*).

The following two passages include information concerning diet and a detailed account of the funerary rituals afforded to the Scythian kings:

> The Scythians blind their slaves, a practice in some way connected with ***the milk which they prepare for drinking*** in the following way: they insert a tube made of bone and shaped like a flute into the mare's anus, and blow; and while one blows, another milks. According to them, the object of this is to inflate the mare's veins with air and so cause the udder to be forced down. They make the blind men stand round in a circle, and then pour the milk into wooden casks and stir it; the part which rises to the top is skimmed off, and considered the best; what remains is not supposed to be so good. The reason why they blind their prisoners of war is connected with the fact ***the Scythians are not an agricultural people, but nomadic*** (Hdt. IV. 2 *emphasis by author*).

> When a king dies, they dig a great square pit, and when it is ready, they take up the corpse, which has been previously prepared in the following way; the belly is slit open, cleaned out, and filled with various aromatic substances, crushed galingale, parsley-seed, and anise; it is then sewn up again and the whole body coated over with wax. In this condition it is carried in a wagon to a neighbouring tribe within the Scythian dominions, and then on to another, taking the various tribes in turn; and in the course of its progress, the people who successively receive it, follow the custom of the Royal Scythians and cut a piece from their ears, shave their hair, make circular incisions on their arms and gash their foreheads and noses, and thrust arrows through their left hands.

Once the funeral procession has reached the final destination for burial...

> Here the corpse is laid in the tomb on a mattress, with spears fixed in the ground on either side to support a roof of withies laid on the wooden

> poles, while in other parts of the great square pit various members of the king's household are buried beside him: one of his concubines, his butler, his cook, his groom, his steward, and his chamberlain-all of them strangled. Horses are buried too and gold cups ...and a selection of other treasures. This ceremony over, everybody with great enthusiasm sets about raising a mound of earth, each competing with his neighbour to make it as big as possible (Hdt. IV. 71).

In Herodotus' description of the geography of the Scythian territory, he distinguishes between land occupied by the nomadic Scythians and those who engaged in agriculture:

> The Borysthenes, the second largest of the Scythian rivers, is, in my opinion, the most valuable and productive not only of the rivers in this part of the world, but anywhere else, with the sole exception of the Nile...It provides the finest and most abundant pasture, by far the richest supply of the best sorts of fish, and the most excellent water for drinking... ***no better crops grow anywhere than along its banks, and where grain is not sown the grass is the most luxuriant in the world.*** An unlimited supply of salt is formed by natural processes at the mouth of ***the river, which also produces a very large spineless fish, good for pickling*** and known locally as *antacaeus*, and a number of other most remarkable things. The course of the river is southerly, and it is known as far as the place called Gerrhus, forty days voyage up; beyond that, nobody can say through what country it flows. We do know, however, that ***it enters the territory of the agricultural Scythians*** after crossing an uninhabited region; for these Scythians live along its banks as far as would take a boat ten days to cover (Hdt. IV. 53 *emphasis by author*).

In addition to Herodotus' *Histories*, a number of other texts exist that also contain information concerning the early nomadic groups of the region. Sima Qian's *Shiji* (Records of the Grand Historian) includes many events and descriptive accounts that concern the nomadic pastoralists of the region. Written between BC 109 to 91, the *Shiji*, contains a number of passages that describe the 'barbarian tribes' who inhabited the lands north of the boundaries of modern-day China that would later be united under a single ruler or *Shanyu*. This confederation of nomadic groups would subsequently be referred to in the *Shiji* as the *Xiongnu*. The major period of Xiongnu rule in this area is traditionally dated from c. 300 BC – AD 100.

Although these passages are filled with considerable bias, they nonetheless provide us with several descriptive accounts of the nomads from the viewpoint of their more sedentary agrarian neighbours.

> The ancestor of the Xiongnu was a descendant of the rulers of the Xia dynasty by the name of Chunwei. As early as the time of the Emperors Yao and Shun and before, we hear of these people, known as Mountain Barbarians, Xiayun, or Hunzhu, living in the region of the northern barbarians and ***wandering from place to place pasturing their animals.*** The animals they raise consist mainly of horses, cows, and sheep, but include such rare beasts as camels, assess, mules, and the wild horses known as taotu and tuoji. ***They move about in search of water and pasture and have no walled cities or fixed dwellings, nor do they engage in any kind of agriculture... The little boys start out by learning to ride sheep and shoot birds and rats with a bow and arrow, and when they get a little older they shoot foxes and hares, which are used for food.*** Thus all the young men are able to use a bow and act as armed cavalry in time of war. ***It is their custom to herd their flocks in times of peace and make their living by hunting,*** but in periods of crisis they take up arms and go off on plundering and marauding expeditions. (*Shiji* 110 [Watson1993:129] *emphasis by author*).
>
> ***From the chiefs of the tribe on down, everyone eats the meat of the domestic animals*** and wears clothes of hide or wraps made of felt or fur. The young men eat the richest and best food, while the old get what is left over, since the tribe honours those who are young and strong and despises the weak and aged. (*Shiji* 110 [Watson 1993: 129-130] *emphasis by author*).

The following passage provides a brief description of Xiongnu burial practices.

> In burials the Xiongnu use an inner and outer coffin, with accessories of gold, silver, clothing and fur, but they do not construct grave mounds or plant trees on the grave, nor do they use mourning garments. When a ruler dies, the minsters and concubines who were favoured by him and who are obliged to follow him in death often number in the hundreds or even thousands. (*Shiji* 110 [Watson 1993: 137).

Later texts describe many aspects of politics and lifestyle during the period of Mongol rule in this region. The major historical date range of the Mongol Period is from AD 1200 – 1400 which largely coincides with the emergence and reign of the leader Temujin who would later be known as Chinggis (Genghis) Khan and his descendants. A number of details were recorded by the Franciscan Friar, William of Rubruck, a traveller who journeyed through the Mongol Empire in the middle of the 13^{th} century. The following passages are concerned with dietary habits and customs that he recorded during his travels.

> The great lords have villages in the south, ***from which millet and flour are brought to them*** for winter. The poor procure (these things) by trading sheep and pelts. The slaves fill their bellies with dirty water, and with this they are content...They eat mice and all kinds of rats which have short tails. There are also many marmots, which are called *sogur*, and which congregate in one hole in winter, twenty or thirty together, and sleep for six months; these they catch in great numbers (William of Rubruck [Rockhill 1900: 20] *emphasis by author*).

Rubruck goes on to describe local wild animals and hunting practices of the Mongols:

> I saw also another kind of animal which is called *areali* [= a wild sheep], which has quite the body of sheep, and horns bent like a ram's, but of such size that I could hardly lift the two horns with one hand, and they make of these horns big cups. They have hawks and peregrine falcons in great numbers, which they all carry on their right hand... ***So it is that they procure a large part of their food by the chase***. When they want to chase wild animals, they gather together in a great multitude and surround the district in which they know the game to be, and gradually they come closer to each other till they have shut up the game in among them as in an enclosure, and then they shoot them with their arrows (William of Rubruck [Rockhill] 1900: 20 *emphasis by author*).

Rubruck also provides a description of the capital of Kharkorum, where he points out items available for trade and purchase:

> The city is surrounded by a mud wall and has four gates. ***At the eastern is sold millet and other kinds of grain, which however, is rarely brought there***; at the western one, sheep and goats are sold; at the southern, oxen and carts are sold; at the northern, horses are sold (William of Rubruck [Rockhill] 1900: 89 *emphasis by author*).

2.3 Archaeological Background

Much of the archaeology of the study region has been principally focussed on the excavation of burials. Many of these mortuary features are often large and clearly visible structures that are easily detectable within the modern-day landscape, which makes them a prime area of investigation. There is sometimes a tendency for researchers to focus on the excavation of larger and more prominent 'elite' tombs and this often excludes the attempt to uncover less sensational information. However, despite the fact that there is a great deal of focus on burial excavations, bio-anthropological concerns are often a side-note to the pursuit of other material culture. This being stated, there are of course many exceptions, such as, Murphy (2003), Tumen (2006), Chikisheva (2008), Zubova (2008), Frohlich et al. (2009), Jordana et al. (2009) to name but a few. Furthermore, because the vast majority of the tombs were looted in antiquity, the study of human remains is all the more necessary, as this can sometimes be the only material available for examination. An additional motive for the focus on burials is resultant from the fact that this region has been predominantly inhabited by nomadic pastoralists, which by contrast to more sedentary communities, leave relatively little evidence in the way of habitation or *occupation* sites (Cribb 1991).

The following background information provides a general summary of the burial features from which the skeletal samples included in this study were excavated. This summary is not an attempt to review the entire archaeological setting of what is a particularly extensive and diverse study area, but rather to describe the major burial types that concern this research. For a selection of additional studies see, Konovalov (1976), Minyaev and Sakharovskaya (2002), Honeychurch and Amartuvshin (2006), Wright (2006), Fitzhugh et al. (2009), Frachetti and Benecke (2009), Miller (2009), Minyaev (2009) and Amartuvshin and Honeychurch (2010). In addition, detailed discussions pertaining to local vs. regional variation in these monumental features are outside the scope of this dissertation. Further information pertaining to particular sites and burial contexts for the samples included for each separate analysis are provided in the following chapters.

Bronze Age/Early Iron Age Khirigsuur and Slab Burials of Mongolia and South-Central Siberia

The burials from which the Late Bronze Age and Early Iron Age samples for this dissertation are derived are from two major mortuary monument types of the region, *khirigsuurs* and *slab burials*. These structures occur most predominantly throughout Mongolia and south-central Siberia and they are often found in close proximity to, or in association with, the well-known 'deer stones' of the region (Takahama and Hayashi 2003; Fitzhugh 2005; Frohlich and Bazarsad 2005). Deer stones are the standing stelae, found in parts of Mongolia and Siberia, which display stylised depictions of deer and other fauna as well as tools, weapons, belts and occasionally human faces (Volkov 1981; Fitzhugh 2005; Honeychurch et al. 2009). Khirigsuurs are somewhat analogous to kurgans (mounded burials) of the region, in that they are typically comprised of a central burial mound which can vary in size and shape. The term *kurgan* denotes a mounded burial which can be comprised of earth or stone. Khirigsuurs consist of a central mound of stones that is often constructed around an inner burial cist that is made of stone slabs and overlain by a capstone (Allard and Erdenebaatar 2005; Honeychurch and Wright 2008; Frohlich et al. 2009). The central mound may also be square or circular and can rise either quite substantially above the ground surface or have a lower profile. These monuments are also comprised of several additional features that distinguish them from typical kurgan burials. The central mound is often surrounded by a square/rectangular or circular alignment of stones, or 'fence' and sometimes smaller clusters of stone circles or mounds are found at varying distances either within the stone fence enclosure, as part of the fence alignment, or outside the stone fence (Allard and Erdenebaatar 2005; Wright 2007; Frohlich et al. 2009). Examples of a round and a square khirigsuur with surrounding stone fence enclosures from the north-western Mongolian Altai region are depicted below in Figures 2.3 and 2.4 respectively.

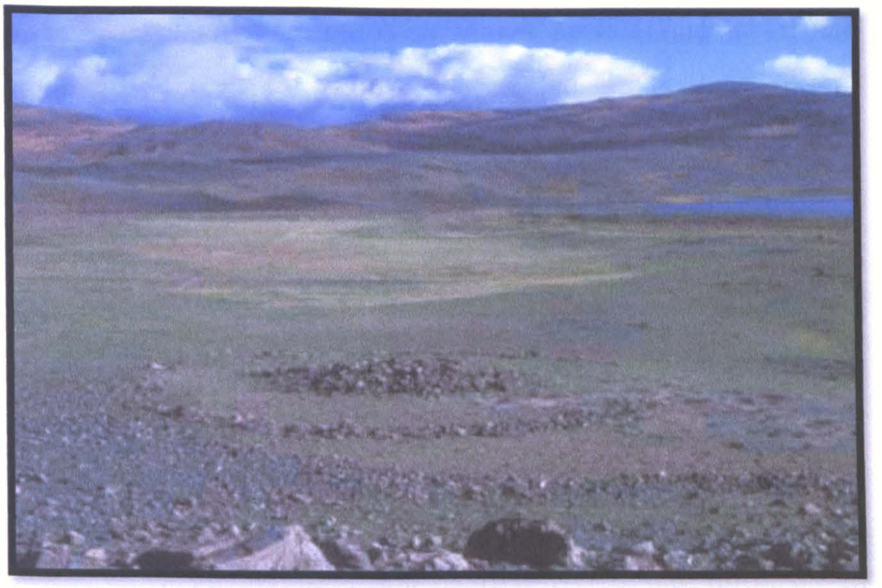


Figure 2.3 Tepfer, Gary. RNKH 00006 TG round khirigsuur. 1999. <http://boundless.uoregon.edu/u?/maic,1203>. (©Gary Tepfer and the Mongolian Altai Inventory).

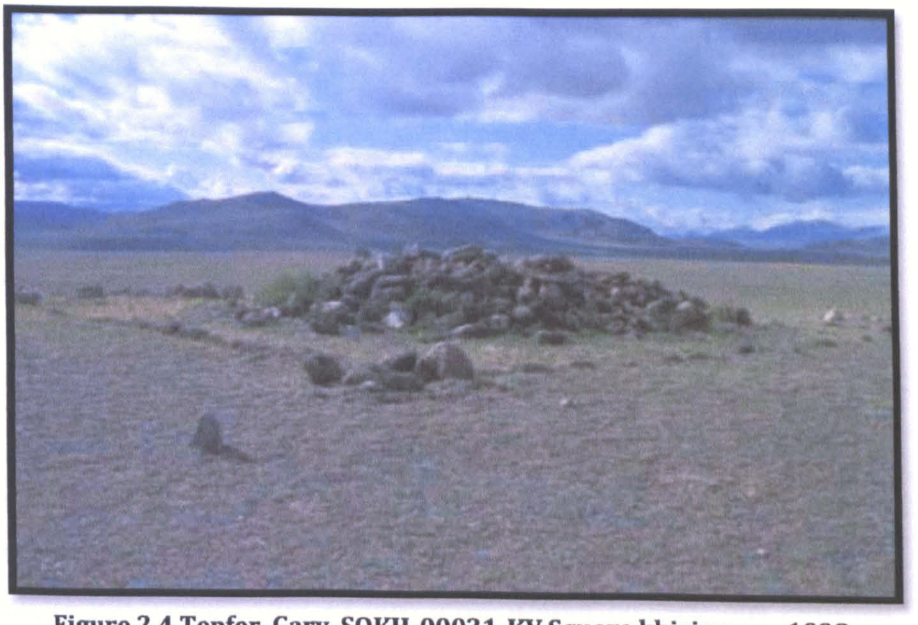


Figure 2.4 Tepfer, Gary. SQKH 00021 KV Square khirigsuur. 1998. < http://boundless.uoregon.edu/u?/maic,1416>. (©Gary Tepfer and the Mongolian Altai Inventory).

In some cases the smaller stone mound features (*satellites*) have been found to contain horse crania (Takahama and Hayashi 2003; Takahama 2005; Allard and Erdenebaatar 2005). Khirigsuurs rarely occur in isolation and are usually found in close proximity to other monuments and are quite visually prominent in the landscape. The size of the entire feature, (inclusive of the central mound, stone fence and satellite mounds) can vary significantly, ranging from only several meters in diameter to extensive complexes that span more than a hundred meters (Takahama and Hayashi 2003; Allard and Erdenebaatar 2005). Like other major burial monuments of the region, the vast majority of these features have been disturbed either in antiquity or modern times (Frohlich et al. 2009). Mortuary inclusions within the main burial mound are virtually absent and often the skeletal material has been disturbed by human/animal interference and taphonomic processes (Ibid). It has also been suggested that these monuments were constructed for other ceremonial or communal purposes in addition to/ or aside from the interment of the deceased (Allard and Erdenebaatar 2005; Wright 2007). Most of the skeletal samples for this dissertation that are from khirigsuur contexts are from western Mongolia and have been designated as khirigsuurs, but are somewhat more comparable to the neighbouring kurgans of the Altai, as they are not comprised of the complex features of the more elaborate monuments of central Mongolia (Honeychurch and Amartuvshin 2010).

Slab burials, which are also sometimes referred to as 'square burials', are an additional type of mortuary feature that has been investigated throughout this region (Tsybiktarov 1998; 2003; Volkov 1995; Honeychurch et al. 2009). Like khirigsuurs, variation in slab burial construction exists on both local and macro-regional levels. These burials are constructed in a rectangular or square formation that is recognisable on the ground surface by large upright stone slabs. The stone slabs both cover and surround the burial pit that can range in depth up to about 1.8 meters (Honeychurch and Amartuvshin 2010: 6). These features can vary in length from one to four meters but significantly larger examples that measure as much as ten metres in length and with stone slabs reaching as high as two meters above the ground surface, have been observed (Tsybiktarov 1995; 2003). There is often an association between khirigsuurs and slab burials and they are sometimes incorporated into the layout of the khirigsuur complex (Allard and Erdenebaatar 2005; Takahama 2005). For example, they may be included as additional satellite features or as part of the stone perimeter enclosure. In addition, examples of reused deer stones have been found incorporated into the slab burial design structure (Honeychurch et al. 2009). Based on typological chronology studies and radiocarbon dating, it is generally accepted that slab burial construction continued for a substantial period of time, until about 400 to 300 BC, following the cessation of khirigsuur construction (discussed in Honeychurch and Amartuvshin 2010). Common mortuary inclusions in slab burials can consist of ceramics, beads, bronze vessels and tools, horse riding paraphernalia such as bits and bridles, as well as faunal remains and worked-bone items (Volkov 1995). A typical slab burial excavated at the site of Baga Gazaryn Chuluu in the north Gobi Desert, Mongolia is depicted in Figure 2.5.

Figure 2.5 Slab burial from Baga Gazaryn Chuluu, north Gobi Desert, Mongolia, BGC EX 08.26 (©image Baga Gazaryn Chuluu Archaeology Project, Amartuvshin and Honeychurch 2010).

Early Iron Age Burials of the Altai and western Mongolia

Some of the most notable archaeological finds and extraordinarily well-preserved human remains that have ever been discovered were unearthed in the foothills of the Altai Mountains, near Pazyryk Valley in southern Siberia in the early to middle part of the 20th century. The majority of this region is comprised of mountainous terrain that includes extensive lakes and river systems with the relatively arid lowlands, thus the environment is one of extremes, where modern-day herders practice high-low pastoral transhumance. One tomb (Barrow 1) was first excavated by M.P Gryaznov in 1929 and later an additional four were investigated by Sergey Rudenko in 1947-9. Since that time a substantial number of burials have been excavated in this region and the term *Pazyryk* has come to denote the archaeological material culture and burial construction types that are similar to, and contemporary with, those that were first investigated. Mallory et al. (2002: 210) suggest that the date range for this first cemetery sequence should be designated between Pazyryk 2 (301-282 BC) and Pazyryk 5 (252-235 BC) based on comparative dendrochronology, radiocarbon dates and art-historical dating. The temporal designation for the major period of Pazyryk culture has generally been established by researchers to date from around the 6^{th} to 4^{th} centuries BC (Marsadolov 2000). These tombs and the bodies interred within them were remarkably well-preserved as a result of the permafrost conditions of the burial environment. These conditions permitted the survival of biological and organic material that is often lost to the modern investigator except in these kinds of atypical circumstances. Most of these tombs were looted in antiquity, but the remaining finds have provided an indication of the significant degree of labour investment and wealth expenditure that went into both the tomb construction itself and the items included within the burials. Figures 2.6, 2.7 and 2.8 below depict a photograph and schematic plans of Barrow (kurgan) 5 from Pazyryk.

Figure 2.6 Barrow (kurgan) 5 at Pazyryk (© L. Marsadolov, adapted from Marsadolov 2000 Figure 50 pg. 52).

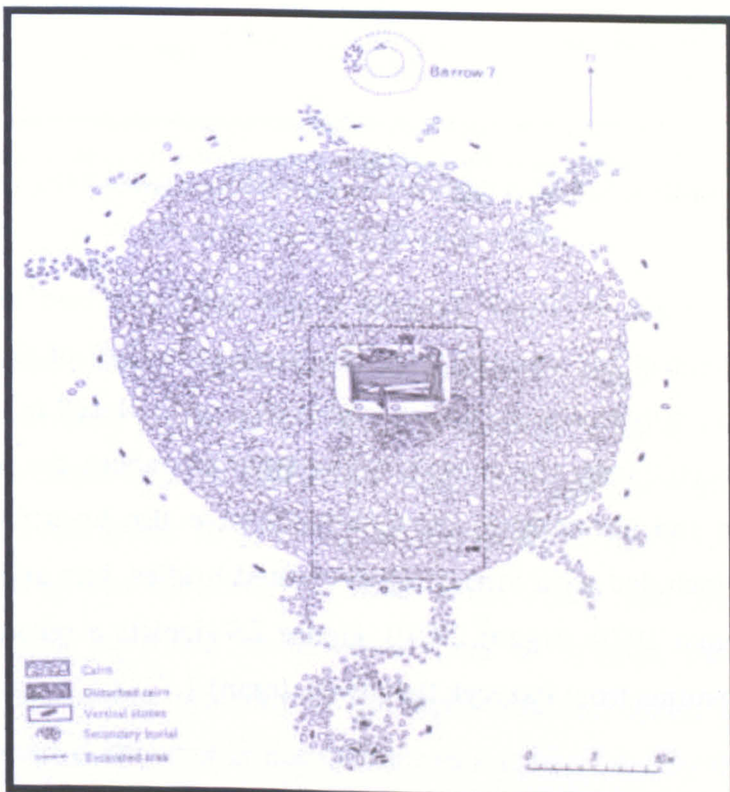


Figure 2.7 Plan drawing of Barrow (kurgan) 5 Pazyryk (adapted from Rudenko 1970, Figure 3 pg. 15).

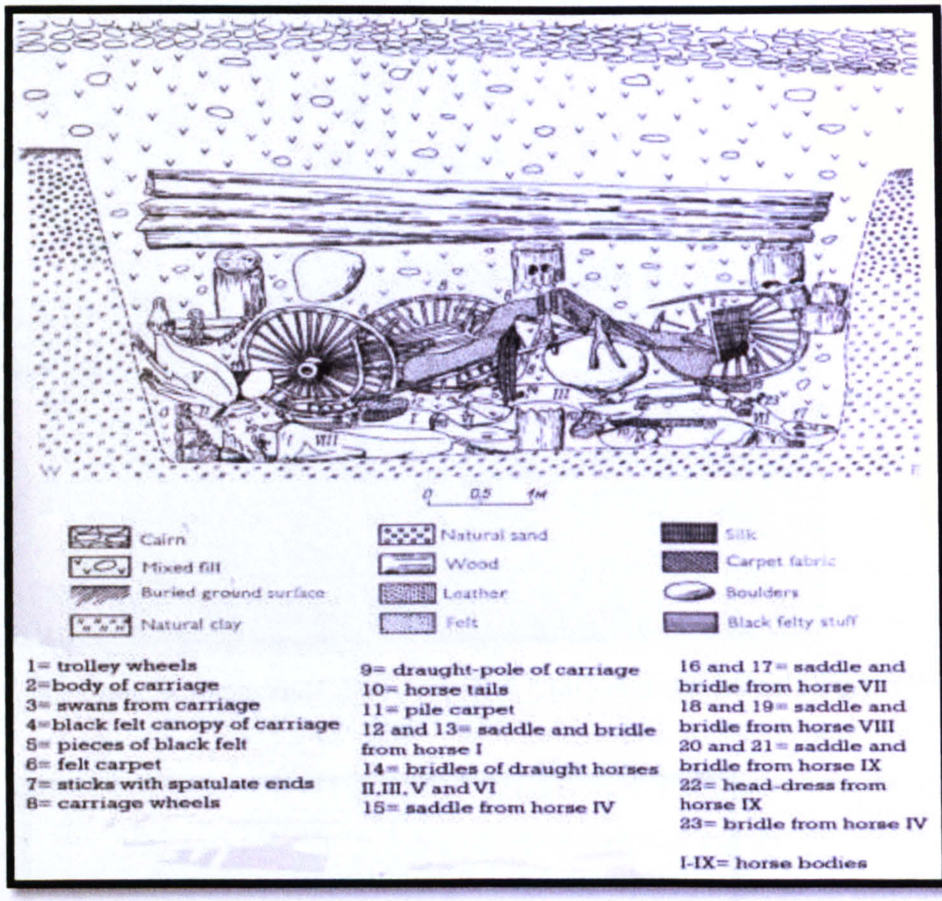


Figure 2.8 Vertical plan illustrating horses and objects in the north section of the burial shaft of Barrow 5 Pazyryk (adapted from Rudenko 1970, Figure 17 pg. 43).

These larger or 'royal' Pazyryk tombs are comprised internally of multiple chambers of log construction. The body or bodies of the individuals buried within are typically in the innermost chambers placed in large wooden coffins constructed from tree trunks. In the outer chambers, the remains of numerous horses and horse-riding paraphernalia have also been found. The horses are often included with intricately decorated bridles, bits and elaborate headgear (Rudenko 1970; Argent 2010). Figure 2.9 depicts a reconstruction of a horse and costume from Pazyryk Barrow (kurgan) 1.

Figure 2.9 Depiction/Reconstruction of horse and horse adornment from Pazyryk Kurgan 1 (adapted from Argent 2010. Figure 3 pg. 168).

Arguably, these elaborate costumes may reflect the status of the horse rather than/or as well as the rider or individuals interred within the burial (Argent 2010). Numerous other items, such as the famous felt hanging depicting the male individual seated atop his horse, as well as vessels and tools adorned with iconography attest to the symbolic importance of the horse within this culture (Rudenko 1970; Argent 2010).

The mummified human bodies were discovered to have been subjected to extensive embalming practices which are in evidence from the removal of the brain through trepanation as well as the removal of internal organs and entrails and by the subsequent re-stitching of the skin following these processes (Rudenko 1970). The nature of the tomb construction and the post-mortem body processing have led some researchers to suggest that these finds corroborate Herodotus' account of the Scythians and when one reads the passages provided above, it is not difficult to understand why this association has been made (Rudenko 1970). However this has, in no small degree, contributed to the notion that this region was inhabited by an essentially homogenous group of nomadic pastoralists. Like the Scythians, this group or culture are considered to have been nomadic pastoralists who primarily subsisted on domesticated animal herding and hunting that was accompanied by seasonal transhumance. Rudenko (1970) suggests that cultivation of cereals would have been difficult in this mountainous environment and that if this activity took place at all it was done on a very limited scale (Ibid). However, more recent research in the region has provided evidence for the influence of agriculture at the site of Bertek-1, kurgan no. 1 where a millstone was discovered (Molodin 2003). The Pazyryk sample for this dissertation also includes individuals who were interred with weapons, elaborate horse-riding equipment, intricately designed textiles, silk clothing, jewellery and numerous other items (Molodin 2003). These kurgans contained artefacts of metal, stone and wood that was elaborately decorated and constructed in the well-known animal-art style of the Eurasian steppes. This artistic style is comprised of zoomorphic images depicting both wild and domesticated fauna and is found in various forms throughout the steppe region on vessels, textiles, tools, horse-riding paraphernalia, jewellery and of course the famous tattoos adorning the body of the man discovered in Barrow 2 at Pazyryk (Rudenko 1970). Fantastical creatures such as griffins and phoenixes are also sometimes depicted. An illustration of this style is provided in Figure 2.10 of a horse bridle from Barrow 5 at Pazyryk.

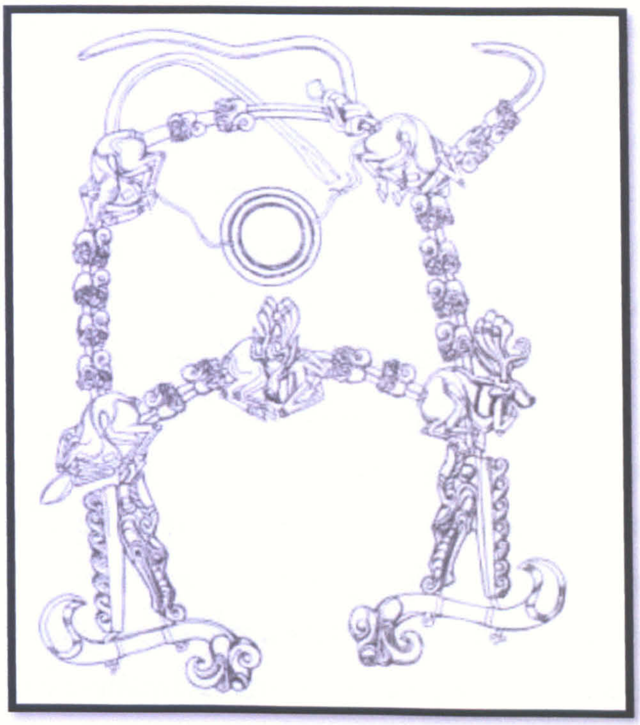


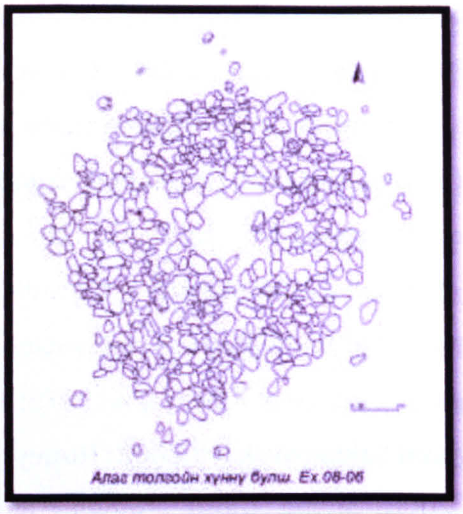
Figure 2.10 Horse bridle constructed in intricate animal-art style of the steppes from Barrow 5 Pazyryk. (adapted from Rudenko 1970, Figure 87 pg. 171).

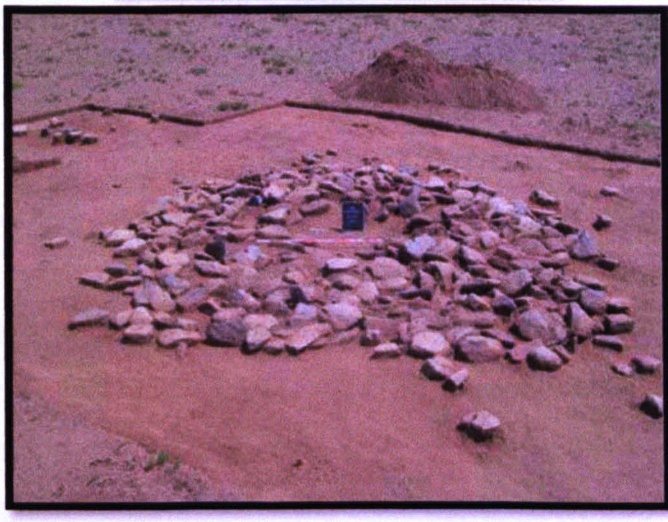
While it is impossible to know the precise motivation and meanings behind these mortuary rites, the level of wealth and labour expenditure is clearly a demonstration of power, ritual practices and ideology associated with these communities (Parker-Pearson 1999). These displays could be related to mortuary practices associated with the status of the individuals interred within and/or *communal* rites associated with a particular strata or group within this society (Ibid *emphasis author*).

An additional sample set included in this dissertation is from western Mongolia and was excavated from burial contexts that are largely contemporaneous with and somewhat analogous to the Early Iron Age, Pazyryk sample. This material was excavated from a cemetery located in the far western reaches of Mongolia at the site of Chandman, Ulangom in Uvs aimag. Uvs aimag is located the far north-west of Mongolia and the location of this site is indicated above in Figure 2.1. Several culture-historical labels have been attributed to this site, such as 'Scythian', 'Chandman', 'Ulangom' and 'Uyuk' culture (Tseveendorj 1980; Novgorodova et al. 1982; Volkov 1995). However, in order to avoid any confusion or assumptions that these labels might elicit, it is sufficient to regard this sample as representative of an Early Iron Age, possibly mobile pastoralist, group. Furthermore this site was characterised by material culture and burial construction types that are typologically distinctive from characteristically Xiongnu Period material culture and burials of Mongolia. The individuals discovered at this site were buried either singularly or in multiple interments and were typically found in flexed rather than supine position (Novgorodova et al. 1982). Several instances of multiple burials appear to have had individuals inserted at later times than when the primary interment was carried out (Ibid). Burial construction was characterised by a stone mound constructed on the ground surface and an internal burial chamber comprised of log planks, similar to contemporary burials found in the Mongolian and Siberian Altai region. Both the burial constructions and certain stylistic elements of the artefacts found in these tombs are analogous to the aforementioned Pazyryk burials of the Altai, as well as contemporary sites in Tuva (Novgorodova et al. 1982; Volkov 1995). Typical animal-art of the steppe region is represented by a schematic design of a wild sheep found on a ceramic vessel and a bronze figurine of a wild sheep. Additional, artefacts found in these burials include, beads, bronze vessels, arrowheads, knives, bronze mirrors, socketed axes and hooks (Ibid).

Iron Age (Xiongnu) Burials of Mongolia and southern Siberia

Towards the end of the first millennium BCE one of the earliest nomadic confederations or *polities* emerged in the steppes of Inner Asia. As discussed above, this confederation would subsequently be designated in ancient Chinese historical texts as the *Xiongnu* (Watson 1993; DiCosmo 2002). This culture-historic label has been applied to this confederation of nomadic pastoralist groups that broadly inhabited the modern-day regions of Manchuria, Inner Mongolia, parts of Siberia, Mongolia and Xinjiang. The Xiongnu are described in several Chinese annals and are designated as the polity who would eventually prompt the first phases of construction of the Great Wall, that was set up to defend the borders of the contemporary Qin (c. 221-206 BC) and Han (202 BC-AD 220) Dynasties. In addition to historical accounts, archaeological investigations of Xiongnu sites that have been carried out over the past decades have revealed evidence for a complex burial rite, ceramic and metalwork industry and support for a stratified, predominantly mobile, pastoralist society (Konovalov 1976; Honeychurch 2004; Honeychurch and Amartuvshin 2006; Kradin 2008). In addition, this confederation appears to have incorporated complex herding systems and developed organisational principles into their political and social structure (Honeychurch and Amartuvshin 2006; 2007; Miller 2009). A substantial number of studies have been devoted to the understanding of large-scale political and socio-economic processes associated with the Xiongnu polity (e.g. Konovalov 1976; Barfield 1981; 2001; DiCosmo 2002; Minyaev and Sakharovskaya 2002; Honeychurch 2004; Tseveendorj et al. 2007; Kradin 2008; Miller 2009). Xiongnu burials have been excavated in abundance throughout Mongolia and southern Siberia and can be broadly divided into two main types. These types are designated as Xiongnu ring tombs and Xiongnu square-ramped tombs. Ring tombs consist of a surface demarcation characterised by a large ring or circle of unaltered stones that is usually visible on the modern-day ground surface. A plan-drawing and photograph of a typical Xiongnu ring tomb from the site of Baga Gazaryn Chuluu in the north Gobi Desert, Mongolia is provided in Figures 2.11 and 2.12.





Figures 2.11 (above) and 2.12. Xiongnu Period ring burial located at Baga Gazaryn Chuluu, in the north Gobi Desert, Mongolia (BGC EX 08.06) This burial contained an adult female and two neonates. (©images Baga Gazaryn Chuluu Archaeology Project, Amartuvshin and Honeychurch 2010).

These burials are found throughout Mongolia and southern Siberia both in small cemetery clusters of three or four burials and in larger groups of several hundred burials (Davydova 1995; 1996; Minyaev 1998; Turbat et al. 2003; Turbat 2006). They may also occur individually but these examples are rare. The surface demarcation of stones can range in diameter from 4 to 10 metres across, although most have been subjected to ground level disturbance and looting, so in many cases it is difficult to determine the precise dimensions of the original structure. These features are built as deep shaft graves which can extend from one to four metres in depth, but on occasion have been found to be significantly deeper. The burial chamber is sometimes lined with stones or wood and the individual is often interred in a wooden coffin. The wooden coffin is typically constructed of hewn planks and is sometimes decorated with intricate latticework and *quadrefoil* designs (Turbat et al. 2003; Miller et al. 2009). Mortuary inclusions are extensive and range from ceramics, human and faunal remains, semi-precious stones, metals, beads, birch-bark containers, buckles, lacquer-ware, worked bone items, and long-distance imported luxury goods, weaponry and horse-riding equipment (Turbat et al. 2003; Turbat 2006). Faunal remains of domesticated and sometimes wild animals are often found within a northern niche of the burial chamber (Ibid). The skeletal samples included in this dissertation from Xiongnu Period contexts are all derived from Xiongnu ring tombs.

The other major type of Xiongnu burial is the larger elite or square-ramped tomb. These features are comprised of unaltered stones arranged in a square to slightly trapezoidal shape with a ramp or path that extends into the central burial chamber (Figures 2.13 and 2.14). They are usually oriented north-south and often contain a range of lavish artefacts, despite the fact that they have been subjected to extensive looting.

Figure 2.13 Xiongnu square-ramped tomb, burial mound 20 from Noin-Ula, north-central Mongolia. (adapted from Polosmak et al. 2008a, Figure 5 pg. 80).

Figure 2.14 Plan drawing of Xiongnu square-ramped tomb, burial mound 20 from Noin-Ula, north-central Mongolia. (adapted from Polosmak et al. 2008a, Figure 4 pg. 79, drawing by V. Efimov and V. Koftorov).

These structures are substantial in size and can measure up to 22 meters on a side and can range anywhere from c. 10 to 18 meters in depth. Burial mound 20, more recently excavated at Noin-Ula in north-central Mongolia, measured 20 x 19 metres for the quadrangular ground surface structure and the final depth of the burial pit was recorded as 18.35 metres (Polosmak et al. 2008a). These tombs are extremely labour intensive and are most likely representative of some portion of the population that was distinct from the rest of society. Burial mound 20 at Noin-Ula also contained a number of items that were indicative of a significant degree of resource expenditure, such as a Chinese (Han) chariot, imported Chinese lacquer-ware and a lacquered coffin (Polosmak et al. 2008b). Additional artefact inclusions in these tombs range from weaponry, metal, wood and bone items, hanging ornaments, ceramic vessels, imported luxury goods, jewellery and a range of other items (Minyaev 2007; 2009). Like the ring tombs, faunal remains are often placed in a northern niche of the burial chamber. The faunal material ranges from horses to other domesticated animals such as sheep and goat, as well as wild fauna, such as deer.

Early Medieval Burials of Kyrgyzstan

The skeletal samples included in this dissertation from Kyrgyzstan were excavated from Early Medieval burial contexts located primarily in the Tian Shan and Lake Issyk-Kul regions and date from approximately AD 200 to 500. These individuals were excavated from typical kurgan burials of the region that were marked on the surface by large mounds constructed from unaltered stones. These burials typically contained a single inhumation although, on occasion, several individuals were interred in a single burial chamber (Anke et al. 1997). Mortuary inclusions from these kurgans included evidence for possible feasting activities, faunal remains of domesticated animals, gold jewellery items, iron and bronze weaponry and ceramic and metal vessels (Tabaldiev 1996). Also discovered within these kurgans was evidence for horse-riding in the form of iron bits, bridles and stirrups and evidence for the symbolic importance of the horse (Tabaldiev 1996; Anke et al. 1997). This symbolic importance is substantiated by iconographic images found on engraved bone items depicting mounted horse-riding archers, saddles and stirrups (Tabaldiev 1996). Based on this type of iconographic evidence as well as ancient historical accounts and the burial inclusions of domesticated animals and horses, these groups are generally considered to have relied on various forms of mobile pastoralism for their primary economic and subsistence needs (Savinov 1989; Tabaldiev 1996). Furthermore, there are numerous examples of burials of this period from these sites and neighbouring areas, where complete articulated horse remains were discovered alongside the deceased individuals (Savinov 1989; Tabaldiev 1996). A plan-drawing of a complete horse skeleton found in kurgan 10 at the site of Bish-tash-koroo is depicted in Figure 2.15. The location of this site is indicated in Figure 2.2 above, site number 5.

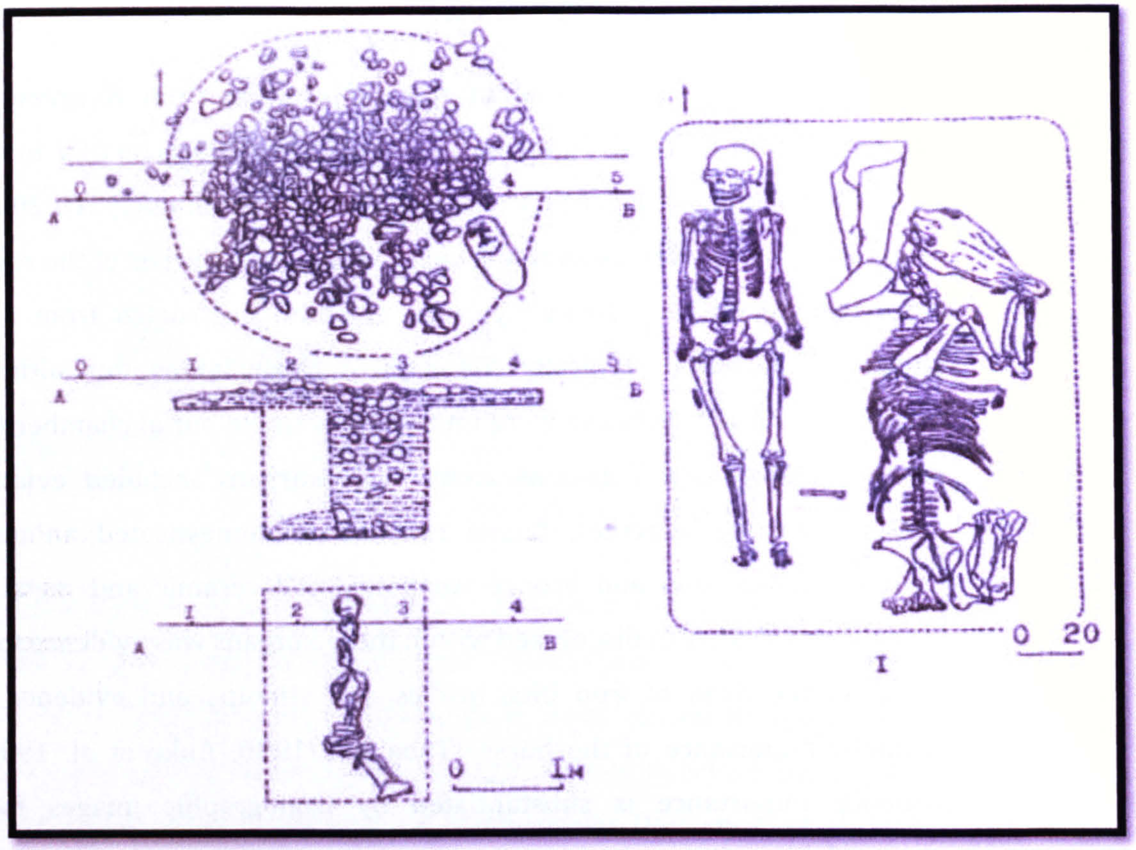


Figure 2.15 Plan-drawing of kurgan 10, alongside the associated human and horse skeletons from Bish-tash-koroo, Kyrgyzstan (adapted from Tabaldiev 1996, Figure 4 pg. 192).

Mongol Period Burials of Mongolia

Several samples of skeletal material included in this dissertation are from burial contexts attributed to the Mongol Period. These individuals were excavated from burials characteristic of this period and date from approximately AD 1200 to 1400. Much of what is known about this period is derived from historical accounts, as well as excavations of settlement and mortuary sites. Extensive research at the site of the former imperial capital of Kharkorum and mortuary excavations throughout Mongolia have provided a basis for understanding diet, imperial statecraft, town planning and social complexity of the period (Rösch et al. 2005; Rogers et al. 2005; Batsaikhan 2006; Crubézy et al. 2006; Honeychurch and Amartuvshin 2006; Erdenebat and Pohl 2009). Palaeobotanical research at the site of Kharkorum has revealed informative evidence pertaining to land-use, diet and trade during the Mongol Period. Investigators have identified a number of species of fruits and nuts that are both local to the area and some non-indigenous species that would have been imported from great distances to reach the site (Rösch et al. 2005; Oyuntuya and Rösch 2007). Several discrete mortuary rites have been identified by researchers and attributed to the Mongol Period. These rites include cremation, inhumation and cave deposition (Crubézy et al. 2006; Batsaikhan 2003; 2006; Erdenebat 2009). The samples included in this dissertation are from inhumations. Like mortuary features from the preceding periods in Mongolia, there is of course local and regional variations in burial construction. These burials are typically marked on the surface by a small mound and oval shaped ring of stones which is constructed over the burial pit that is relatively shallow and usually contains a single individual (Batsaikhan 2006). Some items commonly deposited in these burials include horse riding paraphernalia, such as saddles and bridle pieces as well as jewellery and ceramics. Other artefacts include silk textiles, containers made of birch bark and arrow quivers also made of birch, arrow points, small knives and scissors and faunal remains of wild and domesticated animals (Ibid). Figure 2.16 illustrates a Mongol Period burial from the site of Baga Gazaryn Chuluu in the north Gobi Desert, Mongolia.

Figure 2.16 Mongol Period burial from Baga Gazaryn Chuluu, north Gobi Desert, Mongolia (BGC EX 08.11) This burial contained an older female aged 50+ (©image Baga Gazaryn Chuluu Archaeology Project, Amartuvshin and Honeychurch 2010).

Chapter Three
Sample Information and Osteological Methods

3.1 Sample Information

Several research phases of osteological analysis and sample collection were carried out for this dissertation. A total of nine institutions were visited by the author to carry out this research. The institutions where the skeletal material was studied are as follows: The Institute of Archaeology, the National Museum of Mongolia and the National University in Ulaanbaatar, Jilin University, Center for Chinese Frontier Archaeology in Changchun, the Institute of Archaeology and Ethnography in Novosibirsk and the Institute of Ethnography and Anthropology in St. Petersburg and Manas University and the Historical Institute of the Kyrgyz Academy of Sciences in Bishkek. In addition, a collection of historic period crania was included in the dental analysis in Chapter Four. This collection is currently housed at The National Museum of Natural History, Smithsonian Institution in Washington D.C.

A total of 521 individuals were included in the analyses carried out for this dissertation. Table 2.3 pg. 19 in Chapter Two provides the breakdown of the number of individuals from each site and associated time periods. Table 3.1 below indicates the number of individuals that were analysed from each institution. Every sample could not be utilised for each of the following analyses, therefore additional information pertaining to specific demographic composition and sample sizes are provided in the subsequent relevant chapters.

Table 3.1 Number of individuals studied from each institution.

Location	Institution	Number of Individuals
Russia, St. Petersburg	Peter the Great Museum of Anthropology and Ethnography, Kunstkamera, Russian Academy of Sciences	30
Russia, Novosibirsk	Institute of Archaeology and Ethnography, Siberian Branch of the Russian Academy of Sciences	67
Kyrgyzstan, Bishkek	Kyrgyz-Turkish Manas University	6
Kyrgyzstan, Bishkek	Historical Institute, Kyrgyz Academy of Sciences	20
Mongolia, Ulaanbaatar	National University of Mongolia	78
Mongolia, Ulaanbaatar	Institute of Archaeology, Mongolian Academy of Sciences	95
Mongolia, Ulaanbaatar	National Museum of Mongolia	4
China, Changchun	Jilin University, Center for Chinese Frontier Archaeology	92
United States, Washington D.C.	National Museum of Natural History (Smithsonian Institution)	129
Total		**521**

This dissertation is divided into three distinct areas of analysis. Chapter Four focuses on dental pathology, Chapter Five consists of the stable isotope analysis and Chapter Six is based on the analysis of degenerative joint disease and musculo-skeletal stress markers. Table 3.2 indicates the samples and number of individuals utilised for each separate analysis. Also provided is an indication of whether post-cranial or cranial elements were studied for a particular analysis. Because the samples are housed in a number of separate institutions, and in many cases the burials were excavated many decades ago, curation methods and storage facilities of the skeletal material varied greatly. The majority of these collections were comprised solely of cranial material and in many cases additional skeletal elements may not have been available for inclusion or study by the author. Therefore a more extensive gazetteer including completeness and preservation information for each individual could not be included in this dissertation. When post-cranial skeletal elements were available, these were typically of long bones such as the femur or tibia and upper limb bones. Rarely were any elements of the axial skeleton available for observation. Additionally, whenever post-cranial elements were collected, these were typically stored separately from crania. Constraints on time, funding and practicality did not always allow for attempts to be made at matching individual's post-cranial and cranial elements and in most cases this was simply not possible.

Table 3.2 Samples utilised for each analysis and associated skeletal elements studied.

Sample	ID	Time Periods	Num. Individs.	Skeletal Elements	Analysis
Western Mongolia (multi-small sites)	WMON	Bronze Age	14	Crania	Dental
Taishar, Ulaan Boom, Gobi-Altai, Mongolia	TAI	Bronze Age/Late Bronze Age	8	Crania and Post-Crania	Isotope
Baga Gazaryn Chuluu, Dundgobi, Mongolia	BGC	Multi-Periods	38	Crania & Post-Crania	Isotope
Chandman, Ulangom, North-West Mongolia	CHAN	Early Iron Age	23	Crania	Dental
Gorny-Altai, (multi-small sites) Siberia	PAZ	Early Iron Age	67	Crania & Post-Crania	Dental MSM & DJD
Ivolga, South-Central Siberia	IVO	Iron Age	30	Crania	Dental
Shombuuzin belcher, Khovd, Western Mongolia	SBR	Iron Age	4	Crania & Post-Crania	Isotope
Central Mongolia (multi-small sites)	CMON	Iron Age	20	Crania	Dental
Egiin Gol, North-Central Mongolia	EG	Multi-Periods	49	Crania & Post-Crania	Dental Isotope MSM & DJD
Nileke, Xinjiang	NIL	Iron Age	39	Crania	Dental
Tuchengzi, Inner Mongolia	TUCH	Iron Age	53	Crania & Post-Crania	Dental MSM & DJD
Issyk-kul and Tian Shan, (multi-small sites) Kyrgyzstan	KYR	Early Medieval	26	Crania	Dental
Eastern Mongolia (multi-small sites)	EMON	Mongol Period	21	Crania	Dental
Urga, Central Mongolia (Ulaanbaatar)	URGA	Late Historic	129	Crania	Dental

3.2 Osteological Methods

The following sub-sections provide the osteological methods used throughout this dissertation to establish the likely age-at-death and the sex estimation of the individuals included in this study. As skeletal collections varied in level of completeness and state of preservation, it was not always possible to utilise certain methods which are considered to be more reliable for determining age and sex, such as auricular surface and pubic symphysis age estimation and sex estimation based on cranial and pelvic morphology (Ubelaker 1989). However, all attempts were made to include each method whenever this was possible.

Age-at-Death Estimation

Every attempt was made to carry out multifactorial age-at-death estimation for each individual. Whenever possible, both cranial and post-cranial skeletal material was assessed for age-related developmental and degenerative changes. Table 3.3 indicates each bone and the corresponding area which was assessed for age estimation, as well as the reference for each method used.

Table 3.3 Methods utilised for multifactorial age-at-death estimation.

Bone	Assessment	References
Cranium	Tooth eruption stage	Smith (1991); Ubelaker (1989)
	Cranial suture closure	Meindl and Lovejoy (1985)
Rib	Sternal rib end	İşcan and Loth (1986)
Pelvis	Pubic symphysis	Brooks and Suchey (1990)
	Auricular surface	Lovejoy et al. (1985); Buckberry and Chamberlain (2002)
Long bones (humerus, radius, ulna, femur, tibia)	Epiphyseal fusion	Schwartz (1995); Scheuer and Black (2000b)
	Long bone length (growth)	İşcan (1989); Hoppa (1992); Scheuer and Black (2000b)

Neonates, infants and adolescents were assessed for a likely age-at-death estimation by examining the stage of dental development, epiphyseal fusion stage of the long bones and rates of long bone growth (Scheuer and Black 2000a). Age categories for sub-adults were assigned as follows: Neonate= birth to 1 month, Infant= 1 to 12 months, Young Child= 1 to 6 years, Juvenile= 6 to 12 years, Adolescent= 12 to 17 years. Once an individual has reached eighteen years of age the skeleton has reached developmental maturity and thus was considered fully adult. Dental development is generally regarded as the most accurate means of determining the age-at-death of adolescent individuals, as dentition is less affected by external factors such as environment than other skeletal elements such as long bones (Ibid). Dental eruption takes place throughout the span of infancy, childhood and adolescence and is thought to be primarily resultant from genetic factors, whereas in the long bones, growth occurs in spurts and phases and can be quite variable between individuals of different sex and environment (Chamberlain 1994; Humphrey 2000). Likely age-at-death estimation of neonates, infants, juveniles and young adults under the age of 18 are considered to be relatively accurate, with only about a year or two of variation and even more accurate for very young individuals (Humphrey 2000). Age estimation based on stage of dental eruption followed the standards provided by Smith (1991) and the pictorial charts provided in Ubelaker (1989). Epiphyseal fusion stage was assessed from the long bones of younger individuals and age ranges were assigned based on fusion rates outlined in Schwartz (1995) and Scheuer and Black (2000b). Age assignments based on long bone growth followed standards set out by İşcan (1989), Hoppa (1992) and Scheuer and Black (2000b).

Age-at-death estimations for adult individuals were carried out based on assessments of age-related degenerative changes of specific skeletal elements. Individuals that were solely represented by a cranium were assigned a likely age-at-death based on a combination of cranial suture closure stage and stage of dental eruption for younger individuals. The assessment of cranial suture closures follows the method devised by Meindl and Lovejoy (1985). This method uses a scoring system that examines seven sites located on the ectocranial vault and five sites on the lateral-anterior ectocranial surface. When specific sites were not available for observation, an average of the recorded sites was obtained and substituted in place of the missing site, as advised in Buikstra and Ubelaker (1994: 35). Age estimation based on age-related changes of the 4th sternal rib end was carried out based on guidelines set out by İşcan and Loth (1986). When a 4th rib was not available a 3rd or 5th rib was substituted. Age-at-death estimation based on rates of dental wear rates was not carried out, because the population samples from which commonly used methods such as Miles (1962) and Lovejoy (1985) were devised are considered by the author to be too divergent from those under study here. Age-at-death estimation from the pelvis utilised several methods. These included age-related changes of pubic symphysis morphology set out by Brooks and Suchey (1990) and the examination of degenerative changes of the auricular surface. Auricular surface examination followed the methods set out by Lovejoy et al. (1985) and as a further assessment the revised auricular surface ageing method devised by Buckberry and Chamberlain (2002) was also carried out. Following the age-at-death estimation of adult individuals, they were then divided into the broad age categories of younger adults, middle adults and older adults. Younger adults were considered as to be those aged 17 to 25, middle adults were those aged 25 to 45 and older adults were those aged 45 and older. Individuals that could not be more precisely aged because of lack of skeletal completeness or poor preservation were assigned only as 'Adult' or 'Sub-Adult'

Adult Sex Estimation

Sex estimation was only carried out for fully adult individuals, as current methods for sex estimation before the age of puberty are considered to be unreliable. Adult sex estimation was based on the examination of diagnostic morphological features of the cranium and pelvis and metric data obtained from long bone measurements. For each individual, as many observations as possible were carried out. However, there were several samples that were comprised of a substantial number of incomplete individuals and in many cases the only skeletal material available for analysis was crania. However, it should also be noted that sex estimation based solely on cranial morphology is considered to be relatively accurate at around 80 to 90% (Ubelaker 1989: 53-55). Table 3.4 below indicates the locations observed on the cranium for sex estimation. The corresponding references for each morphological characteristic examined are also provided in Table 3.4.

Table 3.4 Morphological features of the cranium observed for adult sex estimation and corresponding references.

Observation	References
Overall cranial shape	(Schwartz 1995)
Nasal bones	
Occipital and mandibular condyles	
Canine eminence	
Palate	
Depth from incisors to mentum	
Angle of mandible	
Glabellar profile	(Ferembach et al. 1980)
Frontal slope	
Frontal and parietal tuberosities	
Zygomatic process of frontal	
Supraorbital ridges	
Orbital outline	
Zygomatic bone	
Temporal ridges	
Suprameatal crests	
Mastoid process	
Nuchal area	
External occipital protuberance	
Pterygoid plates	
Mandibular ramus (anterior and posterior)	
Mental protuberance	
Lower margin of mandibular corpus	
Mandibular ramus	(Loth and Henneberg 1996)

Table 3.5 indicates the observations included for sex estimation based on morphological features of the pelvis. Twenty-four locations were included for potential observation on the pelvis. For all individuals, including incomplete or badly preserved skeletons, as many locations as possible were observed on both the cranium and pelvis.

Table 3.5 Morphological features of the pelvis observed for adult sex estimation and corresponding references.

Observation	References
Overall structure	(Schwartz 1995)
Pelvic inlet	
Iliac blade (anterior view)	
Greater Sciatic notch	
Auricular surface	
Postauricular space	
Acetabulum	
Sub-pubic angle	
Inferior pubic ramus	
Obturator foramen	
Ischial spine	
Width of sacral ala	
Anterior sacral curvature	
Sacral auricular surface	
Overall shape (anterior view)	(Ferembach et al. 1980)
Iliac crest (vertical view)	
Preauricular sulcus	
Pubic symphysis height	
Pubic rami	
Ischial tuberosity	
Iliac tuberosity	(İşcan and Krogman 1986)
Ventral arc	(Phenice 1969)
Sub-pubic concavity	
Medial ischio-pubic ridge	

Sex estimation based on metric data obtained from long bone measurements was also carried out. These estimations were based on the standards available in Bass (1995) and include measurements of the humerus following guidelines by Dwight (1905) for the humeral head diameter and Stewart (1979:100) for the vertical diameter of the humeral head. Measurements of femur bicondylar width and femoral head diameter were obtained and compared to criteria established by Pearson (1917-1919) and Stewart (1979). These methods are also provided in Bass (1995: 230-231). Individuals that were too incomplete or poorly preserved to carry out sex estimation were not included in comparative analyses based on sex.

Chapter Four
Reconstructing Past Diet and Health from Dental Analysis

The focus of this chapter is the macroscopic analysis of dentition from human skeletal remains to reconstruct past dietary and health patterns in discrete populations from the study region. Since human teeth are among the few skeletal elements directly affected by diet, the analysis of dentition is an essential area of dietary reconstruction. Furthermore, certain dental pathological indicators provide a measure for assessing both individual and group health.

The samples included in this analysis are derived from several geographical and temporal contexts located throughout Siberia, Mongolia, Inner Mongolia, Xinjiang and Kyrgyzstan in order to allow for comparisons to be drawn over both time and space. The recording and analysis of dental pathological conditions has been carried out to provide an indication of variation and similarities in dietary composition within and between population groups. In addition group health is assessed by recording the severity of pathological conditions including ante-mortem tooth loss, caries, abscesses, and periodontal disease. It has been suggested that dental health declined significantly with the widespread transition from hunting-gathering and foraging economies to those based on agriculture (discussed in Larsen 1995). In some aspects, the results of the dental assessment of mobile pastoralist populations will be largely analogous with hunter-gatherer groups. Certain resemblances between the two economies may influence community health in comparable ways. Similarities which may contribute to this occurrence include low population densities, increased mobility and a relatively more varied dietary base than typical prehistoric food-producing agricultural communities. This study aims to examine and refine what is known about dental pathological conditions and dental wear rates in populations from this region which are thought to have relied on a range of subsistence economies, from mixed production mobile pastoralism to more 'pure' mobile pastoralist economies, as well as mixed-economy agriculturalists.

4.1 Examining Diet and Health from Dental Palaeopathology

There are a number of dental pathological conditions which are commonly observable on human skeletal material. These may be found on the teeth themselves as well as on the mandible and maxilla. A vast quantity of literature exists pertaining to the aetiology, manifestation, prevalence and nature of these conditions in both modern and prehistoric populations throughout the world (Hillson 2000). While genetics, environment and oral hygiene all contribute to the manifestation of these conditions, it has also been noted that the diet a person consumes directly influences the types of micro-organisms present in a person's mouth (Roberts and Manchester 2005). On this basis it is argued that it is diet which plays a primarily role in the development of dental pathology in prehistoric populations (Ibid).

The following sub-sections provide a brief description of common dental pathological conditions found in prehistoric skeletal material which have been analysed for the present study. More extensive reviews and discussions of these conditions are provided in Hillson (1996), Freeth (2000) and Waldron (2009). In each sub-section the methods are outlined which were used for recording each of these conditions in the samples included in the following analysis.

Dental Caries

Dental caries are formed from oral processes involving bacteria in dental plaque in combination with the production of acid and the fermentation of dietary sugars, such as sucrose (Roberts and Manchester 1995). Caries occur within an acidic oral environment as part of a destructive demineralisation process that is typically manifested in the form of a cavity on either the enamel or the root of the affected tooth. Even though the presence of caries has been documented on the remains of our earliest human ancestors, the frequency of caries in human populations significantly increased with the widespread introduction of refined sugar into the diet (Hillson 1996). Though oral hygiene and genetics influence an individual's predisposition to the formation of caries, diet is considered to be the most influential factor. A number of previous studies have found strong correlations with an increase in the rate of caries in populations which underwent large-scale changes in economy that were accompanied by a substantial increase in the consumption of cariogenic foods, such as grain. This increase has been observed in prehistoric populations from North America which coincided with the adoption of maize agriculture (Cohen and Armelagos 1984; Larsen 1995). This development is related to the formation of dental caries which are largely a product of the consumption of sucrose and fermentable carbohydrates. Because of this aetiological factor, the frequency of dental caries provides a measure for assessing the degree of carbohydrate or dietary sugar consumption within and between population samples.

In this study, all teeth were observed at the macroscopic level for the presence of dental caries. Caries were recorded as present when there was a necrotic pit in clear evidence on the occlusal surface of the tooth or on the tooth root (Fig. 4.1 below). Caries were recorded as per number of individuals with the condition as well as the number of teeth affected within each sample.

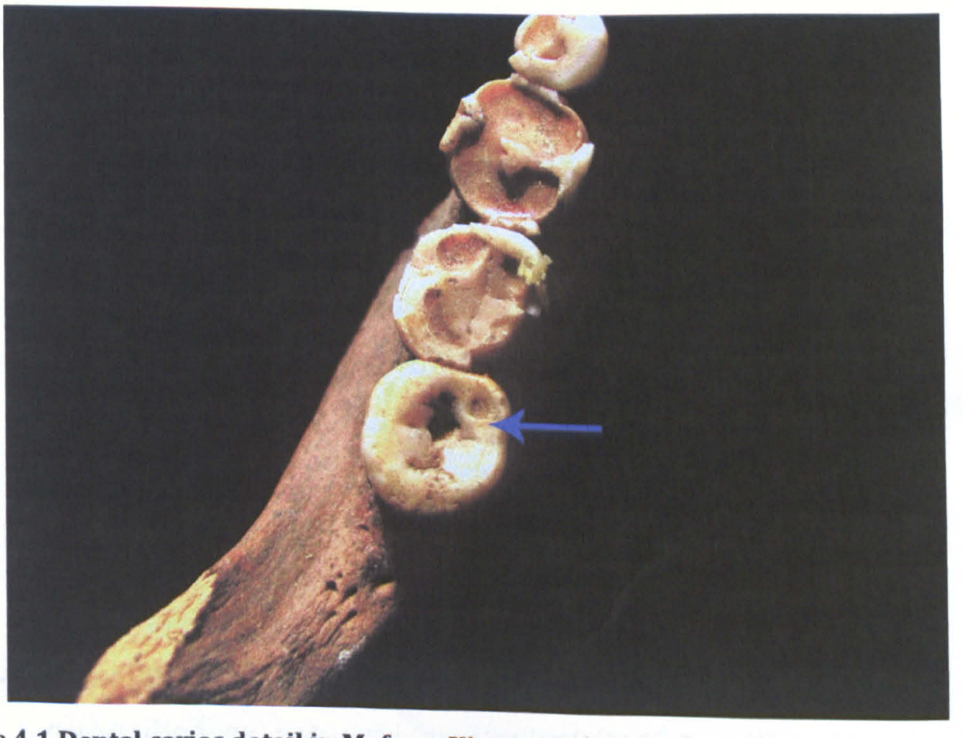


Figure 4.1 Dental caries detail in M_3 from Xiongnu Period sample from Ivolga, S. Siberia (image Author 2009).

Dental Calculus

Dental calculus is also commonly in evidence on the dentition of prehistoric skeletal remains. Dental calculus is mineralised plaque which develops in an alkaline oral environment, as opposed to the acidic environment that is a prerequisite for caries development. This generally creates an inverse relationship between caries and calculus (Hillson 1979). However, both conditions can occur in a single individual's dentition simultaneously, because caries' development is the result of localised bacterial process and an individual may experience different phases of biochemical processes in the oral cavity throughout their life (Hillson 2000; Waldron 2009). Calculus can adhere to any surface of the tooth enamel and on tooth roots. The primary causes of dental calculus are currently not well understood but the major factors appear to be oral hygiene standards and dietary influences (Lieverse 1999). It has been suggested that a high-protein diet can contribute to an increase in calculus deposition (Hillson 1979), but other studies have shown that populations relying on agricultural products have exhibited high instances of calculus deposition as well (see summary in Lieverse 1999 Table 1 pg. 226). When the oral environment is subjected to long periods of alkalinity, brought about by the relationship between pH levels, salivary flow and protein consumption, mineral deposits will occur on the tooth enamel as dental calculus (Hillson 1979). Because the two conditions, caries and calculus are, for the most part, mutually exclusive, the prevalence rates of the two conditions within populations should in theory provide some measure for assessing the degree of protein or carbohydrate intake in the diet (Ibid). However, as mentioned the multi-factorial nature of calculus aetiology complicates this type of straightforward interpretation (Lieverse 1999).

For this study, calculus has been recorded for each individual with observable dentition (Fig. 4.2). Calculus was recorded as both present or absent per individual and scored on a scale of 0=absent, 1=slight, 2=moderate and 3=severe, as described in Brothwell (1981).

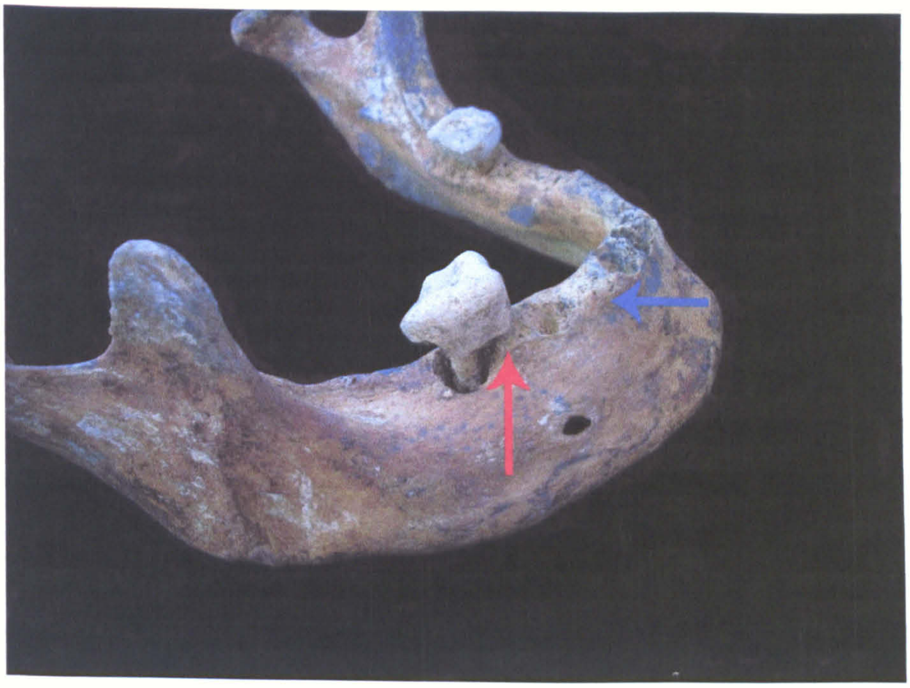


Figure 4.2 Severe dental calculus (red arrow) and ante-mortem tooth loss (blue arrow). Mongol Period (13th Century AD, eastern Mongolia) (image Author 2009).

Periodontal Disease

Periodontal disease is caused by various types of bacteria, viruses and fungi which are present in dental plaque. The condition typically causes an inflammation of the tissues surrounding the teeth and may result in the destruction of alveolar bone and associated tooth loss (Hillson 1996). The most prolific form of the condition, which affects a substantial proportion of modern populations, is commonly known as gingivitis (Waldron 2009). Periodontal disease was assessed and documented for this study by noting presence or absence of the condition on the basis of alveolar resorption in either the mandible or maxilla of more than 3mm as described in Waldron (2009).

Ante-Mortem Tooth Loss

The occurrence of ante-mortem tooth loss (AMTL), teeth lost prior to an individual's death, can often be attributed to periodontal disease. AMTL as a result of periodontal disease occurs from the condition causing a destructive inflammation of the alveolar bone which holds the tooth in place (Hillson 1996). The chronic nature of the condition will then lead to associated tooth loss. Additional causes of AMTL are trauma, nutrition-related conditions such as scurvy, and tooth extraction. Ante-mortem tooth loss is distinguishable from post-mortem tooth loss by the presence of bony remodelling of the tooth socket (see Fig 4.2 above).

For this study, the number of teeth lost ante-mortem was recorded for each location where the condition was observed in the maxilla and mandible for each individual. This was recorded as the number of teeth lost ante-mortem per individual as well as the number of individuals with one or more teeth lost ante-mortem. The results provided for this assessment indicate the number of individuals affected in the sample with one or more teeth lost prior to death.

Dental Abscesses

Both dental caries and periodontal disease can be connected to the development of dental abscesses. This condition is caused by a build-up of plaque between the gum and the teeth creating a periodontal pocket where bacteria then accumulates causing subsequent abscess formation to occur (Hillson 1996). The abscesses are characterised as an inflammation of dental pulp which extends to the alveolar bone where a fistula may or may not be present (Ibid). These are recognised on skeletal material as a sinus development in the alveolar bone (see Fig. 4.3 below). Dental abscesses often result in the loss of teeth associated with the lesion, thus ante-mortem tooth loss can also be associated with the condition. Dental abscesses are serious conditions which can weaken an individual's immune system. This in turn may lead to serious illness or even death, particularly in cases where bacteria enters the bloodstream as a result of the abscess.

For this study, abscesses were recorded when they were clearly observable on the maxillae and mandibles of affected individuals. The number of abscesses was recorded as per individual affected, as well as number of abscesses observed within the entire sample set.

Figure 4.3 Dental abscess associated with left M_1 from Early Iron Age, Pazyryk sample (image Author 2009).

Linear Enamel Hypoplasia

This particular condition is distinct from those discussed above in that it is a result of physiological disruption of the tooth formation during dental development and cannot be directly linked to dietary factors. The aetiology of linear enamel hypoplasia or LEH is still poorly understood but several potential causes have been suggested to account for these lesions. Some non-specific possibilities include infectious diseases and nutritional deficiency (Steckel 2008), whilst other possibilities include, more specifically, Vitamin D deficiency and/or the result of the high temperature of a fever suffered during the period of tooth formation (Hillson 1979). Because the exact cause is uncertain, these lesions are generally considered to be reflective of an episode of physiological stress which occurred during an individual's childhood, but the exact cause is indeterminable. They may also indirectly reflect dietary intake in that a nutritional deficiency during childhood could possibly influence the occurrence of these lesions.

The occurrence of LEH has been documented in this study as a means to assess general health and stress in individuals during childhood. LEH was recorded following the guidelines set out in Steckel et al. (2005). Enamel defects can be manifest on the tooth as pits and grooves as well as small lesions and linear lines on the enamel surface. For this study, only linear grooves which were clearly observable were recorded. As the lesions are most commonly observable on the canines and incisors, only these teeth were scored (Ibid). The observed teeth were then assigned a score as 1 =no lesion, 2= one hypoplastic line present, 3=two or more lines present, as outlined in Steckel et al. (2005). A lesion was only recorded as present when a clear, prominent indention was observable on the tooth.

4. 2 Samples Included in the Dental Analysis

Dental pathology, dental wear and evidence for physiological stress (LEH) was assessed, based on the conditions discussed above, in a total of 11 samples located throughout the study area. Table 4.1 below lists each sample and the Sample ID used throughout this chapter and the associated time period for each group.

Table 4.1Sample information for material included in dental pathology assessment.

Sample ID	Sample Information	Time Period
1 WMON	Multi-Sites Western Mongolia	Bronze Age
2 PAZ	Multi-Sites, Gorny Altai, Siberia	Early Iron Age/ Pazyryk
3 CHAN	Chandman, Ulangom, Western Mongolia	Early Iron Age
4 NIL	Nileke, Xinjiang	Iron Age
5 TUCH	Tuchengzi, Inner Mongolia	Iron Age/ Han Dynasty
6 CMON	Central Mongolia, Multi-Sites	Iron Age/ Xiongnu
7 IVO	Ivolga, South Siberia	Iron Age/ Xiongnu
8 EG	Egiin Gol, North-Central Mongolia	Iron Age/ Xiongnu
9 KYR	Multi-Sites, Issyk Kul and Tian Shan region, Kyrgyzstan	Early Medieval
10 EMON	Multi-Sites, Eastern Mongolia	Mongol Period
11 URGA	Urga (Ulaanbaatar), Mongolia	Historic CE 18th to 19th Century

Figure 4.4 indicates the location of each of these samples. The samples are derived from both temporally and spatially diverse contexts. These groups were left as an independent sample from a single archaeological site whenever possible. In several cases, sites were combined when the sample size was particularly small; e.g. less than 10. In addition, samples were only combined when archaeological sites were in close proximity to one another and when the time periods were the same. It was not possible to pool samples from across the entire region based on, for example, only time period as these were not necessarily from communities with identical subsistence economies and the diversity in ecology and environment throughout the region makes this a further impossibility. Grouped samples were the Early Iron Age, Pazyryk samples from the Siberian Altai, the Bronze Age sample from western Mongolia, the Xiongnu sample from central Mongolia, the eastern Mongolia Mongol Period sample and the Early Medieval Period sample from Kyrgyzstan. As an additional test, when noted, samples were pooled together on the basis of similar economy and similar ecological setting in order to investigate relationships between these factors and dental pathology prevalence and dental wear rates. Sample designations for economy and environment groups are provided in Tables 4.3 and 4.4. See Chapter Five, Figure 5.2 pg. 110 of this dissertation, for an illustration of land cover types for the environment designations listed in Table 4.4. As mentioned previously, climate change has been proposed as a possible major factor in contributing to changes in economic structure and movements of people during the Late Bronze Age transition period in this region (discussed in Anthony 2007). However, palaeoenvironmental studies based on lake cores, phytolith data and isotopic analyses suggest that the climate was likely only somewhat warmer and more humid, but overall was similar to modern climatic conditions (Horiuchi, et al. 2000; discussed in Wright 2006; Stacy 2008). Therefore the basis of sample grouping by environment is justified by this likelihood and it is further stressed that this assessment was included here solely as a test to be conducted alongside the analysis of each individual sample group.

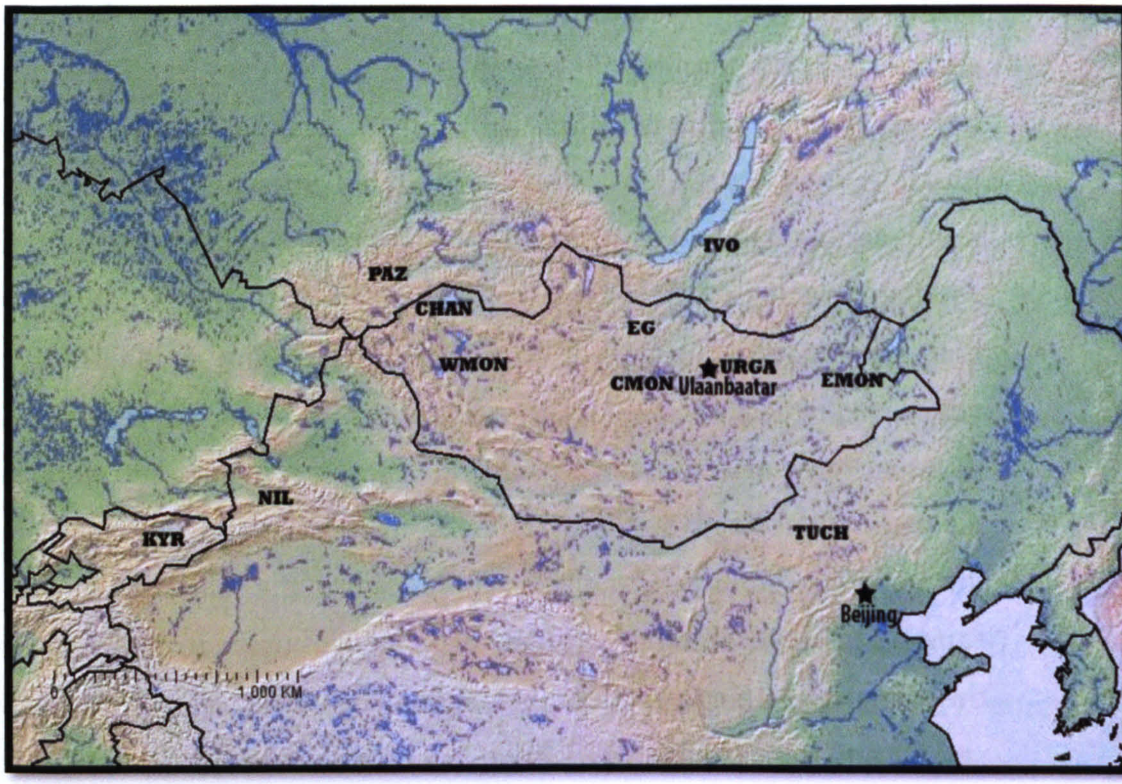


Figure 4.4 Site locations of samples utilised for dental analysis. WMON= (multi-sites/Bronze Age) PAZ=Pazyryk (multi-sites/ Early Iron Age), CHAN= Chandman, Ulangom (Early Iron Age) NIL= Nileke, Xinjiang (Iron Age) TUCH= Tuchengzi, Inner Mongolia (Iron Age) CMON= Central Mongolia (multi-sites Xiongnu/Iron Age) IVO= Ivolga (Xiongnu/Iron Age) EG= Egiin Gol (Xiongnu/Iron Age) KYR= Kyrgyz (multi-sites/Early Medieval) EMON= East Mongolia (multi-sites Mongol Period/CE 13th century) URGA= Urga (historic/CE 18th to 19th century).

A total of 452 individuals were included in this study and a total of 5,668 teeth and 10,004 tooth positions were observed. Table 4.2 provides the demographic profile for each site as well as the total number of teeth and tooth positions observed for each sample set. The largest sample set is the Historic Period sample from Urga. The smallest sample set is Sample 1 from western Mongolia Bronze Age burial contexts.

Table 4.2 Samples utilised for dental pathology assessment and dental wear analysis. BA=Bronze Age, EIA=Early Iron Age, IA=Iron Age, E. Med.=Early Medieval. See Figure 4.4 for locations of each sample. Y=younger adult, M= middle adult, O= older adult.

Sample ID	1 WMON	2 PAZ	3 CHAN	4 NIL	5 TUCH	6 CMON	7 IVO	8 EG	9 KYR	10 EMON	11 URGA	Totals
Time Period	**BA**	**EIA**	**EIA**	**IA**	**Han Dynasty**	**Xiongnu**	**Xiongnu**	**Xiongnu**	**E. Med.**	**Mongol Period**	**Historic**	
Total Inds.	14	67	23	39	53	20	30	30	26	21	129	452
Total Adults	13	59	23	39	51	17	28	28	24	21	122	425
Y	2	14	5	16	17	4	9	8	3	7	35	
M	4	26	13	15	24	8	17	12	15	5	70	
O	7	9	5	8	8	5	2	4	6	5	17	
Total Males	5	36	15	22	28	5	11	17	16	10	73	238
Total Females	7	20	8	17	21	12	9	11	8	9	49	171
Total Sub-adults	1	8	0	0	2	3	2	2	2	0	7	27
Total Teeth	107	932	208	440	793	215	459	394	278	245	1597	5,668
Total Tooth Pos.	203	1640	543	1006	1282	397	630	706	587	411	2599	10,004

In some instances, samples were grouped together on the basis of similar economy or similar environment, as mentioned above (Tables 4.3 and 4.4). It should be pointed out that the economy designations have been applied only as an indication of the major subsistence economy type that was likely carried out by that particular group. However, it is noted that contributions from other food resources were likely to have played various roles in particular communities and these applications are merely indicative of primary subsistence regimes. Pastoralist economies are defined here simply as those which are thought to have relied most extensively on food-production through the maintenance of herds of domesticated animals (Kottak 1994: 238). Agro-pastoralists are defined as those groups which are thought to have relied on subsistence economies 'based on both agriculture and (transhumant) pastoralism' (Kottak

1994: 238). Agriculturalists are defined as those groups which were thought to have relied primarily on plant cultivation for food production (Kottak 1994: 238).

Table 4.3 Major economy designations for each sample. These samples were grouped into two larger samples, Pastoralist, and Agro-Pastoralists.

SAMPLE	ECONOMY
1 WMON	Pastoralist
2 PAZ	Pastoralist
3 CHAN	Pastoralist
4 NIL	Pastoralist
5 TUCH	Agriculturalist
6 CMON	Pastoralist
7 IVO	Agro-Pastoralist
8 EG	Agro-Pastoralist
9 KYR	Pastoralist
10 EMON	Pastoralist
11 URGA	Pastoralist

Table 4.4 Environmental groupings for each sample. Group 1 (Mixed Forest Steppe), Group 2 (Mixed Dry Steppe).

SAMPLE	ENVIRONMENT	SAMPLE GROUP	SAMPLE ID
1 WMON	Semi-desert Steppe		
2 PAZ	Mountain/ Forest Steppe	**GROUP 1 (Mixed Forest Steppe)** **Mountain/Meadow/Forest Steppe**	2 PAZ 3 CHAN 6 CMON 7 IVO 8 EG
3 CHAN	Meadow/Mountain Steppe		
4 NIL	Dry Steppe		
5 TUCH	Dry Steppe		
6 CMON	Meadow/ Forest Steppe	**GROUP 2 (Mixed Dry Steppe)** **Semi-desert/Dry/Meadow/ Steppe**	1 WMON 4 NIL 5 TUCH 9 KYR 10 EMON 11 URGA
7 IVO	Forest Steppe		
8 EG	Forest Steppe		
9 KYR	Dry Steppe		
10 EMON	Meadow Steppe		
11 URGA	Meadow Steppe		

The relationship between advanced age and increased rates of dental pathology and dental wear has been well established (Lukacs 1992; Littleton and Frohlich 1993; Mays 2002). Therefore, it is necessary, when possible, to establish the relative age profile of the samples under study. Table 4.2 provides the age distribution for each sample. In some cases, individuals could only be assigned as 'Adult'. These individuals are included in the Total Adult category in Table 4.2.

It has been suggested that samples should only be compared for prevalence of dental pathological conditions and dental wear when age profiles between samples are similar (Lukacs 1992). As shown in Table 4.5, none of the age profiles are weighted markedly in favour of one particular age category over another. However, the one problematic sample is Sample 1, the western Mongolia Bronze Age group (Sample 1 WMON). This is partially because of the small sample size (n=14), but also because, of the fourteen individuals, seven are in the older adult age category. In light of this, the results of dental wear analysis and dental pathology recording in this sample must be viewed with caution. Furthermore, the difficulties faced with assigning individuals to a precise age group, using only cranial material, have been noted previously in Chapter Three.

In most cases the contextual information for each sample was obtained from multiple sources, such as site reports and manuscripts, often produced in several languages. These sources varied greatly in degree of detail and reported information. In several cases there was virtually no contextual information available, aside from a culture-historical label and regional location from which the individuals were excavated. In other cases, only a very brief description of the excavation site was available. From these sources and from comparable sites in the region, which have been more extensively reported, I have endeavoured to obtain as much information as possible for each sample. However, the aforementioned difficulties have hindered this to some extent. The following sub-sections provide a brief background description for each sample included in this analysis:

Western Mongolia (multi-sites), Bronze Age (khirigsuur/kurgan) contexts (c. 2900 to 1260 BC)

This sample set was combined from several excavation sites located in far western Mongolia, as indicated in Figure 4.4. Beginning in 1998, a number of archaeological excavations were carried out of Bronze Age mortuary features in western Mongolia (Kovalev 2008). The investigators at the site carried out a programme of radiocarbon dating of several of the burial features and these range in date from 2900 BC to 1260 calib. BC (Ibid). Researchers in this region have identified several styles of burial construction and associated material culture (Erdenebaatar and Kovalev 2007). The surface demarcation of these features ranged from flat square or rectangular surface markings of stone, to extensive round stone circle features (Ibid). As discussed in Chapter Two, there is a great deal of regional variation in burial features during this period and in western Mongolia the majority of these are essentially analogous with 'kurgans' of neighbouring sites in Siberia, rather than with the elaborate *khirigsuur* complexes found elsewhere in Mongolia (Honeychurch and Amartuvshin 2010). Based on faunal and iconographic evidence of comparable contexts it is possible that this group was primarily reliant on wild and domesticated animal resources for their dietary needs (Volkov 1995; Kovalev 2008). However, the extent to which other subsistence activities, such foraging and fishing, were carried out is unknown. Furthermore, relatively few details are clear about lifestyle, diet and economy in this region during this period, but future research may shed more light on these issues.

Pazyryk (multi-sites) of the Gorny Altai, Russia (c.700 to 300 BC)

This sample was combined from several sites located within close proximity to one another in the Altai Mountains situated to the north of the modern-day border of Mongolia (Sample 2 Figure 4.4, above). The origination sites for individuals in this sample are designated as follows: Buke, Ulandrik, Ustid, Djolin, Balik-Cook, Ala-Gail, Bertek, Kuraickaya-Steppe, Baratal, Burgazi, Maltaluu and Burati. This material is excavated from contexts attributed to the typical site-type of Pazyryk/Early Iron Age material discussed in Chapter Two. These individuals are believed to have relied primarily on meat and dairy products from domesticated animals for their dietary needs (Rudenko 1970). However, as mentioned in Chapter Two, a millstone was discovered at the site of Bertek-1 and further investigations may yet provide more evidence relating to agriculture and other dietary sources such as fish (Molodin 2003). Rudenko (1970) suggests that additional dietary resources of the Altai communities likely came from hunted animals, such as deer, elk and wild goat. This is supported by iconographic evidence found in the previously discussed animal-art and as rock-art images related to hunting which are found throughout the region (Jacobson 1993).

Chandman, Ulangom, Uvs aimag, Mongolia (c.700 to 400 BC)

This site is located in the far north-western reaches of Mongolia, Uvs aimag, and was discussed previously in Chapter Two. This cemetery represents one of the more extensively excavated sites within the modern-day borders of Mongolia of a site-type attributable to Early Iron Age Period, distinctive from Xiongnu mortuary sites (Tseveendorj 1980; Novgorodova et al. 1982). Dietary consumption for this population may have been similar to that of the contemporary neighbouring groups inhabiting the Mongolian and Siberian Altai and was possibly characterised by a primary dependence on meat and dairy products from domesticated livestock, as well as contributions from hunted animal resources and fishing and foraging activities (Novgorodova et al. 1982: Volkov 1995). However, further research is necessary for a better understanding of the dietary habits of this community.

Nileke, Xinjiang, Iron Age (kurgans) (c. 500 to 221 BC)

This sample is from the site of Nileke, located in the far western region of Xinjiang province in modern-day China near the tributary of the Yili River system (Xinjiang 2006). There are several clusters of burials at this location and excavations revealed archaeological material culture and burial constructions typically attributed to Iron Age mobile-pastoralist site types of the region (Liu and Li 2002; Xinjiang 2006). Burial constructions are kurgans with either single or multiple interments, but single interments were most common. Surface demarcation of the burials was comprised of earthen mounds, some of which had stone rings constructed on top of the mounds. Stone surface demarcations ranged from approximately 10 metres in diameter to the largest at 40 metres. Burials were placed in the bottom of shafts which varied between 1.5 to 2 metres deep. Artefact inclusions were usually located near the head of the individuals, placed towards the west. Typical artefacts found in the burials include items such as ceramics, small iron knives and tools as well as bronze items and faunal remains (Liu and Li 2002). This population is thought to have relied on mobile-pastoralism for their primary subsistence base. However, the nature of and the extent to which they practiced seasonal transhumance is a matter for debate. Additionally, their relative proximity to the contemporary oasis farming communities of the region would have made trade in cultigens an accessible option, although to what extent, if any, supplementary dietary resources were utilised is poorly understood. However, iron agricultural tools and grains have been found in contemporary Saka/Wusun Period kurgans from Xinjiang and the Ferghana Valley (Debaine-Francfort 1989; Kuzmina 1998), further indicating that other dietary resources were likely to be available to this community.

Tuchengzi, Helinge'er, Inner Mongolia, Warring-States and Han Dynasty burials (c.475 BC to AD 220)

This sample is comprised of individuals excavated from the site designated as Tuchengzi, located in Helinge'er County, Inner Mongolia (Figure 4.4). This is a multi-period site with approximately 2,500 burials spanning from approximately 500 BC to the Yuan Dynasty (1271-1368 AD). Only individuals excavated from contexts attributed to the beginning of the Warring States Period (c.475 BC) through to the end of the Han Dynasty (220 AD) were included in this study. Burial construction was generally characterised as rectangular earthen shafts, some of which have an associated tomb ramp. Individuals were sometimes placed in a wooden coffin which, in some cases, was then situated into a brick chamber or catacomb at the bottom of the burial shaft (Nei Menggu 1989). These burials typically contained a single individual but there are several examples of multiple interments. Burial inclusions were ceramics, such as jars, bowls and serving vessels. Bronze and iron items such as belt hooks, rings, and bronze mirrors, as well as swords, daggers and axes were also found. In association with the extensive burial grounds, there is evidence of a long-term habitation site which includes roof tiles and a surrounding wall, as well as non-pastoral faunal resources, such as pig and chicken and agricultural tools, all attributed to the periods of the Warring States and Han Dynasty (Ibid). From the archaeological evidence, it appears that this population relied on agricultural production with additional subsistence resources from domesticated animals. Stable isotope analyses by Gu (2007) carried out on human bone collagen of individuals from this site found low ^{15}N ratios and ^{13}C ratios concurrent with significant dietary contributions from C_4 and C_3 plant material. The C_4 plants resources likely came from millet/broomcorn millet, and the C_3 input from wheat (Ibid). These analyses concluded that a primary diet derived from agricultural products characterised this population.

Central Mongolia (multi-sites), Xiongnu burials (c. 300 BC to AD 200)

This sample was pooled from several excavation sites located in central Mongolia, all derived from Xiongnu Period burial contexts (Khatanbaatar 2007). These individuals were excavated from typical Xiongnu ring style burials discussed in Chapter Two. Artefacts associated with these burials include those commonly found in Xiongnu contexts such as bronze and iron artefacts, including knives, bells and buckles as well as weapons, ceramics, and horse riding equipment. It is generally accepted that the major economy of the Xiongnu Period was one of mobile-pastoralism and thus their diet would have consisted primarily of domesticated animals and animal products (dairy items). However, to what extent this group supplemented their diet with vegetables, cereals and other dietary resources is unknown. This sample set is representative of the local 'elite' burials of the Xiongnu Period and it is possible that they would have had access to a variety of foodstuffs from neighbouring areas. Evidence for agricultural influence has been found in Xiongnu square-ramped tombs in the form of grains, possibly of millet and sorghum in the case of Noin Ula burial mounds 20 and 31 (Korolyuk and Polosmak 2010) and millet from burial 40 at Cheremukhovaya Pad (Konovalov 1976).

Ivolga, South Siberia, Xiongnu burials (c. 300 BC to AD 200)

This sample is derived from Xiongnu Period burials excavated at the site of Ivolga in south Siberia, near Lake Baikal (see Fig.4.4). Excavations at this site have revealed evidence for long-term habitation, a walled 'fortress' and an accompanying cemetery (Davydova 1995). Even though the habitation and 'fortress' area had been known to researchers much earlier, the cemetery wasn't discovered until 1956 (Davydova 1996). Even though the human remains were sometimes scattered and commingled, researchers determined that approximately 244 individuals were represented (Ibid). The majority of individuals were interred in wooden coffin constructions, although some were simply placed directly into pits dug into the ground, others were placed in a stone cists without any wooden structure, while others were provided with a combination of stone and wood constructions. It is likely that this group relied on a mixed diet based on small-scale agriculture, pastoralism, fishing and foraging. Evidence for subsistence activities have been found in the form of archaeological faunal remains of domesticated animals such as sheep and goat and fish bones. In addition, there is evidence for grain storage areas as well as domesticated grains from archaeological contexts which supports the possibility of a multi-resource subsistence base for this community (Davydova 1995).

Egiin Gol, Burkhan Tolgoi, North-Central Mongolia, Xiongnu burials (c. 300 BC to AD 200)

This sample is comprised of individuals excavated from the site of Burkhan Tolgoi, located in the Egiin Gol Valley of northern Mongolia, along the banks of the Selenge River (Fig. 4.4). Over several seasons, around one hundred individuals were excavated from Xiongnu ring-style burials (Turbat et al. 2003). Individuals were typically buried in wood-plank constructed coffins placed in extensive shaft graves. The burial chamber was sometimes surrounded by an additional stone or wood lining and, on occasion, both. Artefacts discovered within the burials are generally representative of the overall range of Xiongnu material culture including weapons, beads, bronze hanging ornaments, horse riding equipment, bronze and iron buckles and plaques, worked-bone and lacquer, amongst other items (Turbat et al. 2003). Faunal remains include horse, goat, sheep, dog and wild animals such as deer (Ibid). This group is thought to have relied on a diet influenced by both wild and domesticated animals, fish, wild berries and vegetables from foraging activities and cultivated grain from agricultural practices. This is supported by the isotopic evidence from this population which is discussed in detail in the following chapter of this dissertation (see isotopic results of EG sample Chapter Five).

Kyrgyzstan (multi-sites), Issyk-kul and Tian Shan Region, Early Medieval kurgans (c. AD 300 to 500)

Individuals excavated from four sites in Kyrgyzstan were pooled together to create the sample included in this analysis. This sample set was pooled from multiple sites due to the low sample numbers from each location. These individuals were all from burial contexts assigned to the Kyrgyz designation of the 'Great Migration Period' or 'Hunnu' burials (AD 300 to 500) (Tabaldiev 1996). In order to avoid the confusion created by this terminology, this sample should simply be regarded as Early Medieval. Even though some of these sites are multi-period, only individuals from contexts attributed to this time frame were included in the sample for analysis. These individuals were derived from four separate sites located on the south-western shore of Lake Issyk-Kul and in the nearby vicinity. Site names are as follows: Japuruk, Uch kurbu, Cuttu balak and Bish-tash-koroo (see Chapter Two for radiocarbon dates and location of each site). It is generally believed that this group engaged primarily in mobile-pastoralism as their major form of subsistence, thus their diet was comprised of domesticated animal and dairy products, but the extent to which they relied on other resources during this period is not well-known. Palaeobotanical evidence from a Saka/Wusun Period settlement, located at the site of Tuzusai just across the modern-day border in Kazakhstan, has indicated the possible agricultural production of millet (Rosen et al. 2000). This finding illustrates the complex relationship between agriculture and pastoralism (although for an earlier period) in this geographic area and does suggest that a mixture of dietary resources cannot be ruled out. It is also possible that the individuals included in this study would have had access to additional dietary resources obtainable from agricultural production in the nearby Ferghana Valley (Sorokin 1961).

Eastern Mongolia (multi-sites), Mongol Period burials (AD 1200 to 1400)

This sample was pooled from Mongol Period burials excavated from several sites located in close proximity to one another in eastern Mongolia (Batsaikhan 2003; Batsaikhan 2006; Ulziibayar et al. 2007). Dietary evidence from the Mongol Period is found in both ancient historical documents and from archaeological excavations. Excavations at the Mongol Period settlement site of

Avraga in Khentii aimag have revealed a substantial amount of carbonized wheat, barley and millet grains, which are suggested to be of local origin (Shiraishi 2009). In addition, faunal remains from Avraga indicate the presence of horses, cattle, sheep, goats, dogs, fish and rodents (Shiraishi 2009: 135).

Even though multiple examples of permanent settlement sites are found from this period, the imperial court was also a mobile one, whereby the ruler and his retinue moved to various residences throughout the year (Shiraishi 2009). In addition, a predominant subsistence strategy of mobile-pastoralism characterised the majority of the population and this is also confirmed in historical accounts of the period (Rockhill 1900). With this in mind, it should be understood that although cereals and other items may have been available, to what degree they were accessible or even desirable to a substantial portion of the population is debatable. Overall, staple dietary resources likely came from domesticated animals in the form of both meat and dairy products. Furthermore, individuals of different social classes would have had access to particular food resources in varying degrees throughout the region.

Central Mongolia, (Urga) Ulaanbaatar, surface collection of Historic Period crania (c. AD 1700 to 1900)

This particular group of individuals was included in the present study primarily to provide a large comparative sample for the others discussed here. This material was acquired in the early 20th century by Aleš Hrdlička during his post as curator of the physical anthropology collection of what is now the Smithsonian Institution, National Museum of Natural History. These crania were obtained from surface collections of skeletal material carried out at the site of Urga (Θргөө), which was the former name of the capital city of Ulaanbaatar from AD 1639 to 1706. However, the material included here could span as late as the early 20th century and at present it is impossible to provide a more precise date range and from this point forward the sample will simply be referred to as Historic Period.

As this material is from a later context, it is likely that these individuals would have relied primarily on a diet based upon traditional pastoralist products of meat and dairy goods, supplemented with additional resources obtained from trade and cultivation practices. This later historic period of Mongolian history was characterised by an emergence and expansion of power obtained by the Buddhist church. In the early part of this date range, the Buddhist church grew increasingly dominant as its wealth was consolidated in the form of land control, monasteries, animal herds and economic ties with the Manchu Empire (Sneath 2007).

4.2.1 Results of the Dental Pathology Analysis

Dental pathological conditions are reported by percentages of affected individuals in each sample and separate reporting is given on a basis of percentage of teeth affected in a sample for caries and LEH. There is justification for each type of reporting, for individual counts this is deemed acceptable because it is at an individual basis where the factors which contribute to the pathological condition, such as diet, environment and genetics occur (Lukacs 1992). However, the counts of total teeth affected can be a desirable method of reporting due to the fact that prehistoric skeletal assemblages are often small and this allows for more robust sample sizes (Ibid). Furthermore, this can make comparisons between sites more valid due to the fact that detecting pathological lesions is directly proportional to the degree of skeletal completeness and preservation of a particular sample (Ibid). Prevalence rates based on individual counts may be more of a reflection of between-site differences in skeletal completeness and preservation, rather than true variation. All results have been assessed for statistical purposes using chi-square tests to analyse categorical and frequency data and for metrical data using two-tailed T-tests specifying unequal variances. In all cases significance was set at $p=0.05$.

Results of Dental Pathology Assessment for all Samples

The results of the dental pathology profile for each sample have been tabulated and are presented in Table 4.5. The results of LEH prevalence are presented separately from the other pathological conditions as they indicate physiological disruption of tooth formation during childhood rather than dietary influence. These results are provided in Tables 4.11a and 4.11b. Dental caries prevalence was variable throughout the samples. The highest percentage of individuals affected was from Sample 7 IVO at 57%. The lowest percentage was from Sample 10 EMON at 5%, followed closely by Sample 2 PAZ at 9%. The results of dental caries should be viewed with caution when reviewed on an individual basis. For example, only 3 caries were found in the entire assemblage from Sample 1 WMON but these were on three separate individuals, thereby causing the rate appear higher. With this in mind, dental caries rates by tooth count can be a more appropriate indicator of the condition. This assessment is provided in Table 4.6 below. Chi-square tests indicate significant association with dental caries for both individual and tooth count frequencies and the separate site locations ($p<0.05$). Chi-square tests also indicate significant association of caries, based on tooth count, with the pooled economy samples ($p<0.05$) but not for samples pooled by environment ($p>0.05$).

Table 4.5 Dental pathology profile of all samples (Individual Count). % indicates the percentage of individuals with at least one example of the lesion present. Numbers in parentheses indicate number of individuals affected.

SAMPLE	Total Num Ind.	Tooth Lesions		Jaw Lesions		
		Caries	Calculus	AMTL	Abscess	Resorption (Per. Disease)
1 WMON	14	21% (3)	64% (9)	71% (10)	50% (7)	57% (8)
2 PAZ	67	9% (6)	84% (56)	54% (36)	30% (20)	19% (13)
3 CHAN	23	13% (3)	65% (15)	48% (11)	30% (7)	43% (10)
4 NIL	39	21% (8)	85% (33)	54% (21)	44% (17)	18% (7)
5 TUCH	53	30% (16)	66% (35)	43% (23)	49% (26)	17% (9)
6 CMON	20	15% (3)	75% (15)	40% (8)	10% (2)	15% (3)
7 IVO	30	57% (17)	90% (27)	30% (9)	27% (8)	13% (4)
8 EG	30	27% (8)	43% (13)	33% (10)	23% (7)	17% (5)
9 KYR	26	35% (9)	73% (19)	54% (14)	27% (7)	19% (5)
10 EMON	21	5% (1)	71% (15)	67% (14)	38% (8)	29% (6)
11 URGA	129	11% (14)	41% (53)	46% (59)	29% (37)	19% (25)

Table 4.6 Dental caries prevalence by tooth count.

SAMPLE	Number of Individuals	Carious Teeth (N)	Total Teeth (N)	Caries Rate (%)
1 WMON	14	3	107	2.80
2 PAZ	67	9	932	0.97
3 CHAN	23	3	208	1.44
4 NIL	39	13	440	2.95
5 TUCH	53	23	793	2.90
6 CMON	20	6	215	2.79
7 IVO	30	25	459	5.45
8 EG	30	8	394	2.03
9 KYR	26	10	587	1.70
10 EMON	21	10	245	4.08
11 URGA	129	17	1597	1.06

The most common condition for the majority of the samples was dental calculus. The two exceptions were Sample 1 WMON and Sample 11 URGA which had slightly higher rates of AMTL than calculus. Several samples had exceptionally high calculus percentage with 84% for Sample 2 PAZ, 85% Sample 4 NIL and 90% for Sample 7 IVO. The lowest percentage of individuals with calculus was Sample 11 URGA at 41%. The prevalence of dental calculus was found to be significantly associated with the independent sample groups ($p<0.05$). The highest percentage of individuals with one or more teeth lost ante-mortem (AMTL) was Sample 1 WMON at 71%. It should be noted however, that this sample had the highest proportion of older individuals namely seven out of fourteen. AMTL was not found to be significantly associated with any of the samples nor with the pooled economy or environment samples ($p>0.05$). The sample with the lowest percentage of AMTL was Sample 7 IVO at 30%, followed closely by Sample 8 EG at 33%. Alveolar resorption (periodontal disease) was found to be significantly associated with independent samples, but not with pooled economy or environment groups ($p>0.05$). The highest percentage was in evidence from Sample 1 WMON, but again, half of this sample is comprised of older adults. The next highest percentage was Sample 3 CHAN at 43%. The lowest frequency of this condition was from Sample 7 IVO at 13%. Dental abscesses were not significantly associated with any of the samples ($p>0.05$) but they were associated with sex for Sample 4 NIL ($p<0.05$).

Comparative Dental Pathology Results between Males and Females

The results of dental pathology frequencies compared between males and females are roughly similar in percentages of individuals affected within the samples. The results of this assessment are provided in Table 4.7. These results should be viewed with caution, as in several cases the sample sizes were very small once they were divided by sex. The only condition significantly associated with sex was dental abscesses in the case of Sample 4 NIL, the Iron Age sample from Xinjiang. No other significant association was found to be related to sex categories for any of the pathological conditions ($p>0.05$). Sample 10 EMON exhibited no females with caries and 10% of males. Also, no abscesses were exhibited in the females from Sample 3 CHAN. Calculus was markedly similar for male and female categories for all samples. One exception is Sample 6 CMON, the Xiongnu Period sample from central Mongolia. This sample showed 89% of females with calculus and 36% of males. However, again the small sample size in this case, particularly for males (n=5) should be noted.

Table 4.7 Dental pathology profile of males and females for all samples. M=males, F=females. Numbers in parentheses indicate number of individuals affected.

SAMPLE			Tooth Lesions				Jaw Lesions					
			Caries %		Calculus %		AMTL %		Abscess %		Resorption (Per. Disease)%	
SEX	Num M	Num F	M	F	M	F	M	F	M	F	M	F
1 WMON	5	7	40 (2)	14 (1)	80 (4)	57 (4)	80 (4)	86 (6)	60 (3)	57 (4)	60 (3)	71 (5)
2 PAZ	36	20	8 (3)	20 (4)	94 (34)	95 (19)	67 (24)	50 (10)	44 (16)	20 (4)	22 (8)	20 (4)
3 CHAN	15	8	7 (1)	25 (2)	67 (10)	63 (5)	67 (10)	25 (2)	47 (7)	0 (0)	27 (4)	13 (1)
4 NIL	22	17	27 (6)	12 (2)	90 (20)	76 (13)	59 (13)	47 (8)	64 (14)	18 (3)	23 (5)	29 (5)
5 TUCH	28	21	32 (9)	19 (4)	64 (18)	67 (14)	43 (12)	52 (11)	57 (16)	48 (10)	11 (3)	10 (2)
6 CMON	5	12	9 (1)	22 (3)	36 (2)	89 (11)	27 (2)	56 (7)	9 (1)	11 (1)	9 (1)	33 (4)
7 IVO	11	9	64 (7)	56 (5)	100 (11)	100 (9)	45 (5)	33 (3)	36 (4)	33 (3)	18 (2)	22 (2)
8 EG	17	11	41 (7)	9 (1)	41 (7)	45 (5)	24 (4)	55 (6)	12 (2)	45 (5)	18 (3)	18 (2)
9 KYR	16	8	31 (5)	50 (4)	75 (12)	63 (5)	69 (11)	38 (3)	31 (5)	25 (2)	31 (5)	13 (1)
10 EMON	10	9	10 (1)	0 (0)	70 (7)	56 (5)	70 (7)	67 (6)	50 (5)	33 (3)	40 (4)	44 (4)
11 URGA	73	49	8 (6)	12 (6)	44 (22)	35 (17)	53 (39)	39 (19)	33 (24)	24 (12)	19 (14)	8 (4)

Results of Dental Calculus by Severity Grade

Calculus was assessed by both presence and absence for each individual as well as by degree of severity. The results of the degree of calculus expression for each sample are provided below in Table 4.8. The sample with the highest percentage of individuals with severe calculus is Sample 10 EMON, the Mongol Period sample from eastern Mongolia at 36%. Sample 3 CHAN had no individuals with severe calculus expression. The highest percentage of individuals with slight calculus was found in Sample 3 CHAN despite the occurrence of no individuals with severe calculus in this group.

Table 4.8 Calculus assessment by severity grade for all samples. Numbers in parentheses indicate number of individuals affected.

SAMPLE	Total Number of Individuals	Total Ind. W/ Calculus	Slight		Moderate		Severe	
1 WMON	14	9	(3)	33 %	(5)	56 %	(1)	11 %
2 PAZ	67	56	(35)	63 %	(9)	16 %	(12)	21 %
3 CHAN	23	15	(13)	87 %	(2)	13 %	(0)	0 %
4 NIL	39	33	(11)	33 %	(21)	64 %	(1)	3 %
5 TUCH	53	35	(20)	57 %	(12)	34 %	(3)	9 %
6 CMON	20	15	(9)	60 %	(5)	33 %	(1)	7 %
7 IVO	30	27	(11)	41 %	(13)	48 %	(3)	11 %
8 EG	30	13	(7)	54 %	(4)	31 %	(2)	15 %
9 KYR	26	19	(3)	16 %	(11)	58 %	(5)	26 %
10 EMON	21	14	(6)	43 %	(3)	21 %	(5)	36 %
11 URGA	129	53	(31)	58 %	(18)	34 %	(4)	8 %

Results of Dental Pathology in Grouped Economy and Environment Samples

The results of dental pathology rates in pooled samples based on economy are provided in Table 4.9. Firstly, a higher percentage of caries was found in the samples for agro-pastoralist (42%) and agriculturalist (30%) economies. The percentage for the pastoralists sample was low at 14%. Chi-square tests found a significant association between caries prevalence and the pooled economy samples ($p<0.05$). Secondly, the results of calculus percentage based on economy are similar for all groups at 63% for pastoralists, 67% for agro-pastoralists and 66% for agriculturalists. Chi-square tests found no significant association between the calculus rates and the pooled economy samples.

AMTL was higher by percentage among the pastoralist samples but not significantly so ($p>0.05$). Abscesses were more prevalent in the agriculturalist sample based on the percentage of the population affected. Abscess frequencies were not found to be significantly associated with the economy grouped samples ($p>0.05$). Alveolar resorption (periodontal disease) was highest among the pastoralist sample group at 23%. However, periodontal disease prevalence was not found to be significantly associated with the pooled economy samples ($p>0.05$).

Table 4.9 Dental pathology profile for samples grouped by primary subsistence economy. Chi-square significance results for association between each condition and samples based on primary economy are provided.

Grouped Economy Samples	Tooth Lesions		Jaw Lesions		
	Caries (p<0.05)	Calculus (p>0.05)	AMTL (p>0.05)	Abscess (p>0.05)	Resorption (Per. Disease) (p>0.05)
Pastoralist	14%	63%	51%	31%	23%
Agro-pastoralist	42%	67%	32%	25%	15%
Agriculturalist	30%	66%	43%	49%	9%

The results of dental pathology rates in grouped samples based on environmental setting are provided in Table 4.10. Overall the results are similar for all pathological conditions between the two combined samples. Caries prevalence was higher in Group 1 Forest steppe sample at 22%, but was similar to Group 2 Dry Steppe at 18%. Caries prevalence was not found to be significantly associated with environmental groupings (p>0.05). Calculus expression was found to be significantly associated with environment groups (p<0.05). A higher percentage of individuals had calculus in the Group 1 Forest Steppe sample at 74% vs. 58% for the Group 1 Dry Steppe sample. No other conditions were found to be significantly associated with environment based on these groups (p>0.05).

Table 4.10 Dental pathology profile for samples grouped by environment. Chi-square significance results for association between each condition and samples based on environment are provided.

Grouped Environment Samples	Tooth Lesions		Jaw Lesions		
	Caries (p>0.05)	Calculus (p<0.05)	AMTL (p>0.05)	Abscess (p>0.05)	Resorption (Per. Disease) (p>0.05)
Group 1 Forest Steppe	22%	74%	44%	26%	21%
Group 2 Dry Steppe	18%	58%	50%	36%	20%

Results of Linear Enamel Hypoplasia Assessment

The results of LEH assessment are provided in Tables 4.11a and 4.11b below. These tables illustrate the results of LEH as observed on incisors and canines in the respective samples. Additionally, the results are provided for both males and females. These results indicate the number of individuals with one or more LEH present and also indicate the results of the number of teeth affected in each sample. The assessment on the basis of tooth count was more robust as sample sizes were small in some cases, particularly when based on individuals affected.

Table 4.11a LEH expression for males and females from Samples 1 to 5. Results indicate number of teeth with one or more LEH and by number of individuals.

Sample	1 WMON		2 PAZ		3 CHAN		4 NIL		5 TUCH	
SEX	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Num. Teeth	4	3	73	38	19	5	36	15	96	54
Num. Teeth With	0	0	9	3	4	0	12	1	33	8
Num. Individuals	2	3	36	22	14	8	16	4	19	14
Num. Individuals With	0	0	7	3	3	0	6	1	10	5

Table 4.11b LEH expression for males and females from Samples 6 to 11. Results indicate number of teeth with one or more LEH and by number of individuals.

Sample	6 CMON		7 IVO		8 EG		9 KYR		10 EMON		11 URGA	
SEX	M	F	M	F	M	F	M	F	M	F	M	F
Num. Teeth	15	23	24	35	56	25	25	10	27	6	203	166
Num. Teeth With	5	7	14	9	7	7	5	0	7	1	20	22
Num. Individuals	5	9	8	8	11	5	5	2	6	2	73	53
Num. Individuals With	1	3	5	4	4	4	2	0	2	1	18	15

Figure 4.5 provides an illustration of the percentage of LEH in the samples on the basis of individual counts. Again, the small sample sizes for this particular assessment must be taken into consideration. No examples of LEH were found for Sample 1 WMON. However, there were only five individuals with teeth available for observation and only seven teeth in total for the whole sample. Sample 9 KYR only had seven individuals with available teeth and Sample 10 EMON had only eight. Figures 4.5 and 4.6 are provided to more clearly illustrate the results reported in Tables 4.11a and 4.11b.

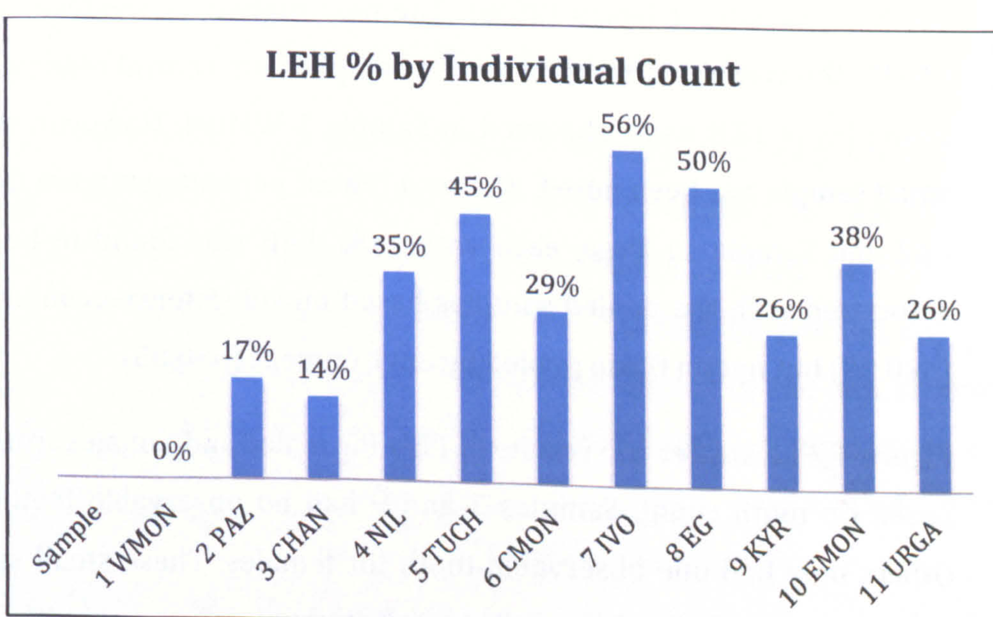


Figure 4.5 LEH percentages of individuals with one or more hypoplastic lesion present for each sample.

The results of LEH by individual counts are variable throughout the samples, with the highest percentage observed in Sample 7 IVO at 56%. This was followed closely by Sample 8 EG at 50%. In this case, Sample 1 WMON was disregarded on the basis of the small sample size. Therefore, the lowest percentage was from Sample 3 CHAN at 14% followed closely by Sample 2 PAZ at 17%.

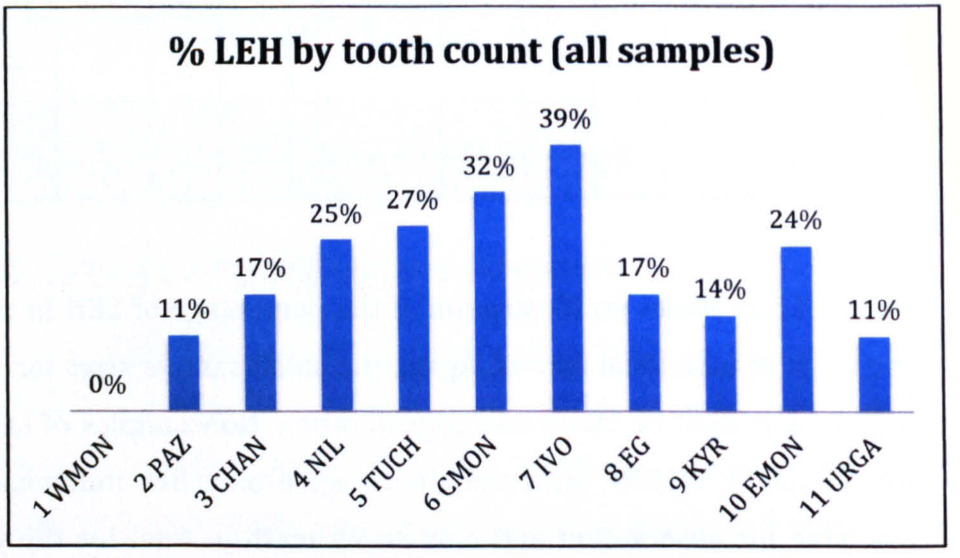


Figure 4.6 LEH percentages for all samples based on tooth count.

Figure 4.6 provides an illustration of the percentage of LEH on the basis of tooth count for all samples. The highest percentage was observed for Sample 7 IVO, the Xiongnu site of Ivolga (39%). The next highest percentage was Sample 6 CMON, the combined Xiongnu Period sample from central Mongolia (32%). No examples of LEH were observed in Sample 1 WMON. However, the extremely small sample has been noted. The next lowest percentages were from Sample 2 PAZ and Sample 11 Urga, each with 11%. LEH was found to be significantly associated with the pooled samples based on subsistence economic groupings ($p<0.05$) but not on those pooled by environment ($p>0.05$).

Figure 4.7 illustrates the results of LEH for males and females from all samples based on tooth count. Samples 3 and 9 had no observable teeth for females. Others only had one observable tooth for females. These small samples make this area of assessment especially tentative.

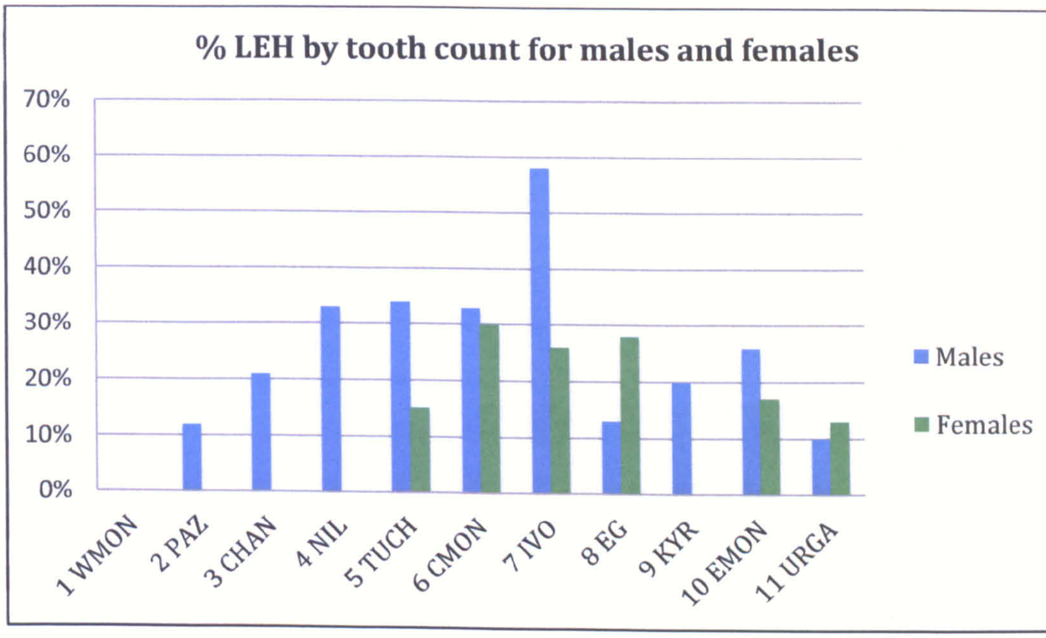


Figure 4. 7 LEH percentages for males and females based on tooth count for all samples.

LEH was found to be significantly associated with sex for Sample 5 TUCH, the Han Dynasty site in Inner Mongolia and Sample 7 IVO, the Xiongnu Period site in southern Siberia ($p<0.05$). For both of these samples, LEH was more prevalent in males than females. No other samples found LEH to be significantly associated with males or females ($p>0.05$). LEH was more prevalent in females than males in Sample 8 EG, the Xiongnu Period sample from northern Mongolia and slightly more prevalent in the historical sample from Urga (Sample 11).

4.2.2 Discussion of the Dental Pathology Analysis

It is well understood that interpretation of dental pathology prevalence will be beset with difficulties, due to problems of accounting for age in skeletal samples, particularly when the samples are small and from the multi-factorial aetiology of these conditions. Additionally, it should be pointed out that the comparison between sites is hindered to some degree by the lack of contextual information for several of the samples. Unfortunately, in some cases it is not possible to determine the relative degree of social stratification differences between the various locations and time periods. For example, social stratification during the Mongol Period is currently poorly understood on the basis of burial practices, so it is difficult to know to what degree the dietary variation between these individuals are comparable to the 'elite' Xiongnu burials. However, more extensive archaeological research in the future may be able to clarify this issue. Furthermore, the Xiongnu burials, irrespective of location, are largely comparable in degree of burial 'wealth' and resource expenditure evidenced in the mortuary practices. Despite these difficulties, the relationship between certain pathological conditions and dietary regimes is observable from this analysis.

Dental Caries and Dental Calculus

The results of dental pathology between the study samples reflect dietary habits in several instances. The rate of occurrence of caries in the samples is generally low, although it is difficult to assess what exactly would constitute a 'low' occurrence in predominantly pastoralist populations. This is primarily because there are few comparative studies of populations which are thought to have diets derived primarily from mobile pastoralist based economies. The results of dental caries frequencies indicate diets low in carbohydrates for all samples. The caries frequencies based on individual counts are generally higher among those samples from the mixed agro-pastoralist economies with the highest being Sample 7 IVO, the Xiongnu sample from Ivolga at 57%. Even though the archaeological data pertaining to dietary consumption for Sample 9 KYR, the Early Medieval contexts from Kyrgyzstan, is relatively limited, the results of the caries frequency for this sample are indicative of some degree of carbohydrate or refined sugar consumption as well, at 35%. The results of caries frequency, based on tooth count, range from 0.97% to 5.45%. A compilation of data by Lukacs (1980 [1989]) of caries prevalence for differing subsistence groups were as follows:

> 'Hunting and gathering: Number of groups = 17, Mean % of carious teeth=1.30 and Range: % of carious teeth= 0.0 to 5.3.
>
> Mixed economy: Number of groups= 13, Mean % of carious teeth= 4.84 and Range: % of carious teeth = 0.4 to 10.3.
>
> Agricultural: Number of groups= 32, Mean % of carious teeth= 10.43 and Range: % of carious teeth= 2.3 to 26.9'. (Lukacs 1989: 281).

The results of this study fall directly into the ranges of all three groups, with the highest percentage from Ivolga occupying the lower end of the agricultural group range. Although Sample 5 TUCH, the Han Period site from Inner Mongolia, had an economic base of primarily agricultural production, the caries frequency is relatively low for this sample also. This can be explained in several ways. One suggestion is based on other studies from East and South-East Asia which have found that communities relying on wet-rice and millet agriculture tend to have lower caries frequencies than those dependent primarily on maize agriculture. This has been observed in studies by Tayles et al. (2000), Domett (2001) and Pechenkina et al. (2002) and was suggested to be resultant from the less cariogenic properties of rice and millet as compared to maize. Another possible contribution to these results was a high degree of reliance on domestic animals which was likely a significant dietary staple for this community. This is supported by the archaeological faunal remains from this site. Overall, the results of dental caries prevalence are in accordance with populations that would have relied extensively on dietary staples which were not highly cariogenic. In addition, the input of cariogenic foods in each of the samples varies to a certain degree, which is likely indicative of local variation in subsistence regimes.

The results of dental calculus prevalence ranged from moderate to severe throughout the samples and are in accordance with a high degree of reliance on dietary staples, which contributed to an alkaline environment within the oral cavity. These results do not conflict with a possible reliance on a substantial degree of protein products for all samples in the study. In comparison, the study by Lillie (1997) of dental pathology in Mesolithic-Neolithic remains from the Dnieper Rapids region of Ukraine found no dental caries and high degree of dental calculus. The results were determined to be reflective of a predominant reliance on hunting, fishing and gathering. The significant calculus prevalence was thought to be resultant primarily from the high protein content of the staple diet. However, rates of dental calculus have been found to be high among prehistoric agricultural populations of South Asia and South America as well and it is possible that a high degree of consumption of certain carbohydrates can also lead to increased calculus prevalence, depending on food preparation methods and the particular foodstuffs in question (discussed in Lieverse 1999 and Lieverse et al. 2007a). What is also notable about the calculus results from this study is that although there is generally a significant degree of calculus throughout the samples, cases of severe calculus expression are relatively rare. This indicates that, while the condition is prolific throughout the study samples, severe calculus was uncommon. Currently, more studies are needed to allow for a better understanding of the aetiological factors involved with calculus deposition and for the time being it remains difficult to directly relate this condition to dietary factors (Ibid). It is, however, likely that significant protein consumption for these groups contributed to the high percentages of dental calculus. Other factors which affect calculus formation include poor oral hygiene and the mineral content of saliva in the oral environment. The observations discussed here are offered as possible suggestions, but future research in this area may shed more light on these particular findings.

Ante-Mortem Tooth Loss, Dental Abscesses and Periodontal Disease (alveolar resorption)

Rates of AMTL and periapical abscesses were variable throughout the samples. These conditions were most prevalent in Sample 1 WMON, the Bronze Age sample from western Mongolia. This is to be expected due to the older age profile of this particular group. The highest percentage of alveolar resorption associated with periodontal disease was also found in this sample. This too is explained by the advanced age of the majority of these individuals as well as the small sample size. The percentage of periapical abscesses was also relatively high in Sample 5 TUCH, the Han Dynasty group from Inner Mongolia at 49%. As abscesses are a serious condition which influence the effectiveness of an individual's immune system, these lesions may indicate a general health deficiency in this group. As this site was a military garrison of the Han Dynasty and the archaeological material found in burial contexts relate to more standard status individuals rather than elites, these results may indicate a lower nutritional level for this community and a lower level of health, which may have been influenced by a lack of nutritional resources. Rates of alveolar resorption are generally low in hunter-gatherer populations (Lukacs 1989) and the results of this condition in the samples used for this study are largely analogous, with the exception of Sample 1 WMON and Sample 3 CHAN. The age profile of Sample 1 has already been noted; however the next highest rate at 43% was from Sample 3 CHAN, the Early Iron Age sample from north-western Mongolia. The similar, moderate rates of this condition in both samples which are in relative proximity to one another geographically and temporally may indicate similar levels of health and oral hygiene standards for these two groups.

Linear Enamel Hypoplasia

The results of LEH indicate low to moderate frequencies of childhood stresses in the respective samples. If Sample 1 WMON is dismissed due to the small sample size the two lowest percentages of individuals affected were from Sample 1 CHAN, the Early Iron Age site from north-western Mongolia at 14% and Sample 2 PAZ, the early Iron Age Pazyryk sites at 17%. The other sample percentages were relatively low with the only two samples with more than 50% of the individuals (with observable teeth) affected, being Sample 7 IVO and Sample 8 EG. However, the percentages for both samples decrease once the assessment is based on tooth count rather than individual. Both samples are from Iron-Age Xiongnu Period contexts from southern Siberia and northern Mongolia. The relatively high percentages of LEH in these samples are indicative of a more frequent occurrence of illness or greater degree of nutritional stress in these groups during childhood. The relatively low percentages from Sample 2 PAZ and Sample 3 CHAN indicate that a smaller proportion of the population likely suffered from episodes of serious illness or physiologically stressful periods during childhood. This may indicate an increased access to a wider nutritional base. Studies of LEH frequencies in prehistoric samples globally indicate an increase in their occurrence which coincides with advent of agriculture in some cases (Cohen and Armelagos 1984). These frequencies can reach as high as 80% as found in a prehistoric group from North America who were intensive maize farmers at the site of Dickson Mounds, Illinois as compared to 45% of previous hunter-gatherer groups at the same site (Goodman et al. 1984). On this basis, the results here are largely comparable to the hunter-gatherer populations and should be regarded as relatively low to moderate. In addition, findings by Pechenkina et al (2002) indicate declining levels of health and increasing rates of LEH during the last part of the Chinese Neolithic. This was thought to be a result of increasing population density, a greater reliance on millet as the staple diet with little input from animal protein and food preparation methods that included extensive boiling (Ibid).

Discussion of Dental Pathology and Sex Variation

The results of the dental pathology assessment divided by sex indicates that, overall, there appears to be no marked discrepancy in conditions between the two groups, with the only exception being observed in the case of dental abscesses for the Sample 4 NIL group. In this group abscesses were found to be significantly associated with sex. Of course these results must be viewed with considerable caution due to the particularly small sample sizes once divided by sex. However, on the basis of these results, it appears that males and females tend to share similar dietary habits. More extensive studies, with increased sample sizes of males and females, would be needed to substantiate this. In other prehistoric groups with subsistence economies based on agricultural food production, a greater variation in dental pathology between the sexes has been observed. Lukacs (1992) found that in Bronze Age Harappan (2500-2000 BC) samples of the Indus Valley, significant differentiation in dental pathology between the sexes could be observed. Lukacs (1992) suggests that the lower caries prevalence for the males may have been due to their greater access to and reliance on protein from hunted animals and further contends that this resource was more readily available to men rather than women due to workload differentiation between the two sexes. The results of LEH based on sex indicate that for the majority of these groups males often suffered more physiological stressed during childhood rather than females. The exceptions were Sample 8 EG and Sample 11 Urga, where a higher percentage of females were affected. Overall, the LEH assessment based on sex does not appear to show any preferential treatment of male children during childhood and also indicates that they were more susceptible to physiological stresses causing growth disruption in these particular groups. However, the small samples sizes for LEH based on both individual and tooth count should be taken into consideration.

Discussion of Dental Pathology and Samples based on Economy and Environment

Several observations can be made based on the results of dental pathology in the pooled economy samples. Interestingly, caries prevalence was found to be significantly associated with economic basis. The higher caries prevalence in the agro-pastoralist and the agriculturalist group indicate a greater degree of carbohydrate or refined sugar consumption in these groups. These results support the archaeological evidence for the sample from Ivolga (discussed above) which suggests some degree of reliance on agricultural products. These results also support the isotopic evidence, provided in Chapter Four (this dissertation) for the Egiin Gol (agro-pastoralist) sample which are indicative of a mixed-economy. The results of calculus prevalence based on the economy grouping are similar for all groups. This can be explained in several ways. As discussed before, if calculus severity can, at least to some degree, be taken to be indicative of high protein diets, then the results across all groups suggest a similar level of protein consumption for all samples based on economy. However, because other studies have also shown a high degree of calculus in populations that relied heavily on carbohydrates, it could be suggested that external factors, such as environment or oral hygiene play as much of a role in calculus formation as does dietary intake (Lieverse 1999). Furthermore, the results for AMTL, abscesses and periodontal disease were not found to be significantly associated with economic groupings. The percentages for all groups were not markedly higher or lower in one particular sample. When the results were pooled for the agriculturalist and agro-pastoralist sample, the percentages remained similar to those of the pastoralist group. These results suggest that individual health as well as genetic and environmental factors, as opposed to diet, may have been just as influential in the causation of these conditions.

The results of the dental pathology assessment based on pooled groups relating to environment show no strong association with the inhabitation of particular environments. Arguably, Group 1 Forest Steppe sample would have had access to more dietary options, due to closer proximity to a wider range of natural resources and food production capabilities. This is appropriately summarised by Schutkowski (2008: 143) who states that, 'Human dietary variation is influenced by the availability of food items in the habitats in the first place. The prevailing ecological circumstances, e.g. geomorphology, climate, seasonality or soil quality, impinge on the spectrum of plant and animal species that can be exploited for food'. However, this area of assessment has not substantiated or refuted this to any measurable degree. Local subsistence regimes on a micro-regional scale, as well as social and political circumstances of the respective time periods from which the samples are from, are likely to have been more, or just as, influential as environment settings.

4.3 Dental Wear Analysis

As a further measure of examining indicators of dietary habits, dental wear or attrition was recorded for the samples used in the dental pathology assessment. Although rates of dental wear can often be used as an indicator of age, the overall rate and severity of attrition also provides an indication of the degree of coarseness or grit in the diet (Molnar 1971; Smith 1972; Walker et al. 1991). Arguably, because meat contains less abrasive particles than vegetables or stone-ground cereals, groups who relied heavily on meat and dairy products as their primary dietary sources may exhibit lower attrition rates than agriculturalist communities. On this basis the dental wear rates of predominately pastoralist communities should be relatively low. However, high degrees of dental wear have been documented in prehistoric hunter-gatherer groups as well (discussed in Smith 1984 and Hillson 2000). Additional observations have been made concerning variation in wear rates for anterior dentition. In some groups it has been suggested that certain wear patterns in the anterior dentition may be related to extra-dietary use of teeth, such as food preparation and craft production which involved the use of the anterior teeth for gripping items or stripping fibrous materials (discussed in Hillson 1996 and

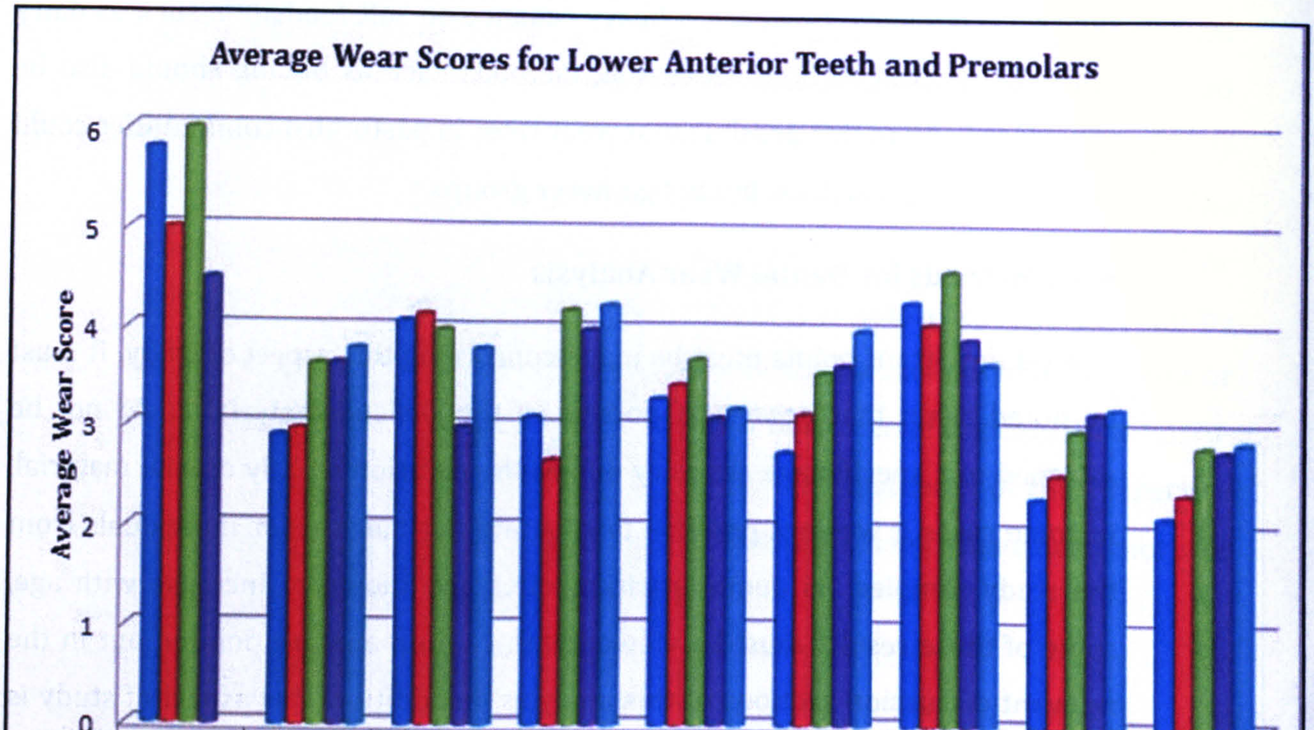
Larsen 1997). Currently, rates of dental wear in predominantly pastoralist communities are not well understood, but it is possible these will be analogous to prehistoric hunter-gather groups, due to the aforementioned similarities in the two economies. However, a heavy reliance on soft foodstuffs such as dairy products, as well as food processing methods such as boiling should also be considered and so it is possible that wear rates in pastoralist communities could be lower than prehistoric hunter-gatherer groups.

4.3.1 Methods for Dental Wear Analysis

Several important points must be made concerning this aspect of study. It must be noted again that because a portion of the skeletal material could not be assigned to a specific age category due to the curation of only cranial material, in some cases it was not possible to separate out much older individuals from the study samples. As dental attrition rates are known to increase with age, some of these results must be viewed with caution and are pointed out in the relevant discussion sections of this analysis. In addition, this aspect of study is intended as an indicator of overall average severity of dental wear and is meant to convey general trends in wear rates between these particular sample sets. Therefore, the inclusion of some older individuals should not skew the overall inferences to any significant degree, unless otherwise noted. Wear scores were recorded for all mandibular permanent dentition with observable occlusal surfaces from the sample sets included in the dental pathology assessment. Degree of dental wear was assigned based on the scoring system devised by Smith (1984).

4.3.2 Results of Dental Wear Analysis

Dental wear scores were assigned for lower molars, premolars and anterior dentition. The results presented here are the average wear scores for all permanent dentition that was available for observation in each sample (Figs 4.8 and 4.9). Averages were obtained from all teeth in the study samples and both left and right side teeth were included in the tabulation. Anterior dentition was not recorded in Sample 4 NIL and Sample 5 TUCH, due to differential recording protocol. The wear results for anterior teeth vs. molars were not found to be significantly different (p>0.05). The lowest average scores are found in the incisors, canines and third molars.



	1 WMON	2 PAZ	3 CHAN	6 CMON	7 IVO	8 EG	9 KYR	10 EMON	11 URGA
P2	5.8 (5)	2.9 (63)	4.08(13)	3.1(10)	3.29(21)	2.76(21)	4.29(14)	2.33(12)	2.15(84)
P1	5 (5)	2.97(59)	4.15(13)	2.67 (9)	3.44(23)	3.14(22)	4.07(15)	2.56 (9)	2.38(83)
C	6 (4)	3.64(47)	4 (8)	4.2 (5)	3.7 (23)	3.57(21)	4.61(18)	3 (18)	2.85(79)
I2	4.5 (4)	3.65(34)	3 (7)	4 (7)	3.1 (15)	3.64(22)	3.92(12)	3.18(12)	2.81(70)
I1	(0)	3.8 (46)	3.8 (5)	4.25 (8)	3.19 (9)	4 (20)	3.67(49)	3.22 (9)	2.89(58)

Figure 4.8 Average wear scores for lower anterior teeth and premolars for all samples. Numbers in parentheses indicate number of teeth available for observation.

Figure 4.9 provides an illustration of the average dental wear grades of the first, second and third molars from each of the study samples. T-tests found significant differences in average wear rates between M_1 and M_3 ($p<0.05$). The highest M_1 score was for Sample 1 WMON but the advanced age profile of this sample group makes it ineligible for comparison with the other samples. The next highest average score for M_1 was from Sample 9 KYR, the Early Medieval sample from Kyrgyzstan. The lowest average wear rates for both anterior teeth and posterior teeth are from Sample 11 Urga, the Late Historic sample.

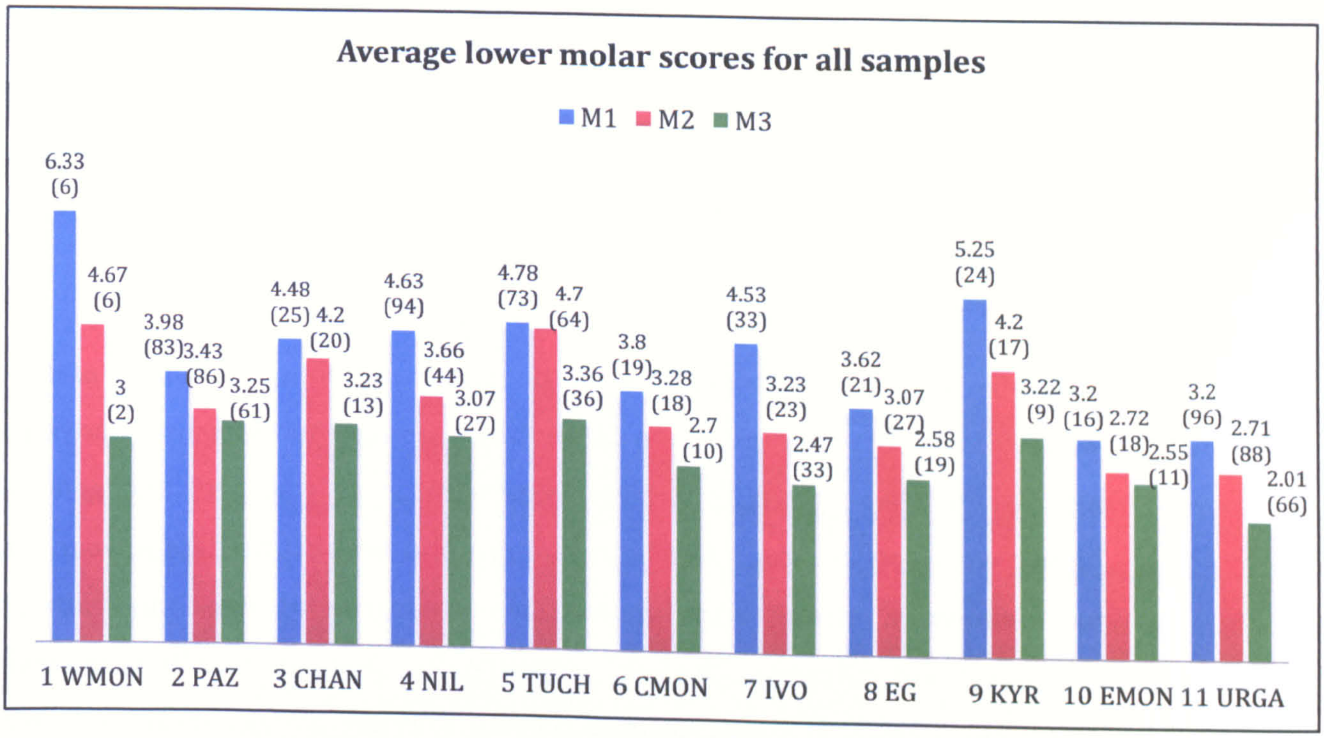


Figure 4.9 Average wear scores for lower molars for all samples. Numbers in parentheses indicate number of teeth available for observation.

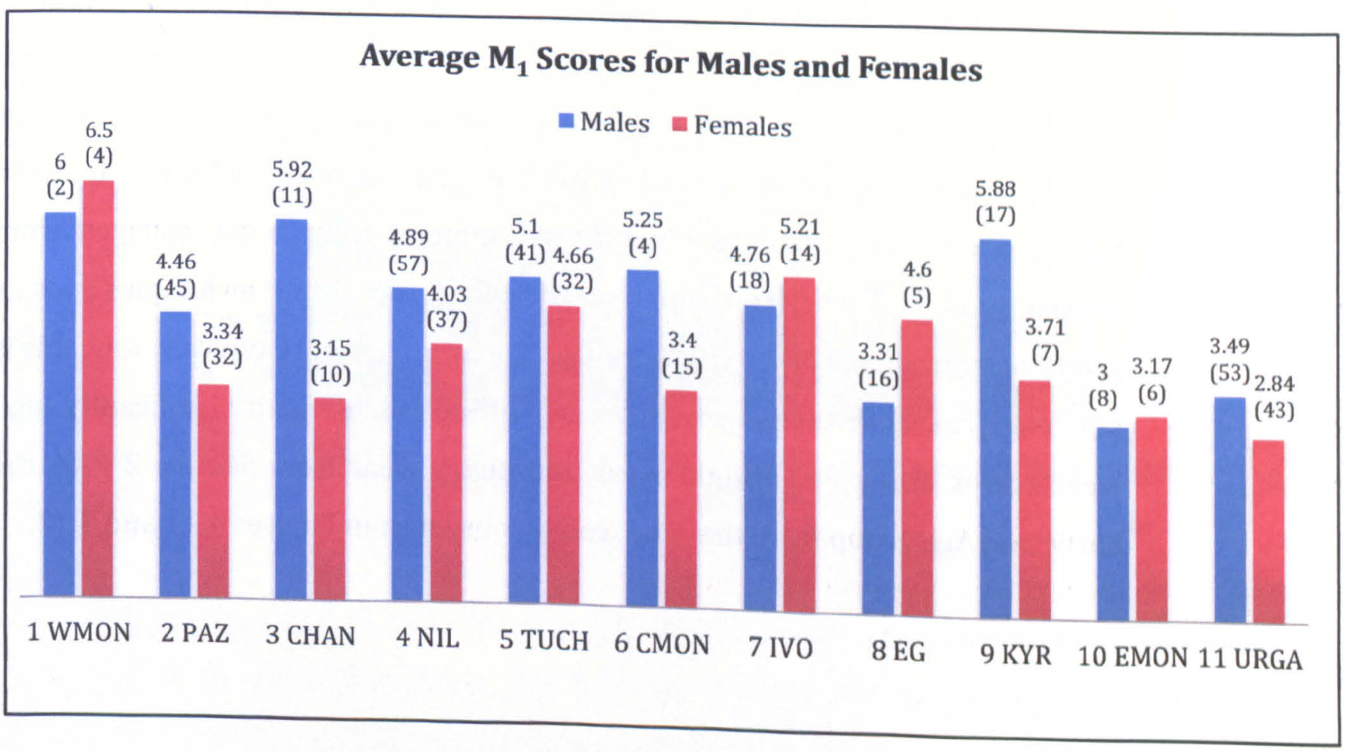


Figure 4.10 Average M_1 wear scores for males and females for each sample. Numbers in parentheses indicate number of teeth available for observation.

The wear scores based on sex show higher average scores for males in seven of the samples and higher scores for females in four. The greatest divergences between males and females were from samples 3 CHAN and 9 KYR. The higher average scores for Sample 1 WMON reflect the older age profile for this group.

4.3.3 Discussion of Dental Wear Analysis

A number of general observations can be made concerning the results of dental wear scoring. Correlations were observable between individuals of advanced age (when it was possible to determine a more precise age) and generally higher wear scores. Studies of both modern and prehistoric dental wear rates have shown a strong correlation between degree of wear and attrition associated with advanced age (e.g. Tomenchuk and Mayhall 1979; Keenleyside 1998; Mays 2002; Pechenkina et al. 2002). Overall, average wear rates were generally low to moderate throughout all the samples, based on the wear scoring stages from 1 to 8 by Smith (1984). With the exception of Sample 1 WMON (the older age sample), only Sample 9 KYR had an average M_1 score which was higher than 5. These scores are suggestive of diets which are generally low in abrasive materials. Examples of abrasive particles which can be found in food are cellulose plant fibres, mineral from bone, collagen from animal tissue and gritty contaminants from food processing techniques such as grinding stones (Hillson 1979). Although the averages were typically low, this is not to suggest that there were not cases of individuals with significantly high wear scores. Examples of light wear and heavy wear from Sample 2 PAZ, the Early Iron Age group from the Altai, can be observed in Figures 4.11 and 4.12.

Figure 4.11 Light wear on lower molars from Early Iron Age, Pazyryk sample (image Author 2009).

Figure 4.12 Heavy wear on lower molars and anterior dentition from Early Iron Age, Pazyryk sample (image Author 2009).

In addition, Figure 4.12 illustrates the degree of attrition that could be found for anterior teeth. This may relate to possible extra-dietary use of teeth as these teeth are not typically used in mastication. Most samples had low average wear scores for the anterior teeth and this degree of anterior tooth was not typical throughout the samples. However, this observation does indicate marked use of the anterior teeth at least in some instances. Ethnographic studies provide a number of examples of individuals using their anterior teeth for assistance while performing particular tasks. Several accounts of Arctic Eskimo populations describe occasions where individuals would use their teeth as an aid for performing particular tasks and at times when their hands were otherwise occupied (discussed in Merbs 1968). Some descriptions include accounts of pulling fishing lines with anterior teeth, cracking seal bones, tearing and cutting meat, preparing seal skins by chewing, and grasping skins while sewing (Ibid).

The results of this study found no strong variation in average dental wear scores between the sexes in these samples. However, historic accounts of the Mongols discuss daily tasks performed by men and women. The following passage provides an account of labour divisions between men and women and offers a potential insight into the respective duties that were carried out by each sex.

> It is the duty of women to drive the carts, get the dwellings on and off them, milk the cows, make butter and *gruit*, and to dress and sew skins, which they do with a thread made of tendons... They also sew the boots, the socks and the clothing... The men make bows and arrows, manufacture stirrups and bits, make saddles, do the carpentering on (the framework) of their dwellings and the carts; they take care of the horses, milk the mares, churn the *cosmos* or mare's milk, make the skins in which it is put; they also look after the camels and load them. Both sexes look after the sheep and goats, sometimes the men, other times the women, milking them. (William of Rubruck [Rockhill] 1900: 22-23).

The consumption of dried meat is another possible source of dietary abrasion. It has been mentioned in historical texts relating to the Mongol army that the troops would typically carry dried meat as part of their basic uniform supplies (Lane 2006). However, to what extent this was eaten as a dietary staple is unknown. There is also little information to suggest how early dried meat may have been used as a typical food source. It should also be noted that in modern times among nomadic pastoralists in Mongolia, dried meat is sometimes included in the diet, but this is often boiled in the same manner as fresh meat (personal observation).

The markedly low wear scores for Sample 11 Urga, the Historical group from central Mongolia, are what would be expected from dentition samples from individuals derived from such a late period context. For this sample, particularly low average scores were observed for anterior teeth as well as molars and premolars. By this time advances in food processing techniques as well as a reliance on soft foods would have resulted in low levels of masticatory stress and overall attrition rates in this population. In addition, the next lowest scores for the M_1 dentition were from Sample 10 EMON, the Mongol Period sample from eastern Mongolia. This finding may also be reflective of the later date of this sample which coincides with a time period when this group was likely to have been more fully engaged in mobile pastoralism as their primary subsistence economy and therefore relied on a substantial degree of dairy, meat and processed foodstuffs as their dietary staples. Similarly, in an examination of temporal changes in tooth wear attrition patterns from Japan spanning from the Jomon Period (c. 4,000 to 300 BC) to modern samples, a marked reduction in dental wear of posterior dentition was observed for the post-medieval samples (Kaifu 1999). The diet of the individuals from Mongolia by this time would likely have been low in abrasive particles due to changes in food preparation techniques and cooking methods. Also, meat, vegetables and cereals were likely to have been processed more commonly during this period, through cooking methods such as boiling or roasting (discussed in Lane 2006), causing it to be less abrasive than in the earlier periods.

4.4 Summary and Conclusions

Overall, this study has allowed for a number of observations to be made concerning health and dietary habits of these populations, despite the difficulties which have been discussed. The low caries prevalence for all the samples is in accord with populations which did not rely extensively on cereal-based diets. Conversely, there is a high degree of dental calculus in all samples which may be related to diets high in protein and is also indicative of an alkaline oral environment which would deter the formation of carious lesions. In addition, the presence of caries in some samples does indicate that cariogenic foods were available and consumed by particular groups. The low to moderate frequencies of other pathological conditions, such as AMTL, abscesses and periodontal disease, indicate relatively good standards of group health based on dental pathology. This is also supported by the relatively low occurrence of LEH. Moderately low attrition rates indicate diets low in abrasive particles and lesser degrees of masticatory stress. More expansive studies using dental microwear analysis and detailed recording of interproximal wear patterns may shed more light on dietary and extra-dietary attrition factors in these populations. Through this assessment, the variation and similarities in dietary regimes from samples which are primarily labelled by their subsistence base, e.g. 'nomadic pastoralist' has been highlighted. Future studies where more contextual information is available will allow for these results to be built upon, so that more nuanced assessments of macro-regional and local variation in dietary regimes and group health can be further assessed.

Chapter Five

Reconstructing Past Diet in Mongolia from Stable Isotope Analysis

This chapter focuses on the reconstruction of past diet from a comprehensive study of stable isotope analyses. The aim of this study is to identify long-term dietary intake of prehistoric inhabitants of distinct areas within the modern-day boundaries of Mongolia. Often based on circumstantial evidence, individuals inhabiting this region during later prehistoric periods are often described as belonging to various nomadic-pastoralist culture groups. The widespread application of culture-historical names and labels based on subsistence strategies obscures the degree of social differentiation between groups who inhabited quite diverse ecological settings throughout this region. This analysis provides a means by which to address variation and dietary complexity both within and between populations. This work also provides a basis for assessing dietary change or continuity over time, as well as dietary variation based on age and sex categories.

As discussed previously, the essential image of the nomadic-pastoralist communities of the Central Asian steppes is often depicted as communities on horseback moving randomly across the landscape without fixed dwellings and surviving solely on the animals which they herd. However, this image is largely being dispelled by archaeological and anthropological work in the region (e.g. Konovalov 1976; Khazanov 1994; Kradin 2008; Honeychurch 2004; Wright 2006; Frohlich et al. 2009; Miller 2009). These studies have effectively demonstrated the complexity of social and political organisation of these communities, as well as the degree to which an in-depth knowledge of local landscapes and pastoral management strategies are necessary not only to survive, but to flourish in this environment. The present study, based on stable isotopic analysis, also seeks to deconstruct the ideal image of a homogenous subsistence regime for all communities across this region, particularly during the Xiongnu Period. While not necessarily incorrect, the widespread usage of labels such as *Xiongnu*, inevitably creates sweeping generalisations which are used to describe all communities that inhabited a vast and extremely diverse landscape.

Variation and adaptation in subsistence practices can be stimulated by changes in socio-political and economic circumstances, as well as by climate and ecological transitions and even by individual choice. Modifications in subsistence regimes can occur at both large and small scales, as well as rapidly or more gradually over time. In order to minimise productive risk, communities may rely on a number of techniques to prepare for times of economic hardship (Halstead and O'Shea 1989; Frachetti and Mar'yashev 2007). Ethnographic studies from regions throughout the world have shown this to be common among mobile-pastoralist communities as well (Salzman 2004). These 'risk buffering' techniques may include the reliance on a range of dietary resources, the implementation of storage technologies, and various types of pastoralist specialisation (Halstead and O'Shea 1989). Unlike other avenues for palaeodietary reconstruction, which are generally based on contextual archaeological, ethnographic and historical evidence, stable isotope analysis provides a quantitative and direct assessment of an individual's dietary composition. This chapter briefly examines palaeodiet reconstruction based on isotopic analyses. Following this summary, the methods, materials, results and discussion of the stable isotope study carried out for this dissertation are provided and examined in detail.

5.1 Stable Isotope Analysis for Palaeodietary Reconstruction

The implementation of stable isotope analyses to reconstruct past dietary habits from human and faunal bone collagen has been in common practice for a number of years. This application has been used widely across temporal and spatial boundaries in order to address a variety of archaeological and anthropological questions. A vast corpus of literature exists on the subject and this summary is not intended as an exhaustive account of the past research in this field. Rather, the aim here is to briefly summarise the main points of the analysis and its limitations and to provide examples of research applications using this approach. For more extensive reviews see, Ambrose (1993), Katzenberg (2000) and Mays (2000). Stable carbon and nitrogen isotope ratios can be used as a means to assess the diet of an organism because a direct relationship exists between the type of food being consumed and the corresponding isotopic signature found in bone collagen. The exact timing of turnover rates in human bones is not well understood, but it is generally accepted that complete bone turnover is achieved at 10 to 30 years (Mays 2000). Therefore, results of the stable isotope analysis from human bone collagen will reflect a long-term dietary average of around the last 10 years of an individual's life. Isotope ratios from dentinal collagen will reflect a more limited time-span and is indicative of the diet consumed during the years the tooth was being formed.

Most applications of stable carbon and nitrogen isotope analyses have focussed on the degree of marine vs. terrestrial input and the contribution of C_4 plants in the diet and nitrogen values are commonly used to monitor trophic levels. Delta ^{13}C values are primarily influenced by two main plant types, those which follow a C_3 photosynthetic pathway and those which follow a C_4. The third type is CAM (Crassulacean Acid Metabolism) plants, which can switch between C3 and C4 pathways. These include plant types such as cacti and agaves. Most plants occurring naturally in temperate environments are C_3 plants. C_4 plants are more commonly found in tropical and subtropical environments as well as in dry regions and areas subjected to high temperatures. The major cultivated C_3 foods are rice, wheat and soybean, while the major C_4 types include maize, millet and sugar cane. Other important C_3 foods include legumes, vegetables, fruits and nuts. C_4 plants have less isotopic fractionation of carbon than C_3 plants, and have average $\delta^{13}C$ values of around -12.5‰ (per mil.), while C_3 $\delta^{13}C$ values average around -26.5‰ (van der Merwe 1982). The carbon and nitrogen isotopic signatures in bone collagen primarily reflect dietary protein intake, thus making it difficult to distinguish clearly between greater or lesser degrees of meat vs. plant intake. However, in some instances, it is possible to address this question, particularly when there are limited possibilities of food sources for a particular population and especially if the diet is low in protein (Mays 2000). Therefore, if C_4 and C_3 plants or terrestrial herbivores consuming these plants make up a significant proportion of the diet, this will be reflected in the $\delta^{13}C$ values. One particular area where the analysis of carbon stable isotopes has proven informative is in study of the adoption of agriculture in certain parts of the world. This is possible because major cultivated crops such as maize and millet are C_4 plants and their occurrence in substantial quantities in temperate environments where C_3 plants are naturally occurring can be indicative of the adoption of agriculture in a community. By looking at changes in diet over time, it has been possible to determine that maize agriculture production in North America was not adopted on a large scale until centuries after the first appearance of the crop in archaeological contexts and that this became the staple dietary resource at starkly different times across separate communities (discussed in Mays 1998; Schutkowski 2008). Stable isotope studies in parts of Western Europe have shown that a widespread adoption of agriculture was carried out within a relatively short time-span, as subsistence regimes changed radically with social circumstances and resource depletion, rather than coinciding with technological capability (Ibid). Additionally, changing processes in animal exploitation, such as in the foddering of animals from cultivated grains, can sometimes be detectable in dietary reconstructions based on $\delta^{13}C$ and $\delta^{15}N$ values (Katzenberg 1989; Makarewicz and Tuross 2006).

Nitrogen isotopic ratios reflect dietary protein consumption and have largely been used to examine the extent of marine vs. terrestrial foods and the influence of freshwater resources in the diet, in addition to monitoring trophic levels within food webs. Nitrogen in the diet becomes enriched as an organism moves up trophic levels through the food web. Consumers which subsist purely on plant foods have lower nitrogen values than those with a mixed diet of meat and plants and those with a purely carnivorous diet will be higher still. The $\delta^{15}N$ values of consumers are 3-5‰ higher than their diet as they move up the food web (Katzenberg 2000).

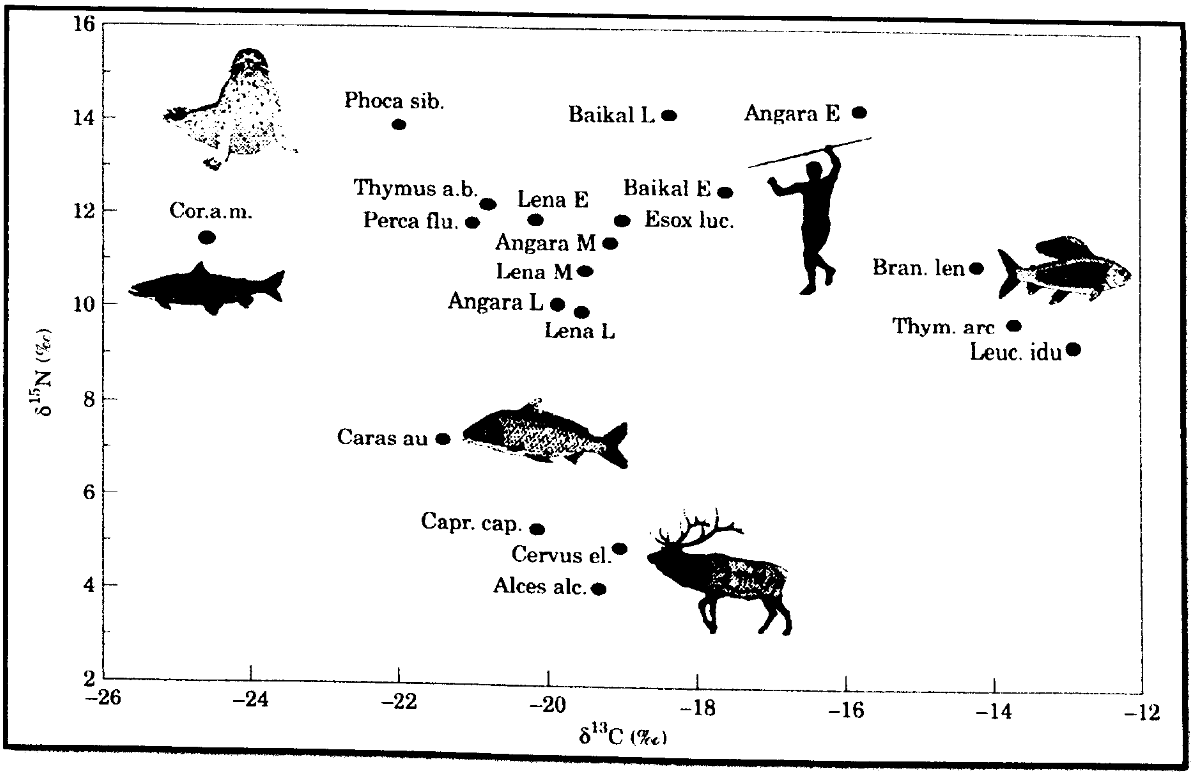


Figure 5.1 Carbon and nitrogen isotope ratios of human and faunal material from the Cis-Baikal region. E= Early Neolithic, M=Middle Neolithic, L=Early Bronze Age (adapted from Katzenberg and Weber 1999, Fig. 2 pg. 656).

Freshwater environments vary from other ecosystems in their average stable isotopic signatures, thus the influence of freshwater resources from lakes and rivers in the palaeodietary record of a population can be assessed. Overall, carbon signatures from freshwater resources are similar to $\delta^{13}C$ signatures from terrestrial foods, although this is variable across different freshwater systems. Both freshwater and marine food chains are comprised of more trophic levels so the consumption of top level carnivores (e.g. large fish and seals) may give elevated C and N results. Some freshwater resources from waters rich in carbon may give $\delta^{13}C$ isotopic signatures in humans which are similar to those from marine environments (Mays 2000). The study by Katzenberg and Weber (1999) found that the range of fish and seals from Lake Baikal had an average $\delta^{13}C$ range from -24.6‰ to -12.9‰, (see Figure 5.1 above). Generally nitrogen, rather than carbon, values provide the best indication of the degree of influence of freshwater resources for dietary reconstruction. Delta ^{15}N signatures are typically found to be elevated in these food webs as a result of trophic level effects, though this varies widely from one system to another. Katzenberg and Weber's (1999) Lake Baikal study also indicated average $\delta^{15}N$ values of 14± 1·1‰ for freshwater seals, while $\delta^{15}N$ values from deer and elk were quite low, ranging from 4 to 5‰. Due to the observed degree of variation between systems, it is helpful if local faunal samples are available in order to characterise the range of both carbon and nitrogen isotopic signatures of the particular food web in question.

Delta ^{15}N values have also been found to be sensitive to environmental circumstances. Previous studies have demonstrated that $\delta^{15}N$ values in both humans and animals are elevated in arid environments (see Heaton et al. 1986; Sealy et al. 1987). A systematic correlation has been observed in the $\delta^{15}N$ values of animal bone collagen from southern Africa where there is a 1.2‰ decrease in $\delta^{15}N$ that corresponds to every 100mm increase in average rainfall (Sealy et al. 1987). These elevated nitrogen levels are explained as the result of physiological processes where more urea and less water are excreted in animals from water-stressed environments. As part of this process the nitrogen which leaves the body will be ^{15}N depleted urea and the nitrogen which remains to be synthesised in the body will be enriched in ^{15}N, this in turn in reflected in δ ^{15}N values of human consumers of these animals (Ambrose 1993). Additionally, the carbon ratios of C_3 plants from water stressed environments tend to have higher $\delta^{13}C$ values than those from other environments. However, C_4 plants appear to be generally unaffected by environmental factors such as humidity, temperature and light intensity (Ibid).

5.2 Reconstructing Past Diet in Mongolia: concerns and considerations

A number of important issues must be mentioned with regards to the present isotopic study of Mongolian material. Firstly, it should be noted that some of the individuals included in this study are derived from burials that were excavated during earlier projects and thus some contextual information pertaining to certain individuals was not fully available. Secondly, individuals have been assigned to a time period based predominately on associated archaeological material, burial construction type and radiocarbon dates when available. However, in some cases there were no archaeological finds and a burial may have been assigned to a particular time period based purely on the nature of grave construction. While every attempt has been made to be certain of the time placement, future radiocarbon dating of these questionable burials (n=2) may place them in earlier or later periods than those which I have assigned here. Also, every attempt was made to use the best preserved skeletal elements from each individual in order to minimise the possibility of diagenesis. The possibility of diagenesis was also checked for by establishing the carbon to nitrogen ratio and the % collagen yield. In each case these results were within acceptable ranges. Furthermore, when repeatability of particular samples was low, further tests were run until an acceptable result was achieved. Finally, age and sex assignment was based on the methods discussed in Chapter Three, with the exception of 8 samples from EG where information on these individuals was obtained from osteological reports as this material was not available for re-analysis (Nelson and Naran 1999; Nelson 2000). When it was not possible to assign an individual to a specific age category they were placed into an Adult or Sub-Adult category. Children and juveniles were not given a sex assignment and adults who could not be assigned an age or sex are not included in the comparisons based on these categories. Faunal remains were included from Egiin Gol, Baga Gazaryn Chuluu and Shombuuzin Belchir. This was carried out to provide a means of assessing trophic level shifts in diet at these locations. However, it should be pointed out that these were derived exclusively from Xiongnu Period burial contexts. Therefore, variation in earlier and later periods of faunal signatures could not be assessed from this study. There was no faunal material available for analysis from the site of Taishar in the Gobi-Altai. Additionally, there were no freshwater fish bones available from the Egiin Gol region, which would have been beneficial for a more comprehensive understanding of diet from this population. However, it is reasonably close to the previously discussed Lake Baikal sites. Despite these difficulties, as this is the first comprehensive isotopic study of human remains from this region, this investigation provides a sound basis for future isotopic research in this area where some of these difficulties can potentially be remedied.

5.2.1 Materials and Methods

The focus of this analysis is primarily on two main locations in Mongolia. These locations are the Egiin Gol Valley in northern Mongolia (hereafter EG) and Baga Gazaryn Chuluu (hereafter BGC) in the north Gobi Desert. Additional samples were analysed from the sites of Shombuuzin belchir (hereafter SBR) located in Khovd aimag, western Mongolia and Taishar, (Ulaan Boom) located in the Gobi-Altai region (hereafter Taishar). Figure 5.2 indicates the location of each of these sites. This figure also illustrates the diverse range of environments associated with each location under study. The following sub-sections provide a brief summary of background information for each of these locations.

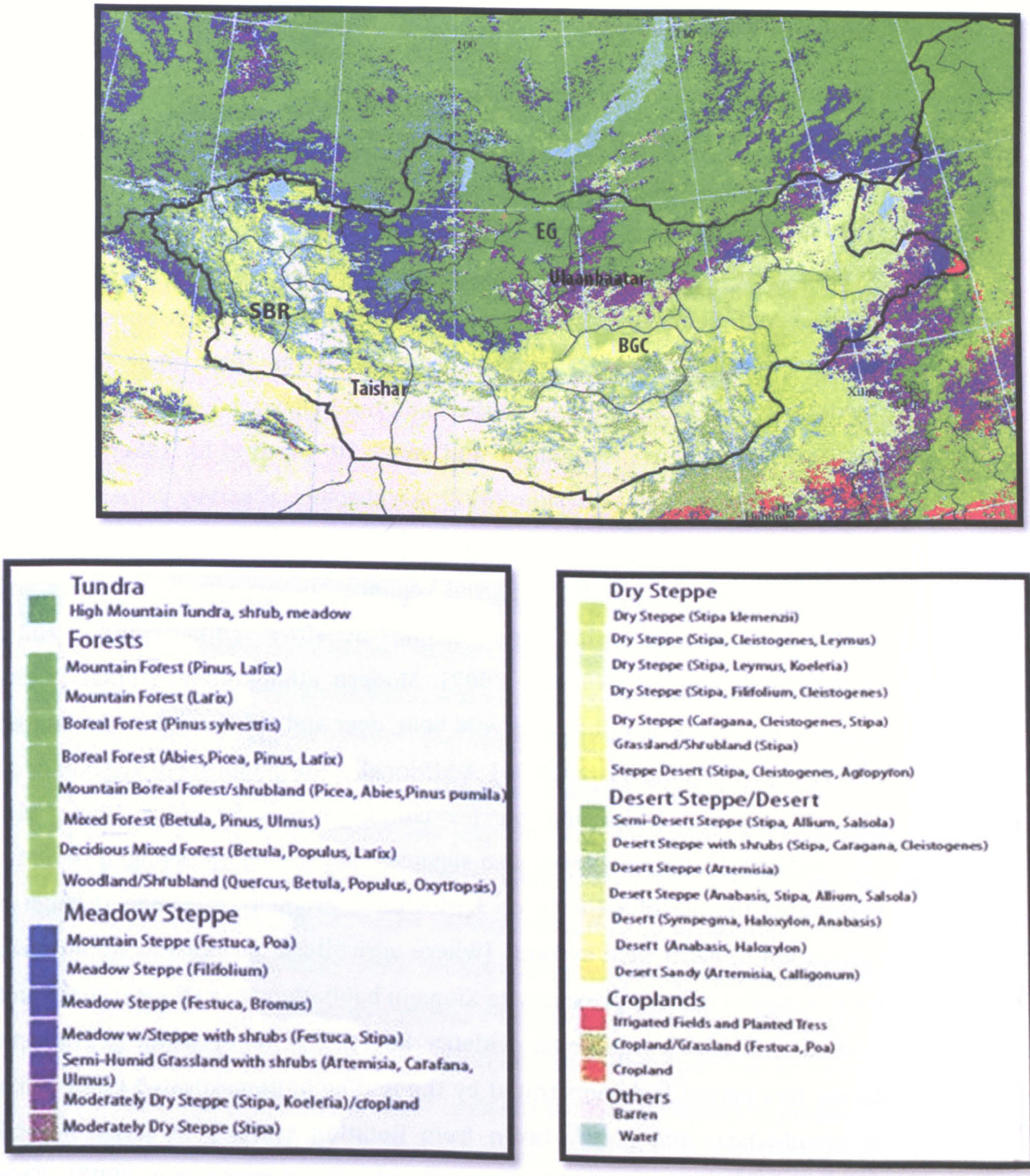


Figure 5.2 Sample sites from Mongolia and corresponding land cover/environment at each location. EG =Egiin Gol, BGC= Baga Gazaryn Chuluu, SBR= Shombuuzin Belchir. Map adapted from GANA (Grasslands in Asia and North America) Seasonal Land Cover Map. This map and legend has been adapted and are a product of the TEAL workshop, May 19-June 13 1997, Sioux Falls, South Dakota, U.S.A. (available at http://www-basin.nies.go.jp/project/lugec/Proceedings/15)T.%20CHULUUN.pdf).

Egiin Gol, Bulgan aimag

The samples included in this study from Egiin Gol are predominately from Xiongnu period ring burials. These are from the large cemetery site of Burkhan Tolgoi (discussed in Chapter Four) and from survey excavations in the nearby vicinity. This region is an area of forest-steppe with an abundance of natural resources in the form of nearby lakes and the extensive river systems of the Selenge and Egiin Gol. Annual precipitation in this area is approximately 340mm, making this area comparably more fertile than other regions of modern-day Mongolia. Herders in the Egiin Gol Valley typically practice short-distance seasonal transhumance and move at most 8 to 15km in range (Honeychurch and Amartuvshin 2007). Archaeological survey evidence of the Egiin Gol Valley suggests an economy based on multi-resource agro-pastoralism, which includes a partial reliance on agricultural products and seasonal hunting-gathering and fishing activities (Honeychurch 2004; Honeychurch and Amartuvshin 2007). Modern ethnographic studies in the region corroborate this finding as wild boar, deer and elk continue to be hunted in this region (Erdenebaatar 2000). Additionally, the gathering of vegetables as well as seasonal fruits and berries continues to take place (Ibid). The archaeological survey evidence also suggests that during the Xiongnu period a substantial degree of reliance on agricultural products is visible through a correlation of relict field systems (where agricultural production would have been possible) in close proximity to Xiongnu habitation sites (Honeychurch and Amartuvshin 2007). Additional evidence for reliance on agricultural products during this period is demonstrated by the finding of domesticated grains such as bread-wheat and barley taken from flotation samples of archaeological contexts (Honeychurch 2004; Honeychurch and Amartuvshin 2007). This degree of agricultural reliance is in contrast to the later Uighur Period (c. AD 6th to 9th centuries) site distribution in the Egiin Gol Valley which suggests that socio-political processes taking place during this time, particularly the development of the two main urban centres of Khar Balgas and Baibalik, brought about a predominately more mobile-pastoralist economy rather than one focussed toward agriculture (Ibid). Additionally, the presence of extensive one focussed toward agriculture (Ibid). Additionally, the presence of extensive burial grounds and labour intensive burials in the Valley during the Xiongnu Period suggests a significant degree of local 'tethering' to the area which is implied by the scale of land use and reuse in the region during this time (Ibid).

Baga Gazaryn Chuluu, Dundgobi aimag

The samples included from BGC are primarily from Xiongnu Period ring burials. These were excavated over a number of years primarily from survey excavations carried out alongside a large-scale pedestrian survey of the region (Amartuvshin and Honeychurch 2010). Several samples of earlier Bronze Age and Early Iron Age burials as well as later Mongol Period burials have also been included in the sample set. The terrain of BGC is a rocky outcrop of granite rocks and boulders situated within a vast expanse of desert-steppe. The rocks average between 1400 m and 1760 m a.s.l. in elevation while the total granite range covers approximately 85 km^2 (Wright et al. 2007). BGC is dominated by a central valley that stretches in a in a north-westerly direction from the centre of the rocks. Situated within the ridges and valleys of the granite outcrop, archaeological features are found in abundance. The average annual rainfall at BGC is quite low at 180mm per year. At BGC, it is generally accepted that some form of mobile-pastoralism was widely adopted during the late Bronze Age/Early Iron Age, although exactly when this occurred and to what extent is still a matter of debate. Prior to this widespread adoption, subsistence activities appear to have been comprised primarily of mobile hunting and gathering (Wright et al. 2007). Current inhabitants of the area rely predominantly on nomadic-pastoralism for their subsistence needs within a modern-day cash-based market economy. Sheep and goat are the primary herd animals and comprise the staple diet along with a variety of secondary milk and cheese products. Horses, camel and cattle (on a limited scale) are also herded in this area. Isotopic studies of modern-faunal material from BGC have suggested that it is possible to detect evidence for foddering practices in the carbon and nitrogen isotopic signatures (Makarewicz and Tuross 2006), although proof of foddering in early prehistoric periods has yet to be established. Modern herders rely on a combination of well water and surface water for their animals and typically engage in short-distance transhumance by moving only 5 to 10km every few weeks (Ibid).

Shombuuzin belchir, Khovd aimag

The samples from SBR are from Xiongnu Period ring burials excavated during the summer of 2008 by the Mongol-American Khovd Archaeology Project (Miller et al. 2009). This site is situated in the far westerly region of Mongolia of Khovd aimag, within the Mongolian Altai mountain range and is located at 2380 m.a.s.l. The highest elevation in this province is the Munhhairkhan peak at 4204 m.a.s.l. This is an arid region characterised by severely cold winters and short summers. Annual rainfall is approximately 123mm, but this can vary erratically from year to year. Annual temperatures range in extreme from 40°C at the highest and as low as -30°C in winter. The vegetation cover is predominately desert-steppe and steppe grasses. The environmental conditions are such that the preservation of archaeological material, even in relatively shallow burials is remarkably well-preserved. The site is situated within the mountain valley of the Tsenkher River and within close proximity to the river itself (Miller et al. 2009). Within the nearby vicinity of the Xiongnu cemetery site are preceding Bronze Age archaeological features and later Medieval/Turkic features. Faunal material from Xiongnu burial contexts is predominately of sheep/goat and there have yet to be any finds indicating a reliance on agricultural products such as grain. Modern-day products grown in the region are watermelon, tomatoes and potatoes, none of which are indigenous to the area. Sheep, goat, yak and yak/cattle cross called *khainag* are most commonly herded in this area. Inhabitants of this area rely predominately on sheep and goat for their subsistence along with milk and cheese products, but again within a market cash-based economy that places different types of pressure on pastoralist economies than existed previously (Honeychurch 2010). Other animals inhabiting the high mountain areas of Khovd include wild sheep, ibex and snow leopard.

Taishar, Ulaan Boom, Gobi-Altai aimag

The samples included in this study from Taishar (Ulaan Boom) are all from Bronze Age *khirigsuur* burials. These burials were excavated as part of a rescue archaeology/CRM project carried out by the Institute of Archaeology in Ulaanbaatar. The subsistence regime of the prehistoric inhabitants of this site is poorly understood. Only a small amount of faunal material was recovered from these features and these are possibly intrusive. These finds were of sheep/goat and some horse remains. This is an extremely arid region receiving less than 100mm of rain per year. Annual temperatures can reach as high as 45°C in the summer and as low as -40°C in winter. Vegetation in this region is sparse, consisting mainly of desert-steppe grasses and underground water is used for sustaining herds. Modern-day herders rely primarily on sheep and goat. Others animals commonly herded in this region include cattle on a very limited scale, as well as camel and horses. Herders move their flocks several times a year and for extreme migrations may move up to 190km.

5.2.2 Sample Information

A total of 83 individuals were included for stable carbon and nitrogen isotopic analysis of human bone collagen and collagen from dentine. Dentinal collagen was analysed from 1 individual from BGC and 8 individuals from EG. A total of 34 individuals were included from EG, 29 adults, 10 males and 14 females and 5 sub-adults. From BGC, a total of 37 individuals were included, 31 adults, 15 males, 14 females and 6 sub-adults. From SBR, 4 individuals were included, 2 male adults and 2 sub-adults. From Taishar, 8 individuals were included, 7 adults, 4 males and 3 females and 1 sub-adult. Table 5.1 indicates the number of individuals from each site.

Table 5.1 Sample sizes for each site included in isotopic analysis. Unsexed category includes sub-adults and adults that could not be sexed.

Sample	Males	Females	Unsexed	Total
EG	10	14	5 adults 5 sub-adults	34
BGC	15	14	2 adults 6 sub-adults	37
SBR	2	0	2 sub-adults	4
Taishar	4	3	1 sub-adult	8
Total Sample				83

From Egiin Gol, 5 samples were assigned to Late Bronze Age/Early Iron Age contexts, 27 to Xiongnu Period contexts and 2 individuals from Medieval/Mongol Periods. From BGC 8 individuals were from Bronze Age and Late Bronze Age/Early Iron Age contexts, 21 from Xiongnu contexts and 8 from Medieval/Mongol Period contexts. All individuals from the site of SBR are from Xiongnu burial contexts. All individuals from the site of Taishar are dated to Bronze Age contexts and were excavated from *khirigsuur* burial features.

Table 5.2 Sample sizes for each burial context included in isotopic analysis. All faunal samples are from Xiongnu burial contexts.

Sample	Bronze Age	Xiongnu	Medieval	Total Human	Total Faunal
EG	5 (slab burial)	27	2	34	13
BGC	8 (slab burial)	21	8	37	6
SBR	0	4	0	4	5
Taishar	8 (khirigsuur)	0	0	8	0

Skeletal preservation of these samples varied widely, from extremely poor to exceptionally well-preserved even to the extent in some cases of soft tissue being present. Overall, the samples chosen for analysis were obtained from well-preserved skeletal material and the few included from those that were poorly preserved were minimal. A total of 24 faunal samples were included for analysis. 13 were from EG, 6 from BGC and 5 from SBR. All faunal samples were derived from Xiongnu burial contexts. All faunal material analysed were either from *Ovis capra* or *Bos* species. See Tables 5.3, 5.4, 5.5 and 5.6 at the end of this chapter for full detailed sample lists.

All human and faunal material was assessed for $\delta^{13}C$ and $\delta^{15}N$ isotopic ratios. The stable isotope analysis of the human and faunal bone collagen was carried out at the NERC Isotope Geosciences Laboratory at the British Geological Survey in Keyworth (UK). A small bone sample was obtained from each individual for destructive analysis. These were predominately rib samples with the exception of several long bone samples where ribs were not available. The samples were prepared following a modified Longin method (Brown 1988) and is summarised briefly here.

Between 0.5 and 1.0 grams of the bone sample was mechanically cleaned and placed in approximately 8ml of cold 0.5M HC1 to demineralise the material. Following the demineralisation process, the remaining solid was then thoroughly rinsed and solubilised in a solution of pH3 HCl at 70°C and placed in a hot block for 48 hours. The solutions were then filtered using 8μm Ezze filter to remove any remaining solids such as un-dissolved bone and soil contaminants. The solution was then centrifuged at 4000 in a Heraeus Megafuge 1.0 before freeze drying. The extracted collagen was then measured in 0.6mg aliquots and placed in small tin capsules and analysed in triplicate to check for repeatability. The samples were then analysed for carbon and nitrogen by Continuous Flow Isotope Ratio Mass Spectrometry (CFIRMS). The instrumentation utilised consists of an Elemental analyser (Flash/EA) coupled to a ThermoFinnigan Delta Plus XL isotope ratio mass spectrometer via a ConFlo III interface. Isotope ratios reported in this study are expressed using the delta (δ) notation in parts per thousand (per mil: ‰) relative to a standard: $\delta(‰) = ((R_{sample}/R_{standard}) - 1) \times 1000$.

Collagen carbon and nitrogen isotopes ratios ($\delta^{13}C$ and $\delta^{15}N$) are reported in parts per mil relative to Vienna Pee Dee Belemnite (vPDB) and ambient inhalable reservoir (AIR) standards respectively. Delta ^{13}C and $\delta^{15}N$ ratios were calibrated using an in-house reference material M1360p (powdered gelatine from British Drug Houses) with expected delta values of -20.32‰ (calibrated against CH7, IAEA) and +8.12‰ (calibrated against N-1 and N-2, IAEA) for C and N respectively.

For statistical purposes, all datasets were checked for normal distribution. This was done either by Kurtosis tests for small samples or Kolmogorov-Smirnov tests for those with 10 or more samples. All datasets were found to be normal with the exception of the nitrogen results of Pre-Xiongnu dataset from BGC. Individual BGC EX 07.07 was identified as an outlier with a significantly low $\delta^{15}N$ value at 8.98‰. Once this individual was removed, this dataset was considered normalised. Multi-way Analysis of Variance (ANOVA) tests were carried out to check for significant variation in results when more than two datasets were being compared. Two-tailed T-Tests were used to compare two sample sets.

5.2.2 Results

Collagen was well preserved in the majority of the samples analysed, with only a few samples exhibiting very low collagen yield. Collagen yield ranged from .01% to 25% with the latter being in the region of modern standards. Full sample lists of all isotopic results of both human and faunal remains are provided in Tables 5.3, 5.4, 5.5 and 5.6 at the end of this Chapter. These tables also provide the collagen weight percentage for each sample analysed. The C: N atomic ratios fall within the expected ranges set out by DeNiro (1985) and Ambrose (1990) and ranged from 3:3 to 3:4 for all individuals. The average values for the human samples from each site are as follows: Average $\delta^{13}C$ for EG was -16.30‰ and average $\delta^{15}N$ 12.0‰, averages for BGC were $\delta^{13}C$ -15.86‰ and $\delta^{15}N$ 13.34‰. The averages for SBR were $\delta^{13}C$ -17.40‰ and $\delta^{15}N$ 14.48‰ and for Taishar were $\delta^{13}C$ -17.51 ‰ and $\delta^{15}N$ 14.73‰. Figure 5.3 provides an illustration of the distribution of these averages as compared with the averages for the three samples of faunal material.

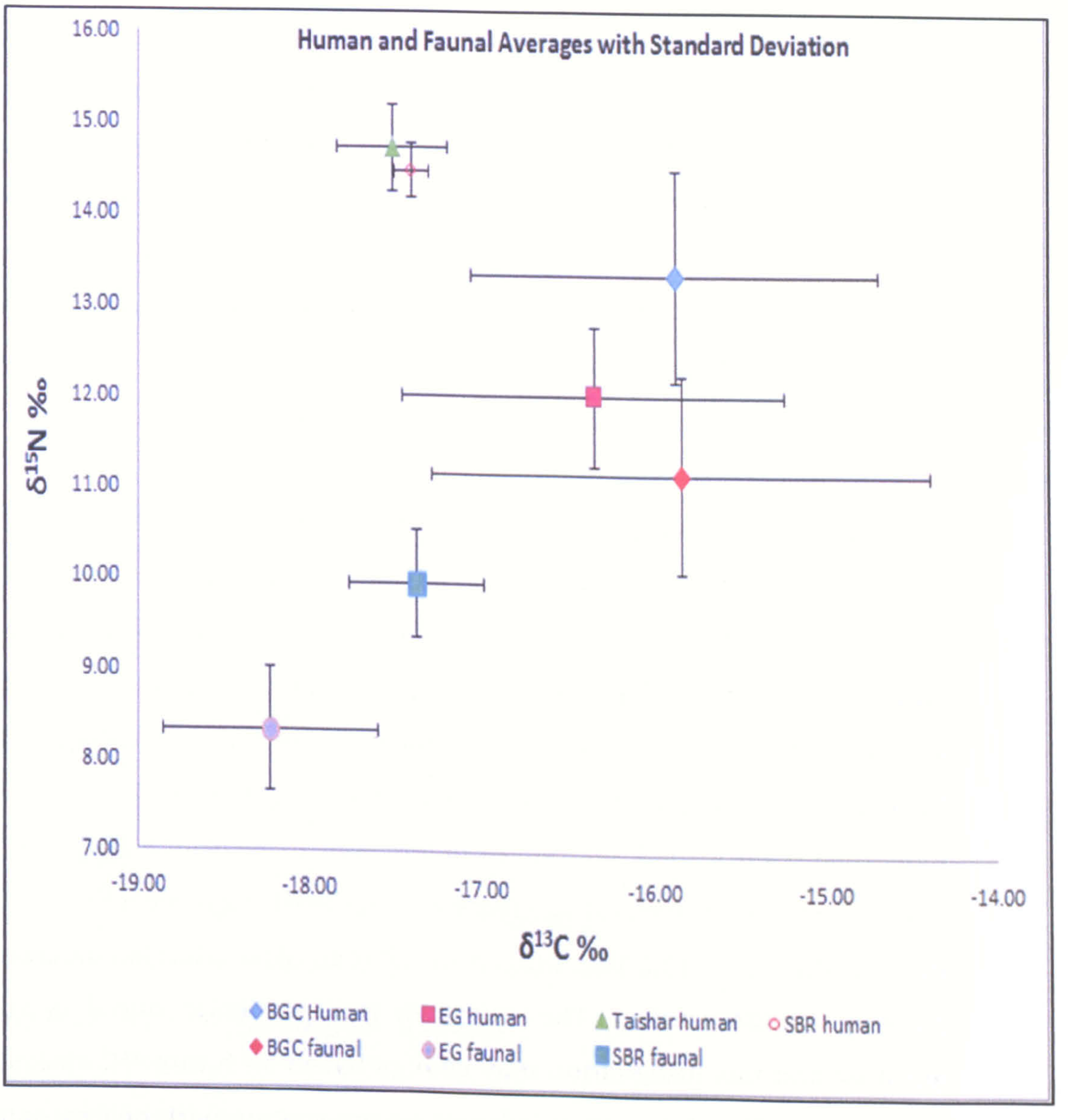


Figure 5.3 Average $\delta^{13}C$ and $\delta^{15}N$ values and standard deviation from human and faunal bone collagen from all samples.

The results indicate that on average the $\delta^{15}N$ human values from BGC are 1.34 ‰ higher than those of Egiin Gol. The results from SBR and Taishar are higher in $\delta^{15}N$ values than both BGC and EG. The difference in $\delta^{15}N$ between SBR and Taishar is .25‰ higher at Taishar. On average the $\delta^{13}C$ results from BGC are .44‰ less negative than the average from EG. The $\delta^{13}C$ averages from SBR and Taishar are more negative than both BGC and EG. The $\delta^{13}C$ averages from SBR being 1.21‰ more negative than EG and 1.54‰ more negative than BGC.

The results of statistical analyses show that $\delta^{15}N$ values are significantly different between EG and BGC ($p<0.05$), while $\delta^{13}C$ values were not found to be statistically significant at ($p>0.05$), between these two locations. In the cases of Taishar and SBR, $\delta^{15}N$ values were significantly different from both BGC and EG ($p<0.05$), although they were not significantly divergent from one another ($p>0.05$). Significant variation in $\delta^{13}C$ values was found between EG vs. Taishar and SBR and BGC vs. SBR and Taishar ($p<0.05$). However, $\delta^{13}C$ values between Taishar and SBR were not significantly different ($p>0.05$).

The highest $\delta^{15}N$ value was from a Xiongnu Period adult female from BGC (EX08.04b) at 15.46‰. The lowest nitrogen values are from two individuals with $\delta^{15}N$ values of 8.98‰ (EX 07.07) and 10.93‰ (EX 08.18) from BGC and an infant from EG (T-84)at 10.85‰ and also an adult female from EG (T-92) with 10.91‰. These values represent the extreme ends of the distribution from these sites (see Figure 5.4 below). The most negative $\delta^{13}C$ value is from an individual from EG (EX 00.05), an older adult male from a Medieval (Turkic) Period burial with a result of -18.24‰. The least negative $\delta^{13}C$ value is from BGC (EX 08.18) at -12.25‰. BGC EX 08.18 is an older adult female from what is possibly an EIA context. The dating of this particular burial is still under question and this designation may change based on future ^{14}C analysis. At the present time, this designation is based on association with nearby dated burial features as there were no artefacts from this context which could be attributed confidently to a time period.

Figure 5.4 illustrates the results and corresponding averages of the faunal material from EG, BGC and SBR. The results of the faunal material indicate higher average $\delta^{15}N$ for BGC samples at 11.17 ‰ compared to EG at 8.34‰. The average of the 5 samples from SBR had $\delta^{15}N$ signatures of 9.94‰.

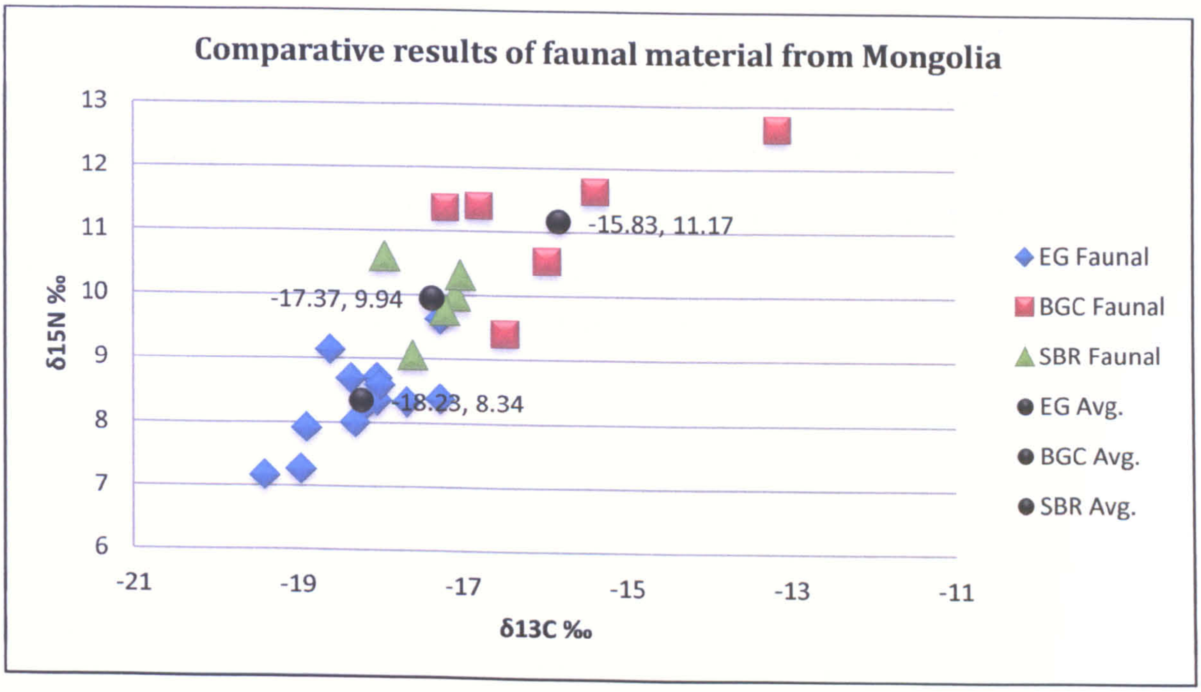


Figure 5.4 Results of δ ^{13}C and δ ^{15}N isotopic values of faunal samples from 3 sites in Mongolia. Average results are indicated for each location. EG n=13, BGC n=6, SBR n= 5.

The δ ^{13}C averages of the faunal material were less negative at BGC at -15.83‰ than EG at -18.23‰. The δ ^{13}C average of the faunal samples from SBR is -17.73‰. The highest δ ^{15}N value is from BGC at 12.64‰ and the lowest is from EG at 7.17‰. The most negative δ ^{13}C value was from EG at -19.40‰ and the least negative is from BGC at -13.16‰.

5.2.3 Discussion

The results of this analysis show marked variation in human carbon and nitrogen isotope ratios between population samples. The results generally reflect the dependence of the individuals from BGC on protein derived from terrestrial animal products, such as meat and dairy resources. The EG individuals appear to have depended on a more mixed dietary input which possibly included a higher proportion of protein from vegetables and wild animals. The results from Taishar and SBR are indicative of a predominant reliance on terrestrial animals and animal products and the inhabitation of arid environments.

The faunal results from the sites of EG and BGC indicate trophic level shifts between humans and their staple food sources as reflected in δ ^{13}C and δ ^{15}N values in both sample sets. Figures 5.5 and 5.6 provide comparisons between human and faunal values from these two sites.

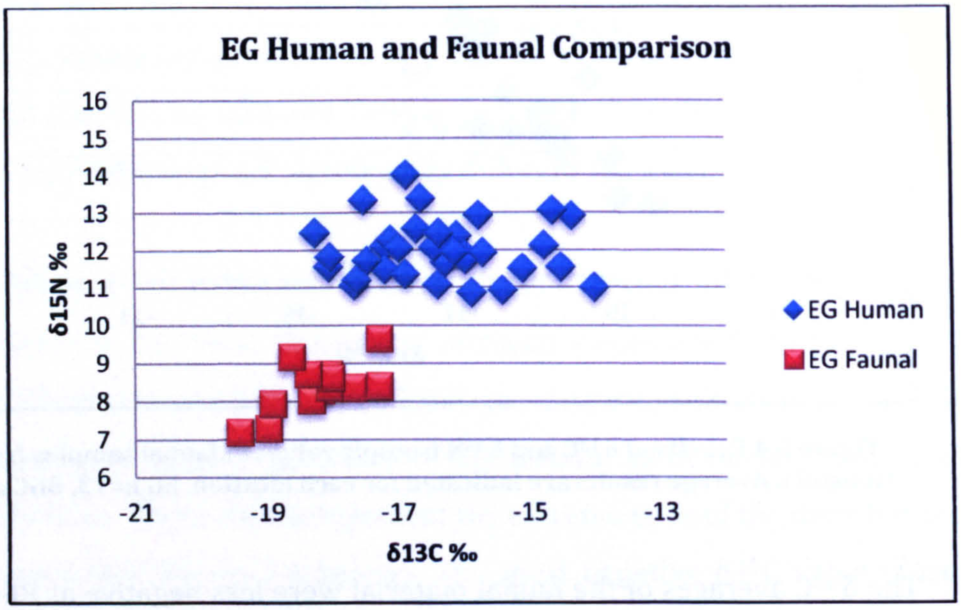


Figure 5.5 Results of δ ^{13}C and δ ^{15}N values for human and faunal material from EG. Human n=34, Faunal n=13.

The EG data clearly shows the distinct trophic level differences between human and faunal values, which are on average 1.93‰ more negative in faunal δ ^{13}C ratios. The difference between δ ^{15}N values are on average 3.66‰ higher in humans than in the faunal material.

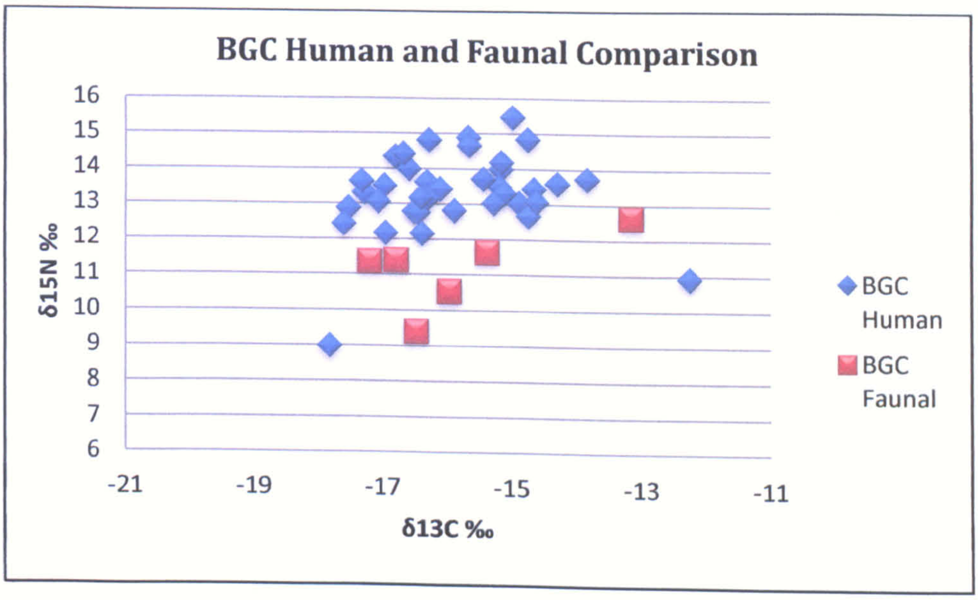


Figure 5.6 Results of $\delta^{13}C$ and $\delta^{15}N$ values for human and faunal material from BGC. Human n=37, Faunal n=6.

The BGC faunal values are somewhat more spread than those from EG but are still distinctive from the human values. The nitrogen values of the faunal material from BGC are higher on average than those from EG and correspond to the high nitrogen values found in human material from BGC. On average the $\delta^{13}C$ values of humans are .03‰ more negative than the faunal material. The average $\delta^{15}N$ values indicate a shift of 2.17‰ higher in human values.

Figure 5.7 illustrates the results of all $\delta^{13}C$ and $\delta^{15}N$ values from the human samples from all sites in Mongolia. The samples generally cluster into distinct groups, although there are some overlapping values, particularly in the $\delta^{13}C$ results from EG and BGC. T-Tests found no significant difference between $\delta^{13}C$ values from EG and BGC ($p>0.05$). As mentioned before, variation in $\delta^{15}N$ values between EG and BGC was found to be highly significant ($p<0.05$). Interestingly, the values from SBR and Taishar both cluster together with elevated nitrogen values and the most negative carbon values. This can be explained largely by environmental factors as these are from the two most arid regions of all the samples in question.

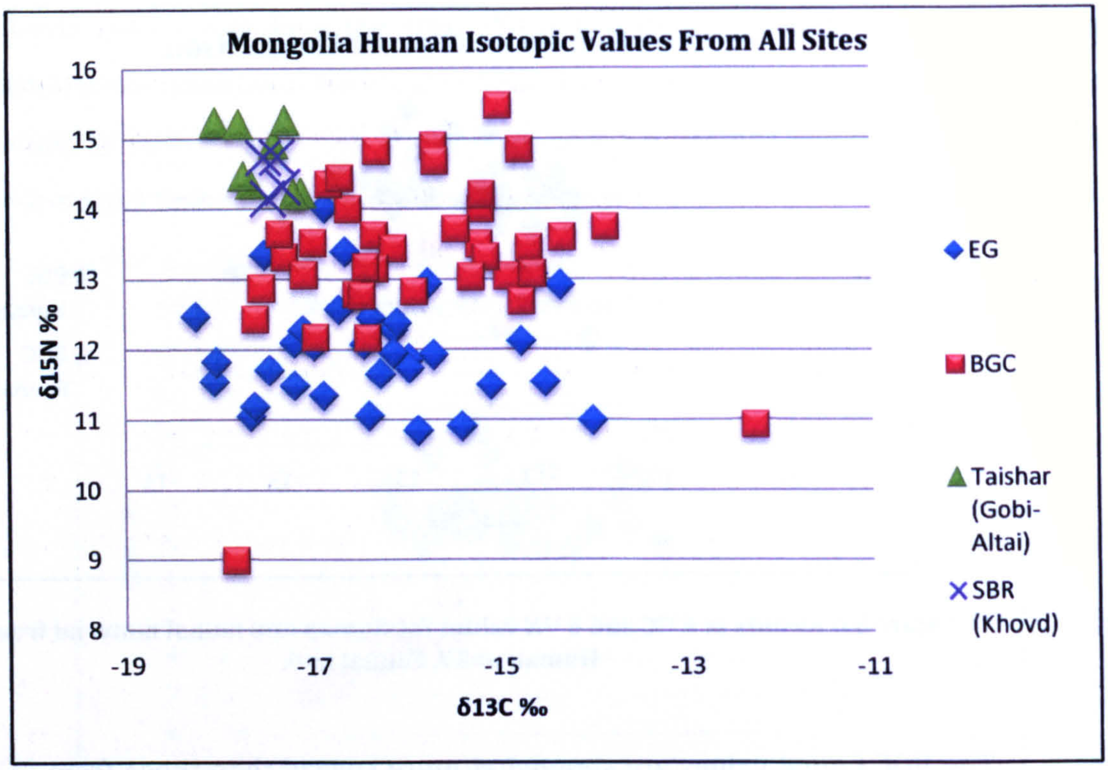


Figure 5.7 Results of δ ^{13}C and δ ^{15}N values from human bone collage from all individuals from sites in Mongolia. EG n= 34, BGC n= 37, Taishar n=8, SBR n=4.

Archaeological evidence suggests that the EG population may have supplemented their diet with aquatic resources as fish bones have been found in some contexts there. The nitrogen values from this sample could be consistent with populations *supplementing* their diet with freshwater fish, although none are as elevated as those from Lake Baikal (Katzenberg et al. 2009). In addition, it is believed that the individuals nearer to Lake Baikal were possibly reliant on freshwater seals and this would significantly elevate nitrogen levels due to the high trophic level of these consumers (Ibid.). Based on this data it is not possible to confidently suggest that the results of a significant level of fish consumption are indicated for the EG sample. However, neither has this possibility been disproven. The δ^{13}C values of the EG sample generally reflect a mixed diet of terrestrial animals with contributions from a mix of C_3 and C_4 plants, though this appears to be predominately C_3. This dietary mixture could have come from local small-scale agriculture production and foraging-hunting-fishing activities, which would have supplemented the main diet based on the consumption of domesticated animals and animal products.

The $\delta^{15}N$ values from BGC, SBR and Taishar are all significantly elevated when compared to the values from EG ($p<0.05$). Environmental circumstances appear to have had an effect on these values. These locations are each characterised by the most extreme temperatures and degree of aridity. A significant reliance on aquatic resources in the diet could produce this level of elevated nitrogen values. However, at these three locations, this possibility is not particularly viable as there are very few *staple* sources of freshwater fish that these groups could have relied upon as a primary dietary source. Therefore, these high values appear to reflect the build-up of nitrogen levels as a result of the consumption of terrestrial animals from water-stressed environments (as discussed earlier in the opening section of this chapter).

The two exceptions in the elevated nitrogen values of the human samples from BGC are the previously discussed individuals (BGC EX07.07 and EX 08.18). The results for BGC EX 07.07 plot directly in the range of a sample set of Early Neolithic individuals from China (Hu et al. 2008) which is indicated in Figure 5.13 in the following section of this Chapter. There are several explanations for these individuals with very low nitrogen values. It is possible that they may have lived most of their lives in some other area where they had a significantly different diet than that which was common at BGC. Alternatively, physiological effects of illness or malnourishment could have influenced these values or for social reasons they may have had a different diet. Unfortunately, BGC EX07.07 was represented by a single bone, so a detailed osteological assessment could not be attempted to substantiate a possible nutritional deficiency. With regards to BGC EX08.18, this individual not only had the 2nd lowest $\delta^{15}N$ value but also the least negative $\delta^{13}C$ value. This individual was represented by approximately 70% of the skeleton and preservation was fair. These are the remains of an older adult female which showed some signs of degenerative changes but nothing that would indicate a serious illness or nutritional deficiency. One possibility to account for this result may be that this individual could have moved to this area within the last years of life and the isotopic values represent a dietary regime from a former location. Another possibility is that for social or health reasons, this individual subsisted on a different diet than others. For both of these individuals their diets were much lower in protein than one would expect from the consumption of terrestrial animals and animal products. The case of BGC EX08.18 in particular, indicates a greater degree of C_4 plant influence in the diet, evidenced from the δ ^{13}C value for this individual.

Isotopic Variation and Sex

Studies in other regions have been able to identify social complexity from dietary variation based on age and sex categories (discussed in Mays 1998; Schutkowski 2008). From the two large sample groups (EG and BGC), all adults that could be sexed were compared to determine if there appears to be any patterning in diet based on this category. Figures 5.8 and 5.9 provide comparative illustrations of the comparison between human values based on sex categories for BGC and EG.

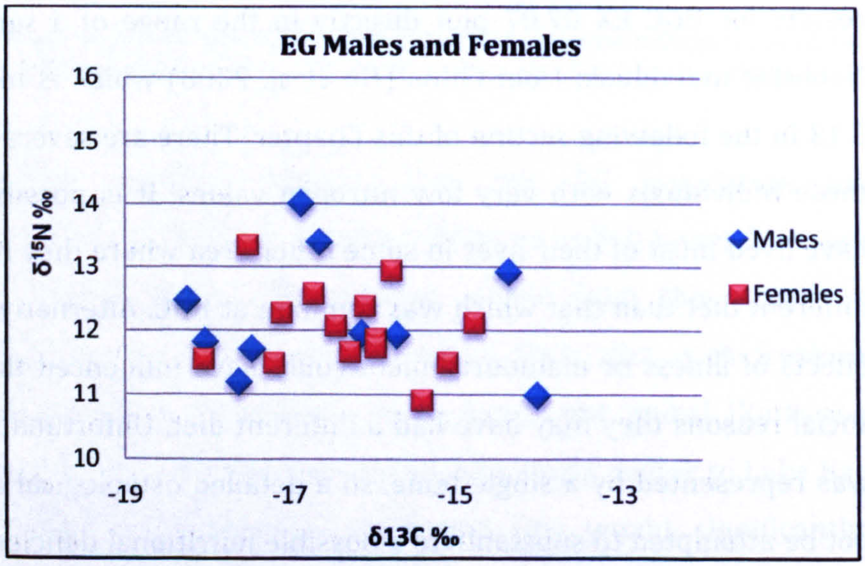


Figure 5.8 Results of δ ^{13}C and δ ^{15}N values for males and females from EG. Males = 10, Females = 14.

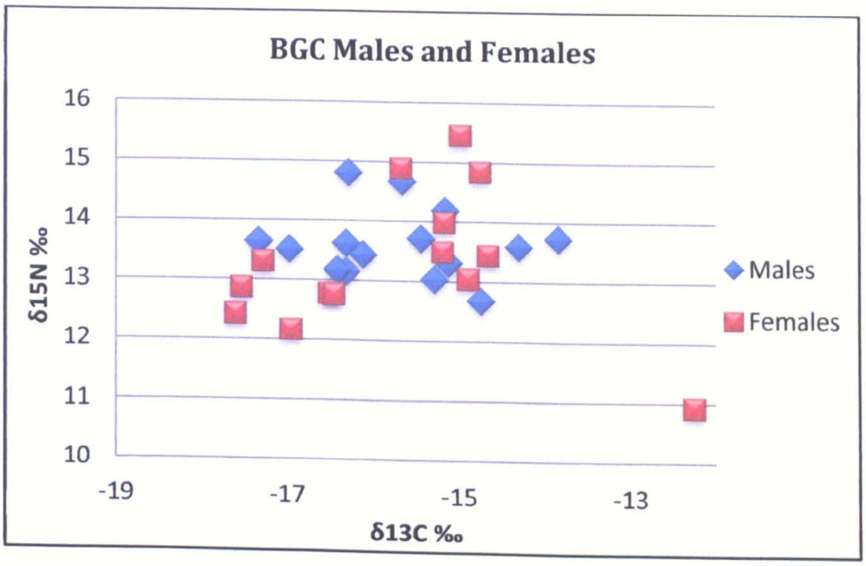


Figure 5.9 Results of $\delta^{13}C$ and $\delta^{15}N$ values for males and females from BGC. Males= 15, Females= 14.

This comparison found no marked patterns in dietary variation based on the sex of individuals at either EG or BGC. At EG males had on average $\delta^{13}C$ values of -16.49‰ and $\delta^{15}N$ values of 12.24‰. Females from EG had average $\delta^{13}C$ values of -16.30‰ and average $\delta^{15}N$ values of 12.03‰. At BGC males had on average $\delta^{13}C$ values of -15.68‰ and $\delta^{15}N$ values of 13.62‰. Females from BGC had average $\delta^{13}C$ values of -15.71‰ and $\delta^{15}N$ values of 13.31‰. T-tests found no significant difference between $\delta^{13}C$ or $\delta^{15}N$ values from either EG or BGC based on sex ($p>0.05$). At BGC the most elevated $\delta^{15}N$ values were found in three females, although on average these nitrogen values were lower than males. At EG the most elevated $\delta^{15}N$ value was from a male individual and on average, males had slightly more elevated values than females. These findings and the distribution of results suggests that overall, males and females shared similar diets at their respective locations.

Isotopic Variation and Age

Comparisons were also carried out on the samples from EG and BGC based on age categories. These were simply divided into adult and sub-adult age groups. Figures 5.10 and 5.11 illustrate the distribution of $\delta^{13}C$ and $\delta^{15}N$ values for individuals based these categories.

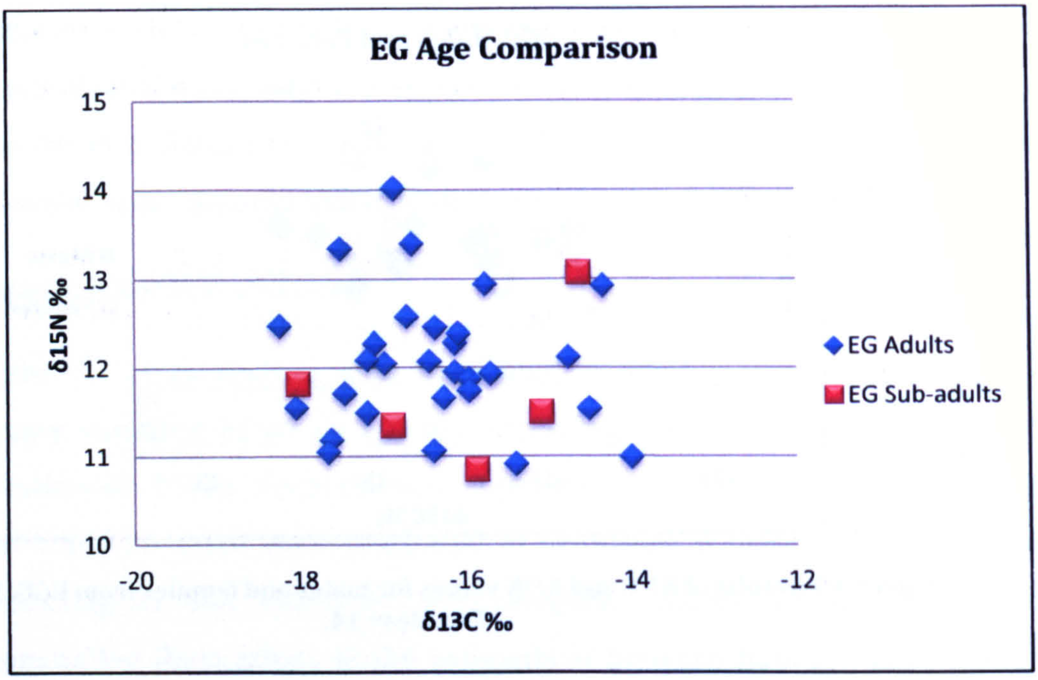


Figure 5.10 Results of δ ^{13}C and δ ^{15}N values for adults and sub-adults from EG. Adults n= 29, Sub-adults n=5.

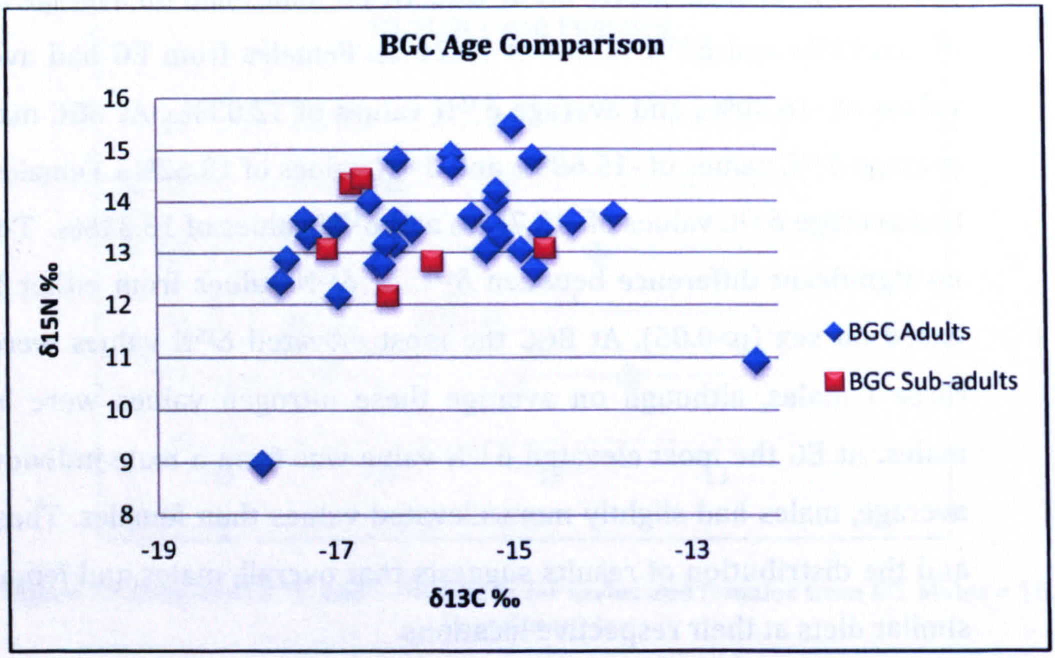


Figure 5.11 Results of δ ^{13}C and δ ^{15}N values for adults and sub-adults from BGC. Adults n= 31, Sub-adults n=6.

The results from EG indicate average δ^{13}C values of -16.38‰ for adults and -16.09‰ for sub-adults. The results of δ^{15}N values from EG show an average of 12.07‰ for adults and 11.72‰ for sub-adults. For BGC the average δ ^{13}C values are -15.79‰ for adults and -16.24‰ for sub-adults. Delta^{15}N values from BGC average 13.34‰ for adults and 13.31‰ for sub-adults. T-Tests found no significant differences between δ^{13}C or δ^{15}N values from either EG or BGC based on age categories ($p>0.05$). Overall, the pattern of results shows similar diets for individuals from both age categories at respective site locations. No strong arguments can be made to support any dietary variation based on age, although it should be pointed out that the samples for sub-adults are quite small at both locations (EG n=5, BGC n=6) and future studies that could include more sub-adult samples would be able to shed more light on weaning practices and childhood diet in general.

Dietary Variation Over Time

An additional area of examination was to compare dietary variation over time at the site of BGC. This assessment was only carried out for this sample set, as this was the only location were sufficient material was available from pre- and post-Xiongnu periods. Figure 5.12 provides an illustration of the distribution of $\delta^{13}C$ and $\delta^{15}N$ values for individuals based on time period.

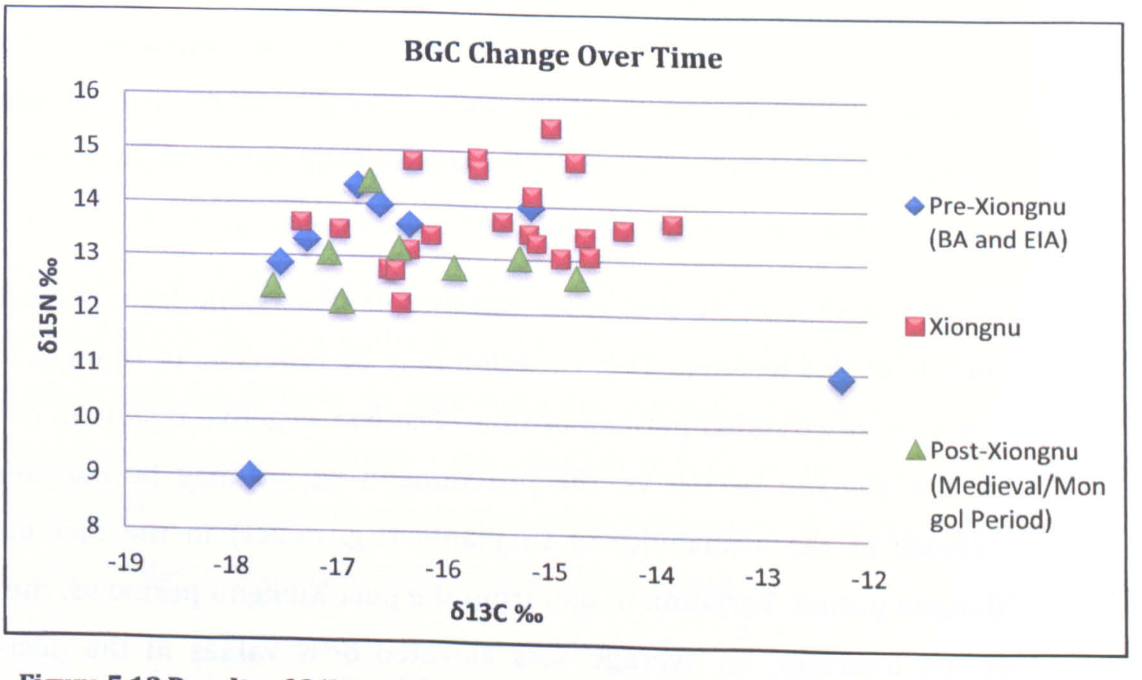


Figure 5.12 Results of $\delta^{13}C$ and $\delta^{15}N$ values of humans from BGC based on time period. Pre-Xiongnu n=8, Xiongnu n=21, Post-Xiongnu n=8.

The results of this particular assessment should be viewed with caution as the datasets available for respective time periods were very small for pre-Xiongnu and post-Xiongnu material. The dataset for pre-Xiongnu period is only 8 samples and those from post-Xiongnu contexts are 8 individuals and 21 individuals are assigned to the Xiongnu period. For pre-Xiongnu average $\delta^{13}C$

values are -16.22 ‰ and for Xiongnu these are -15.55‰. Delta ^{15}N values for pre-Xiongnu average at 12.75‰ and for Xiongnu are 13.70‰. Average post-Xiongnu $\delta^{13}C$ values are -16.33‰ and $\delta^{15}N$ values are 12.97‰. These results show on average more negative $\delta^{13}C$ values for pre-Xiongnu material when compared to the Xiongnu dataset at 0.67‰. Average $\delta^{15}N$ values are 0.95‰ higher for Xiongnu period than pre-Xiongnu period samples. The post-Xiongnu dataset indicates on average 0.78‰ more negative $\delta^{13}C$ values when compared to the Xiongnu period dataset. The average $\delta^{15}N$ values are more elevated by 0.73‰ in the Xiongnu period dataset than in the post-Xiongnu dataset.

All datasets were tested for normality using Kurtosis tests and were found to be within accepted distribution ranges, with the exception of the samples from the pre-Xiongnu period as discussed earlier. Individual BGC EX07.07 was removed from the dataset for comparisons based on $\delta^{15}N$ values. Multi-way ANOVA tests indicate that pre-Xiongnu $\delta^{13}C$ values are significantly different than those from Xiongnu period at p=.018, while $\delta^{15}N$ values were not significantly different at p=.974. Xiongnu period vs. those from later period contexts (Medieval and Mongol periods) were found to be significantly different in $\delta^{15}N$ values at p=.037 but not in $\delta^{13}C$ values at p=.057.

These results indicate that some variation is observable from respective time periods at this location. This variation may be reflective of changes in dietary trends over extended periods of time. The less negative results in $\delta^{13}C$ values for the Xiongnu period vs. the pre-Xiongnu period may be indicative of an increase in the availability of C_4 plants (e.g. millet) in the diet during the Xiongnu period. Variation in diet from the post-Xiongnu period vs. the Xiongnu period indicates, on average, less elevated $\delta^{15}N$ values in the post-Xiongnu period. This may indicate that during this time there was either less reliance on protein from terrestrial animals and animal products which is indicated by lower nitrogen and/or there were more dietary options available from plant products and these results indicate a more mixed diet for these individuals from post-Xiongnu contexts. These are intriguing possibilities but again should be viewed with considerable caution due to the small sample sizes. Future research where more samples are available from respective time periods from a single location would allow for more conclusive observations to be made concerning diachronic variation or continuity in dietary regimes.

5.3 The Implications of the Stable Isotope Analysis from Mongolia in a Wider Context

In order to place these results into a broader contextual framework, comparative datasets from published sources were examined alongside the results from Mongolia. This provides a measure for assessing both spatial and diachronic variation in subsistence regimes from populations across Eurasia as compared with those from the Mongolia samples. Figure 5.13 depicts the $\delta^{13}C$ and $\delta^{15}N$ values of human bone collagen from the Mongolia samples and published datasets.

The datasets in Figure 5.13 are comprised of 10 individuals from the early Neolithic site of Xiaojingshan in northern China, 15 individuals from Neolithic Yangshao sites of northern China, 6 individuals from the Neolithic site of Dereivka in Ukraine, 28 individuals from the Bronze Age site of Khuzir-Nuge XIV located on the shore of Lake Baikal in Siberia, and the respective samples from Mongolia as discussed before. From Figure 5.13 it can be observed that the results from Mongolian samples are generally distinctive from the data from the published sources. However, some overlapping results are observable, particularly in the case of the $\delta^{15}N$ results from SBR and Taishar, with the data from Bronze Age Siberia. As previously discussed, the elevated nitrogen at these sites is likely resultant from a combination of high protein diets of terrestrial animals and animal products coupled with environmental circumstances, rather than from the staple consumption of freshwater fish.

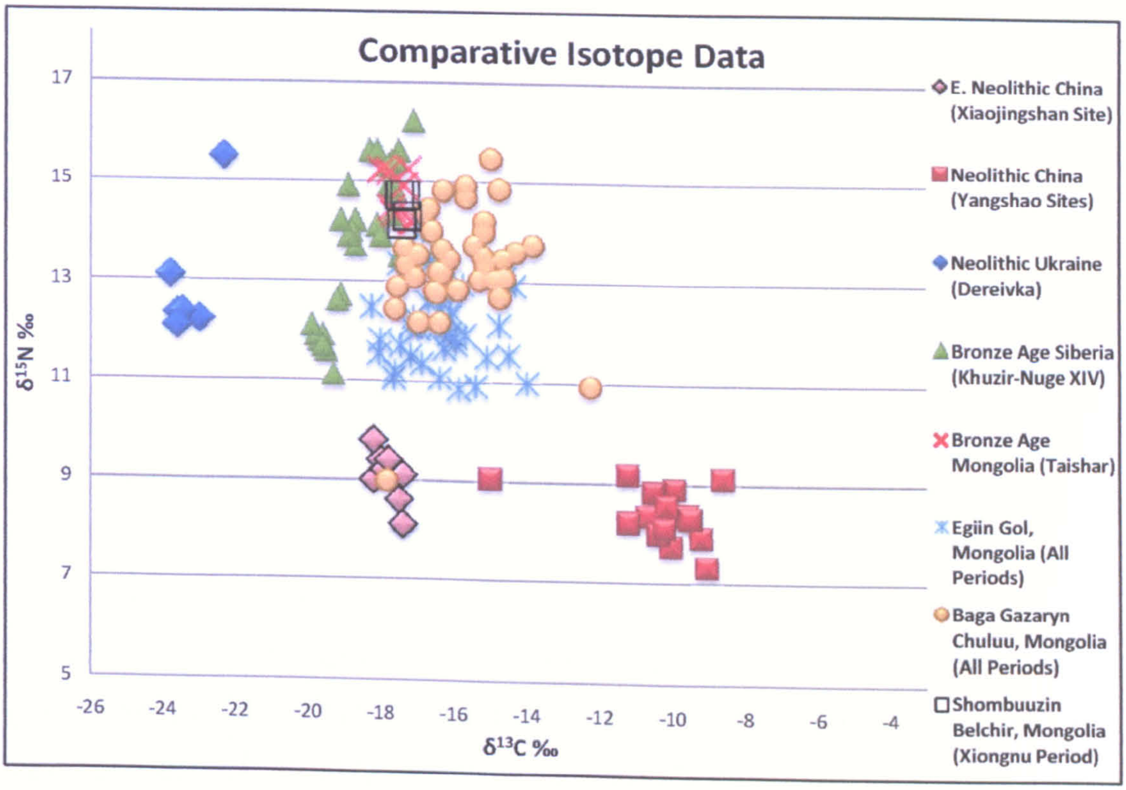


Figure 5.13 Comparison of isotopic results from Mongolia with published datasets. Data for E. Neolithic Xiaojingshan after (Hu et al. 2008), Data for Neolithic China Yangshao Sites after (Pechenkina et al. 2005), Data for Neolithic Ukraine Dereivka after (Lillie et al. 2010), Data for Bronze Age Siberia Khuzir-Nuge XIV Lake Baikal after (Katzenberg et al. 2009).

The most distinctive diets are from the two sample sets from northern China and the sample from the Ukraine. The study of carbon and nitrogen isotopic signatures at the site of Xiaojingshan in northern China provides an indication of human dietary variation from a neighbouring region. The assessment by Hu et al. (2008) examined the $\delta^{13}C$ and $\delta^{15}N$ isotopic signatures in human remains excavated from the early Neolithic period (c. 8000 BP) site of Xiaojingshan attributed to the Houli Culture. The results of this study found that in this early period, millet was not yet established as a significant contributor to human diets to the degree that it would be in subsequent periods. It is also noted that a high proportion of C_3 plants likely contributed significantly to the diet. By comparison with the results from Mongolia it is observed that the $\delta^{13}C$ signatures of these individuals are within the same range. This can be accounted for by the mixed diet of the northern China samples which is comparable to the samples from Mongolia in this aspect. However, the results do reflect the even greater dependence on terrestrial animals and animal products in the samples from Mongolia. The $\delta^{15}N$ signatures are significantly lower in the samples from northern China and also demonstrate that the populations from Mongolia relied more heavily on terrestrial animal products and possibly fish in the case of northern Mongolia. Furthermore, the climatic influence on $\delta^{15}N$ values of the samples from Mongolia, with the exception of EG, has been previously noted.

The study by Pechenkina et al. (2005) examined carbon and nitrogen isotopic signatures in human and faunal remains from Neolithic farming communities from the Yellow and Wei River basins in northern China. This assessment allowed for several inferences to be made about the degree to which millet agriculture contributed to the dietary resources of these Yangshao Culture groups which are dated some 1000 years later than the previously discussed study of the Houli Culture by Hu et al. (2008). The results indicate a dual relationship between the production of millet for human consumption as well as in the use of millet as fodder for animal husbandry purposes (Ibid). The results show very high $\delta^{13}C$ values and low $\delta^{15}N$ for pig and dog remains and are thought to indicate a diet based primarily on the consumption of C_4 plants. By contrast, the $\delta^{13}C$ values from human samples indicate a more mixed diet with consumption of more terrestrial resources and non-C_4 plants foods. However, the human signatures do indicate a significant contribution of C_4 resources in the diet, whether from the consumption of domesticated animals fed on millet or from the consumption of millet itself. These results are in accordance with the general isotopic carbon and nitrogen isotopic signatures associated with the consumption of C_4 staple crops. This can be contrasted with the results from Mongolia which show significantly higher $\delta^{15}N$ values and more negative $\delta^{13}C$ values.

The study by Lillie et al. (2010) provides a broad comparative analysis of carbon and nitrogen isotopic ratios from a number of sites spanning various time periods and locations in Ukraine. A selection of data from the Neolithic cemetery of Dereivka 1, located in the Kirovograd region is indicated in Figure 5.13. The human $\delta^{13}C$ values ranged from -23.74‰ to -21.7‰ and the $\delta^{15}N$

values ranged from 9.9‰ to 10.5‰. It is suggested that the $\delta^{15}N$ values reflect diets of individuals primarily consuming terrestrial resources with the exception of those above 11.8‰ which were possibly consuming more freshwater fish. The $\delta^{13}C$ results are explained by the consumption of terrestrial herbivores and freshwater fish which inhabit different environments (such as shallow or deep water). Other studies have shown that fish with different migratory patterns, habitats and trophic levels will produce a varied range of $\delta^{13}C$ values (Katzenberg and Weber 1999). Thus the consumption of specific fish types will produce a corresponding variation in human values based different dietary habits (such as the consumption of certain types of fish) and this may account for variation in $\delta^{13}C$ values from Dereivka. The elevated $\delta^{15}N$ values are similar to those from Mongolia but the $\delta^{13}C$ values are clearly substantially more negative. This is reflective of a greater reliance on freshwater fish at Dereivka and an overall lack of C_4 influence in the diet.

An understanding of isotopic variation of freshwater ecosystems is directly relevant to the present study as the individuals from EG in northern Mongolia are thought to have relied to some extent on fish from the extensive river systems of the Egiin Gol Valley. This is borne out in the archaeological record by the discovery of fish bones and in ethnographic studies of modern inhabitants of the area. However, the extent to which these individuals relied upon these resources in the past is poorly understood. The extensive isotopic work which has been carried out at Lake Baikal and surrounding environs is beneficial for the present study in order to place these results into a wider context. Additionally, as there were no freshwater faunal samples from the local area available to be included in this study, the data from Lake Baikal currently provides the best means of assessing the results of isotopic data presented here. However, this should be viewed with caution as the Lake Baikal ecosystem is quite unique in composition and thus it is likely that local faunal signatures from the Egiin Gol river system would vary from this location. Therefore, the comparative data from the Lake Baikal region simply provided a means of assessment to place these results into a broader macro-regional context. The study by Katzenberg et al. (2009) analysed human bone collagen for carbon and nitrogen isotopic signatures from individuals excavated from a Bronze Age cemetery, Khuzhir-Nuge XIV, located on the western shore of Lake Baikal. This study found that the consumption of fish and possibly of seals contributed to the $\delta^{15}N$ results. Overall, the results from this study are thought to indicate a mixed-subsistence diet based on both freshwater resources and terrestrial food consumption, though the high nitrogen results are thought to primarily reflect the fish and the possible seal consumption (Katzenberg et al. 2009). The variation in $\delta^{13}C$ signatures of humans, despite the occurrence of no natural C_4 plants in this location, is explained by the variation at the food web base from Lake Baikal. This explanation is substantiated by previous studies of flora and fauna isotopes from Lake Baikal which found that within the freshwater food web, a significant degree of variation occurred between distinct types of fish (Katzenberg and Weber 1999). The results from EG in Mongolia show some overlapping values in $\delta^{15}N$ results, although on average those from Khuzhir-Nuge are more elevated. This is explained by the possibility of a more mixed-diet for the individuals from Mongolia as compared to those from Khuzhir-Nuge.

5.4 Summary and Conclusions

The results and discussion presented here has clearly shown that it is possible to recognise variation in diet from discrete populations inhabiting distinct areas of Mongolia, even in cases where archaeological contexts are remarkably similar. The results for all samples from Mongolia generally fall within expected isotopic ratios associated with a predominant consumption of protein derived from terrestrial animals and animal products as opposed to populations consisting primarily on C_4 agricultural crops. The elevated $\delta^{15}N$ values from BGC, Taishar and SBR provide an indication of the effects of climatic influence on isotopic signatures. This finding reinforces the need for contextualising samples within their local environmental settings in order to account for isotopic variation in discrete populations. The analysis of faunal material has illustrated distinct trophic level shifts between humans and the resources they were predominantly consuming. The assessment of dietary change over time at BGC has provided a starting point for examining possible changes or continuity in subsistence regimes as local circumstances changed, either socially or politically. Even though the results of this area of assessment are tentative at this stage, more comprehensive studies of dietary variation and continuity over time will allow for more conclusive observations to be made concerning dietary regimes and associated subsistence strategies. Finally, the overall findings of this assessment more clearly illustrate and refine our knowledge concerning the degree to which dietary variation can be found both within and between discrete populations from Mongolia. Populations that may be defined under the same archaeological and historical designations, but did not necessarily engage in identical subsistence strategies.

Tables of Isotope Results

Table 5.3 Results of isotopic analysis for all human samples from EG.

Site	Context ID	Time Period	Coll Wt %	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	C:N (atomic)
EG	EG EX 00.4	LBA/EIA	22.9	-17.65	11.05	3.4
EG	EG EX 00.6a	LBA/EIA	21.9	-18.04	11.55	3.4
EG	EG EX 00.9	LBA/EIA	15.9	-17.18	12.09	3.4
EG	EG 00.12	LBA/EIA	2.7	-18.02	11.82	3.3
EG	EX 97.1	EIA	23.5	-17.61	11.19	3.4
EG	EG EX 00.14	Xiongnu	21.4	-14.33	12.92	3.4
EG	EG BUR 45	Xiongnu	0.07	-16.12	12.28	3.3
EG	EG BUR 46a	Xiongnu	10.3	-17.50	13.34	3.3
EG	EX 99.08	Xiongnu	20.2	-16.85	14.01	3.4
EG	EG2 T-12	Xiongnu	22	-16.08	12.38	3.3
EG	BT T-23	Xiongnu	23.9	-14.62	13.07	3.4
EG	EG T-27	Xiongnu	0.06	-16.63	13.39	3.3
EG	EGT32a	Xiongnu	10.3	-16.36	12.45	3.3
EG	EG T33a	Xiongnu	0.05	-17.18	11.49	3.3
EG	BT T-35	Xiongnu	21.3	-14.75	12.12	3.3
EG	BT T-37a	Xiongnu	23.5	-17.45	11.71	3.3
EG	BT T-48	Xiongnu	20.7	-16.26	11.66	3.4
EG	BT T-51	Xiongnu	11	-15.95	11.87	3.4
EG	BT T-52	Xiongnu	26.2	-15.08	11.50	3.3
EG	BT T-54	Xiongnu	0.06	-16.12	11.95	3.3
EG	BT T-56	Xiongnu	23.5	-15.75	12.94	3.4
EG	BT T-60	Xiongnu	21.6	-17.09	12.27	3.3
EG	EGT-64	Xiongnu	0.05	-14.50	11.54	3.3
EG	BT T-68	Xiongnu	22.5	-15.95	11.74	3.4
EG	EGT-72	Xiongnu	0.09	-16.70	12.57	3.3
EG	EGIT-74	Xiongnu	27.8	-16.38	11.06	3.3
EG	BT T-75	Xiongnu	17	-16.97	12.05	3.3
EG	EGT-78	Xiongnu	11.2	-16.43	12.07	3.3
EG	BT T-84	Xiongnu	24.3	-15.86	10.85	3.3
EG	BT T-88	Xiongnu	20.8	-15.69	11.93	3.3
EG	BT T-91	Xiongnu	22.4	-16.87	11.35	3.4
EG	EGT-92	Xiongnu	10.3	-15.39	10.91	3.3
EG	EG EX 00.5	(Turkic/Uighur)	0.06	-18.24	12.47	3.3
EG	EG EX 00.2	Mongol	25.9	-13.99	10.99	3.3

Table 5.4 Results of isotopic analysis for all human samples from BGC.

Site	Skeleton ID	Time Period	Coll Wt %	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	C:N (atomic)
BGC	EX 07.23	BA	19.4	-16.31	13.62	3.3
BGC	EX 08.21a	BA	0.06	-16.80	14.34	3.3
BGC	EX 07.01	LBA/EIA	19.6	-16.59	13.99	3.4
BGC	EX 07.07	LBA/EIA	9.2	-17.82	8.98	3.3
BGC	EX 07.19b	EIA	19.3	-17.28	13.31	3.4
BGC	EX 08.17	EIA	6.4	-17.53	12.87	3.3
BGC	EX 08.18	EIA	17.3	-12.25	10.93	3.3
BGC	EX 08.25	EIA	12.2	-15.17	13.99	3.3
BGC	EX 08.25	LEIA	12.2	-15.17	13.99	3.3
BGC	EX 03.03	Xiongnu	22	-14.89	13.04	3.4
BGC	EX 03.07	Xiongnu	18.2	-13.84	13.73	3.3
BGC	EX 04.01	Xiongnu	14	-15.12	13.31	3.3
BGC	EX 04.02	Xiongnu	16.1	-16.51	12.78	3.4
BGC	EX 04.10	Xiongnu	14.5	-15.66	14.67	3.4
BGC	EX 05.02	Xiongnu	19.6	-15.19	13.49	3.4
BGC	EX 05.05	Xiongnu	18.1	-14.62	13.07	3.4
BGC	EX 06.08	Xiongnu	18.1	-16.39	12.16	3.4
BGC	EX 06.09	Xiongnu	12.5	-16.97	13.51	3.4
BGC	EX 07.16	Xiongnu	18.8	-16.11	13.43	3.4
BGC	EX 07.25b	Xiongnu	23.2	-16.28	14.81	3.3
BGC	EX 08.02	Xiongnu	19.9	-14.75	14.84	3.3
BGC	EX 08.03	Xiongnu	19.8	-15.67	14.89	3.4
BGC	EX 08.04a	Xiongnu	10.9	-17.33	13.64	3.4
BGC	EX 08.04b	Xiongnu	14.4	-14.98	15.46	3.3
BGC	EX 08.05	Xiongnu	16.7	-16.45	12.76	3.3
BGC	EX 08.06	Xiongnu	20.9	-14.66	13.44	3.3
BGC	EX 08.08	Xiongnu	15.7	-14.30	13.59	3.3
BGC	EX 08.13	Xiongnu	22.3	-16.31	13.15	3.4
BGC	EX 08.19	Xiongnu	12	-15.16	14.19	3.3
BGC	EX 05.04	Xiongnu	19.6	-15.44	13.71	3.4
BGC	EX 07.15	Medieval (Turkic)	22.2	-16.68	14.43	3.4
BGC	EX 08.10	Mongol	20	-16.41	13.17	3.4
BGC	EX 08.11	Mongol	24	-17.60	12.43	3.4
BGC	EX 08.12	Mongol	23.1	-14.74	12.68	3.3
BGC	EX 08.14	Mongol	20.7	-17.07	13.06	3.4
BGC	EX 08.15	Mongol	21.8	-15.28	13.03	3.3
BGC	EX 08.16	Mongol	23.1	-16.95	12.17	3.4
BGC	EX 08.22	Mongol	14	-15.89	12.82	3.3

Table 5.5 Results of isotopic analysis for all human samples from Taishar and SBR.

Site	Skeleton ID	TIME PER	Coll Wt %	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	C:N (atomic)
Taishar	TAI 3	BA (khirigsuur)	14.6	-17.39	14.92	3.4
Taishar	TAI 4	BA (khirigsuur)	24.9	-17.10	14.22	3.4
Taishar	TAI 5	BA (khirigsuur)	0.01	-17.64	14.35	3.8
Taishar	TAI 6	BA (khirigsuur)	0.05	-17.72	14.46	3.4
Taishar	TAI 9	BA (khirigsuur)	0.04	-18.02	15.23	3.4
Taishar	TAI 12a	BA (khirigsuur)	13.6	-17.77	15.20	3.4
Taishar	TAI 19	BA (khirigsuur)	14.9	-17.18	14.20	3.4
Taishar	TAI 20	BA (khirigsuur)	15.6	-17.27	15.25	3.4
SBR	SBR12	Xiongnu	21.2	-17.29	14.31	3.4
SBR	SBR13	Xiongnu	23.7	-17.50	14.72	3.4
SBR	SBR14	Xiongnu	23.7	-17.45	14.14	3.4
SBR	SBR18	Xiongnu	22.8	-17.35	14.73	3.4

Table 5.6 Results of isotopic analysis for all faunal samples from EG, BGC and SBR.

Site	Context ID	Time Period	Species	Collagen Wt %	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	C:N (atomic)
EG	EGT12FB	Xiongnu	sheep/goat	10.6	-19.40	7.17	3.3
EG	EGT18FB	Xiongnu	Cow	0.09	-18.16	8.29	3.3
EG	EGT32FB	Xiongnu	Cow	20.4	-18.30	8.01	3.3
EG	EGT37FB	Xiongnu	Cow	21.2	-18.03	8.70	3.4
EG	EGT48FB	Xiongnu	Cow	21.1	-17.67	8.33	3.3
EG	EGT59FB	Xiongnu	Cow	19	-18.03	8.35	3.4
EG	EGT67FB	Xiongnu	Cow	21.2	-18.96	7.27	3.3
EG	EGT77FB	Xiongnu	sheep/goat	17.4	-18.00	8.59	3.3
EG	EGT81FB	Xiongnu	sheep/goat	15.4	-18.35	8.69	3.3
EG	EGT85FB	Xiongnu	sheep/goat	17.3	-18.89	7.92	3.3
EG	EGT85FBC	Xiongnu	Cow	21.5	-17.27	8.38	3.3
EG	EGT87FB	Xiongnu	sheep/goat	16.6	-18.60	9.14	3.3
EG	EGT88FB	Xiongnu	sheep/goat	20.1	-17.27	9.63	3.4
BGC	BGC0302FB	Xiongnu	sheep/goat	19.7	-15.97	10.54	3.3
BGC	BGC0802FB	Xiongnu	sheep/goat	20.7	-13.16	12.64	3.3
BGC	BGC0803FB	Xiongnu	Cow	17.7	-15.38	11.64	3.3
BGC	BGC0804FB	Xiongnu	Cow	0.09	-16.79	11.40	3.3
BGC	BGC0806FB	Xiongnu	sheep/goat	0.09	-17.20	11.37	3.3
BGC	BGC0813FB	Xiongnu	sheep/goat	13.2	-16.48	9.41	3.3
SBR	SBR12FB	Xiongnu	sheep/goat	12.5	-17.08	9.99	3.3
SBR	SBR14FB	Xiongnu	sheep/goat	16.7	-17.60	9.06	3.4
SBR	SBR15FB	Xiongnu	sheep/goat	15.1	-17.94	10.60	3.4
SBR	SBR16FB	Xiongnu	sheep/goat	15.2	-17.21	9.76	3.3
SBR	SBR18FB	Xiongnu	sheep/goat	0.07	-17.02	10.31	3.3

Chapter Six

Reconstructing Health and Activity Patterns from Degenerative Joint Disease and Musculo-Skeletal Stress Marker Analysis

This chapter explores health and activity related patterns of degenerative joint disease and musculo-skeletal stress markers in three population samples from archaeological sites located throughout the study region. This analysis has been applied to the Early Iron Age Pazyryk sample from Siberia, the Xiongnu Period sample from the site of Burkhan Tolgoi, from the Egiin Gol Valley in north-central Mongolia and to the Han Dynasty sample, Tuchengzi from Inner Mongolia. There have been a multitude of prior studies which have focussed on reconstructing health and activity patterns in past populations based on the analysis of degenerative joint disease and musculo-skeletal stress markers (e.g. Bridges 1991; Hawkey and Merbs 1995; Molnar 2006; Molnar et al. 2009; Lieverse et al. 2007; Lieverse et al. 2009). Such studies have assessed archaeological skeletal material from populations throughout the world and from differing time periods. However, comparatively few studies of this nature have been applied to skeletal material from Mongolia and the nearby surrounding regions. This assessment will provide a foundation for future studies which may be applied to comparable populations.

The examination of *musculo-skeletal stress markers*, or MSMs, involves the macroscopic examination of certain muscle and ligament attachment sites on post-cranial skeletal material in order to reconstruct habitual anatomical movement based on particular morphological expressions at these sites. Degenerative joint disease assessment, or DJD, consists of the macroscopic examination of degenerative changes observed on skeletal material at particular joint locations. It has been suggested that the patterning of DJD is largely resultant from long-term habitual anatomical movements which have impacted certain joint locations (Larsen 1997). Additionally, Waldron (1994) has noted that because the condition is not found at fixed (immovable) joint locations, such as those of the cranial sutures, it is likely that habitual anatomical movements *are* a primary cause of the condition.

This assessment has been carried out to examine variation and similarities in MSM and DJD expression both within and between samples and based on sex and age categories whenever possible. This type of enquiry allows for observations to be made concerning the relationship between DJD and MSMs with variation in activities associated with subsistence economies, environmental settings and cultural practices, as well as with genetic and biological factors. In some cases, researchers have been critical of the study of MSMs and DJD as a measure for determining physical activities (Waldron 1994; Jurmain 1999). While others maintain that there is value to this type of assessment if due caution is exercised, methodology is clearly reported and results are critically evaluated (Stirland 1991; Stirland 1998; Larsen 1997; Lieverse et al. 2007). The approach adopted here is one of caution, wherein musculoskeletal markers and degenerative joint disease patterns have been assessed for providing a broad indication of habitual anatomical movements, workload variation and joint disease prevalence, without determining *specific* activities or 'occupations' (as advised in Knüsel 2000). Throughout this chapter, other studies pertaining to the relationship between MSMs, DJD and specific activities are discussed with the full knowledge of the limitations of such types of assessments. Their inclusion is in order to provide a comparative basis for evaluating the results generated from the present study. In addition to reconstructing activity patterns, DJD analysis has been carried out to provide an indication of overall group health, based on the severity and prevalence of the condition as it is represented both within and between sample groups. In addition, both MSMs and DJD do have multifactorial aetiologies and these should be kept in mind. Other factors which can influence the prevalence, severity and patterning of DJD and MSMs include age, weight, genetics, health and diet (Jurmain 1999). However, in studies of prehistoric skeletal material, body weight appears to be less of an issue. The review of osteoarthritis studies carried out by Weiss and Jurmain (2007) suggested that the correlation between a higher body mass index and DJD appears to be a modern-day occurrence associated with rising levels of obesity. Additional factors related to the occurrence of MSM and DJD expression include workload, mobility patterns and physiological stresses, which have impacted particular joints and muscle and ligament attachment sites.

6.1 Samples Utilised for Degenerative Joint Disease and Musculo-skeletal Stress Marker Analysis

The samples used for both the DJD and MSM assessment are comprised of three groups which were also included in the dental pathology assessment from Chapter Four. As mentioned, the three samples included here are from the Early Iron Age, Pazyryk sample from the Gorny Altai region, Siberia, the Iron Age, Xiongnu Period sample from the site of Burkhan Tolgoi in the Egiin Gol Valley, Mongolia and the Han Dynasty sample, Tuchengzi, from Inner Mongolia. The sample ID's for this chapter are Sample 1 PAZ =Pazyryk, Sample 2 EG= Egiin Gol and Sample 3 TUCH= Tuchengzi. Descriptions of the archaeological background for each of these samples are provided in Chapter Four. The sample ID's for these samples from Chapter Four are Sample 2 PAZ (Sample 1 here), Sample 8 EG (Sample 2 here) and Sample 5 TUCH (Sample 3 here). Figure 4.4 Chapter Four, indicates the location of each site. Table 6.1 below indicates the sample ID's and relevant demographic information for each sample.

Only fully adult individuals were included in this assessment, as individuals still in the early stages of physical development would not exhibit the evidence of accumulated stresses at the relevant muscle and ligament attachment sites (Robb 1998) and are not commonly affected by degenerative joint disease (Jurmain 1999). Individuals with long bones with visible epiphyseal lines were excluded from the study. Wherever cranial material could not be matched to long bone elements and wherever no innominates were present, sex was determined based on long bone robusticity measurements (following ageing methods discussed in Chapter 3). A total of 110 individuals were included in this study. Of these individuals, 70 were assigned as male and 40 were assigned as female.

Table 6.1 Sample Information for DJD and MSM assessment with age and sex breakdown provided. Y=younger adult, M=middle adult, O=older adult and A= Adult. Individuals that could not be more precisely aged were designated only as 'Adult'.

Sample	Time Period	Sample ID	Total Males	Total Females	Age Breakdown		Total Individuals
Multi-sites of the Gorny Altai, Siberia	Early Iron Age (Pazyryk)	Sample 1 PAZ	13	9	Y	4	22
					M	8	
					O	4	
					A	6	
Burkhan Tolgoi, Egiin Gol, Mongolia	Iron Age (Xiongnu Period)	Sample 2 EG	27	15	Y	6	42
					M	26	
					O	7	
					A	3	
Tuchengzi, Inner Mongolia	Iron Age (Han Dynasty)	Sample 3 TUCH	30	16	Y	2	46
					M	6	
					O	2	
					A	36	
Total Sample							**110**

Several additional concerns pertaining to these samples must be noted here, particularly with reference to the assignment of specific adult age categories. The foremost complication for both the analysis of MSMs and DJD was the inability to precisely account for age in these particular samples. More specifically, Sample 3, the Tuchengzi sample from Inner Mongolia proved the most complicated in this regard. Due to curation practices, wherever long bones were collected and stored separately from other skeletal elements, it was impossible to determine a precise age category for the majority of these individuals. In most instances, long bone elements such as femora and humeri were grouped together and stored separately from crania. Other elements, such as innominates and ribs, were either not collected or were not available for analysis. As this material is necessary for post-cranial skeletal age-at-death estimation, it was impossible to assign more specific estimations based solely on long bone material. Individuals with severe joint disease or strong MSMs could have been excluded upon the assumption that they were of an advanced age, but this would have imposed a circular bias on the assessment. In the case of the other two samples, some individuals could be more precisely aged by matching crania to the long bone elements and by virtue of the fact that more complete skeletal material was available. However, these samples were small once divided into age categories, particularly Sample 1 PAZ. In cases where post-cranial material could not be matched to corresponding crania and where no skeletal elements used for ageing were available, these individuals were designated simply as 'Adult'. Table 6.1 provides the breakdown of each sample into respective age categories. Age ranges are younger= 17 to 25, middle= 25 to 45 and older = 45+. Six individuals in Sample 1 PAZ, three individuals in Sample 2 EG and thirty-six individuals in Sample 3 TUCH could not be assigned to a specific age category and were designated as Adult.

6.2 Methods Utilised for Degenerative Joint Disease Assessment

In each of the three samples, post-cranial skeletal material was assessed macroscopically for the presence of DJD at four joint locations. In most cases there were very few, or zero vertebral elements available for observation and as a result of this, spinal joint disease could not be assessed. In addition, it is well-understood that to diagnose specific types of joint disease, complete skeletons are ideal. This is particularly the case when one wishes to establish the presence of certain conditions, such as rheumatoid, psoriatic or gouty arthritis (Rogers 2000). However, the aforementioned difficulties involving the degree of skeletal completeness in these samples made a more specific assessment of this nature prohibitively difficult. Despite these aforementioned concerns, the focus on four main synovial joints has provided a measure for assessing joint disease as it is related to habitual anatomical movements, the degree of physical workload and group health.

For this study, DJD was assessed in each sample by observing morphological changes on the skeleton at four major joint locations, namely the elbow, shoulder, hip and knee. Other terminologies commonly employed to denote degenerative pathological changes in articular joints are osteophytosis, osteoarthritis and osteoarthrosis (in the case of vertebral bodies) (Larsen 1997). For the purposes of this study, the more general term *degenerative joint disease* has been employed in order to avoid implying that the pathology documented here may have been accompanied by inflammatory responses at the joint locations, which does not always occur (Ibid). The pathological processes associated with joint disease generally include two types of reactive developments which are found on the skeleton. These developments occur as either new bone formation, such as the growth of osteophytes or as bone degeneration, which can result in pitting on the joint surface (Roberts and Manchester 2005). For this assessment, the prevalence and severity of the condition was determined based on the presence and degree of several common characteristics which are considered to be indicative of degenerative joint disease. These characteristics include lipping or marginal osteophytes, porosity and eburnation (Roberts and Manchester 2005). For each joint location, specific surfaces were examined to determine if any of these features were present. Two surfaces were examined for the shoulder joint. These were the glenoid fossa of the scapula, and the proximal articular surface of the humerus. Four surfaces were examined for the elbow joint. These were the trochlea and capitulum of the distal humerus and the corresponding articular surfaces of the proximal radius and ulna, including the radial notch of the ulna. For the hip joint, the acetabulum of the innominate bone and the corresponding articular surface of the proximal femur were examined. Two locations were assessed for the knee joint, the distal femur and the corresponding articular surface of the proximal tibia.

When one or more of the features, i.e. lipping, porosity, or eburnation, was present at a particular joint location, with the exception of marginal osteophytes (lipping), this was sufficient criteria to merit a score based on the presence and severity of the condition. Figures 6.1 and 6.2 provide an illustration of moderate and severe degenerative joint disease at two separate joint locations. The occurrence of marginal osteophytes had to be accompanied by one of more of the other features in order to merit a score for the presence of DJD, as advised by Rogers et al. (1987). The scoring system utilised, was based on that by Bridges (1991) with modified descriptions for each category based on the scoring system available in Steckel et al. (2005: 32) and is as follows:

0= No trace

1=trace or minimal (slight marginal osteophytes coupled with discernable degenerative/productive changes to the joint surface)

2=minor (moderate changes to the joint surface with osteophytes less than about 3mm)

3=moderate (more extensive changes to the joint surface with at least 50% of the area affected and marginal osteophytes greater than 3mm)

4=severe (extensive or complete modification of the joint surface and/or joint fusion, at least 80% of the joint surface affected)

Figure 6.1 Moderate DJD in Proximal Radius and Ulna from Iron Age Xiongnu Sample 2 EG, north-central Mongolia (image Author 2008).

Figure 6.2 Severe DJD in Distal Femurs from Iron Age Han Dynasty Sample 3 Tuchengzi, Inner Mongolia (image Author 2008).

The scores recorded for each individual were combined into an arthritis (joint disease) index. The arthritis index was calculated by dividing the total number of joint surfaces scored for each joint location, by the sum total of the arthritis scores and is averaged for groups of individuals based on age and sex categories. Arthritis indexing is the most appropriate method for assessing joint disease for this particular study, because of the generally incomplete nature of the skeletal samples. The arthritis index provides a true prevalence rate and additionally allows for incomplete skeletal material to be included in the study. Severity is reflected in the sum of arthritis scores and prevalence is taken into account by the total number of joint surfaces which were scored. All results were assessed for significant differences in DJD expression within and between samples, for both males and females, using two-tailed T-tests specifying unequal variances. Significance value was set at $p=0.05$. Significance testing was carried out using absolute values for each sample set rather than averages.

6.2.1 Results of the Degenerative Joint Disease Assessment

The results of the degenerative joint disease assessment are displayed in separate arthritis indexes for each sample. Table 6.2 provides the results of the assessment for Sample 1 PAZ. Within this sample a greater prevalence and severity of DJD was observed for males at all joint locations. Within the male sample the variation in DJD for each joint location was not found to be statistically different ($p>0.05$ in all cases). For the female sample, only the variation in DJD between the shoulder and the hip joints was found to be significantly different ($p<0.05$).

Table 6.2 Joint disease index for Sample 1 PAZ, Early Iron Age samples from Gorny Altai. NJS= number of joint surfaces, SAS= sum of arthritis scores, SAS/NJS= average arthritis score.

Sample 1 PAZ				
Arthritis Index	Sex	NJS	SAS	SAS/NJS
Shoulder	Males	16	19	1.19
	Females	16	14	0.88
Elbow	Males	59	68	1.15
	Females	52	33	0.63
Hip	Males	25	29	1.16
	Females	21	15	0.71
Knee	Males	41	45	1.1
	Females	27	11	0.41

The most severely affected joint for both males and females was the shoulder joint. The least affected joint in this sample was the knee joint for both males and females. Variation in DJD between males and females at the shoulder and hip joints was not significant ($p>0.05$), while the results at the elbow and knee joints was significantly different between males and females ($p<0.05$).

Table 6.3 Joint disease index for Sample 2 EG, Xiongnu sample from Egiin Gol, north-central Mongolia. NJS= number of joint surfaces, SAS= sum of arthritis scores, SAS/NJS= average arthritis score.

Sample 2 EG				
Arthritis Index	Sex	NJS	SAS	SAS/NJS
Shoulder	Males	59	57	0.97
	Females	30	22	0.73
Elbow	Males	122	71	0.58
	Females	72	35	0.49
Hip	Males	60	60	1
	Females	30	18	0.6
Knee	Males	73	52	0.71
	Females	33	21	0.64

Table 6.3 provides the results of the index for Sample 2 EG. The results for this sample also illustrate a greater degree of severity and prevalence of DJD for males, at all joint locations. The most affected joint for males was the hip joint, whilst for females, it was the shoulder joint. The least affected joint for both males and females was the elbow joint.

For the males in Sample 2 EG, the DJD results for the shoulder vs. the elbow joints and the elbow vs. the hip joints was found to be significantly different (p<0.05). All other cases were not found to be statistically different for males. For females, no variation in DJD between the four joint locations was found to be statically different (p>0.05 in all cases). The variation between males and females at the shoulder, elbow and knee joints was not significant (p>0.05), whilst the difference between males and females for the hip joint was significant (p<0.05).

Table 6.4 Joint disease index for Sample 3 TUCH, Han Dynasty sample from Inner Mongolia. NJS= number of joint surfaces, SAS= sum of arthritis scores, SAS/NJS= average arthritis score.

Sample 3 TUCH				
Arthritis Index	Sex	NJS	SAS	SAS/NJS
Shoulder	Males	28	38	1.36
	Females	19	23	1.21
Elbow	Males	92	89	0.97
	Females	55	56	1.02
Hip	Males	43	82	1.91
	Females	22	23	1.05
Knee	Males	56	77	1.38
	Females	28	23	0.82

Table 6.4 provides the results of the DJD assessment for Sample 3 TUCH. In this sample, a greater degree of severity and prevalence of DJD was observed for males at all joint locations, with the exception of the elbow joint, where females had a higher incidence and severity of the condition. The most severely affected joint for males was the hip joint, while females were mostly affected at the shoulder joint. The least affected joint for males was the elbow joint and the least affected joint for females was the knee joint.

For males in Sample 3 TUCH, DJD results for all joint locations were found to be significantly different (p<0.05), with the exception of the shoulder vs. knee joint (p>0.05). Variation in DJD for females in this sample was not found to be significantly different for all joints (p>0.05). The results of DJD variation in the shoulder and elbow joints between males and females was not significant (p>0.05). However, variation in the condition at the hip and knee joints was found to be significantly different between males and females (p<0.05).

Figures 6.3 and 6.4 illustrate the distribution of DJD in respective age categories for Sample 1 PAZ and Sample 2 EG. Sample 3 TUCH was not included in the age distribution assessment due to the aforementioned problems with assigning age ranges for this material. The results of DJD distribution for age categories illustrate an increase in the condition through the successive age categories. Two exceptions can be observed in Sample 1 PAZ for the elbow and knee joints, where middle adults have higher severity and prevalence of the condition than older adults. T-tests found no significant distribution in the results for both joint locations between middle and older adults ($p>0.05$).

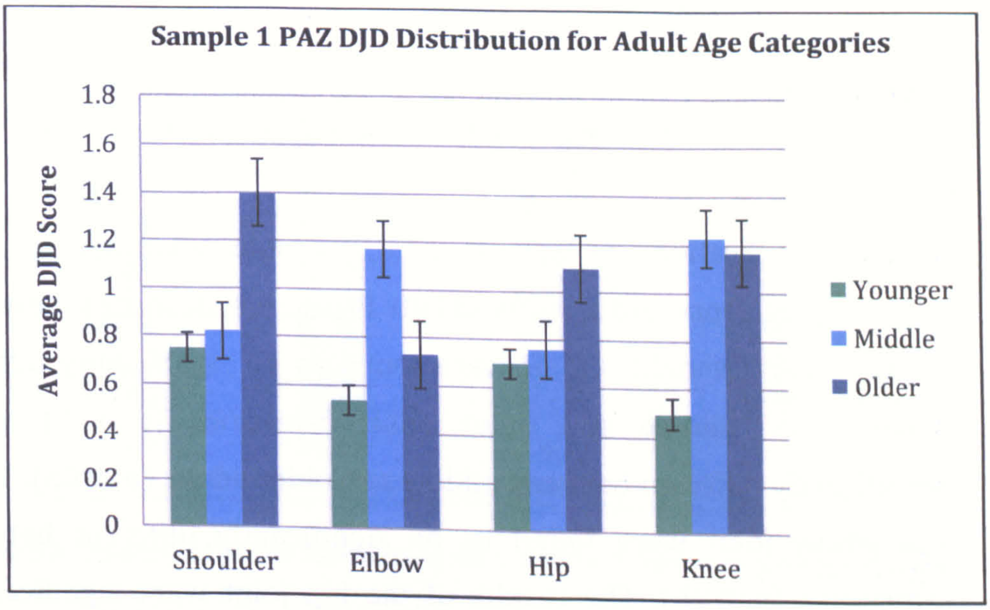


Figure 6.3 Sample 1 PAZ, DJD distribution by age category. Younger= 17 to 25, Middle= 25 to 45, Older= 45+. Error bars indicate standard error.

However, T-tests did find significant variation between the young adult and middle adult age categories and between young and old age groups at the elbow joint ($p<0.05$). T-tests found no significant variation between any groups for the hip joint ($p>0.05$), while at the knee joint, young adults vs. middle and older adults was found to be significant ($p<0.05$). However, variation between middle and older adults for the knee joint was not significant ($p>0.05$).

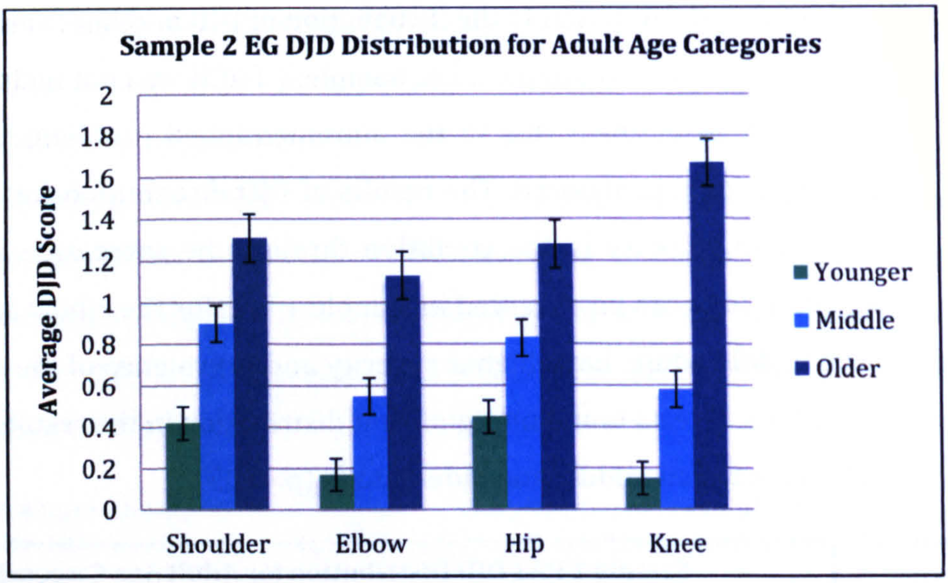


Figure 6.4 Sample 2 EG, DJD distribution by age category. Younger= 17 to 25, Middle= 25 to 45, Older= 45+. Error bars indicate standard error.

At all joint locations for Sample 2 EG, the older adult age category had the highest prevalence and severity of DJD. Figure 6.4 illustrates these findings. The results of the shoulder joint were found to be significantly different for the younger vs. middle and older adult categories ($p<0.05$), but was not significantly different between middle and older adults ($p>0.05$). The results for the elbow joint were found to be significantly different between all age categories ($p<0.05$). The results of the hip joint were significantly different between younger and older adults ($p>0.05$) but not between younger and middle adults or middle and older adults ($p>0.05$). The greatest variation between the age groups can be observed in the results for the knee joint, where younger adults had an average arthritis index score of 0.15, while older adults had an arthritis index score of 1.67. For the knee joint, variation between all age groups was found to be statistically significant ($p<0.05$).

Figures 6.5 and 6.6 provide illustrations of comparative DJD results between samples for males and females for each group. Figure 6.5 provides the results of the assessment for males. The highest degree of severity and prevalence of the condition was from Sample 3 TUCH for the shoulder, hip and knee joints. Sample 1 PAZ had a slightly higher incidence of the condition at the elbow joint. T-tests indicate that variation between Sample 3 TUCH and Sample 2 EG at the shoulder and elbow joints is significant ($p<0.05$). In addition, variation between Sample 3 TUCH and Sample 2 EG at the hip and knee is also significant ($p<0.05$). Significant difference was also noted between Sample 1 PAZ and Sample 3 TUCH at the hip joint ($p<0.05$), but not at the knee joint ($p>0.05$). No significant difference was found between Sample 1 PAZ and Sample 2 EG for all joint locations ($p>0.05$).

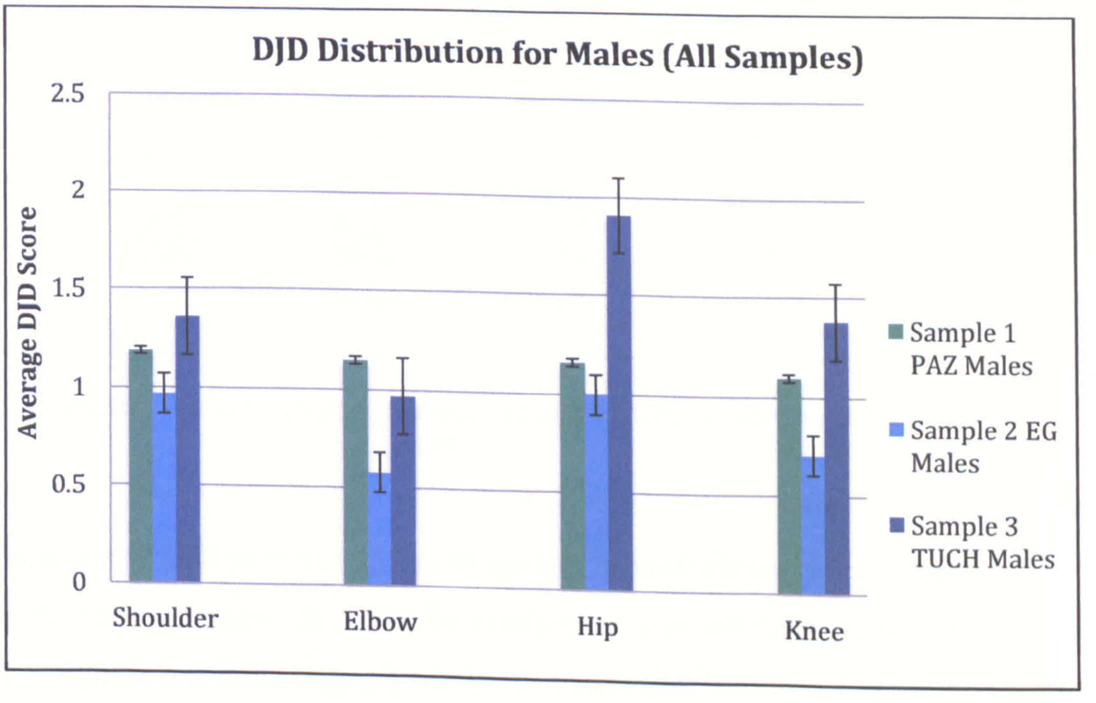


Figure 6.5 Results of DJD for Males from All Samples. Error bars indicate standard error.

Figure 6.6 illustrates the variation in DJD for females from each sample. For all joint locations, females from Sample 3 TUCH had the highest degree of severity and prevalence of the condition. The results between Sample 1 PAZ and Sample 2 EG are similar for all joint locations, with the greatest variance between the two samples at the knee joint.

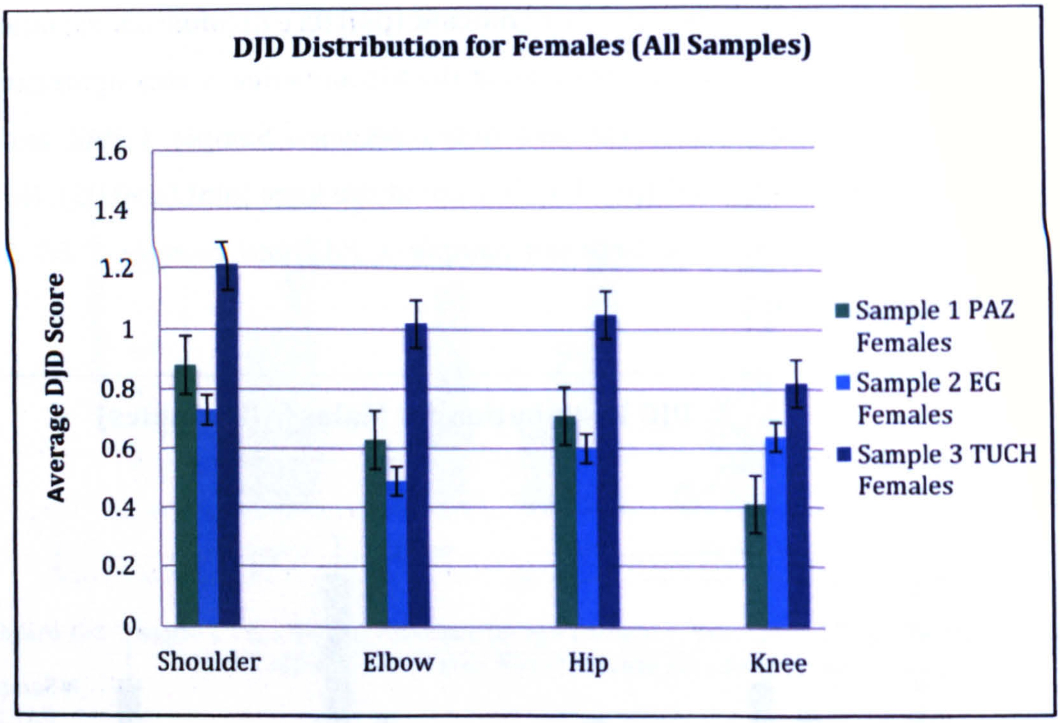


Figure 6.6 Results of DJD for females from all samples. Error bars indicate standard error.

Sample 2 EG had the lowest degree of DJD in the shoulder, elbow and hip joints. The sample with the lowest instance of DJD at the knee joint was Sample 1 PAZ. T-tests indicate that differences between Sample 2 EG and Sample 3 TUCH were significant for the elbow joint results ($p<0.05$). All other joint locations between samples for females were not significantly different ($p>0.05$).

6.2.2 Discussion of the Degenerative Joint Disease Assessment

The results of the DJD assessment allow for several observations to be made concerning the distribution of the condition both within and between samples. The variation in prevalence and severity at certain joint locations can be attributed to a number of factors which are discussed below. Even though it is recognised that aspects such as age and weight influence the development of DJD, the results of variation in bio-mechanical stresses related to repetitive physical activity are observable here as well. In addition, other studies have found that degenerative joint disease in the major lower limb joints, i.e. the hip and knee is commonly found to be more prevalent and severe than those of the upper limb i.e. the shoulder and elbow (discussed in Bridges 1992). This was suggested to be resultant from the greater degree of anatomical stresses which are placed upon these joints, because of their weight-bearing properties (Ibid). In some cases, this appears to be reflected in the results generated from the present study.

Degenerative Joint Disease and Age

In the two samples where distribution of DJD according to age categories could be assessed, several observations can be made. Overall, an increased prevalence and severity of the condition is in evidence in most cases, throughout the successive age categories. The two exceptions where this was not the case was in Sample 1 PAZ for the elbow and knee joints. This sample showed a slightly higher prevalence and severity of the condition in middle adults vs. older adults for these joints. This result is most likely an artefact of the small size of Sample 1 PAZ once divided by age category. When divided by age groups, this sample had only four individuals in the older adult age category. No significant difference was found between the middle and older adult age categories for these joints, which further supports this probability. With the exception of the hip joint, all other joint locations showed significant differences between younger adults vs. middle and older adult age categories. These results indicate that there is a significant increase in the condition throughout the adult life-span, but this variation appears to be comparatively less marked between middle and older adults than with younger adults. The results of DJD assessed by age category for Sample 2 EG are largely analogous with Sample 1 PAZ. For all joint locations, the greatest prevalence and severity of the condition was in evidence for the older adult age category. This result is indicative of the continuation of physical activity and skeletal degeneration throughout the duration of adult life. This finding suggests that *anatomically* demanding activities did not taper off at any point throughout the life-span. Similarly to Sample 1 PAZ, the results for younger adults vs. middle and older adults demonstrate more significant variation between these groups than with middle vs. older adults, indicating a more marked difference in DJD between the youngest and oldest adults in this group.

Sample 1 PAZ DJD Discussion

The results of the DJD assessment for Sample 1 PAZ indicate that males exhibited a similar degree of prevalence and severity of the condition at all joint locations based on the results of the arthritis index. Even though the shoulder joint was the most affected, this was not significantly higher; while at the same time, results for the knee joint were not significantly lower than any other. This finding suggests that there may have been no *specific* physical activity carried out by males that placed undue stress on one particular joint over the other, at least to any significant degree. For females in this sample, the findings are similar in that there was no significant variation in the condition between joints, with the exception of the shoulder vs. the hip joint. This indicates that a greater degree of degenerative processes affected females at the shoulder joint to a more significant degree, as compared to the hip joints. In addition to the other aetiological factors mentioned before, this may be resultant from the possibility that females carried out some type of habitual anatomical movement that placed more strain on the shoulder joint or upper limbs rather than at the hip joint.

Sample 1 PAZ: Comparison of Males vs. Females

The comparison between males and females in this sample found that the joints were similarly affected between the two groups. Similarities arise in that the most affected joint was the shoulder and the least affected was the knee. In addition, the variation between males and females at the shoulder joint was not found to be significantly different; indicating that at this joint location, both groups were similarly affected. This is also the case for the hip joint, where results were not significantly different. Significant difference in DJD was found between males and females for the elbow joint and for the knee joint. This may indicate that variation in habitual activities is reflected in the divergent findings for these two joints, although genetic and environmental factors, as ever, cannot be ruled out. As Larsen (1997) has pointed out, in most prehistoric populations, regardless of major subsistence economy or socio-cultural variation, males tend to exhibit higher levels of osteoarthritis than females. The results of the present study found that males had a greater prevalence of DJD in most instances, although this was not always significantly greater. By comparison, in modern populations females are more often affected by osteoarthritis, but this dimorphism is most apparent after the age of menopause in women and more commonly affects the knee joint (discussed in Larsen 1997; Weiss and Jurmain 2007). The significant variation at the elbow joint between males and females in this sample may be indicative of divergent physical activities between the two sexes. The study by Bridges (1991) found that variation in DJD patterns in females corresponded with habitual anatomical movements associated with different types of food processing activities carried out across several prehistoric samples from North America. This comparison is not meant to suggest that the variation found in Sample 1 PAZ at the elbow joint is related to grain processing, but rather to illustrate the possibility that some activity carried out by males may have been a significant factor in the development of DJD at this joint as compared to the results for females. This is further supported by the fact that the upper limb joints are less affected by an individual's weight because they are non-weight bearing.

Sample 2 EG DJD Discussion

The results for Sample 2 EG indicate that DJD was more prevalent in males rather than females at all joint locations. The joint most affected in males was the hip, while the joint least affected in males was the elbow. For males, the variations between the results of the shoulder joint vs. those of the elbow joint were found to be statistically different. This finding indicates that the shoulder joint was affected to a greater degree by aetiological factors of the condition than the elbow. This result may be indicative of a greater degree of habitual movement carried out at the shoulder joint as opposed to the elbow joint in males. For females, the joint most affected was the shoulder joint and, like males, the least affected joint was the elbow. No statistically significant difference was found between the results for any joint location for females.

Sample 2 EG: Comparison of Males vs. Females

The comparative results between males and females indicate that at all joint locations, males exhibited higher average scores. The only statistically significant difference between males and females was for the hip joint where males had a score of 1 and females a score of 0.6. This occurrence may be the result of several factors such as greater anatomical stress in males from increased body mass or some physical activity carried out by males which was not carried out by females or at least one which did not affect them to the same degree. The results for the other joint locations were similar for both males and females and do not exhibit a significant degree of sexually dimorphic differences in DJD prevalence.

Sample 3 TUCH DJD Discussion

The results for Sample 3 TUCH indicate that the most severely affected joint for males was the hip joint. This result was found to be significantly different from all other joint locations. This finding suggests some type of physical activity carried out by male individuals which more greatly affected this joint over the others. The least affected joint in males was the elbow joint. The most severely affected joint for females was the shoulder joint and the least affected joint was the knee joint. No variation in DJD between the four joint locations was found to be significantly different for females. This result indicates that there was not likely any specific activity that more greatly influenced the development of the condition at one joint over another. However, the higher degree at the shoulder joint over the others may indicate some physical activity that was carried out by this joint which influenced the development of the condition at this joint location over the others in females, although again not to a statistically significant degree.

Sample 3 TUCH: Comparison of Males vs. Females

The comparative results between males and females for Sample 3 TUCH are similar to the other two samples in that males exhibited higher scores, on average, than females at most joint locations. The one exception to this finding was at the elbow joint where females exhibited a higher prevalence and severity of the condition than males, although this difference was not found to be statistically significant. Females scored on average 1.02 and males scored 0.97 for the elbow joint. Even though this result was not significantly different, it may indicate that females were engaged in some habitual activity that prompted more development of the condition at the elbow over males. Statistically significant differences were found in the results for the hip joint between males and females and for the knee joint. In both cases males had a higher prevalence and severity of the condition. This finding may also be resultant from divergent physical activities and workload between males and females, as well as variation in body size between males and females.

By comparison, Lieverse et al. (2007) carried out a comprehensive study of osteoarthritis in hunter-gatherer samples, spanning the Late Mesolithic to the Bronze Age from Siberia's Cis-Baikal (north-west Lake Baikal) region. The most commonly affected joints were found in the vertebral column, while the results of the other joint locations varied throughout the samples. In addition, this assessment found that the levels of activity were similar throughout the successive periods but that more specific osteoarthritis patterns could be related to differences in mobility practices and particular activities. In some samples an increase in joint disease at the knee was suggested to be resultant from increased levels of mobility employed in far-reaching hunting excursions carried out by certain groups. In addition, extensive walking over rough terrain while carrying heavy loads was thought to be an influential factor (Ibid). It may be that the results generated in the present study are also reflective, at least to some extent, of variation in mobility patterns between males and females at this site due to the significant variation in lower limb results.

Comparison of Degenerative Joint Disease between Samples

Comparisons between the three sample groups provide a measure for assessing the results of the condition as it may be related to factors such as lifestyle, economy and environmental settings for each particular group. In some instances it has been possible to observe variation in DJD patterns between populations as they may be related to differences in major subsistence economies (e.g. see Bridges 1992). Larsen's review of biological changes in human populations with the introduction of agriculture suggested that on the basis of previous studies, no clear relationship has been established between rates and expression of joint disease between hunter-gatherer populations or farming communities (1995). In some instances, a higher degree of the condition was found in hunter-gatherer population samples and a lesser degree in agriculturalist population samples, while in other cases the opposite was noted. Larsen suggests that while no *overall* defining relationship appears to exist between subsistence regimes and the condition on a universal scale, it does appear that meaningful patterns have been observable in discrete settings (Ibid). Comparisons by Eshed et al. (2010) between Natufian hunter-gatherers and Neolithic farming communities in the Levant found no increase in the prevalence of arthritis with the introduction of agricultural activities. It was suggested that this finding may indicate that while daily activities may have become more varied with the large scale adoption of agriculture, the overall health profile, as related to arthritis was not affected by this development. In addition to the lack of change over time in these groups, no significant differences were found between males and females either within or between these samples.

In the present study, the sample where males had the highest instance of DJD was Sample 3 TUCH for all joints with the exception of the elbow joint, where Sample 1 PAZ was slightly higher. The most severely affected joint out of all the samples was the hip joint for Sample 3 TUCH. The results for this joint were found to be significantly different than those from Samples 1 PAZ and 2 EG ($p<0.05$). One possible suggestion is that this result is reflective of variation in activity and bio-mechanical stress related to subsistence regimes. Based on archaeological, isotopic and dental pathology evidence it is thought that the EG group engaged in agricultural production for their primary subsistence needs, while the other two groups relied more heavily on pastoralism as their major economic base (discussed in Chapter Four). It may be that bio-mechanical workload stresses, involved with agricultural cultivation practices, or other divergent activities, have contributed to this finding in the hip joint for males across these samples.

One particular comparison is provided by a modern clinical study of osteoarthritis of the hip in individuals from farming and sedentary occupations in Great Britain, where a markedly higher instance of the condition was found in farmers (Croft et al. 1992). Especially higher instances were found in farmers who had worked in the same occupation for over ten years. However, even individuals who had only been in farming occupations for only one year had a higher occurrence of the condition than the individuals engaged in sedentary occupations, such as office work. An additional correlation was observed in that instances of the condition increased with the height and age of the individual. General heavy lifting activities were suggested as the most likely contributing factor, as the occurrence of osteoarthritis could not be associated with one specific type of farming. Other possible contributions were suggested to have arisen from body vibrations from the use of modern agricultural machinery and extensive walking over rough terrain (Ibid). Furthermore, the review of osteoarthritis by Weiss and Jurmain (2007) note eight additional studies which found correlations between increased rates of osteoarthritis of the hip in farmers from modern clinical studies.

This comparison has not been provided in order to propose that it is possible to determine if individuals were farmers based on instances of DJD of the hip, but rather to suggest that variation in food production activities between these groups may have contributed to the results presented here. In females from Sample 3 TUCH, the results for the hip joint were also higher than the other two samples, although this was not found to be significantly higher. This may also reflect a divergence in activity which placed more stress at this joint location for females from this site in comparison to the other groups. In addition, it should be noted that, while age could not be precisely controlled for in Sample 3 TUCH, the age profile of the crania samples used in the dental pathology assessment in Chapter Four of this dissertation (while all are not from the same individuals included in this chapter) the age profile of that sample was not skewed abnormally towards older adults. The most commonly represented individuals included in Chapter 4 were in the middle adult age category. Moreover, based on archaeological interpretations there was no suggestion that this cemetery appeared to have been reserved solely for older or infirm individuals (Nei Menggu 1989). With these considerations in mind, it is likely that these results are not exclusively reflective of any significant divergence in age profiles between the samples, but of course because of the lack of age control the possibility of influence from age variation cannot be fully dismissed. Even though age and weight are known to be aetiological factors contributing to DJD patterns, in modern studies obesity has been found to be strongly correlated with cases of joint disease at the knees while by comparison, the link between the condition and obesity at the hip joints appears to be very weakly correlated (discussed in Waldron 2009). This supports the proposition that divergent activity patterns could also be represented in this instance, in addition to or aside from biological/age-related variation.

A further area of enquiry involves the question of variation between social standing for these particular sample groups. Samples 1 PAZ and 2 EG are comprised of individuals excavated from local elite or upper strata burials characteristic of Pazyryk (Molodin 2003) and Xiongnu (Minyaev and Sakharovskaya 2002 Turbat et al. 2003) archaeological contexts. Conversely, Sample 3 TUCH the Han Dynasty sample from Inner Mongolia is comprised of individuals excavated from burials which were, by comparison, not as lavishly furnished or elaborately constructed (Nei Menggu 1989). In addition, as this site was thought to possibly be the burial place for a military garrison (Gu 2007), it is probable that these individuals carried out daily activities which were likely to be different from those carried out by the other two groups. Physically demanding activities may have included tasks performed for subsistence purposes, such as food preparation and cultivation, military occupational pursuits, various types of craft production and general daily labour involving heavy lifting and carrying. It is possible that the position in society occupied by members of each respective group may have contributed to the divergence in the overall degree of workload carried out between these population samples. The findings of DJD which are generally higher in Sample 3 TUCH for both males and females are potentially indicative of a greater degree of physically demanding activities or overall workload which was carried out by members of this group in comparison to the other two. A comparative study by Tainter (1980) of prehistoric North American populations found a lesser degree of osteoarthritis in individuals excavated from higher status burials, suggesting that this group carried out less physically demanding tasks than those of lower social standing. Therefore, these patterns may be related to biological factors associated with sexual dimorphism and biological variation, coupled with differences in economic base and social status.

6.3 Methods Utilised for Musculo-skeletal Stress Marker Analysis

As a further measure of reconstructing activity patterns, a comprehensive study of musculo-skeletal stress markers was undertaken on these samples. This type of assessment involves the macroscopic examination of specific muscle and ligament attachment sites on the skeleton. The origin and insertion sites of muscles are called *entheses* and ligament attachments are termed *syndesmoses*. The term *'musculo-skeletal stress marker'* is used to encompass both of these categories. In some studies these lesions have also been referred to as 'markers of occupational stress' (e.g. Kennedy 1989; Kennedy 1998). The term *musculo-skeletal stress marker* has been employed for the present study as the more general and appropriate definition for this particular assessment. This usage was considered to be preferable in order to avoid any misconceptions that might arise from definitions which include the term 'occupation'. As it has been pointed out above, this assessment was not carried out in an attempt to determine specific occupations of the individuals included in this study, but rather to reconstruct patterns of anatomical movements. The term 'occupational marker' largely arose from forensic cases and clinical/medicinal studies (Kennedy 1989). In the field of forensics, investigators have examined these lesions in order to establish an unidentified persons' occupation, while in clinical studies they have been examined to document the effects of repetitive strain from various occupational and industry hazards and athletics/sports medicine (Ibid).

Musculo-skeletal stress markers or MSMs, for the purposes of this assessment, follows the definition provided by Steen and Lane (1998: 342) which describes these lesions as 'bony changes produced during normal habitual use of muscles and ligaments at their attachment sites, where "normal" implies any amount of daily activity produced over an individuals' lifetime'. Through the methodological study of these lesions, it has been suggested that it is sometimes possible to recognise similarities and variation in activity patterns both within and between sample groups (Hawkey and Merbs 1995; Steen and Lane 1998; Molnar et. al. 2009). The present study focussed on muscle and ligament attachment sites located on both the upper and lower limb of the post-cranial skeleton. The major focus was on insertion sites, with the exception of two muscle origin sites. It has been suggested that because a greater degree of mechanical forces are typically applied at the insertion sites, reconstructions of anatomical movements should mainly be focussed on these locations (Kennedy 1989; Hawkey and Merbs 1995). Each muscle and ligament attachment site assessed for this study is listed in Table 6.5. This table also indicates the corresponding bone and location where each muscle or ligament site was examined.

In total, thirty attachment sites were included in the assessment with twenty-three from the upper limb and seven from the lower limb. The two muscle origins were the attachment sites for the common extensor muscles and the common flexor muscles. The designation of *common* refers to the shared bony origin site for these muscle groups. All other muscle and ligament sites were areas of insertion. The attachment site of the common extensor muscles is located on the lateral epicondyle of the distal humerus and the site of the common flexors origin is located on the medial epicondyle of the distal humerus. The three ligament sites included in the assessment are each located on the clavicle and include the *costoclavicular* ligament, the *trapezoid* ligament, and the *conoid* ligament. The additional sites of the upper limb included in this assessment are as follows: on the scapula, *trapezius* and *pectoralis minor*; on the humerus, *supraspinatus, infraspinatus, teres minor, pectoralis major, latissimus dorsi, teres major, deltoid, coracobrachialis* and common extensors and common flexors (as mentioned above); on the ulna, *brachialis*, *anconeus* and *triceps brachii*; on the radius, *biceps brachii*, *pronator teres*, *supinator* and *pronator quadratus*. The attachment sites of the lower limb are as follows: on the femur, *iliopsoas*, *gluteus maximus*, *gluteus medius*, *adductor longus* and *quadratus femoris*; on the fibula, *biceps femoris* and on the tibia, *semitendinosus*. Hereafter, *triceps brachii* and *biceps brachii* will be referred to as *triceps br.* and *biceps br.* respectively.

Table 6.5 Muscle and Ligament Attachment Sites and Corresponding Skeletal Elements (table based on Machicek 2006 Table 1, attachment site locations after Gosling et. al. 2002).

Bone	Muscle/Ligament	Location of Attachment Site
Clavicle	Costoclavicular ligament	inferior sternal end of clavicle, costal tuberosity
Clavicle	Subclavius	subclavian groove
Clavicle	Trapezoid ligament	trapezoid line
Clavicle	Conoid ligament	conoid tubercle
Scapula	Trapezius	acromion and spine of scapula
Scapula	Pectoralis minor	coracoid process
Humerus	Supraspinatus	top of greater tubercle
Humerus	Infraspinatus	back of greater tubercle
Humerus	Teres minor	back of greater tubercle
Humerus	Pectoralis major	greater tubercular crest, floor of intertubercular groove
Humerus	Latissimus dorsi	lesser tubercular crest, floor of intertubercular groove
Humerus	Teres major	lesser tubercular crest
Humerus	Deltoid	deltoid tuberosity
Humerus	Coracobrachialis	medial humeral shaft
Humerus	Common Extensors	lateral epicondyle distal humerus
Humerus	Common Flexors	medial epicondyle distal humerus
Ulna	Brachialis	coronoid process and tubercle of ulna
Ulna	Anconeus	lateral olecranon process
Ulna	Triceps brachii	olecranon process
Radius	Biceps brachii	radial tuberosity
Radius	Pronator teres	pronator tuberosity
Radius	Supinator	proximal ⅓ of lateral radius
Radius	Pronator quadratus	distal ¼ of anterior radius
Femur	Iliopsoas	lesser trochanter
Femur	Gluteus maximus	gluteal tuberosity
Femur	Gluteus medius	lateral surface of greater trochanter
Femur	Adductor longus	middle medial lip of linea aspera
Femur	Quadratus femoris	crest below greater trochanter
Fibula	Biceps femoris	lateral proximal head of fibula
Tibia	Semitendinosus	proximal medial shaft of tibia

These muscles and ligaments were chosen for inclusion in this assessment because of the variety of anatomical movements and functions which are performed by these ligaments and muscle groups. In addition, these attachment sites have been included in other comparable assessments (e.g. Hawkey and Merbs 1995; Eshed et. al. 2004; Lieverse et. al. 2009). Table 6.6 lists both the upper and lower limb muscles and ligaments included in this study and the corresponding anatomical actions performed by each muscle or ligament.

Table 6.6 Actions performed by each muscle and ligament included in MSM assessment, (Actions available in Gosling et al. 2002, table based on Machicek 2006 Tables 2 and 3).

Muscle/Ligament	Actions Performed By Each Muscle or Ligament
Costoclavicular ligament	Anchors the clavicle and prevents medial displacement and elevation at the medial end of the clavicle
Subclavius	Anchors and stabilises the clavicle during movement at the shoulder
Trapezoid ligament	Reinforces the joint between the scapula and clavicle
Conoid ligament	Reinforces the joint between the scapula and clavicle
Trapezius	Elevates, retracts and rotates the scapula
Pectoralis minor	Protraction and rotation of the scapula
Supraspinatus	Initiates abduction of the humerus and works with deltoid, is a weak flexor at the arm
Infraspinatus	Carries out lateral rotation and abduction of the humerus
Teres minor	Primary function is to laterally rotate the humerus and is a weak adductor
Pectoralis major	Strong adductor and flexor of the arm at the shoulder joint and provides medial rotation of the humerus
Latissimus dorsi	Strongly adducts and flexes the humerus at the shoulder joint, also medially rotates the humerus at the shoulder
Teres major	Extends, adducts and medially rotates the humerus at the shoulder joint
Deltoid	Actions occur at the shoulder joint, primary abductor of the arm, middle part carries out flexion and medial rotation of the arm while the posterior section carries out extension and lateral rotation of the arm
Coracobrachialis	Weak flexion at the shoulder, adducts the arm and stabilises the shoulder
Common Extensors	Group of muscles which carry out extension and supination of the forearm
Common Flexors	Group of muscles which carry out pronation of the forearm and weak flexion at the elbow joint
Brachialis	Strong flexor at the elbow joint
Anconeus	Initiates extension at the elbow, abducts ulna during pronation
Triceps brachii	Strong extensor of the arm at the elbow joint, the long head aids in adduction when the arm is abducted
Biceps brachii	Supinates the forearm and when supinated is a strong flexor at the elbow joint, weak flexor at the shoulder joint
Pronator teres	Pronates the forearm and flexes the elbow
Supinator	Primary function is to supinate the forearm
Pronator quadratus	Pronates the forearm and deep fibres bind the radius and ulna
Iliopsoas	Flexes and stabilises the hip and carries out medial rotation at the hip joint
Gluteus maximus	Strong extensor at the thigh particularly during walking and running, also extends the trunk on the hip, stabilises the knee joint during walking and standing and assists in lateral rotation
Gluteus medius	Extends and abducts the hip, also works with gluteus minimus to contract and prevent tilting of the pelvis during locomotion
Adductor longus	Assists in medial rotation of the femur and adducts the hip
Quadratus femoris	Strong lateral rotator and adductor of the thigh
Biceps femoris	Flexes the lower limb, extends the thigh and laterally rotates leg with flexed knee
Semitendinosus	Flexes the leg and extends the thigh, carries out medial rotation of the leg with flexed knee

At each muscle and ligament attachment site, three categories were assessed for the presence and degree of a particular morphological expression. These three categories follow those set out by Hawkey and Merbs (1995) and are termed *robusticity, cortical defect* and *ossification exostosis*. Descriptions of each category are provided below. Following the macroscopic examination at each attachment site, a numeric score was assigned for each category and was graded as follows:

0= No expression of the trait
1= Faint expression
2= Moderate expression
3= Strong expression

Robusticity is expressed by the localised swelling and/or ridging of the bone at the attachment site. Hawkey and Merbs describe this feature as, 'the normal reaction of the skeleton to habitual muscle usage and reflects daily activities that produce rugged markings at the musculoskeletal site of attachment' (1995: 328). Below, Figure 6.7 illustrates the robusticity category with the corresponding scores at the deltoid attachment site ranging from 1 to 3.

Figure 6.7 Robusticity scores 1, 2 and 3 from Left to Right at *Deltoid* Attachment Site. Xiongnu Period Sample 2 EG from north-central Mongolia (image Author 2009).

Cortical Defect is represented by pitting or furrowing at the muscle or ligament attachment site. These features are sometimes referred to as 'stress lesions' and arise from isolated and non-pathological bony reactions at muscle and ligament attachment sites (Hawkey and Merbs 1995). Figure 6.8 illustrates a grade 3 cortical defect score at the *costoclavicular* ligament attachment site on the inferior clavicle.

Figure 6.8 Cortical Defect Score of 3 at *Costoclavicular* Attachment Site. Xiongnu Period Sample 2 EG from north-central Mongolia. (image Author 2009).

Ossification exostosis is observable at the ligament or muscle attachment site as a bony spur (or exostosis) projecting from the cortex of the bone. This feature is considered to be the result of a 'bone avulsion injury' or '*macro-trauma*' which occurred at the site of attachment (Hawkey and Merbs 1995: 329). This type of macro-trauma might occur from a sudden tear at the site of attachment, which will in turn prompt new bone growth (Kennedy 1989; Hawkey and Merbs 1995). Figure 6.9 provides an illustration of a bilateral score of 3 for ossification exostosis at the *iliopsoas* attachment site on the lesser trochanter of the posterior femur.

Figure 6.9 Bilateral Ossification Exostosis Score of 3 at *Iliopsoas* Attachment Site. Xiongnu Period Sample 2 EG from north-central Mongolia. (image Author 2009).

The categories of *robusticity* and *cortical defect* are considered as chronic bony responses that are resultant from long-term bio-mechanical activity and sustained muscle usage throughout an individual's life span. These two categories are considered an interrelated continuum of one another, while *ossification exostosis* represents an abrupt and sudden injury or 'macro-trauma' at the site of attachment. Because of this, the first two categories of robusticity and cortical defect have been combined following the studies by Hawkey and Merbs (1995); Peterson (1998); Eshed et al. (2004) and Lieverse et al. (2009). The third category, ossification exostosis, was left as an independent assessment. The combined scores for the robusticity and cortical defect categories were converted to the following scale ranging from 0 to 6.

Robusticity score of 0 =0
Robusticity score of 1 =1
Robusticity score of 3 =2
Robusticity score of 3 =3
Cortical Defect score of 1=4
Cortical Defect score of 2=5
Cortical Defect score of 3=6

The observations for the ossification exostosis category were kept as ranging from 0 to 3 as per the original scale (see above pg. 167). A mean score was calculated for each muscle and ligament site for both males and females and left and right sides for each sample, for the combined robusticity and cortical defect category. A mean score was also calculated for the ossification exostosis category for both left and right sides. Bilateral asymmetry was assessed by dividing the mean left side MSM scores by the right side mean MSM scores and then multiplying by 100, following the study by Peterson (1998). Scores which are 100 indicate no asymmetry between left and right sides. Scores over 100 indicate more left side asymmetry and those less than 100 indicate a greater degree of right side asymmetry. Scores which are near 100 indicate that there is little asymmetrical variation between the two sides. This calculation was carried out for the robusticity/cortical defect category and examined bilateral variation in upper limb results only. Bilateral asymmetry was not assessed for the lower limb results because they are less affected by factors such as mechanical loading associated with individual handedness (Steele 2000). Paired T-tests were run to determine any significant variation in bilateral asymmetry for males and females both within and between samples after Hawkey and Merbs (1995). Following this assessment, left and right sides were combined and then averaged to obtain a single mean MSM score for each muscle or ligament attachment site, following the studies by Eshed et al. (2004) and Lieverse et al. (2009). The mean MSM scores for combined left and right sides were then ranked and are displayed in descending order. This provides an indication of the muscles/ligaments used most often or to the strongest degree, without being influenced by the smaller sample sizes when divided by side. These results were then analysed to determine significance in variation between all samples for both males and females using the Mann-Whitney U/Wilcoxon rank sum test. As MSM scores represent ordinal data, nonparametric tests are also considered appropriate (Robb 1998; Eshed et al. 2004). For all statistical tests significance was set at $p=0.05$.

6.3.1 Results of Musculo-Skeletal Marker Analysis

The findings of the musculo-skeletal marker assessment have been divided into upper and lower limb results. The categories of robusticity and cortical defect have been combined into one category as previously discussed and are presented separately from the ossification exostosis results. One particular complication involved with the analysis of MSMs concerns the issue of data reduction. In order to deal with the substantial amounts of data generated from this type of assessment, it is necessary to reduce the information to more manageable datasets (Robb 1998). The results of the Mann-Whitney U/Wilcoxon rank sum tests indicated no significant differences either within or between groups based on sex or total sample comparisons ($p>0.05$). Even though no differences were found to be significant, as Robb (1998: 369) points out, 'For social interpretation, the significance of muscle marking data may lie more in configurations of skeletal features- the pattern of muscle marking at many sites- than in a marking at any specific site'. In addition, comparisons based on sex are provided to illustrate similarities and differences in the highest and lowest ranked muscles/ligaments used, and the focus is not on the actual mean MSM scores. However, when comparisons were made between samples of the same sex, variation between mean MSM scores have been taken into consideration.

Upper Limb MSM Results

The upper limb results of the MSM analysis are presented in Tables 6.7 through 6.15 below. The results of the bilateral asymmetry assessment are presented in Tables 6.8, 6.11 and 6.14. Table 6.7 provides the results of the combined left and right side robusticity/cortical defect category for Sample 1 PAZ. For males the highest mean MSM score was obtained for *brachialis* with a score of 4.18. This was followed by the *costoclavicular* attachment site with a mean score of 4.00. The lowest mean score for males was *pronator quadratus* with 1.54. For females the highest mean score was *pectoralis minor* with 3.99, followed by *trapezius* at 3.88. In contrast with the males, *brachialis* ranked third and *costoclavicular* ranked sixth for females. The lowest mean score for females was *supinator* with 0.73. By contrast the *supinator* muscle for males exhibited a mean score of 1.79.

Table 6.7 MSM Upper Limb Robusticity and Cortical Defect scores for Sample 1 PAZ Males and Females. MSM Score= Mean Score, Number of Sites= number available for observation.

SAMPLE 1 PAZ MALES Robusticity and Cortical Defect				**SAMPLE 1 PAZ FEMALES Robusticity and Cortical Defect**			
Muscle/ Ligament	**Rank**	**MSM Score**	**Number Sites**	**Muscle/ Ligament**	**Rank**	**MSM Score**	**Number Sites**
Brachialis	1	4.18	28	Pec. min.	1	3.99	4
Costoclav	2	4.00	16	Trapezius	2	3.88	8
Pec. min.	2	4.00	4	Brachialis	3	3.76	28
Comm Ext	4	3.83	32	Comm Ext	4	3.74	22
Biceps br.	5	3.77	26	Conoid	5	3.50	12
Anconeus	6	3.64	26	Costoclav	6	3.44	14
Trapezius	7	3.63	6	Trapezoid	7	3.40	14
Pec. maj.	8	3.5	30	Biceps br.	8	3.27	30
Deltoid	9	3.49	32	Pec. maj.	9	3.23	24
Teres maj.	10	3.35	32	Subclav	10	3.21	14
Lat. dorsi	11	3.14	32	Deltoid	11	3.20	26
Conoid	12	3.09	12	Anconeus	12	2.79	28
Subclav	13	3.07	16	Teres maj.	13	2.75	24
Trapezoid	13	3.07	14	Pron. ter.	14	2.50	30
Pron. ter.	15	2.97	22	Comm Flex	15	2.47	26
Triceps br.	16	2.89	26	Infraspin	15	2.47	22
Comm Flex	17	2.75	34	Lat. dorsi	17	2.42	24
Teres min.	18	2.65	24	Coracobr	18	2.13	24
Infraspin	19	2.43	24	Triceps br.	18	2.13	24
Coracobr	20	2.04	32	Teres min.	20	1.55	22
Supinator	21	1.79	24	Pron. quad.	21	1.38	26
Supraspin	22	1.57	26	Supraspin	22	1.26	22
Pron. quad.	23	1.54	24	Supinator	23	0.73	28

Table 6.8 presents the results of the bilateral asymmetry assessment for Sample 1 PAZ males and females. These results indicate that there is a certain degree of marked asymmetry at particular muscle/ligament sites for both males and females. For females in this sample, *pectoralis minor* could not be assessed for bilateral asymmetry, as there were no right side elements available for observation. For males the majority of the muscle/ligament sites were dominant on the right side. Sixteen sites were right side dominant, five were left

side dominant and two were equal for males. For females the majority of the muscle/ligament sites were left side dominant. Twelve were left side dominant, nine were right side dominant and one was equal. Paired T-tests found significant differences between male left and right side scores ($p<0.05$), but not for females ($p>0.05$). T-tests between males and females for left sides were not significant ($p>0.05$), but right side comparisons were significant ($p<0.05$).

Table 6.8 Sample 1 PAZ Patterns of bilateral asymmetry in MSM Scores by sex. Calculated by: (mean left MSM score/mean right MSM score) x 100. Muscles/Ligaments listed in alphabetical order.

Muscle/Ligament	SAMPLE 1 PAZ MALES Bilateral Asymmetry	SAMPLE 1 PAZ FEMALES Bilateral Asymmetry
Anconeus	113	86
Biceps brachii	101	101
Brachialis	98	104
Common Extensors	95	104
Common Flexors	87	109
Conoid ligament	68	100
Coracobrachialis	91	82
Costoclavicular ligament	100	72
Deltoid	91	104
Infraspinatus	62	112
Latissimus dorsi	79	107
Pectoralis minor	100	/
Pectoralis major	75	88
Pronator quadratus	95	83
Pronator teres	91	150
Subclavius	104	103
Supinator	127	284
Supraspinatus	109	77
Teres major	84	94
Teres minor	76	107
Trapezius	93	107
Trapezoid ligament	96	85
Triceps brachii	98	82

Table 6.9 presents the results of the upper limb ossification exostosis assessment for Sample 1 PAZ. For males the highest mean score was for *costoclavicular* at 1.13 and the lowest mean scores were for *subclavius* and *supinator* with 0.00. The highest ranked sites for females were for *pectoralis*

minor and *trapezius*, each with mean scores of 1.00. The lowest ranked for females were six sites which each had a mean score of 0.00. These were the common flexors, *deltoid*, *infraspinatus*, *pronator teres*, *supraspinatus* and *triceps br*.

Table 6.9 MSM Upper Limb Ossification Exostosis results for Sample 1 PAZ Males and Females. MSM Score= Mean Score, Number of Sites= number available for observation.

SAMPLE 1 PAZ MALES Ossification Exostosis				SAMPLE 1 PAZ FEMALES Ossification Exostosis			
Muscle/ Ligament	**Rank**	**MSM Score**	**Number Sites**	**Muscle/ Ligament**	**Rank**	**MSM Score**	**Number Sites**
Costoclav	1	1.13	8	Pec. min.	1	1.00	2
Pec. min.	2	1.00	2	Trapezius	2	1.00	4
Brachialis	3	0.93	14	Costoclav	3	0.75	7
Trapezius	4	0.75	3	Trapezoid	4	0.58	7
Biceps br.	5	0.55	13	Brachialis	5	0.57	14
Pec. maj.	5	0.55	15	Pec. maj.	5	0.42	12
Anconeus	7	0.54	13	Anconeus	7	0.29	14
Teres maj.	8	0.52	16	Biceps br.	8	0.29	15
Comm Ext	9	0.51	16	Subclav	9	0.29	7
Pron. quad.	10	0.42	12	Comm Ext	10	0.19	11
Trapezoid	10	0.42	7	Conoid	10	0.17	6
Pron. ter.	12	0.37	11	Lat. dorsi	12	0.17	12
Conoid	13	0.33	6	Teres maj.	13	0.17	12
Triceps br.	14	0.23	13	Teres min.	14	0.17	11
Coracobr	15	0.20	16	Coracobr	15	0.09	12
Deltoid	15	0.20	16	Pron. quad.	16	0.07	13
Lat. dorsi	15	0.20	16	Supinator	17	0.05	6
Teres min.	18	0.17	12	Comm Flex	18	0.00	13
Infraspin	19	0.10	12	Deltoid	18	0.00	13
Supraspin	20	0.09	13	Infraspin	18	0.00	11
Comm Flex	21	0.07	17	Pron. ter.	18	0.00	15
Subclav	22	0.00	8	Supraspin	18	0.00	11
Supinator	22	0.00	12	Triceps br.	18	0.00	11

Table 6.10 presents the results of the upper limb robusticity/cortical defect assessment for Sample 2 EG males and females. The highest ranked site for males was *costoclavicular* with a mean score of 4.04, followed by *brachialis* with a mean score of 4.00. The lowest ranked site for males was *supraspinatus* with a mean score of 1.06. For females the highest ranked site was *brachialis* with a mean score of 3.78, followed by the second ranked site common extensors with

a mean score of 3.74. By comparison, the common extensors for males also had a mean score of 3.74. The lowest ranked for females was *pronator quadratus* with a mean score of 1.46.

Table 6.10 MSM Upper Limb Robusticity and Cortical Defect results for Sample 2 EG Males and Females. MSM Score= Mean Score, Number of Sites= number available for observation.

SAMPLE 2 EG MALES Robusticity and Cortical Defect				SAMPLE 2 EG FEMALES Robusticity and Cortical Defect			
Muscle/ Ligament	**Rank**	**MSM Score**	**Number Sites**	**Muscle/ Ligament**	**Rank**	**MSM Score**	**Number Sites**
Costoclav	1	4.04	64	Brachialis	1	3.78	52
Brachialis	2	4.00	62	Comm Ext	2	3.74	39
Comm Ext	3	3.74	60	Costoclav	3	3.66	42
Trapezius	4	3.72	38	Pec. maj.	4	3.52	46
Trapezoid	5	3.56	72	Deltoid	5	3.47	46
Deltoid	6	3.48	62	Trapezoid	6	3.44	44
Pec. maj.	7	3.45	60	Trapezius	7	3.34	26
Pron. ter.	7	3.45	60	Teres maj.	7	3.29	46
Anconeus	9	3.37	54	Biceps br.	9	3.21	42
Biceps br.	10	3.35	60	Conoid	10	3.10	40
Conoid	11	3.29	74	Anconeus	11	3.00	46
Teres maj.	12	3.28	60	Pron. ter.	12	2.83	40
Pec. min.	13	3.18	40	Lat. dorsi	13	2.71	46
Subclav	14	2.95	64	Comm Flex	14	2.66	40
Triceps br.	15	2.72	54	Subclav	15	2.57	42
Comm Flex	16	2.68	56	Pec. min.	16	2.42	22
Lat. dorsi	17	2.56	60	Infraspin	17	2.38	32
Coracobr	18	2.32	60	Triceps br.	18	2.17	44
Pron. quad.	19	2.17	62	Coracobr	19	2.15	42
Teres min.	20	2.08	50	Teres min.	20	2.13	38
Supinator	21	1.91	62	Supraspin	21	1.52	38
Infraspin	22	1.64	50	Supinator	22	1.49	42
Supraspin	23	1.06	54	Pron. quad.	23	1.46	42

Table 6.11 presents the results of the bilateral asymmetry assessment for Sample 2 EG males and females. For both males and females the majority of the sites were right side dominant. For males, eight were left side dominant, thirteen were right side dominant and two were bilaterally equal. For females, six were left side dominant, sixteen were right side dominant and one was bilaterally equal. Paired T-tests found significant differences between left and right sides for males and left and right sides for females ($p<0.05$). Significant

differences were also observed for comparison between male and female left side scores ($p<0.05$), but not for right side scores ($p>0.05$).

Table 6.11 Sample 2 EG Patterns of bilateral asymmetry in MSM scores by sex. Calculated by: (mean left MSM score/mean right MSM score) x 100. Muscles/Ligaments listed in alphabetical order.

Muscle/Ligament	SAMPLE 2 EG MALES Bilateral Asymmetry	SAMPLE 2 EG FEMALES Bilateral Asymmetry
Anconeus	101	93
Biceps brachii	97	98
Brachialis	100	105
Common Extensors	108	104
Common Flexors	105	113
Conoid ligament	86	101
Coracobrachialis	104	83
Costoclavicular ligament	97	97
Deltoid	106	95
Infraspinatus	95	66
Latissimus dorsi	93	94
Pectoralis minor	102	71
Pectoralis major	92	93
Pronator quadratus	83	106
Pronator teres	105	100
Subclavius	103	76
Supinator	97	55
Supraspinatus	51	68
Teres major	92	96
Teres minor	85	63
Trapezius	94	95
Trapezoid ligament	100	101
Triceps brachii	95	91

Table 6.12 provides the results of the upper limb ossification exostosis category for Sample 2 EG. The highest ranked site for both males and females was *costoclavicular*. Males exhibited a mean score 1.41 and females exhibited a mean score of 1.03. The second ranked site for males was *teres minor* with a mean score of 1.13. The second ranked site for females was *brachialis* with a mean score of 0.70. The lowest ranked site for males was *supinator* with a mean score of 0.10. The three lowest ranked sites for females were *infraspinatus, pectoralis minor* and *supraspinatus,* each with a mean score of 0.00. The lowest

ranked site for females that received a score was *teres minor* with a mean result of 0.05.

Table 6.12 MSM Upper Limb Ossification Exostosis results for Sample 2 EG Males and Females. MSM Score= Mean Score, Number of Sites= number available for observation.

SAMPLE 2 EG MALES Ossification Exostosis				**SAMPLE 2 EG FEMALES Ossification Exostosis**			
Muscle/ Ligament	**Rank**	**MSM Score**	**Number Sites**	**Muscle/ Ligament**	**Rank**	**MSM Score**	**Number Sites**
Costoclav	1	1.41	32	Costoclav	1	1.03	21
Teres min.	2	1.13	39	Brachialis	2	0.70	20
Infraspin	3	0.84	39	Biceps br.	3	0.57	21
Brachialis	4	0.81	31	Comm Ext	4	0.56	20
Conoid	5	0.76	37	Trapezoid	5	0.47	22
Supraspin	6	0.70	42	Anconeus	6	0.33	23
Trapezius	7	0.61	28	Pec. maj.	7	0.31	23
Trapezoid	8	0.58	36	Conoid	8	0.30	20
Comm Ext	9	0.57	30	Comm Flex	9	0.25	20
Biceps br.	10	0.50	30	Coracobr	10	0.24	21
Anconeus	11	0.44	27	Trapezius	11	0.24	13
Teres maj.	12	0.28	30	Triceps br.	12	0.23	22
Pron. ter.	13	0.24	30	Teres maj.	13	0.22	23
Deltoid	14	0.23	31	Lat. dorsi	14	0.21	23
Comm Flex	15	0.22	28	Pron. ter.	15	0.16	20
Triceps br.	15	0.22	27	Pron. quad.	15	0.14	21
Subclav	17	0.21	32	Deltoid	17	0.13	23
Pron. quad.	18	0.20	31	Subclav	18	0.06	21
Coracobr	19	0.17	30	Supinator	19	0.06	21
Pec. min.	20	0.15	20	Teres min.	20	0.05	19
Lat. dorsi	21	0.14	30	Infraspin	21	0.00	16
Pec. maj.	21	0.14	30	Pec. min.	21	0.00	11
Supinator	23	0.10	31	Supraspin	23	0.00	19

Table 6.13 presents the upper limb results of the robusticity/cortical defect assessment for Sample 3 TUCH males and females. The results for this sample are somewhat more tentative than the others because there were several sites for both males and females that could not be assessed due to incompleteness of the skeletal material. For males, no sites for *pectoralis minor* or *trapezius* could be assessed. For females, no sites for *conoid, costoclavicular, pectoralis minor, subclavius, trapezius* or *trapezoid* could be assessed. In addition, for males several muscles/ligaments had only six sites available for observation. These

were *costoclavicular, conoid, trapezoid* and *subclavius*. The highest ranked for males was *costoclavicular* with a mean score of 4.13, followed by *conoid* with a mean score of 3.88. The highest ranked for females was *brachialis* with a score of 3.80, followed by the second ranked common extensors with a score of 3.56. By comparison, males had a mean score of 3.66 for *brachialis* and 3.48 for common extensors. The lowest ranked site that could be assessed for males was *infraspinatus* with a mean score of 0.84. The lowest ranked that could be assessed for females was *pronator quadratus* with a mean score of 1.54.

Table 6.13 MSM Upper Limb Robusticity and Cortical Defect results for Sample 3 TUCH Males and Females. MSM Score= Mean Score, Number of Sites= number available for observation.

SAMPLE 3 TUCH MALES Robusticity and Cortical Defect				SAMPLE 3 TUCH FEMALES Robusticity and Cortical Defect			
Muscle/ Ligament	**Rank**	**MSM Score**	**Number Sites**	**Muscle/ Ligament**	**Rank**	**MSM Score**	**Number Sites**
Costoclav	1	4.13	6	Brachialis	1	3.80	20
Conoid	2	3.88	6	Comm Ext	2	3.56	38
Trapezoid	3	3.75	6	Biceps br.	3	3.33	22
Brachialis	4	3.66	32	Deltoid	4	2.96	38
Comm Ext	5	3.48	54	Triceps br.	5	2.90	14
Biceps br.	6	3.30	32	Pron. ter.	6	2.89	22
Deltoid	7	3.26	52	Pec. maj.	7	2.76	38
Pec. maj.	8	3.16	54	Teres maj.	8	2.66	38
Teres maj.	8	3.16	54	Comm Flex	9	2.58	38
Pron. ter.	10	3.05	32	Anconeus	10	2.38	16
Triceps br.	11	2.97	28	Teres min.	10	2.38	28
Anconeus	12	2.94	30	Supinator	12	2.07	22
Lat. dorsi	13	2.79	54	Lat. dorsi	13	1.97	38
Coracobr	14	2.53	64	Coracobr	14	1.95	38
Subclav	15	2.25	6	Supraspin	15	1.80	26
Comm Flex	16	2.22	52	Infraspin	16	1.75	27
Teres Min.	17	1.97	50	Pron. quad.	17	1.54	20
Supraspin	18	1.47	52	Conoid			0
Pron. quad.	19	1.29	32	Costoclav			0
Supinator	20	1.05	32	Pec. min.			0
Infraspin	21	0.84	39	Subclav			0
Pec. min.			0	Trapezius			0
Trapezius			0	Trapezoid			0

Table 6.14 presents the results of the bilateral asymmetry assessment for Sample 3 TUCH males and females. Males and females both exhibited a majority of sites with right side dominance. Males had eight sites with left side dominance, twelve with right side dominance and one which was bilaterally equal. Two sites, *pectoralis minor* and *trapezius*, could not be assessed due to lack of skeletal elements. For females, four sites were left side dominant and thirteen sites were right side dominant. Six sites could not be assessed for females. These were *conoid, pectoralis minor, subclavius, trapezius* and *trapezoid.* Paired T-tests found no significant variation between male left and right sides ($p>0.05$). Significant variation was found between female left and right sides ($p<0.05$). Comparisons between males and females for both left and right sides were not found to be significant ($p>0.05$).

Table 6.14 Sample 3 TUCH Patterns of bilateral asymmetry in MSM scores by sex. Calculated by: (mean left MSM score/mean right MSM score) x 100. Muscles/Ligaments listed in alphabetical order.

Muscle/Ligament	SAMPLE 3 TUCH MALES Bilateral Asymmetry	SAMPLE 3 TUCH FEMALES Bilateral Asymmetry
Anconeus	100	81
Biceps brachii	104	71
Brachialis	95	95
Common Extensors	106	109
Common Flexors	97	98
Conoid ligament	107	/
Coracobrachialis	71	105
Costoclavicular ligament	94	/
Deltoid	96	85
Infraspinatus	147	122
Latissimus dorsi	94	83
Pectoralis minor	/	/
Pectoralis major	94	87
Pronator quadratus	50	37
Pronator teres	92	81
Subclavius	125	/
Supinator	136	48
Supraspinatus	95	87
Teres major	87	97
Teres minor	107	90
Trapezius	/	/
Trapezoid ligament	88	/
Triceps brachii	102	117

Table 6.15 presents the upper limb results of the ossification exostosis category for Sample 3 TUCH males and females. The same sites for both males and females that could not be assessed for the robusticity/cortical defect category were not available for this category either. The highest ranked site for males was *costoclavicular* with a mean score of 1.50, followed by *biceps brachii* with a score of 0.89. For females, the highest ranked was *triceps* with a score of 0.55, followed by common extensors with a score of 0.47. By comparison, males exhibited a mean score of 0.52 for common extensors and 0.43 for *triceps br.* Out of the sites that could be observed for males, the lowest ranked was *pronator quadratus* with a mean score of 0.00. For females, five sites were

equally ranked lowest with mean scores of 0.00. These were *latissimus dorsi, pectoralis major, pronator teres, supinator* and *teres minor*.

Table 6.15 MSM Upper Limb Ossification Exostosis results for Sample 3 TUCH Males and Females. MSM Score= Mean Score, Number of Sites= number available for observation.

SAMPLE 3 TUCH MALES Ossification Exostosis				SAMPLE 3 TUCH FEMALES Ossification Exostosis			
Muscle/ Ligament	**Rank**	**MSM Score**	**Number Sites**	**Muscle/ Ligament**	**Rank**	**MSM Score**	**Number Sites**
Costoclav	1	1.50	3	Triceps br.	1	0.55	10
Biceps br.	2	0.89	16	Comn Ext	2	0.47	25
Conoid	3	0.75	3	Biceps br.	3	0.33	11
Comm Ext	4	0.52	27	Brachialis	3	0.33	13
Pron. ter.	5	0.50	16	Supraspin	5	0.29	7
Trapezoid	5	0.50	3	Coracobr	6	0.14	25
Brachialis	7	0.44	16	Anconeus	7	0.13	12
Triceps br.	8	0.43	14	Comm Flex	8	0.11	24
Anconeus	9	0.34	15	Deltoid	9	0.10	19
Teres maj.	10	0.29	27	Infraspin	10	0.07	14
Subclav	11	0.25	3	Teres maj.	11	0.05	19
Lat. dorsi	12	0.23	27	Pron. quad.	12	0.02	10
Pec. maj.	12	0.23	27	Lat. dorsi	13	0.00	19
Coracobr	14	0.22	27	Pec. maj.	13	0.00	19
Deltoid	15	0.19	26	Pron. ter.	13	0.00	11
Comm Flex	16	0.15	26	Supinator	13	0.00	11
Teres min.	17	0.08	25	Teres min.	13	0.00	14
Infraspin	18	0.05	25	Conoid			0
Supraspin	19	0.04	26	Costoclav			0
Supinator	20	0.01	12	Pec Min.			0
Pron. quad.	21	0.00	11	Subclav			0
Pec. min.			0	Trapezius			0
Trapezius			0	Trapezoid			0

Lower Limb MSM Results

Table 6.16 presents the lower limb robusticity/cortical defect and the ossification exostosis results for Sample 1 PAZ for both males and females. For both males and females the highest ranked was *gluteus maximus* for the robusticity/cortical defect category. Males had a mean score of 3.84 whilst females had a mean score of 3.29. The second highest ranked in this category for males was *gluteus medius* with a mean score of 3.61 and for females this was *iliopsoas* with a mean score of 3.24. The lowest ranked robusticity/cortical defect category for both males and females was *quadratus femoris*. Males had a mean score of 1.66, whilst females had a mean score of 0.56. In the ossification exostosis category the highest ranked for males was *adductor longus* with a mean score of 0.86. In this category the highest ranked for females was *biceps femoris* with a mean score of 0.34. The lowest ranked in this category for males was *iliopsoas* and *quadratus femoris* which each scored 0.27. The lowest ranked in this category for females was *adductor longus* with a mean score of 0.00.

Table 6.16 MSM Lower Limb results for Sample 1 PAZ, Males and Females. MSM Score= Mean Score, Number of Sites= number available for observation.

Sample 1 PAZ Robusticity and Cortical Defect Lower Limb							
Males				**Females**			
Muscle/Ligament	Rank	MSM Score	Number Sites	Muscle/Ligament	Rank	MSM Score	Number Sites
Glut. max.	1	3.84	36	Glut. max.	1	3.29	26
Glut. med.	2	3.61	36	Iliopsoas	2	3.24	28
Iliopsoas	3	3.48	34	Add. long.	3	1.98	24
Add. long.	4	3.23	29	Semitend	4	1.85	24
Biceps fem.	5	3.21	24	Glut. med.	5	1.75	21
Semitend	6	2.79	42	Biceps fem.	6	1.29	20
Quad. fem.	7	1.66	27	Quad. fem.	7	0.56	26
Sample 1 PAZ Ossification Exostosis Lower Limb							
Males				**Females**			
Muscle/Ligament	Rank	MSM Score	Number Sites	Muscle/Ligament	Rank	MSM Score	Number Sites
Add. long.	1	0.86	14	Biceps fem.	1	0.34	10
Glut. max.	2	0.60	17	Semitend	2	0.30	11
Glut. med.	3	0.58	18	Glut. med.	3	0.29	14
Biceps fem.	4	0.50	12	Iliopsoas	4	0.24	13
Semitend	5	0.30	28	Quad. fem.	5	0.09	13
Iliopsoas	6	0.27	22	Glut. max.	6	0.07	13
Quad. fem.	6	0.27	15	Add. long.	6	0.00	12

Table 6.17 provides the lower limb results for the robusticity/cortical defect category and ossification exostosis for both males and females for Sample 2 EG. In the robusticity/cortical defect category the highest ranked for both males and females was *gluteus maximus*. Males exhibited a mean score of 3.95, whilst females showed a mean score of 3.56. The lowest ranked in this category for both males and females was *quadratus femoris*. Males had a mean score of 2.13 whilst females had a score of 1.25. In the ossification exostosis category the highest ranked again for both males and females was *gluteus maximus*. Males had a mean score of 0.93 whilst females had a mean score of 0.84. In this category the lowest ranked for males was *biceps femoris* with a mean score of 0.32. In this category the lowest ranked for females was *adductor longus* with a mean score of 0.15.

Table 6.17 MSM Lower Limb results for Sample 2 EG, Males and Females. MSM Score= Mean Score, Number of Sites= number available for observation.

Sample 2 EG Robusticity and Cortical Defect Lower Limb							
Males				**Females**			
Muscle/Ligament	Rank	MSM Score	Number Sites	Muscle/Ligament	Rank	MSM Score	Number Sites
Glut. max.	1	3.95	58	Glut. max.	1	3.56	25
Glut. med.	2	3.90	52	Biceps fem.	2	3.42	26
Iliopsoas	3	3.59	54	Glut. med.	3	3.07	17
Add. long.	4	3.30	63	Add. long.	4	2.87	28
Semitend	5	3.26	74	Semitend	5	2.79	27
Biceps fem.	6	2.92	52	Iliopsoas	6	2.63	16
Quad. fem.	7	2.13	47	Quad. fem.	7	1.25	10
Sample EG Ossification Exostosis Lower Limb							
Males				**Females**			
Muscle/Ligament	Rank	MSM Score	Number Sites	Muscle/Ligament	Rank	MSM Score	Number Sites
Glut. max.	1	0.93	28	Glut. max.	1	0.84	14
Glut. med.	2	0.90	26	Biceps fem.	2	0.79	13
Add. long.	3	0.68	32	Semitend	3	0.47	14
Iliopsoas	3	0.68	28	Glut. med.	3	0.35	9
Semitend	5	0.61	36	Quad. fem.	5	0.25	4
Quad. fem.	6	0.34	23	Iliopsoas	6	0.17	9
Biceps fem.	7	0.32	25	Add. long.	7	0.15	14

Table 6.18 provides the results of the lower limb robusticity/cortical defect and ossification exostosis category for Sample 3 TUCH for both males and females. For both males and females *biceps femoris* could not be assessed due to the lack of fibulas available for observation. In the robusticity/cortical defect category the highest ranked for males was *gluteus medius* with a mean score of 3.52. For females in this category, the highest ranked was *semitendinosus* with a mean score of 3.15. By comparison, males had a mean score of 3.40 for *semitendinosus*. In the robusticity/cortical defect category the lowest ranked for both males and females was *quadratus femoris*. Males had a mean score of 1.00 whilst females had a mean score of 0.52. In the ossification exostosis category the highest ranked for males was *gluteus maximus* with a mean score of 1.03. The highest ranked for females in this category was *adductor longus* with a mean score of 0.44. By contrast males had a mean score of 0.55 for *adductor longus*. The lowest ranked in this category for males was *quadratus femoris* with

a mean score of 0.13. The lowest ranked in this category for females was *iliopsoas* with a mean score of 0.00.

Table 6.18 MSM Lower Limb Results for Sample 3 TUCH, Males and Females. MSM Score= Mean Score, Number of Sites= number available for observation.

Sample 3 TUCH Robusticity and Cortical Defect Lower Limb							
Males				**Females**			
Muscle/Ligament	Rank	MSM Score	Number Sites	Muscle/Ligament	Rank	MSM Score	Number Sites
Glut. med.	1	3.52	68	Semitend	1	3.15	14
Glut. max.	2	3.46	80	Glut. max.	2	2.97	42
Semitend	3	3.40	30	Glut. med.	3	2.86	26
Iliopsoas	4	3.05	74	Add. long.	4	2.37	46
Add. long.	5	2.61	80	Iliopsoas	5	1.65	40
Quad. fem.	6	1.00	39	Quad. fem.	6	0.52	24
Biceps fem.			0	Biceps fem.			0
Sample 3 TUCH Ossification Exostosis Lower Limb							
Males				**Females**			
Muscle/Ligament	Rank	MSM Score	Number Sites	Muscle/Ligament	Rank	MSM Score	Number Sites
Glut. max.	1	1.03	40	Add. long.	1	0.44	23
Add. long.	2	0.55	40	Glut. max.	2	0.14	21
Iliopsoas	3	0.50	37	Semitend	3	0.13	7
Glut. med.	4	0.47	34	Glut. med.	4	0.07	14
Semitend	5	0.41	15	Quad. fem.	5	0.07	12
Quad. fem.	6	0.13	24	Iliopsoas	6	0.00	20
Biceps fem.			0	Biceps fem.			0

6.3.2 Discussion of the Musculo-skeletal Stress Marker Analysis

There have been a range of previous studies which have focussed on the reconstruction of activities that people may have carried out in the past from osteological analyses. These studies have examined MSMs as well as other skeletal modifications (such as joint disease or non-metric traits) to suggest that the results of certain activities may be recognisable on skeletal material. Some examples of these activities include archery (Molnar 2006), javelin throwing (Dutour 1986) and horse riding (Courtaud and Rajev 1998). Kennedy (1989) provides a detailed list of various occupations and activities which have been addressed through assessments of this nature. Other studies have adopted a broader approach and have not attempted to suggest specific activities of individuals but rather have aimed to establish patterns of movements on a group basis, in effort to determine if variation exists based on factors such as social status (Robb 1998), sexual divisions of labour (Eshed et al. 2004) and age (Molnar 2009). Even though the present study does not attempt to correlate specific activities with MSM patterning, the results nonetheless allow for observations to be made concerning the reconstruction of anatomical movements both within and between sample groups. The following sub-sections discuss the results of the robusticity/cortical defect MSM assessment. The results of the ossification exostosis category are summarised following these evaluations.

Sample 1 PAZ MSM Discussion

Several observations can be made concerning the combined upper limb left and right side MSM results for Sample 1 PAZ. For males, the three highest ranked muscles/ligaments were *brachialis, costoclavicular* and *pectoralis minor.* The fourth highest ranked was the common extensors. *Brachialis* is a strong flexor muscle at the elbow joint and the *costoclavicular* ligament works with the *trapezoid* and *conoid* ligament to reinforce the shoulder joint and prevent medial displacement of the clavicle. *Pectoralis minor* protracts and rotates the scapula. The study by Hawkey and Merbs (1995) also found the *costoclavicular* ligament to be highly ranked and received a mean score of 4.24. The present study exhibited a mean score of 4.00 for males and 3.44 for females. Hawkey and Merbs (1995) indicated that the high rank for the *costoclavicular* ligament in Thule Eskimo populations was likely attributable to the bilateral rotational movements at the shoulder joints associated with paddling a kayak. In the present study *pectoralis minor* and *trapezius* ranked highest for females, followed by *brachialis* and common extensors. Similarities between males and females can be observed in the high ranks for *pectoralis minor* and *brachialis* and suggests that both groups carried out movements which required strong flexion at the elbow joint. One activity requiring strong elbow flexion and scapular rotation could consist of carrying heavy loads with bent elbows.

Sample 1 PAZ: Bilateral Asymmetry

The assessment of bilateral asymmetry within this sample is also informative on several counts. For males, the results of bilateral asymmetry patterns indicated an equal side use for the *costoclavicular* ligament and *pectoralis minor* and *brachialis* was only slightly right side dominant. This suggests that the muscles/ligaments most highly ranked were primarily used in anatomical movements that were bilateral in nature. For females, the highest ranked muscle, *pectoralis minor,* could not be assessed for bilateral asymmetry. The second highest ranked muscle, *trapezius*, was found to be left side dominant, although this was not markedly so. *Brachialis* and the common extensors were also found to be left side dominant for females, but again this asymmetry was slight. The most marked asymmetry for females was for the *supinator* muscle which scored 284. There were twelve left side observations and sixteen right side observations for this attachment site, so it is unlikely that this result is reflective of sampling issues. This result suggests that females were carrying out some type of habitual movement that primarily involved left side supination of the forearm, as opposed to right side. However, it should also be noted that the combined left/right side mean MSM score for *supinator* was the lowest ranked of all the muscles/ligaments for females in this samples. Therefore, whilst the asymmetry may be notable, it does not appear that the activity which contributed to this result was carried out to any marked degree.

Sample 1 PAZ: Lower Limb

The lower limb results for Sample 1 PAZ are generally similar for both males and females with regards to the most highly ranked muscles. The combined left and right mean MSM scores for both sexes indicate that the highest ranked muscle was *gluteus maximus*. This result indicates strong extension of the thigh as well as lateral rotation at the hip joint. The other muscles which ranked highly for both males and females were *iliopsoas* and *adductor longus*. *Iliopsoas* also flexes and stabilises the hip joint and *adductor longus* assists in medial rotation of the femur and adduction at the hip joint. In addition, no significant differences were found between males and females for the lower limb results.

These findings suggest that lower limb anatomical actions carried out between the sexes appear to be generally similar. While the mean scores for males are higher, the ranking of muscle usage are largely comparable in distribution.

Sample 2 EG MSM Discussion

A number of observations can also be made concerning the upper limb results of Sample 2 EG for both males and females. The highest ranked muscles/ligaments for males were costoclavicular, brachialis and the common extensors. These rankings indicate strong flexion at the elbow joint and anchoring at the clavicle and a high degree of extension and supination of the forearm. The three highest ranking muscles/ligaments for females were brachialis, the common extensors and *costoclavicular*. These upper limb rankings between males and females indicate that comparable anatomical movements and relative degrees of muscle/ligament usage were similar at these sites. Furthermore, no significant differences were observed from the statistical tests.

Sample 2 EG: Bilateral Asymmetry

Bilateral asymmetry patterns indicate that both males and females exhibited right side dominance for a majority of the muscle/ligament sites. For both males and females this right side dominance was found to be significant. However, the differences between males and females were not found to be significant. This further supports the possibility that males and females were carrying out similar anatomical movements of the upper limb in this sample. Marked asymmetry is observable in the result for males for *supraspinatus* which received a score of 51, indicating a pronounced degree of right side dominant use of this muscle. *Supraspinatus* works in combination with *deltoid* and works to initiate abduction of the humerus. This muscle ranked twenty-third for males and this rank indicates a low degree of use for this particular muscle. Marked asymmetry for females can be observed in the results for *infraspinatus, supinator, supraspinatus,* and *teres minor*. All of these sites exhibit right side dominance for females in this sample. Both *supraspinatus* and *infraspinatus* are utilised to abduct the humerus, whilst *supinator* carries out *supination* of the forearm and the primary function of *teres minor* is to laterally rotate the forearm. Each of these muscles ranked in the bottom seven for the combined mean MSM scores and this indicates a generally low degree of utilisation of these muscle groups. However, the findings for both males and females indicate that while a particular muscle or ligament may not have been extensively utilised, right side dominance is markedly observable in those cases.

Sample 2 EG: Lower Limb

The lower limb results for Sample 2 EG are similar to those of Sample 1 PAZ. The comparative results between males and females from the combined left and right side mean MSM scores are largely similar as well. No statistical significance was observed for the variation between male and female lower limb results for this sample either. For both males and females *gluteus maximus* ranked the highest. This finding illustrates that both males and females were influenced similarly by anatomical actions which consisted of thigh extension and lateral rotation at the hip joint. Variations between males and females are observable in the ranking for *biceps femoris.* For males this muscle ranked sixth, whilst for females it ranked second. This suggests that females were engaged in movements that comprised a marked degree of flexion and extension of the thigh. *Biceps femoris* is also used to laterally rotate the leg when the knee is flexed.

Sample 3 TUCH MSM Discussion

The upper limb results of the combined left and right side mean MSM scores for the robusticity/cortical defect category for Sample 3 TUCH allow for a number of observations to be made. Unfortunately, because of the incompleteness of the skeletal material for this sample, several of the more commonly used muscles/ligaments of the other two samples cannot be compared. Muscles/ligaments which were not available for observation in this sample are *pectoralis minor* and *trapezius* for males and *conoid, costoclavicular, pectoralis minor, subclavius, trapezius* and *trapezoid* for females. The three highest ranking sites for males are *costoclavicular, conoid* and *trapezoid.* Each of these ligaments works at the shoulder and are utilised during rotational movements at this joint and to prevent medial displacement and to provide stability for the clavicle (Hawkey and Merbs 1995). Out of the sites that could be assessed for females, the highest ranked were *brachialis* and the common extensors. Common extensors ranked fifth for males in this sample. Interestingly, the mean MSM scores for females at the common extensors was 3.56, whilst for males the mean score was 3.48. Even though the results were not *statistically* significant, the higher ranking and elevated mean MSM score for females may indicate a greater degree of anatomical movements which involved extension and supination of the forearms. In addition, *biceps brachii* ranked third for females. *Biceps brachii* is a strong flexor at the elbow joint and supinates the forearm. Dutour (1986: 222) describes elevated stress lesions at the site of *biceps brachii* as being common in individuals that habitually carry heavy loads with their elbows bent, such as bakers and masons. Furthermore, it is *brachialis* which is the stronger flexor at the elbow and the high result for this muscle correlates with marked muscle usage of *biceps brachii* as well. These actions would commonly be used during activities involving the carrying of heavy loads and/or other tasks requiring extensive use of the forearms.

Sample 3 TUCH: Bilateral Asymmetry

Bilateral asymmetry patterns for males indicate right side dominance for *costoclavicular*, left side dominance for *conoid* and right side dominance for *trapezoid*. However, the results for these sites were not right side dominant to a marked degree and paired t-tests indicated no significant differences between left and right side results for males ($p>0.05$). Bilateral asymmetry patterns for both males and females indicated right side dominance for *brachialis* and left side dominance for common extensors. In the case of females, paired t-tests indicated significant variation in left and right side results ($p<0.05$). As discussed above, *brachialis* is utilised in actions involving strong flexion at the elbow joint.

Sample 3 TUCH: Lower Limb

The lower limb results for Sample 3 TUCH show similar patterns for males and females The highest ranked muscle for males was *gluteus medius* and the highest ranked for females was *semitendinosus*. *Gluteus medius* carries out extension and abduction at the hip and *semitendinosus* flexes and extends the thigh and also carries out medial rotation at the knee. *Semitendinosus* also ranked highly for males and *gluteus medius* also ranked highly for females. These results suggest that similar anatomical actions of the lower limb were carried out by both males and females. Furthermore, no statistically significant variation was found between the results of the lower limb based on sex.

Comparison of Musculo-Skeletal Markers between Samples

The results of the MSM analysis allow for a number of observations to be made when comparisons are carried out between the three samples. Tables 6.20 and 6.21 present the comparative results of same sex bilateral asymmetry patterns between samples. Figures 6.10 and 6.11 illustrate the mean MSM results of the robusticity/cortical defect category for twelve high ranking muscles/ligaments of the upper limb compared between males and females for all samples. In previous studies, same sex comparisons over time and between sites have been informative with regards to variation and continuity in labour regimes. For example, the study by Eshed et al. (2004) of Natufian hunter-gatherers and Neolithic farming communities in the Levant, found a correlation in upper-limb MSMs and an increase in overall stress in the farming community as compared to the hunter-gatherers. Based on the results of this study it was suggested that females in the farming communities had taken on a greater proportion of labour responsibilities than females from the previous period (Ibid).

Upper Limb Mean MSM Comparison: Males

Figure 6.10 illustrates the comparative results for males of the combined left and right mean MSM scores between samples. The highest scoring attachment site was *brachialis* for Sample 1 PAZ.

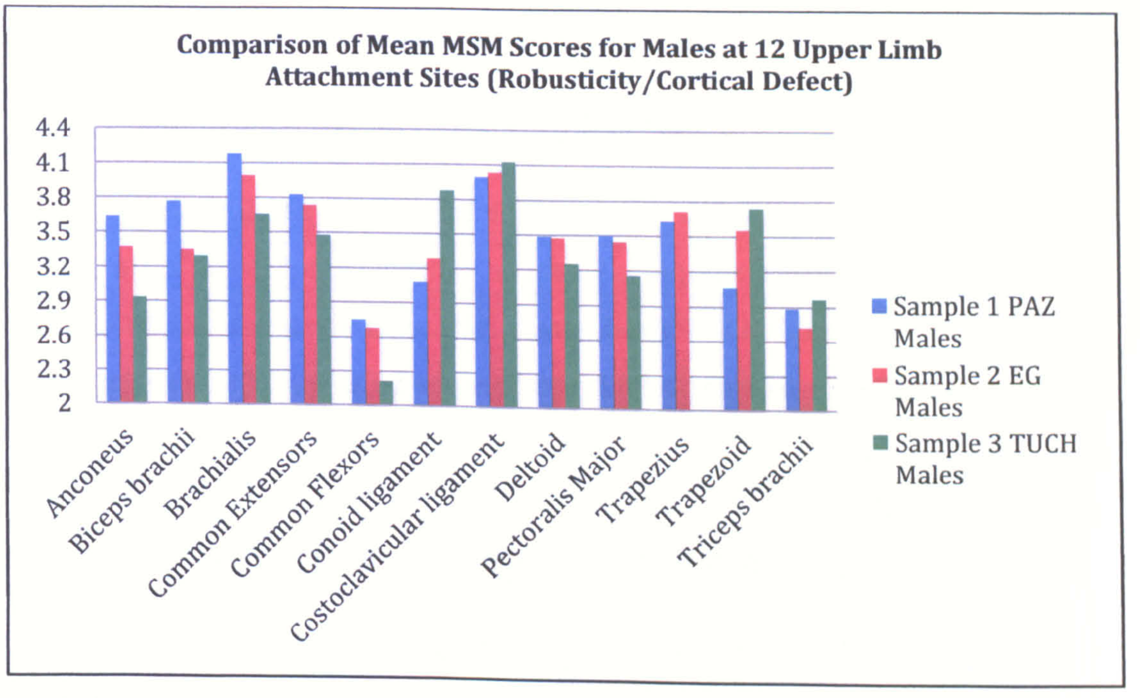


Figure 6.10 Comparison of Mean MSM Scores for Males from All Samples at 12 Upper Limb Attachment Sites for Robusticity/Cortical Defect Category, Combined Left and Right Side Scores.

Sample 1 PAZ exhibited a mean score of 4.18 for *brachialis*, whilst Sample 2 EG had a mean score of 4.00 and Sample 3 TUCH had a mean score of 3.66. The *brachialis* muscle is a strong flexor muscle at the elbow joint. The common flexor muscles also carry out flexion at the elbow joint. The common flexors scored generally low for all three samples, with Sample 3 TUCH exhibiting the lowest mean score of the three at 2.22. Sample 1 PAZ had a mean score of 2.75 and Sample 2 EG had a mean score of 2.68. This finding corresponds with the results for *brachialis* in that the lowest scoring for these two attachment sites was for Sample 3 TUCH. This finding suggests that this group may have carried out tasks or habitual movements which utilised somewhat less flexion at the elbow joint than the other two groups. *Costoclavicular* scored highly for all three samples, with Sample 3 TUCH scoring slightly higher than the other two. For *costoclavicular* Sample 1 PAZ males had a mean score of 4.00, Sample 2 EG had a mean score of 4.04 and Sample 3 TUCH had a mean score of 4.13.

Costoclavicular works with *trapezoid* and *conoid* at the shoulder joint to anchor the clavicle and reinforce the joint between the scapula and the clavicle. The *costoclavicular* ligament also prevents medial displacement and elevation of the clavicle. *Conoid* and *trapezoid* also scored highly for all samples. These results indicate that males across all samples show similar degrees of elevated biomechanical stresses at the shoulder joints.

Bilateral Asymmetry Comparison: Males

Table 6.19 presents the results of the bilateral asymmetry comparison for males between all three samples. All three samples exhibited a majority of sites with right side dominance. Paired t-tests indicated no significant differences between the results for Sample 1 PAZ and Sample 2 EG ($p>0.05$). Comparisons between Sample 1 PAZ and Sample 3 TUCH were significantly different for right side scores ($p<0.05$). The comparison between Sample 2 EG and Sample 3 TUCH were not significant for left or right side scores ($p>0.05$).

Table 6.19 Comparison of bilateral asymmetry patterns between samples for males. Muscles/Ligaments are listed in alphabetical order.

Muscle/Ligament	SAMPLE 1 PAZ MALES Bilateral Asymmetry	SAMPLE 2 EG MALES Bilateral Asymmetry	SAMPLE 3 TUCH MALES Bilateral Asymmetry
Anconeus	113	101	100
Biceps brachii	101	97	104
Brachialis	98	100	95
Common Extensors	95	108	106
Common Flexors	87	105	97
Conoid ligament	68	86	107
Coracobrachialis	91	104	71
Costoclavicular ligament	100	97	94
Deltoid	91	106	96
Infraspinatus	62	95	147
Latissimus dorsi	79	93	94
Pectoralis minor	100	102	/
Pectoralis major	75	92	94
Pronator quadratus	95	83	50
Pronator teres	91	105	92
Subclavius	104	103	125
Supinator	127	97	136
Supraspinatus	109	51	95
Teres major	84	92	87
Teres minor	76	85	107
Trapezius	93	94	/
Trapezoid ligament	96	100	88
Triceps brachii	98	95	102

Even though some examples of marked bilateral asymmetry have been discussed in the previous sections, the most highly ranked muscles between the three sample groups generally display relatively little degree of bilateral asymmetry. The exception to this is for the *conoid* ligament, where Sample 1 PAZ scored a 68, indicating somewhat more pronounced right side dominance at this site than the other two samples.

Upper Limb Mean MSM Comparison: Females

Figure 6.11 illustrates the mean MSM at twelve upper limb sites for females across all samples. The highest mean score was for *pectoralis minor* for Sample 1 PAZ with a score of 3.99. This site is not indicated in Figure 6.11, as it ranked quite low for Sample 2 EG and was unobservable for Sample 3 TUCH.

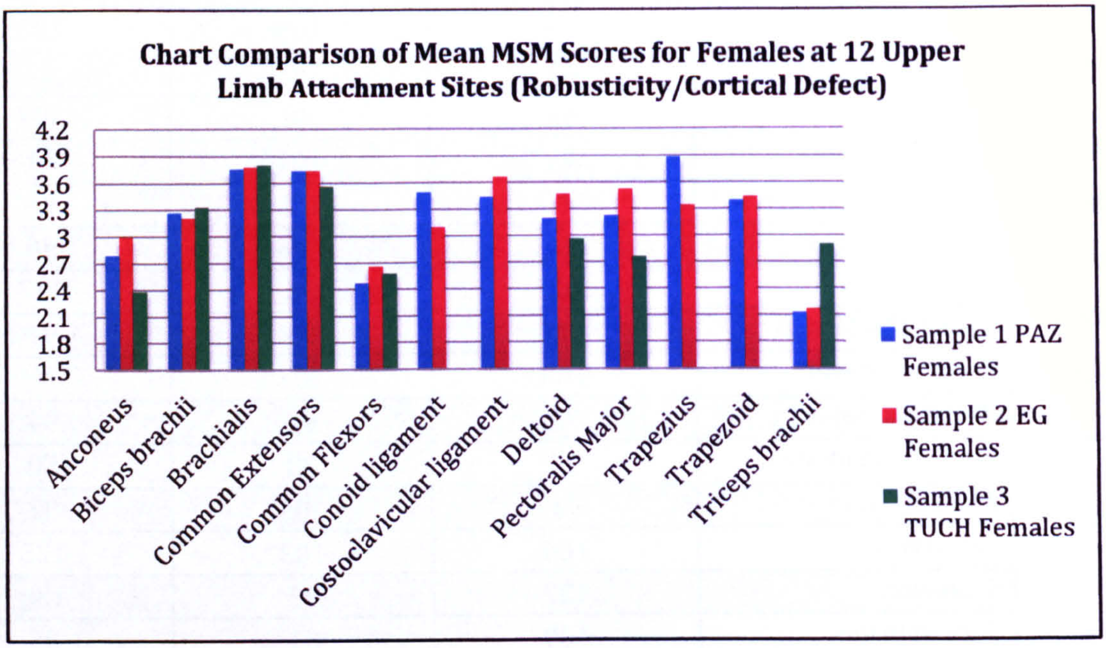


Figure 6.11 Comparison of Mean MSM Scores for Females from All Samples at 12 Upper Limb Attachment Sites for Robusticity/Cortical Defect Category, Combined Left and Right Side Scores.

Out of the additional results that are indicated in Figure 6.11, the highest mean score was 3.88 for *trapezius* from Sample 1 PAZ. Sample 2 EG exhibited a mean score of 3.34 for *trapezius* and this site was unobservable for Sample 3 TUCH. All three samples exhibited similar mean scores for *brachialis,* common extensors and common flexors. Common flexors exhibited lower mean scores across all samples as compared to *brachialis* and common extensors. The mean scores for *biceps brachii* were also similar across all samples. These findings indicate elevated muscle usage at sites which primarily engage in flexion and extension at the elbows. An additional observation can be addressed with regards to the results for *triceps br.* Sample 1 PAZ exhibited a mean score of 2.13 for this site, Sample 2 EG had a mean score of 2.17 and Sample 3 TUCH had a mean score of 2.90. *Triceps br.* is a strong extensor at the elbow joint and is also involved with controlling flexion at the elbow joint particularly when extensive weight is placed on the upper limb. The elevated mean score and higher ranking for Sample 3 TUCH indicates that this action was carried out to a greater degree in this sample as compared to the other two.

Bilateral Asymmetry Comparison: Females

Table 6.20 presents the results of the bilateral asymmetry comparison for females between the three samples. Sample 1 PAZ exhibited a majority of sites with left side dominance, whilst Samples 2 EG and 3 TUCH exhibited a majority with right side dominance. Paired T-tests between the samples indicated no significant variation between Samples 1 PAZ and 2 EG for left and right side results ($p>0.05$). Comparisons between Sample 1 PAZ and Sample 3 TUCH were not significant for either left or sides ($p>0.05$). This was also the case for comparisons between Samples 2 EG and 3 TUCH for both left and right sides ($p>0.05$).

Table 6.20 Comparison of bilateral asymmetry patterns between samples for females. Muscles/Ligaments are listed in alphabetical order.

Muscle/Ligament	SAMPLE 1 PAZ FEMALES Bilateral Asymmetry	SAMPLE 2 EG FEMALES Bilateral Asymmetry	SAMPLE 3 TUCH FEMALES Bilateral Asymmetry
Anconeus	86	93	81
Biceps brachii	101	98	71
Brachialis	104	105	95
Common Extensors	104	104	109
Common Flexors	109	113	98
Conoid ligament	100	101	/
Coracobrachialis	82	83	105
Costoclavicular ligament	72	97	/
Deltoid	104	95	85
Infraspinatus	112	66	122
Latissimus dorsi	107	94	83
Pectoralis minor	/	71	/
Pectoralis major	88	93	87
Pronator quadratus	83	106	37
Pronator teres	150	100	81
Subclavius	103	76	/
Supinator	284	55	48
Supraspinatus	77	68	87
Teres major	94	96	97
Teres minor	107	63	90
Trapezius	107	95	/
Trapezoid ligament	85	101	/
Triceps brachii	82	91	117

Like the results for males, the comparisons of bilateral asymmetry patterns between females for all samples are generally similar for muscles which ranked highest. The results for *biceps br.*, *brachialis*, common extensors, common flexors and *triceps br.* are all relatively close to 100, indicating little in the way of side dominance. A particularly notable example of bilateral asymmetry is observable in the results for *supinator* which are markedly pronounced in left side dominance for Sample 1 PAZ and right side dominance for Samples 2 EG and 3 TUCH. Even though this muscle ranked low for all three samples, the left and right side variation between these sample groups is evident.

Lower Limb Mean MSM Comparison: Males

Figure 6.12 presents the combined left and right side mean MSM results for males from each sample for all lower limb muscle sites. The muscles with the highest mean MSM scores are largely comparable. The mean MSM values for *gluteus maximus, gluteus medius* and *iliopsoas* generally scored highest and are similar for all samples. One example of marked variation between the three sample groups can be observed in the results for *quadratus femoris.* This site exhibited a mean score of 1.66 for Sample 1 PAZ, 2.13 for Sample 2 EG and 1.00 for Sample 3 TUCH. The major function of *quadratus femoris* is to laterally rotate the hip and adduct the thigh. The lower mean result for this muscle for Sample 3 TUCH suggests that this anatomical action was carried out to a lesser degree in this group as compared to the other two for males.

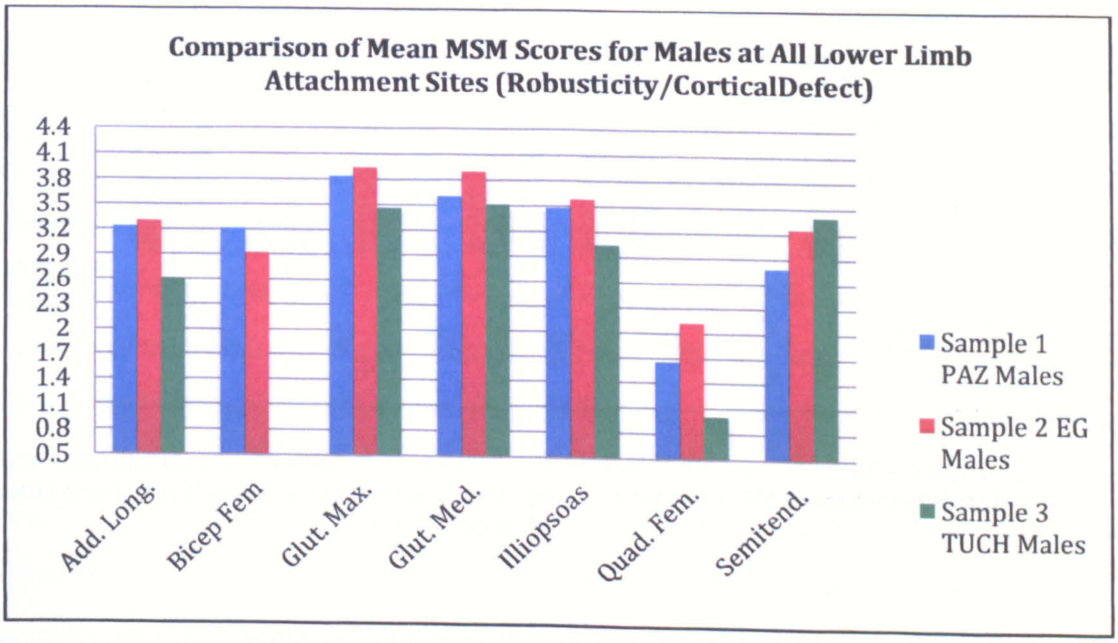


Figure 6.12 Comparison of Mean MSM Scores for Males from All Samples at All Lower Limb Attachment Sites for Robusticity/Cortical Defect Category, Combined Left and Right Side Scores.

Lower Limb Mean MSM Comparison: Females

Figure 6.13 below illustrates the lower limb results for females from the combined left and right side mean MSM scores for the robusticity/cortical defect category. These results are somewhat similar to males in that *gluteus maximus, gluteus medius* and *iliopsoas* generally display the most elevated mean scores. However, the variation at these three sites is greater between females than males. Sample 1 PAZ exhibits a markedly lower mean score for *gluteus medius* compared to the other two samples. This suggests less extension and abduction at the hip for this group. The results for *quadratus femoris* are also similar to males in that pronounced variation can be observed in the mean scores for this attachment site. Sample 2 EG displayed the highest mean score for this site at 1.25, whilst Sample 1 PAZ had a mean score of 0.56 and Sample 3 TUCH had a mean score of 0.52. The markedly higher result for Sample 2 EG indicates a greater degree lateral rotation at the hip for this group.

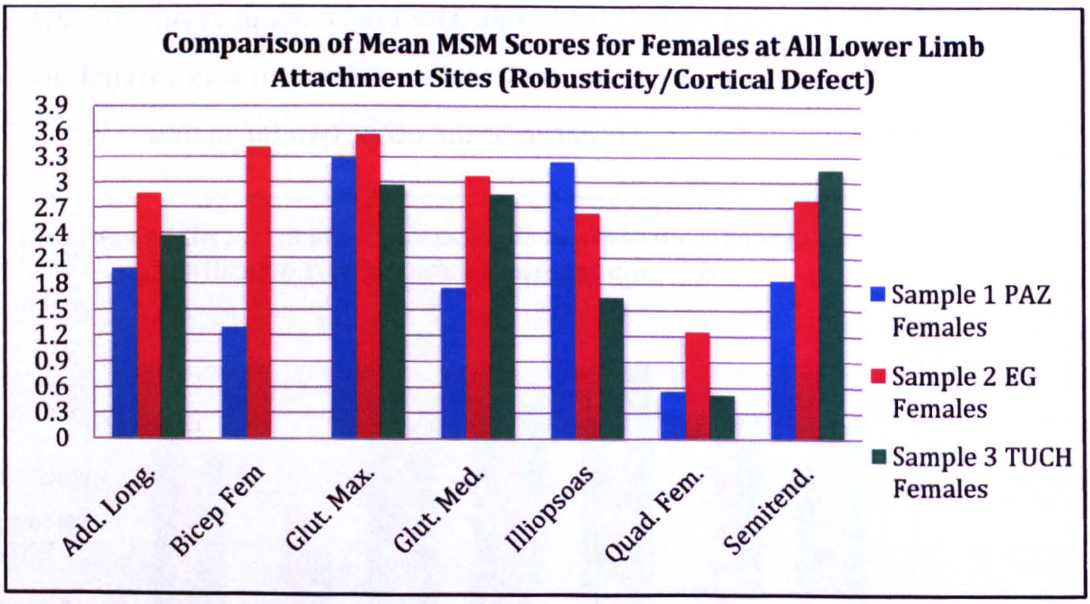


Figure 6.13 Comparison of Mean MSM Scores for Females from All Samples at All Lower Limb Attachment Sites for Robusticity/Cortical Defect Category, Combined Left and Right Side Scores.

An additional site which was highly variable among females was *biceps femoris.* The mean score for Sample 1 PAZ was 1.29 whilst the mean score for Sample 2 EG was 3.42. *Biceps femoris* ranked sixth for Sample 1 PAZ and second for Sample 2 EG. This site was unobservable for Sample 3 TUCH. The combined variation of Sample 2 EG for both *quadratus femoris* and *biceps femoris* indicate that females from this group possibly engaged in some habitual activity that differed from the other groups. This activity involved flexion and extension of the thigh and lateral rotation of the hip.

Ossification Exostosis Discussion

The primary focal point of this assessment has been on the robusticity/cortical defect observations, rather than ossification exostosis. The reason is that the present study focussed primarily on anatomical reconstructions based on long-term habitual movements and muscle/ligament usage. However, several observations can be made concerning the results of the ossification exostosis evaluation. The combined left and right side mean results of this category were generally low for all samples. This suggests that there appears to be a relatively low degree of *macrotraumas* evident on the skeletal material assessed for the present study. The comparative study by Lieverse et al. (2009) of Siberian Neolithic to Hunter-Gatherer groups also noted the very rare occurrence of these lesions in those samples. For the present study, across all samples, males tend to exhibit higher mean scores and females exhibited more cases of muscles/ligaments with no scores for ossification exostosis. This is generally observable in both upper and lower limb results. The upper limb results indicate that the highest ranked muscles in this category were similar to those of the robusticity/cortical defect category. The muscles/ligaments most affected were *costoclavicular, pectoralis minor* and *triceps br.* The high rank for *triceps br.* was observed for females from Sample 3 TUCH. By comparison, for males in this sample *triceps br.* ranked eighth. It is also worth noting that this muscle scored fifth in rank for females for the robusticity/cortical defect category. This result suggests that some activity carried out by females likely predisposed them to abrupt macro-traumas at this attachment site, as compared to the other groups. This variation is not only distinctive from males from this sample but also females from Sample 1 PAZ which exhibited no score for this site and from Sample 2 EG where this muscle ranked twelfth. The lower limb results for all samples indicate the highest ranked muscles in this category were *gluteus maximus, adductor longus* and *biceps femoris.* These results suggest that a greater degree of macro-traumas occurred during anatomical actions which involved extension of the thigh and medial rotation of the femur.

6.4 Summary and Conclusions

The examination of both degenerative joint disease and musculo-skeletal stress markers has provided a measure for assessing health and activity related patterns in these samples. Overall, it appears that a divergence in activity and workload patterns is most obvious between the Han Dynasty sample, Tuchengzi from Inner Mongolia than the other two samples from north-central Mongolia and the Siberian Altai. It is possible that this finding is related to variation in subsistence regimes or a greater degree of workload in the Tuchengzi sample which may in turn be related to social factors, such as occupation or status. Another alternative is that the Tuchengzi sample is comprised of individuals biologically dissimilar to the Pazyryk and Egiin Gol samples and the results presented here are a reflection of this variation. Further studies in this area would be necessary in order to more appropriately assess this possibility.

Health has been addressed through the study of degenerative joint disease in that it is a condition which affects a significant proportion of both ancient and modern populations. It is likely that the common degenerative joint ailments of today, which may hinder an individual's ability to carry out physically demanding tasks throughout the progression of adult life, were also a significant factor in antiquity. This assessment was hindered by several factors, most importantly the inability to more precisely ascertain the age profile of Sample 3 TUCH. In addition, once samples were divided into age categories for DJD analysis, the low sample sizes made those particular results less reliable overall. Furthermore, because of the degree of missing data which is inevitable in MSM analysis, the samples were too small once divided by age to be properly assessed for variation in mean scores based on age. Another complicating factor is that at present it is difficult to gauge what would be considered to be a high or low instance of DJD in predominately pastoralist or agro-pastoralist populations from this region. However, future comparative research may allow for a more comprehensive picture of DJD rates and severity to be assessed between samples from similar economies and socio-cultural settings in this particular geographic setting. Similarly, very few MSM studies of pastoralist populations of the study regions currently exist. This also has the potential to be remedied through future studies. Despite these difficulties, the current assessment has demonstrated through the examination of DJD and MSM's that some patterns of anatomical movement are observable both within and between these population samples. Even though attempts were not made to directly relate these patterns to specific activities, the overall results suggest that divergence in social standing, variation and similarities in habitual tasks and degree of workload, coupled with biological variation between populations, is likely to have contributed to the findings presented here.

Chapter Seven
Conclusion

It was pastoral nomadism that eventually became the ruling order, though not the sole order.

-Owen Lattimore [1940:54]

What has emerged most vividly through the course of this research are the multiple and changing communal stories of the groups of people who inhabited the vast steppe-lands of Inner Asia at critical turning points in the course of recent human evolution. These stories encompass both social and adaptive developments that occurred within local communities and across the region as a whole. The major aim of this dissertation was to elicit a greater understanding of the early communities of this region through the reconstruction of dietary habits, group health, activity patterns and collective workload regimes. The focus of this study on human skeletal remains allowed for an in-depth enquiry into the past life-ways of these peoples. The examination of the human skeleton in its own right offers unique insights into previous life-ways that are unobtainable by other means, simply by virtue of the fact that the human skeleton itself is the most *direct* historical and biological link to our past (Larsen 2002; Sofaer 2006; Lorentz 2008).

7.1 General Conclusions

The objectives of this dissertation as set out in Chapter One were to reconstruct past diet and health from osteological analyses, to reconstruct dietary habits from stable isotope analyses and to identify activity and workload patterns through the analysis of degenerative joint disease and musculo-skeletal stress markers. The sub-sections which follow provide an overview of the conclusions observed from this study. While it is acknowledged that in this type of broad summary oversimplifications are inevitably made, the aim here is simply to highlight the general trends that are observable from this assessment.

7.1.1 Reconstructing Diet

The reconstruction of dietary habits was undertaken through the investigation of dental pathological conditions associated with dietary intake and by stable carbon and nitrogen isotope analyses carried out on human and faunal skeletal remains. Differential prevalence rates and expressions of dental pathology and wear patterns, as well as isotopic analyses have indicated both similarities and variation in dietary habits between population samples. What has most notably emerged from these results is a portrait of *local* dietary variation that appears to have been accompanied by strategic dietary-resource exploitation. This is aptly summarised by Watson (1971: 98) through his mention of the '*broad unity* and *local diversity* that characterises the "nomadic world"' (*emphasis by author*). Local vs. macro-regional dietary variation was evident, in some cases, even when between-population mortuary rites were markedly uniform across broad geographical expanses (e.g. Xiongnu ring tombs from discrete sites across Mongolia and south-central Siberia). The assessment of common dental pathological conditions has provided evidence for dietary habits on several accounts. In particular, the examination of dental caries prevalence rates has contributed a number of important findings concerning these populations. The frequency of dental caries was generally low for each of the samples and the results were similar to ranges found in prehistoric hunter-gatherer and mixed-economy groups (Lukacs 1989). These findings indicate a low dependency on cariogenic foods for these communities. This was the case even for the Han Dynasty, Tuchengzi sample from Inner Mongolia, which was thought to have relied more heavily on cultigens such as millet, as based on stable isotope studies by Gu (2007) of this population. This result can be explained by the likelihood of a mixed dietary base for this group that included a substantial portion of domesticated animals and animal products in their diet and on the lesser cariogenic properties of millet. The low frequency of dental caries as a whole for these groups is also in accordance with findings from other investigations of prehistoric populations from East and South-East Asia. Several studies have reported that populations relying on millet or wet-rice agriculture tend to exhibit lower frequencies of caries when compared to those that relied on maize as their staple crop (Tayles et al. 2000; Domett 2001; Pechenkina et al. 2002). This occurrence has been attributed to the relatively less cariogenic properties of starch in comparison to sucrose (discussed in Temple and Larsen 2007). It is also important to note that it was the Xiongnu Period sample from Ivolga that exhibited the highest instance of dental caries among all the groups. While it is generally believed that the Xiongnu relied primarily on domesticated animals, as mentioned in the ancient historical sources discussed in Chapter Two, this finding supports arguments for a multi-resource based economy for some Xiongnu communities. This result further illustrates that this group not only had access to but also partook of other dietary resources, aside from domesticated animals and animal products. Whether this was due to ecological factors associated with resource availability or social aspects such as group status or cultural choice, is unclear at this point. It is likely that a combination of these factors were involved. Variation between the other groups is in evidence as well and overall, this variation roughly corresponds with a greater prevalence of caries for the groups that were thought to have subsisted on naturally occurring terrestrial plant foods and/or cultigens to lesser or greater extents based on archaeological contextual information and isotopic analyses.

The results for dental calculus were less informative with regards to dietary reconstruction. At this stage, without a better understanding of calculus aetiology, it is difficult to directly relate calculus deposition to dietary habits. Significant association was found between the frequency of calculus formation and the respective samples and the highest percentage was observed in the sample from Ivolga. The results for the other samples were variable and ranged from 85% to 41% of individuals affected. The lowest frequency was observed in the Late Historic Period sample from Urga. This could indicate that by this later period, changes in dietary composition and advances in oral hygiene standards may have precipitated a decline in calculus deposition. While in some populations it has been suggested that rates of calculus are related to high protein or high carbohydrate diets, other factors such as oral hygiene standards and predisposition to calculus formation appear to be as influential as diet (discussed in Lieverse 1999). Therefore, further studies pertaining to the causes of calculus formation are necessary to refute or substantiate possible dietary influences with regards to the calculus results for these communities. Not only has the analysis of dental pathology been informative with regards to between-group comparisons, but the examination of within-group variance based on sex has also aided in dietary reconstruction. Overall, there was relatively little variation in dental pathology between males and females and in all groups neither dental caries nor calculus was significantly associated with sex. This indicates that both sexes generally had access to the same dietary resources throughout all groups. This also suggests that there was very little variation between the sexes with regards to the predisposition for calculus formation or a marked divergence in oral hygiene standards. The assessment of dental macro-wear patterns has indicated a broad trend toward softer more extensively processed foods as evidenced by the markedly low attrition rates for the Late Historic Period sample from Urga. This area of examination has also found examples of the extensive use of anterior teeth in some samples, which suggests extra-dietary use of dentition and/or possible masticatory compensation as a result of other dental pathological conditions such as abscesses or ante-mortem tooth loss of posterior teeth.

The analysis of stable carbon and nitrogen isotopes has also provided a foundation for a better understanding of dietary-related resource exploitation strategies at four separate locations situated within present-day Mongolia. By contrast to dental pathology analysis, stable isotope studies have the ability to provide *direct* information concerning the long-term dietary habits of a given population. Broadly speaking, the results of this assessment have shown that local adaptive subsistence strategies are observable at discrete locations and these could be changeable over time. Marked variation is in evidence between the individuals from Baga Gazaryn Chuluu, Taishar and Shombuuzin belchir in comparison to the individuals from Egiin Gol particularly with regards to the $\delta^{15}N$ values which were significantly variable. Broadly speaking, the results indicate a high reliance on animal protein for all groups but suggest a more mixed diet for the individuals from Egiin Gol. Furthermore, these analyses have proven informative with regards to *individual* diet as well as dietary habits of a *communal* nature. Marked variation in individual diets can be observed in the results of the two more clearly divergent individuals from Baga Gaza Gazaryn Chuluu (BGC EX 07.07 and EX 08.18). The results for these two individuals suggest that even within a particular group, individuals could have a diet that varied from the population norm. This is an intriguing area of enquiry that offers important insights into the reconstruction of individual life histories in the distant past. The results of dietary variation based on age and sex in the stable isotope study indicated no significant differences between any groups. This supports the findings of the dental pathology analysis where little variance was also observed between males and females and suggests similar access to dietary resources between the sexes.

An additional area of consideration that was highlighted through the course of the stable isotope assessment was the possibility of environmental influences on $\delta^{15}N$ signatures from samples that were derived from very arid environments. The significantly elevated $\delta^{15}N$ signatures of both human and faunal material from the most arid locations Taishar, Shombuuzin belchir and Baga Gazaryn Chuluu suggest that environmental factors are likely to have influenced these results. The $\delta^{15}N$ values were found to be significantly elevated when compared to the results from the site of Egiin Gol in north-central Mongolia which is a comparatively more temperate environment. Furthermore, the associated faunal material from the same sites and contemporary burial contexts also showed significantly elevated $\delta^{15}N$ signatures in comparison to the Egiin Gol faunal material. This result reinforces the need for assessing isotopic signatures of human skeletal material in combination with local flora and fauna samples whenever possible and opens up further avenues for investigating palaeo-climatic influences on isotopic signatures from this particular region.

7.1.2 Reconstructing Health

Community health levels were assessed through the analysis of dental and skeletal indicators. The examination of linear enamel hypoplasia, periodontal disease and dental abscesses has aided in the investigation of group health, as well as the analysis of degenerative joint disease. Linear enamel hypoplasia (LEH) was relatively low-to-moderate for these groups, indicating low levels of nutritional and/or episodic stress during childhood. The highest percentage of LEH, by both individual and tooth count, was observed in the Xiongnu sample from Ivolga. LEH frequencies based on tooth count were found to be significantly associated with respective samples. LEH was also significantly associated with sex in the Han Dynasty sample from Tuchengzi and the Iron Age Xiongnu sample from Ivolga. In both groups, males exhibited significantly higher instances of LEH. This result suggests that in these groups males experienced a greater instance of physiological stress than females during childhood. These two Iron Age groups are roughly contemporary with one another and both appear to have utilised mixed-economy subsistence strategies for their dietary needs, as observed from the dietary reconstruction and archaeological contextual information. In the majority of the samples, LEH was more common amongst males than females with two exceptions, namely the Xiongnu sample from Egiin Gol and the Late Historic sample from Urga. Given the small sizes of the samples once divided by sex, the results of this area of enquiry must remain tentative at this stage. Nonetheless, they provide a broad indication of low levels of periodic stress during childhood which may be related to higher status for some groups and/or the broader nutritional base of mixed-economy populations when compared to those relying more exclusively on a single staple crop.

Rates of periodontal disease were found to be significantly associated with the sample groups but were not significantly associated with sex. The frequency of periodontal disease between the sample groups ranged from as low as 13% in the Xiongnu sample from Ivolga to 57% in the Bronze Age sample from western Mongolia. Ante-mortem tooth loss rates were not found to be significantly associated with respective sample groups or within samples based on sex. The percentage of individuals affected by ante-mortem tooth loss was highest in the Bronze Age western Mongolia sample at 71%. The moderate-to-high rates of all dental pathological conditions for the Bronze Age sample from western Mongolia can be attributed at least in part to the advanced age profile of this group and possibly to a lower standard of group health. The frequency of dental abscesses was not found to be significantly associated with the sample groups but was significantly divergent based on sex for one sample. This finding was observed in the Iron Age sample from Nileke, Xinjiang which exhibited a greater number of abscesses in males as compared to females. This may indicate variation in health between the sexes for this group, as abscesses can become a serious condition that potentially compromises an individual's immune system (Waldron 2009). Overall, the findings of this area of assessment indicate relatively moderate-to-high standards of group health, though this was variable over both time and space and between pathological conditions. High standards of group health for some samples may be reflective of access to a greater range of dietary resources and/or group status. For instance, the Xiongnu Period samples and the Pazyryk samples are from burials that likely belonged to upper strata members of the population and it is possible that a higher position in society afforded these individuals greater access to other dietary resources and exposure to less overall hardship. Finally, the results of the dental pathology health indicators roughly suggest similar standards of health for both males and females within each respective group.

The results of the degenerative joint disease (DJD) assessment also provide a barometer of overall community health in the three samples that could be included in this area of consideration. The three groups included were the Iron Age Pazyryk sample, the Iron Age Xiongnu Egiin Gol sample and the Han Dynasty Tuchengzi sample. The findings of this investigation showed some degree of variation between the three groups. The results for the Egiin Gol and Pazyryk samples were roughly similar to one another, while the Tuchengzi sample was more divergent. The results of the DJD assessment also exhibited a direct correlation between rates of the condition and advanced age. This finding indicates that throughout the adult life-span, workload and physical demand on joints does not appear to have tapered off at any point. In Cohen's broad comparative review of stress in prehistoric hunter-gatherer vs. farming communities it was suggested that rates of arthritis are more indicative of the 'severity of peak or intermittent demand on muscles and joints rather than simply the number of hours of work involved in the two economies' (1987: 273). Some studies of prehistoric populations have observed a decline in workload that appears to be associated with the adoption of agriculture, while other studies have observed the opposite (discussed in Cohen 1987). The results of this study found that the Han Dynasty Tuchengzi sample, which was thought to have engaged in cultivation at least to some degree, generally exhibited a higher degree of DJD between these three groups. This can be explained by variation in biology between this group as compared to others and/or divergent activity and workload patterns. Broadly speaking, these results indicate that this group was also subjected to a higher rate of 'peak' demand on joints when compared to the other two. Overall, community health indicators have shown a marked variation over both time and place for these populations. This is due in part to the wide geographic and temporal spread of the samples included in this analysis. Because of the broad range of population samples, this area of study has provided an indication for *local* community health standards that were influenced by a multitude of factors that are distinctive to each time and place.

7.1.3 Reconstructing Activity Patterns

Group activity reconstruction was carried out through the examination of degenerative joint disease and musculo-skeletal stress marker analysis. This area of assessment was focussed on three sample groups where post-cranial material was available for analysis, namely Tuchengzi, Egiin Gol and Pazyryk. Several broad observations can be made concerning this area of consideration. Overall, the results of the MSM assessment indicate that variation and similarities are in evidence both within and between sample groups. The results of the MSM analysis roughly show less variation in habitual anatomical movements between the three samples than the results of the DJD assessment. This supports arguments that suggest that DJD is likely to be more reflective of overall skeletal degeneration and that activity reconstructions based *solely* on joint disease patterns are unreliable (Waldron 1994; Jurmain 1999). However, the patterns of DJD have proven informative on a broader scale in the assessment of variation and similarities in group health over the expansive time frames and geographic settings of this dissertation. Furthermore, the combined results of the MSM assessment have provided a more nuanced perspective with regards to the reconstruction of habitual anatomical movements.

The general findings of the MSM analysis indicate that individuals from the three groups appear to have been engaged in similar *degrees* of activity and workload. However, the results of the MSM assessment do indicate some variation in habitual anatomical movements and bilateral asymmetry between groups. This was observable in the results for Egiin Gol and Pazyryk that showed a divergence in muscle usage in the lower limbs in comparison to those from Tuchengzi. All samples showed a similar degree of habitual anatomical activity that involved joints of the upper limb that would have been used extensively in heavy lifting and carrying activities, although this was evident to lesser or greater extents in some groups over others. The markedly low instances of ossification exostosis across all groups indicate very few cases of macrotraumas at muscle attachment sites. This is similar to the findings of Lieverse et al. (2009) of Siberian Neolithic and Hunter-Gatherer groups which observed no cases of ossification exostosis. The MSM patterns between males and females were informative with regards to the lower-limb results which exhibited no significant variation between the sexes. This indicates that while body size may have influenced the mean MSM scores, the lack of significant variation in the specific muscles used suggests similar lower-limb activity patterns for both males and females. This finding is also likely to be reflective of the weight-bearing properties of the lower-limb in general (Weiss 2003). This examination has also indicated that variation in joint disease between the sexes need not necessarily correlate with significant variation in musculo-skeletal stress marker findings. The patterns of DJD, coupled with the results of the MSM analysis, suggest a more divergent workload regime for the Han Dynasty Tuchengzi sample in comparison to the Early Iron Age Pazyryk sample and the Xiongnu sample from Egiin Gol. This is potentially reflective of variation in activity patterns and/or differences in community status. These results are also possibly linked to habitual activities associated with divergent subsistence regimes and biological variation between these groups. An additional explanation that may account for the variation between the two more mobile groups, the Pazyryk and Egiin Gol samples and the proposed more sedentary Tuchengzi sample, may be that the genetic or biological makeup of the populations are too divergent to meaningfully compare, at least with regard to assessing habitual activity patterns. It may be that difference in population genetics between these groups is such that the Tuchengzi sample may vary biologically from the others to such a degree that the MSM results appear markedly divergent solely because of this factor. Such variation could for example be related to the overall body mass of these individuals or even genetic predisposition (Jurmain 1999). In addition, it has been suggested that the joints of individuals of a smaller size may experience a higher instance of DJD due to a greater degree of mechanical loading being placed on smaller joint surfaces (Weiss and Jurmain 2007). Even though this was suggested to explain variation in DJD between males and females, this potentially has some bearing on population differences as well. In order to further investigate this suggestion, it will be necessary to carry out similar analyses on additional samples of individuals from this region. Currently, this explanation should be considered as a likely proposal to account for the variation observed between these particular groups. Further studies that incorporate better controls for body size will allow for more comprehensive conclusions to be drawn when comparing markedly divergent population groups as well as males vs. females (Weiss 2003). Overall, this enquiry has reinforced the need for further investigations of similar populations from this region in order to more appropriately perform between-group comparisons. Future research employing improved controls for age estimation and body mass can be implemented and this, coupled with more concise contextual information, will allow for an expansion upon these results. Broadly speaking, the reconstruction of activity and workload has provided an indication of both similarities and variation in MSM and DJD patterns that were influenced by a myriad of factors that require further investigation.

7.2 Concerns and Considerations

Overall, the main objectives of this research have been met, although not entirely without complications. A major obstacle was the lack of archaeological context information for many of the skeletal samples. In some cases full contextual information was available while in other cases it was largely absent. However, as a substantial portion of these samples were excavated during early periods before modern-day recording standards and curation practices had been implemented, this was not an entirely unexpected occurrence. In some cases, osteological material was divided into separate skeletal elements and could not be reassembled into complete individuals. This particularly hampered the analysis of musculo-skeletal stress markers and degenerative joint disease in that some individuals could not be assigned a precise age-at-death estimation. The stable isotope analyses were hindered to a certain degree by several factors as well. These included the lack of contextual information for some samples, lack of an extensive range of faunal material and, more specifically, a lack of faunal samples from the site of Taishar. An additional problem encountered in some cases was small sample sizes which hindered statistical analyses and meaningful assessments. However, this problem was unavoidable and in most archaeological or bio-anthropological research projects, sample sizes are rarely optimal. This was dealt with as effectively as possible. Despite these concerns however, the issues and complications which have been raised throughout the course of this research have great potential to be remedied in the future. This will come to fruition through modern archaeological techniques that include appropriate documentation and recording methods and from proper storage and curation of skeletal material. Furthermore, future studies will benefit from enhanced standards in archaeological practice, particularly in the case of mortuary excavations, where bioarchaeological concerns are included at the outset of project design. This will certainly aid in the level and degree of contextual information available to future researchers.

7.3 Future Research Possibilities

There are several areas of assessment that could be expanded upon based on the findings from this dissertation. A number of further enquiries could be carried out in regard to the reconstruction of past diet. More specifically, the examination of dental wear patterns would be greatly enhanced through a comprehensive programme of dental micro-wear analysis, utilising scanning electron microscopy. This type of analysis utilises high definition images to provide a detailed pattern of dietary abrasiveness related to the consumption of specific food types and food preparation technology (Mahoney 2006). Unfortunately, these analyses were outside the scope of this dissertation but would be a productive area for future enquiry. In addition to aiding in the reconstruction of diet, these analyses would complement the study of activity patterns by allowing for a full investigation of the possibility of extra-dietary use of teeth. The observations discussed in Chapter Four of individuals exhibiting very heavy wear in the anterior dentition would be a productive starting point for such an examination.

Several additional areas of potential consideration have emerged based on the results of this dissertation. Most notably, this would involve a more detailed examination of the timing, nature and cultural consequences associated with the earliest phases of the adoption of nomadic pastoralism in this region. This could potentially be addressed through a comprehensive study of stable isotope analysis that included a larger sample of earlier (Bronze Age and Late Bronze Age) skeletal material from Mongolia. This in turn could be coupled with the aforementioned dental micro-wear analyses. Unfortunately, this possibility is limited somewhat by the relatively few skeletal samples from earlier burial contexts that are available for such an assessment. In addition, where these do exist, there are very few samples of skeletal material from later period contexts. This further complicates the examination of *local* dietary variation over time. Despite these difficulties, this remains a compelling possibility nonetheless.

The examination of dietary variation over time at Baga Gazaryn Chuluu which is presented in Chapter Five of this dissertation has provided an early indication of the degree of variation that can diachronically occur within a single site location. The results for the Bronze Age and Late Bronze Age/Early Iron Age are in some cases markedly divergent when compared to the isotopic values from the later periods. This divergence is most obvious in the values for the two individuals that were clearly different from the rest of the population. Several suggestions were proposed to account for this variation, such as the possibility that these individuals were migrants, or for some cultural or nutritional reason they subsisted on diets divergent from the majority of the other individuals. However, in some cases the faunal signatures of wild sheep and goats from BGC, which are provided in the study by Makarewicz and Tuross (2006:868), exhibit markedly lower ranges in $\delta^{15}N$ isotopic values than were achieved from the Xiongnu Period domesticated faunal samples that were assessed for this dissertation. While it is not possible to directly compare modern faunal data to prehistoric humans, it does suggest that it may be feasible to address the question of individuals relying on a significant degree of protein derived from non-domesticated animals that exhibit lower nitrogen values than the domesticated animals. This would be most appropriately addressed through a comprehensive study of both archaeological human and faunal material from a single site and derived from contexts dating to this transitional phase.

Finally, future research could directly address questions pertaining to variation in diet, health and activity based on individual or group ranking as well as age and gender categories. This investigation could combine full isotopic and osteological analyses with detailed information obtained from burial contexts. While many investigations of this type have been carried out in neighbouring regions, and further abroad (e.g. Le Huray and Schutkowski 2005; Linderholm et al. 2006), relatively few have been applied to archaeological contexts from Mongolia. This type of assessment could only be appropriately performed in cases where sufficient contextual information was available for particular samples. This would enable comprehensive comparisons to be made both within and between groups of individuals who may have had a greater or lesser access to differential resources or may have engaged in different activities based on their position in society.

7.4 Concluding Remarks

The overall results of this research have provided a basis for a more thorough understanding of past life-ways of the ancient inhabitants of Inner Asia. These results illustrate the value of using a bio-anthropological approach to investigate these populations. The broad findings of this research illustrate how dietary habits and associated group organisational structures as well as individual and group health can be assessed through the systematic study of human skeletal remains. The overarching view that arises from this work is one of communities and individuals engaged in a range of food exploitation practices coupled with a dynamic picture of health, activity and workload patterns that varied over both time and space.

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