OSTEOARTHRITIS IN MIDDLE HOLOCENE HUNTER-GATHERERS FROM THE CIS-BAIKAL REGION OF SIBERIA, RUSSIA

A Thesis Submitted to the College of

Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Master of Arts

In the Department of Archaeology and Anthropology

University of Saskatchewan

Saskatoon

By

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ABSTRACT

The Cis-Baikal region of Siberia offers a well-preserved suite of cemetery sites, enabling detailed reconstruction of lifeways among middle Holocene hunter-gatherer groups. Broadly, these cemeteries feature two biologically and culturally distinct populations, separated by an 800-1000 year hiatus: the Early Neolithic (8000-7000/6800 cal BP) Kitoi culture ("pre-hiatus") and the Late Neolithic-Early Bronze Age (6000/5800-4000 cal BP) Isakovo-Serovo-Glaskovo or ISG cultural complex ("post-hiatus"). For over two decades, the Baikal-Hokkaido Archaeology Project (BHAP) has investigated middle Holocene hunter-gatherer adaptations using a variety of interdisciplinary methods. This research builds upon previous BHAP work on osteoarthritis (OA) and activity reconstruction in the Cis-Baikal by examining human remains from three large cemeteries located throughout the region — Lokomotiv and Shamanka II (pre-hiatus), and Ust'-Ida I (post-hiatus). More specifically, I employ data on OA severity for the temporomandibular joint (TMJ), shoulder, elbow, wrist, hip, knee, ankle, and the vertebral column to test hypotheses about temporal, spatial, and sex-based differences in activity patterns. Data presented here are generally consistent with findings of previous BHAP studies, indicating temporal and local variation in ancient activity patterns, as well as sex-based differences. Male groups from the three cemeteries under study here exhibited relatively consistent (high) OA severity scores, while female groups from the Angara River Valley (regardless of time period) featured higher OA severity scores than those from the South Baikal. I suggest that local demographic and environmental factors likely played an important role in producing these differences.

ACKNOWLEDGEMENTS

First, I would like to thank my supervisor Dr. Angela Lieverse for her patience, encouragement, and support throughout this entire process. I am especially grateful for your thoughtful and thorough editing, which always provided me with clarity and structure. Thank you for always believing that I was capable of completing this project. Your confidence in me pushed me to continue when I was ready to throw in the towel many times. I am forever grateful.

To my committee members Dr. Ernest Walker and Dr. David Cooper, thank you for your guidance and your time. I appreciate your contributions to my growth as an academic. Thank you for asking hard questions and for treating me as a peer whose research was worthy of thoughtful review.

Thank you to both the Baikal-Hokkaido Archaeology Project (BHAP), and the Northern Scientific Training Program (NSTP) for funding my research. I am grateful to have had the opportunity to travel to Russia and collect my own data.

To Olga Ivanovna Goriunova, Vladimir Ivanovich Bazaliiskiy, Alexey Novikov, and Ian Scharlotta who welcomed and supported me while I was in collecting data in Russia thank you for making my experience an immensely positive one.

To my mom and dad, who are the most supportive and loving parents, thank you for kindness, humor, and love. Your constant encouragement and unwavering support has always brought stability to my world. Thank you.

I also wish to thank all of my friends who have stuck by me throughout these last few years. Despite my frequent leanings towards becoming a hermit, thank you all for never allowing that tendency to solidify. To that end, special mention must go to Sheena Changela and Reanne Ridsdale for their tenacity and refusal to let me become a recluse.

To my two wonderful kitty creatures, thank you for always putting your needs above mine, thank you for chewing up many drafts of my thesis to show your own frustration at this project, and for always being happy to see me.

And lastly, to my husband Ben, thank you for being with me, in the thick of it, every day. Thank you for your countless hours of assistance with my thesis and your incredible patience and kindness while doing so. Our thesis-less future now appears and I cannot wait to see what it brings.

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1. Chapter One: Introduction and Background

1.1. Introductory Remarks

The study of human remains allows for the reconstruction of past lifeways and can contribute to current understandings of human adaptation and behavior, particularly over periods of cultural transition and environmental change. The Cis-Baikal region of Siberia (Figure 1.1) offers researchers a well-preserved suite of cemetery sites dating to the middle Holocene (8800 – 4000 cal BP), a time of substantial cultural change (Weber and Bettinger 2010). For roughly two decades, the Baikal-Hokkaido Archaeology Project (BHAP) has conducted interdisciplinary research examining middle Holocene hunter-gatherer adaptation and cultural change in the face of fluctuating environmental conditions. This research will build upon previous work undertaken by BHAP researchers on activity reconstruction, mobility, and health in the Cis-Baikal.

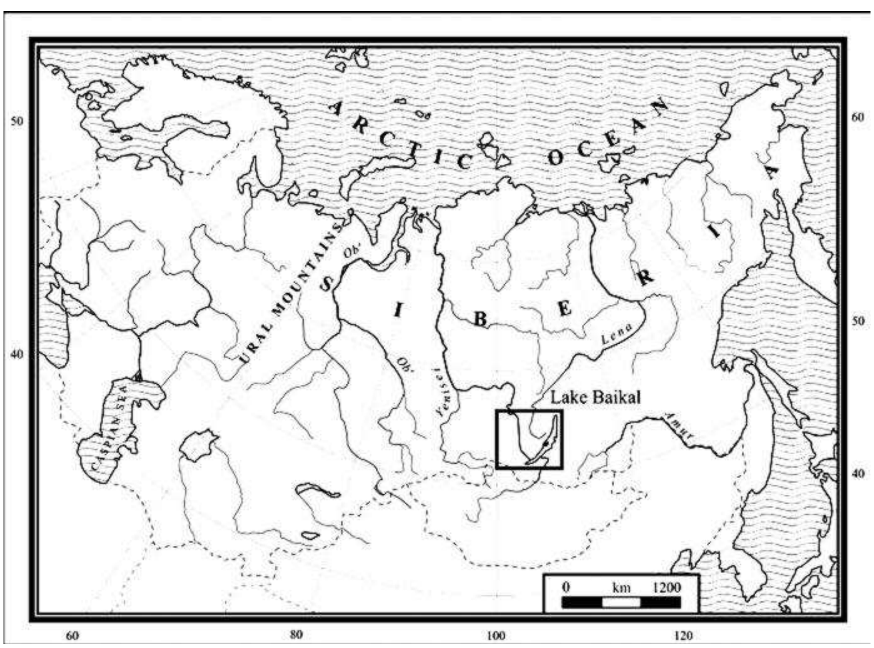


Figure 1.1: Map of Siberia (Russian Federation) showing the Cis-Baikal (adapted from Lieverse et al. 2007).

Two biologically and culturally distinct populations, separated by an 800-1000 year Middle Neolithic (7000/6800 – 6000/5800 cal BP) hiatus, have been identified in the region's culture-historic sequence: the Early Neolithic Kitoi culture (8000 – 7000/6800 cal BP) and the Late Neolithic-Early Bronze Age Isakovo-Serovo-Glaskovo (ISG) cultural complex (6000/5800 – 4000/3400 cal BP; Weber and Bettinger 2010). The hiatus has been characterized by a lack of formal cemeteries in the region, although occupation layers dating to this time are still found at habitation sites. On this basis, some have suggested that population densities among Middle Neolithic groups were lower than during the preceding period, and that a major shift in their behavior is clear from the complete abandonment of burial practices that had been in place for approximately 1000 years (Kuzmin 2007, Weber and Bettinger 2010). The nature of the 'hiatus' remains largely unclear and is a major component of the research undertaken by scholars working in the region.

The goal of this research is to reconstruct past life ways though the examination of osteoarthritic distribution and severity for both the Kitoi people of the Early Neolithic (EN), represented by human skeletal materials from the cemeteries of Shamanka II (SHA; n=155) and Lokomotiv (LOK; n=99), and the ISG people of the Late Neolithic-Early Bronze Age (LN-EBA), represented by the cemetery of Ust'-Ida I (UID; n=67; Figure 1.2). Data for this project were recorded following the standards for scoring osteoarthritis described by Buikstra and Ubelaker (1994:115-123). These data were subsequently analyzed using non-parametric statistical tests, including Kruskal-Wallis ANOVA, Mann-Whitney, and Wilcoxon Pairs in order to identify both inter- and intra-site differences.

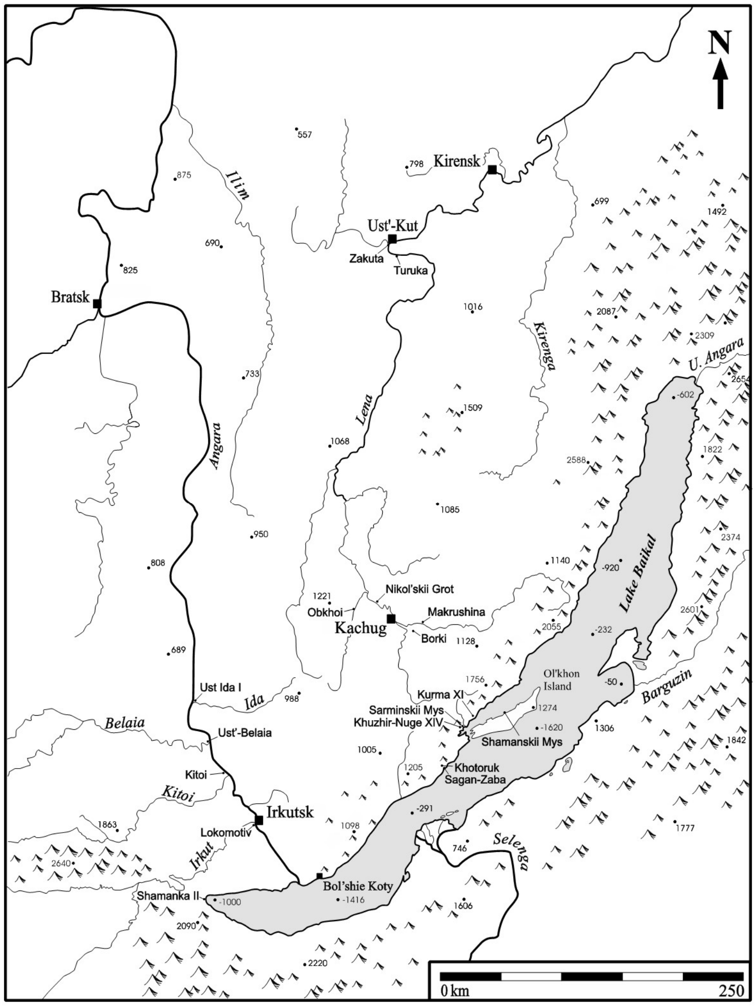


Figure 1.2: Map of the study area (adapted from Weber et al. 2011).

This chapter (Chapter One) presents background information on the culture-history and geography of the Cis-Baikal region, as well as current and ongoing research by BHAP scholars. This chapter also outlines hypotheses about prehistoric variation among Cis-Baikal hunter-gatherer groups, which I test in subsequent chapters. In Chapter Two, I discuss relevant literature on the use of osteoarthritis (OA) data as a method of activity reconstruction. Chapter Three outlines the materials and methods of data collection and analysis used in this study. Chapter Four presents the results of statistical analyses, and Chapter Five offers a discussion and interpretation of these results, focusing on the broad behavioral hypotheses outlined in Chapter One. Finally, in Chapter Six I summarize these findings and offer several potential directions for areas of future research on the basis of my analysis.

1.2. Culture-History of the Cis-Baikal

The cultural development of the Cis-Baikal during the middle Holocene is characterized by technological innovations as well as large-scale cultural and biological changes (Bazaliiskii 2010, Weber et al. 2002, Weber and Bettinger 2010). The current culture-history model used by BHAP scholars can be found below in Table 1.1 (from Weber and Bettinger 2010). The start of the Early Neolithic (EN; 8000 – 7000/6800 cal BP) brought with it the bow and arrow, ground stone tools, ceramics, and the practice of formal burials in large, multi-generational cemeteries (Okladnikov 1950, Weber et al. 2002, Weber and Bettinger 2010). Unlike elsewhere in the world, the Neolithic in the Cis-Baikal did not feature crop or animal domestication, and inhabitants remained foragers in this area until the later Iron Age (Weber and Bettinger 2010). A.P. Okladnikov's (1950, 1955) work in the 1950s distinguished several culture-historic groups that he attributed to the Neolithic and Bronze Age periods. On the basis of material culture similarities, he posited a continuous series of cultural developments beginning with the "primitive" Isakavo, and then Serovo groups, followed by the Kitoi and finally the Early Bronze Age Glaskovo culture (Okladnikov 1950). After the publication of Okladnikov's work in the 1950s, radiocarbon dating overturned this chronology, both reordering the culture historic sequence by placing the Kitoi culture firmly in the Early Neolithic, and demonstrating a long-term absence in burial activity (Mamonova and Sulerzhitskii 1986, 1989).

The Middle Neolithic (MN; 7000/6800 – 6000/5800 cal BP) is most commonly referred to as the hiatus. This period saw the complete disappearance of formal burial practices: to date, no burial has been reliably radiocarbon dated within it (Weber and Bettinger 2010, Weber et al. 2010). It is important to note that human occupation in the Cis-Baikal continued, as Middle Neolithic layers are present at habitation sites (Kuzmin 2007, Weber et al. 2002, Weber and Bettinger 2010). What is clear, however, is that a major change in cultural practices took place during this time, after which, a culturally and genetically distinct population, known as the Isakovo-Serovo cultural complex of the Late Neolithic (LN; 6000/5800 – 5200/5000 cal BP), inhabited the area (Mooder et al. 2005, 2006, 2010, Weber et al. 2002, Weber and Bettinger 2010). The Early Bronze Age (EBA; 5200/5000 to 4000/3400 cal BP) saw the introduction of copper and/or bronze artifacts (Weber et al. 2002, Weber and Bettinger 2010). Classified as the Glaskovo cultural complex, it is well accepted as a continuous evolution from the Isakovo-Serovo tradition, allowing these three to be grouped together as one unit for the purposes of analysis (Weber et al. 2002, Weber and Bettinger 2010). In this study, I employ the term "EN" to refer to hunter-gatherers who inhabited the Cis-Baikal during the Early Neolithic, and "LN-EBA" (Late Neolithic-Early Bronze Age) to refer to this combined culture-historic unit.

TABLE 1.1: Culture-History Model of Middle Holocene Cis-Baikal.

Period	Mortuary tradition	Angara and South Baikal (cal BP)	Upper Lena (cal BP)	Little Sea (cal BP)
Late Mesolithic	Lack of archaeologically visible mortuary sites	8800-8000	8800-8000	8800-8000
Early Neolithic	Kitoi and other	8000-7000/6800	8000-7200	8000-7200
Middle Neolithic	Lack of archaeologically visible mortuary sites	7000/6800-6000/5800	7200-6000/5800	7000/6800-6000/5800
Late Neolithic	Isakovo, Serovo	6000/5800-5200	6000/5800-5200/5000	6000/5800-5200/5000
Early Bronze Age	Glaskovo	5200/5000-4000	5200/5000-3400	5200/5000-4000

Adapted from Weber and Bettinger (2010)

1.3. Geography, Climate, and Resources in the Cis-Baikal

The Cis-Baikal region of Siberia is located to the north and west of Lake Baikal, situated between 52°N and 58°N latitude (Atlas SSSR 1984). As the oldest and deepest fresh water lake in the world, Lake Baikal is home to a rich array of aquatic and terrestrial resources and it, along with numerous watersheds, offers a particularly hospitable landscape for human occupation (Kozhov 1963, Weber et al. 2011). The region is located within a southern taiga and transitional steppe-forest zone, with dense boreal forest dominating the northern landscape transitioning to open steppe-forest in the southern portion (Khotinskii 1984, Kozhov 1963). The area to the west includes the Angara river basin from its source at the lake all the way to Ust'-Ilimsk and the area to the east includes the upper Lena river all the way north to Kirensk (Figure 1.2). The region on the northwest coast of the Lake is home to the Primorskii mountain range, which extends north, becoming the Baikalski Mountains (Kozhov 1963). The Cis-Baikal also includes the west coast of

Lake Baikal including its largest island, Ol'khon. Vegetation is the region is dominated by larch (*Larix*), spruce (*Picea*), cedar (*Cedrus*), pine (*Pinus*), and fir (*Abies*) trees (Khotinskii 1984). Edible plants and fungi, such as berries, pine nuts and, mushrooms also grow in this area and would have been seasonally available (Khotinskii 1984, Kozhov 1963, Weber et al. 2011).

Great diversity among faunal resources is known throughout the region, owing to the overlapping of three large Eurasian faunal complexes known as the European/Siberian, Central Asiatic, and Eastern Asiatic families (Kozhov 1963). Despite great diversity there are relatively few species that were important subsistence animals for the middle Holocene people of the Cis-Baikal (Shvetsov et al. 1984, Sokolov 1959). Six ungulate species tend to dominate the terrestrial faunal remains at habitation sites, these being the red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus pygargus*), moose (*Alces alces*), reindeer (*Rangifer tarandus*), musk deer (*Moschus moschiferus*), and Siberian Mountain Goat (*Capra sibirica*). Numerous omnivores and carnivores also inhabit the area, and they include the brown bear (*Ursus arctos*), wolf (*Lupus lupus*), lynx (*Felis lynx*), and bobcat (*Gulo gulo*). Additionally the sable (*Martes zibellina*), squirrel (*Sciurus vulgaris*), hare (*Lepus timidus*), Siberian polecat (*Martes sibiricus*), fox (*Vulpes vulpes*), ermine (*Martes erminea*), and chipmunk (*Eutamias sibiricus*) are among the most important and most common fur-bearing species inhabiting the area (Kozhov 1963, Shvetsov et al. 1984, Sokolov 1959).

Aquatic food resources in the Cis-Baikal are abundant. The three main basins (Lake Baikal, the Angara, and the upper Lena) are home to numerous fish species including sturgeon (*Acipenser baeri*), burbot (*Lota lota*), grayling (*Thymallus arcticus*), pike (*Esox Lucius*), omul' (*Coregouns autumnalis*), and whitefish (*Coregonus laveretus*; Kozhov 1963, Sorokin and Sorokina 1988). The lake itself is also home to the Baikal seal (*Pusa sibirica*) or nerpa, the world's only true species of freshwater seal (Kozhov 1963, Pastukhov 1993).

With cold five-month winters and warm and dry two-month summers, the climate of the Cis-Baikal is defined as markedly continental. Average July and January temperatures are 20°C and -26°C respectively (Atlas SSSR 1984, Weber et al. 2002). Environmental proxy data and climate model simulations for northern Inner Asia, within which the Cis-Baikal lies, suggest a trend of warming and drying during the Holocene (White and Bush 2010). A noteworthy and abrupt increase in regional aridity occurred between 7500 and 6500 years BP. This coincides, and perhaps even directly preceeds, the hiatus period of the middle Neolithic (White and Bush 2010).

While these cultural and environmental changes coincide with one another, making the causal links between them remain uncertain and go beyond the scope of this study. Research on climate by BHAP scholars is ongoing and continues to add context and depth to our knowledge of this region and its inhabitants.

1.4. Previous and Ongoing Research in the Cis-Baikal

Previous and ongoing research in the area by BHAP scholars has yielded a wealth of information pertaining to population demographics, diet, subsistence strategies, migration patterns, health, and activity reconstruction of EN and LN-EBA groups. The cemeteries (defined as an area used repeatedly and exclusively for disposal of the dead) used by Cis-Baikal inhabitants are considered reasonable proxies for a once living group of people (Weber and Bettinger 2010). Demographic data from these cemeteries suggest that EN populations lived in larger groups within the Angara River Valley and in the southwest area of the lakeside (often referred to as the South Baikal micro-region). During the LN-EBA, Cis-Baikal hunter-gatherers lived in smaller groups, but their population throughout the Cis-Baikal was larger overall and their geographic distribution spread further, and included the upper Lena River Valley as well as the Little Sea micro-region, which includes Ol'khon Island (Figure 1.2; Weber et al. 2011).

Weber and colleagues (2002, 2011) theorize that the relatively large EN populations were less mobile than smaller, later (LN-EBA) groups, and that high population density on the Angara River may have required some EN individuals (primarily males) to conduct logistical foraging trips in order to acquire resources. As locally-available resources became depleted over time, these logistical forays are expected to have involved traveling greater distances from the home bases of EN groups. In contrast, the smaller groups of the later LN-EBA period are believed to have employed high residential mobility, and thus relatively low logistical mobility (thus relying relatively little on logistical forays by small, primarily male segments of the population). Despite this high residential mobility, their annual seasonal round remained smaller than expected, in the sense that no group travelled throughout the entire Cis-Baikal, although isotopic analysis does suggest that some individuals migrated from one area to another (Scharlotta and Weber 2014, Weber and Goriunova 2013, Weber et al. 2002, 2011). Due to a lack of burials during the Middle Neolithic hiatus, much less is known about the adaptive strategies of these groups. However, it has been suggested that there was an overall decrease in population density and socio-economic complexity, as well as an increase in mobility during this time (Weber and Bettinger 2010).

DNA analyses have confirmed that the Kitoi and ISG populations belong to different genetic haplogroups, with EN Kitoi groups belonging to an older stratum dating back as far as the Paleolithic (Mooder et al. 2005, 2006, 2010). The LN-EBA groups appear to be part of a more recent stratum that also contains modern native Siberian groups (Mooder et al. 2005, 2006, 2010). Of particular interest to this research is the finding that the Kitoi communities of SHA and LOK were closely related biologically, implying that social interactions were taking place between the two groups (Mooder et al. 2010). The impetus for both the decline of the EN Kitoi groups from the Cis-Baikal region as well as the original homeland of the migrating LN-EBA population remains unclear (Weber et al. 2002, White and Bush 2010), although Movsesian and colleagues (2014) have recently argued, on the basis of non-metric cranial traits, that these populations may not have differed as much as previously suspected.

Isotopic data suggest that both the Kitoi and the ISG exploited similar resources of local game and fish and seasonally available plant foods (Katzenberg et al. 2012, Weber et al. 2011). It had been previously theorized that the Kitoi groups had a heavier reliance on fishing; however, data from these studies has suggested that this was likely only the case on the Angara River (Katzenberg et al. 1999, 2010, 2012, Okladnikov 1950, 1955, Weber et al. 2002, 2011, Weber and Goriunova 2012). Isotopic signatures from LOK and UID (both within the Angara River Valley) show that fish formed a larger portion of the diet for the EN Kitoi people at LOK. Alternatively, for the ISG people from UID, ungulates were a larger part of their diet (Weber et al. 2011). The isotopic signatures at SHA suggest that the EN people living on the southern coast of the lake were eating locally available fish and ungulate species, as well as the Baikal seal, which would have been available in winter and early spring (Weber et al. 2011). Given their distance from the lake, it is not surprising that seal was not consumed at LOK or UID (Weber et al. 2011).

Isotopic ratios of carbon and nitrogen were also used to analyze weaning ages and inter-birth intervals at the EN sites of SHA and LOK, and for LN samples from UID. These data suggest that the infants from UID were weaned earlier than those from the EN groups, allowing for shorter inter-birth intervals and offering complementary evidence to the overall population increase during the LN-EBA (Waters-Rist et al. 2011). It was also noted that some infants died during breastfeeding in the EN sample, something not seen in the latter group, which suggests a considerable stressor affecting the EN population (Waters-Rist el al. 2011). Earlier studies on dental enamel hypoplasia also suggest there were annual stress episodes for the EN Kitoi people, while LN-EBA groups did not experience this physiological stress to the same degree or with the same regularity (Lieverse et al., 2007b, Water-Rist et al. 2006).

Studies on entheseal changes, skeletal morphology, and post-cranial non-metric traits have all suggested that Kitoi males were engaged in higher over-all activity levels and increased terrestrial mobility when compared to contemporary females and the later LN-EBA males and females (Lieverse et al. 2009, 2013; Macintosh 2011; Stock et al. 2010). Despite a paucity of archaeological evidence for the use of watercraft, upper limb entheseal changes and postcranial robusticity data are all consistent with watercraft use by all middle Holocene inhabitants of the Cis-Baikal, with some evidence suggesting that ISG women were less strenuously using their upper limbs (Lieverse et al. 2007a, 2011, Stock et al. 2010). Lower limb entheseal data reveal an overall trend of increased activity in the lower limb during the EN (Lieverse et al. 2013). These data also note that the EN site of LOK showed higher aggregate scores overall, when compared to all the other sites under study for both males and females. Lievere and colleagues suggest that this could be due, in large part, to this site being located in the Angara River Valley, which housed a large population during the EN. Evidence for this comes in the form of two other large EN cemeteries located within the vicinity, those being the Ust'-Belaia and Kitoi cemeteries. They theorize that the high population density in this particular micro-region at this time would have increased competition for resources in the area, making it plausible that the LOK population would have been engaged in intensive and frequent logistical foraging, thus increasing strain on the lower limbs (Lieverse et al. 2013, Weber et al. 2002).

Lieverse and colleagues (2007a) previously studied the prevalence of osteoarthritis in the Cis-Baikal. Results of the prevalence data indicated that overall physical activity levels remained relatively constant throughout the entire middle Holocene and that only minimal differences in prevalence existed between males and females from all sites, regardless of temporal period (Lieverse et al. 2007a). Differences in the distribution of specific joints showed that knee osteoarthritis was more prevalent in EN males compared to contemporary females and later LN-EBA males. Activities that would account for these changes in knee osteoarthritis include squatting, kneeling, and walking over rough, steep and snow-covered terrain while carrying heavy loads (Lieverse et al. 2007a). Prevalence rates for the vertebral column, which are suggestive of load-bearing stress to the neck and back, showed lower prevalence rates in EN females when compared to males from the same period and the LN-EBA females. While sexual differences were noted amongst the EN populations, no such differences were seen among the LN-EBA (Lieverse et al. 2007a). Notably, this study did not include data on OA severity.

More recently, Lieverse, Mack, et al. (2016) published an examination of OA severity among middle Holocene groups, using the data collected and analyzed for this thesis. Among other findings, the results of that study suggested major behavioral differences between the two Early Neolithic sites (SHA and LOK). These severity data are discussed in more detail below (in Chapters Four, Five and Six).

1.5. Research Hypotheses

Here, I employ data on the severity of osteoarthritis among the EN Kitoi people and the ISG groups of the LN-EBA in order to further investigate differences in the adaptive regimes of these two groups (i.e.,lower residential but higher logistical mobility for EN Kitoi groups, especially EN males). Further, I use data on osteoarthritis severity from a large synchronic sample to test whether it is possible to discern differences between the two EN cemeteries and if these comparisons can illuminate potential differences in mobility and lifestyle between the two micro-regions in which they are found (Angara River Valley and South Baikal). Finally, I compare males and females from contemporaneous populations to evaluate the existence of a gendered division of labor.

More specifically, this research is guided by three hypotheses that I discuss below and revisit in the following chapters:

1. *Diachronic patterning:* I hypothesize that overall OA severity rates were higher in EN populations when compared to the LN-EBA groups. LN-EBA groups appear to have lived in relatively small communities and employed a broad subsistence base. In contrast, larger community sizes and greater competition over a relatively narrow range of (primarily aquatic) resources may have resulted in greater stress and higher overall physical activity levels during the EN, especially at the Angara River site of LOK (see above).

2. *Gendered division of labor:* The use of residential vs. logistical foraging strategies would result in differing OA severity between the sexes as follows: a) EN males are expected to have exhibited elevated OA severity and EN females to have exhibited lower OA severity, as the latter are believed to have been less involved in logistical foraging. b) Again, LN-EBA people tended to live in smaller, more mobile groups and were engaged in higher rates of residential mobility than the EN groups. Thus, OA severity data for LN-EBA groups should show a more consistent degree of severity across both sexes.
3. *Synchronic patterning:* If differences between micro-regions impacted the activity patterns of ancient hunter-gatherers, these differences should be reflected in OA severity scores. It has been suggested that subsistence practices among groups in the Angara River Valley may have produced more physical strain than fishing the southern coast of Lake Baikal (as represented here by SHA). Further, evidence from EN cemetery concentrations along the Angara River suggests that competition for resources between communities, as represented by cemeteries, was higher and may have resulted in increased levels of physical stress. This should correspond to higher levels of OA severity at those cemeteries (i.e., LOK in this sample).

2. Chapter Two: Review of Osteoarthritis Literature

2.1. Introduction

Osteoarthritis (OA), or degenerative joint disease, is a common pathological condition seen in the skeletal remains of past populations (Adatia et al. 2012, Jurmain 1995, Weiss and Jurmain 2007). Today, osteoarthritis is nearly ubiquitous among elderly people and has become a major cause of disability (Adatia et al. 2012, Haq et al. 2003, Jackson et al. 2004). OA is a chronic condition that affects synovial or diarthrodial joints of the body through the breakdown of articular cartilage (Haq et al. 2003, Jurmain 1999, Nuki 1999). The morphology of a normal healthy synovial joint includes subchondral bone surfaces with smooth contours and well-defined margins. The surfaces of the bones are covered in a layer of hyaline (articular) cartilage, which is lubricated by synovial fluid that sits within the surrounding joint capsule (Rogers et al. 1987, Rogers and Waldron 1995). With OA there is a loss of this joint space, a breakdown of the articular cartilage, and morphological changes to the surfaces of the subchondral bones of the joint such as lipping (bony spurs or osteophyte formation), eburnation or sclerosis, and porosity (Adatia et al. 2012, Haq et al. 2003, Jackson et al. 2004).

The aetiology of OA is multifactorial and the clinical understanding of the risk factors and pathogenesis of the disease remain poorly understood even today (Jackson et al. 2004). Risk factors that are associated with the development of OA include age, trauma, physical activity, repetitive motions, sex, ethnicity, genetics, obesity, diet, and bone density (Haq et al. 2003). Biomechanical factors such as physical activity level and repetitive motions are considered especially important factors affecting disease progression (Jackson et al. 2004, Larsen 1997). It is because of these biomechanical factors that archaeologists studying human skeletal remains have found the study of OA to be of great utility (Larsen 1997, Rogers and Waldron 1995, Weiss and Jurmain 2007). By comparing and contrasting the prevalence, degree of severity, and patterning recorded from skeletal remains, OA has become a useful tool in identifying specific repetitive activities, and reconstructing activity patterns and overall activity levels of past populations (e.g. Bridges 1991, 1994, Derevenski 2000, Hodges 1991, Jurmain 1990, Klaus et al. 2009, Lieverse et al. 2007a, Merbs 1983, Rojas-Sepulveda et al. 2008, Walker and Hollimon 1989).

2.2. Clinical Perspectives on Osteoarthritis

Modern epidemiological studies on osteoarthritis attempt to understand the risk factors, pathogenesis, progression, and treatment of the disease. Current clinical perspectives suggest that worldwide prevalence of OA is high and/or on the rise in many populations and that it poses significant socioeconomic and public health concerns around the world (Adatia et al. 2012, Buchanan and Kean 2002, Zhang and Jordan 2008). Despite these concerns, as well as decades of clinical research, strategies to prevent, slow, or reverse the disease remain elusive and treatment is largely limited to management of the symptoms (Jackson et al. 2004, Sokolove and Lepus 2013).

Clinical diagnosis of OA is based on symptoms as described by the patient, often coupled with radiographs of the joint(s) in question (Adatia et al. 2012, Haq et al. 2003, Hunter and Felson 2006). Patients diagnosed and treated for OA are most often over the age of 50 and complain of pain and stiffness in the affected joint(s) (Haq et al. 2003). Additional symptoms can include swelling, tenderness, reduced range of motion, and muscle atrophy in the affected limb(s) (Haq et al. 2003, Hunter and Felson 2006, Cook et al. 2007). Symptoms are typically aggravated by physical activity or movement and alleviated by rest (Hunter and Felson 2006). The exact source of the pain experienced by patients suffering from OA remains somewhat unclear and, as the disease progresses, the pain becomes more constant. Loss of, or damage to, the cartilage is not believed to be responsible for the body's pain response, as innervation is not present in this tissue. However, the periosteum (which envelopes the bone), joint capsule, and subchondral bones are all innervated and are potential sources of pain (Dieppe and Lohmander 2005, Felson 2006, Hunter and Felson 2006).

In addition to clinical patient histories, the radiographs can allow for the identification of joint space narrowing, osteophyte formation (lipping), bone cysts, and sclerosis of the subchondral bones (Haq et al. 2003, Hunter and Felson 2006). The changes visible on radiographs are associated with the later stages of the disease, and it fact common for patients to have the descriptive symptoms of pain and stiffness, but with little or no evidence visible on radiograph (Hannan et al. 2000, Haq et al. 2003).

A third method of clinical diagnosis involves the identification of inflammation in the affected joint(s). The term “arthritis” implies inflammation, which was not traditionally considered part of the disease process (Weiss and Jurmain 2007). Current clinical perspectives now support the notion that localized inflammation is part of the disease, and in fact it is clear that inflammation is present prior to the above mentioned physical changes that would be visible on a radiograph (Kuettner and Goldberg 1995, Punzi et al. 2005, Sokolove and Lepus 2013, Weiss and Jurmain 2007). Laboratory analysis of synovial fluid can distinguish between osteoarthritis and other systemic inflammatory forms of arthritis such as rheumatoid arthritis, reactive arthritis, or septic arthritis (Sokolove and Lepus 2013). A white cell count in the synovial fluid below 1000 per cubic millimeter is consistent with a diagnosis of osteoarthritis, with results above this consistent with inflammatory arthritic diseases (psoriatic arthritis, rheumatoid arthritis, and gout) (Hunter and Felson 2006). Elevated levels of inflammatory plasma proteins in the blood and synovial fluid in a patient can also indicate that patients are suffering from OA (Sokolove and Lepus 2013).

Treatment of the disease today involves non-drug therapy, drug therapy, surgical intervention or a combination thereof. Non-drug therapies include the use of exercise and/or physical therapy, weight loss programs, and mechanical aids that support proper joint alignment especially while walking (Haq et al. 2003). These therapies can aid in building muscle mass to support the joint, which is especially important in weight bearing joints such as the knee, as quadriceps weakness has been associated with pain and progression of knee OA (Slemenda et al. 1997). Weight loss is considered especially helpful in obese patients suffering from OA in weight bearing joints such as the hip and knee and mechanical aids and shock-absorbing footwear helps to reduce the impact load on these joints. These types of non-drug therapies are typically done under the supervision of an occupational therapist or physiotherapist (Haq et al. 2003).

Drug therapies are often used in combination with the treatment strategies mentioned above and aim to control pain, inflammation or both. Non-steroidal anti-inflammatory drugs (NSAIDs), as well as injections of corticosteroids, or hyaluronic acid derivatives directly into the joint have all been shown to have some success in treating the symptoms of OA in clinical trials (Haq et al. 2003). Non-prescription drug treatments such as glucosamine and chondroitin sulphate as well as the use of topical creams that contain capsaicin are also commonly considered useful in managing pain and inflammation, although their efficacy appears to be largely anecdotal (Haq et al. 2003). Clinical studies on the use of glucosamine sulphate suggest a large placebo response with no true pain relief (Hughes and Carr 2002).

Surgical interventions are a last resort when all other medical interventions have proven unsuccessful at managing a patient's symptoms. Arthroscopic techniques have been used to remove dead or damaged tissue and can improve symptoms, although progression of the disease does not stop (Haq et al. 2003, Hunter and Felson 2006). Other surgical techniques are more invasive and are typically considered only if all other techniques have failed. Cartilage transplants or grafts may be effective in treating some patients with severely degraded cartilage (Haq et al. 2003). Osteotomy is another technique, which involves modifying the shape of a bone(s) in order to change the alignment of a joint in the hopes of alleviating pain. This technique has been shown to slow the rate of progression in the earlier stages of OA (Haq et al. 2003, Hunter and Felson 2006). Arthrodesis, or artificial ankylosis, involves ossifying two bones in a joint, has shown to significantly relieve pain. This technique, however, would not be suitable for joints that must remain moveable such as the hip or knee (Haq et al. 2003). Total joint replacement is considered the last and final solution, although when successful, this can provide up to 20 years of pain free joint use (Haq et al. 2003, Hunter and Felson 2006).

2.3. Aetiology and Risk Factors

As was mentioned above, the risk factors associated with OA include age, trauma, physical activity, repetitive motions, sex, ethnicity, genetics, obesity, diet, and bone density (Hunter and Felson 2006, Garstang et al. 2006, Haq et al. 2003, Nuki 1999, Punzi and Oliviero 2005, Weiss and Jurmain 2007). Although OA is found in all age groups, there is a strong correlation between advancing age and occurrence of the disease (Adatia et al. 2012, Cook et al. 2007, Garstang et al. 2006, Haq et al. 2003, Hodges 1991, Hunter and Felson 2006, Jurmain 1977, Jurmain and Kilgore 1995, Sokolove and Lepus 2013). As the body ages, its ability to repair itself lessens, overall strength decreases, and neurological responses slow (Garstang et al. 2006). Some studies have shown that 80% of individuals over the age of 65 have some radiographic evidence of OA, although these individuals do not necessarily experience any symptoms (Oliveria et al. 1995, Takeda et al. 2011).

Sex is another major risk factor and clinical evidence suggests that men under 50 years of age typically have more OA overall than women in this age category, but that after 50 years of age women have higher incidence of OA (Garstang et al. 2006). Upon reaching the age of 80 the sex differences are no longer relevant and prevalence of both sexes is relatively equal (Adatia et al. 2012, Haq et al. 2003). Women typically have higher levels of OA in the knee, hand, and hip, while some evidence suggests that vertebral OA preferentially affects males (Adatia et al. 2012, Garstang et al. 2006, Weiss and Jurmain 2007). While bioarchaeologists have often considered these differences as evidence of distinct gender roles, one must be cautious of applying this concept too broadly and without considering the biological risk factors such as hormones, body size, and anatomy that could account for the appearance of sex-based difference in OA (Weiss and Jurmain 2007).

Complicating these sex-based differences in modern clinical studies is obesity, as this plays a major role in our understanding of the disease as it exists today. Overweight or obese people have higher prevalence rates of OA (Haq et al. 2003, Jackson et al. 2004, Sokolove and Lepus 2013). While weight-bearing joints are affected more severely through the increased mechanical load/wear and tear on the cartilage of these joints, non-weight bearing joints are also affected by body weight, albeit for somewhat unknown reasons (Adatia et al. 2012). This may not be significant for archaeological remains, as obesity appears to be a largely modern phenomenon (Weiss and Jurmain 2007), but today it is considered the strongest modifiable risk factor (Haq et al. 2003). This is especially true for OA of the knee, which has been found to be three times as likely in obese persons versus non-obese persons (Gibson et al. 2010).

Osteoarthritis affects all ethnicities; however, populations of European descent typically show higher incidence rates than do those of Asian descent (Adatia et al. 2012, Haq et al. 2003). The exact reasons for this difference in incidence rates is somewhat unclear, although it is believed that squatting practices of Asian populations offer some protection to the hips (Adatia et al. 2012). This may be changing as obesity increases among modern Asian populations and as average age-at-death increases and a larger proportion of the population enter old age (Fransen et al. 2011). There is also some evidence that suggests the prevalence of OA is higher in rural Asian populations, due to a more physically demanding lifestyle (Buchanan and Kean 2002).

New insights into genetic influences on OA have shown that some joints appear to be more susceptible to the condition than others. Some gene mutations that can be passed hereditarily are associated with abnormal cartilage and bone function (Nuki 1999). For these individuals, underlying medical conditions passed down genetically would be at least partially responsible for the development of OA. Studies have also suggested that particular joints are more affected by a genetic predisposition to OA than others. For example, OA of the vertebrae and hip appear to be under more genetic control than that of the knee (Jurmain and Weiss 2007, Sambrook et al. 1999, Spector and MacGregor 2004, Spector et al. 1996a).

Diets high in vitamins C and D can slow the progression of the disease (McAlindon et al. 1996a, 1996b). Vitamin C is an antioxidant and promotes collagen production, possibly providing some benefit in protecting against OA (Haq et al. 2003). Vitamin D deficiencies have been linked to an overall increased risk of knee OA (Haq et al. 2003). Additionally, Buchanan and Kean (2002) noted that high bone density predisposes one for OA, while osteoporosis or low bone density protects one from developing OA.

Physical activity and repetitive motions (often referred to as 'occupation' in the clinical literature), together with obesity (discussed above) are considered the modifiable risk factors for the development and progression of OA (Jackson et al. 2004). Closely related to these two risk factors is trauma, more specifically musculoskeletal injuries to the joints, which occur more frequently during high-level competitive sports. While these types of injuries to the joints are not confined to professional or high-level athletes, they are often considered relevant risk factors in sports medicine studies on OA. Muscle strains, ligament sprains and contusions, meniscal tears, and fractured bones, among other injuries can all increase the likelihood of developing OA, or further hasten the progression of the disease (Kuijt et al. 2012, Nuki 1999, Takeda et al. 2011, Wolf and Amendola 2005).

Clinical studies of athletes have provided evidence that high levels of mechanical stress beginning at an early age may be a major contributing factor in the development of osteoarthritis (Cooper et al. 1996, Thelin et al 1997, Rossignol et al. 2003). An early study by Adams (1965) on baseball pitchers found a positive correlation between incidences of elbow OA in adult pitchers who began throwing as children. This may be of use when studying archaeological remains, as life expectancy was shorter overall, and physically demanding activities most likely began during childhood or adolescence (Weiss and Jurmain 2007).

Studies on elite athletes today are most often focused on OA of the knee, as this joint typically has the highest prevalence rates (Takeda et al. 2011). High levels of physical activity can severely impact the amount of pressure applied to joints. The effect of running versus walking on the weight bearing joints of the leg (hip, knee and ankle) is approximately twice the impact load on the ankle and hip and up to six times the impact in the knee (Jurmain 1999). Studies have shown that knee OA among former professional athletes (soccer and football players, long distance runners and weight lifters) is higher than the general population, although prevalence rates can differ widely between studies due to methodological differences (Kuijt et al. 2012, Takeda et al. 2011). Professional athletes regularly engage in high intensity, load-bearing sports, making the risk of injury relatively high when compared to the average population, especially in the lower extremities (Wolf and Amendola 2005). According to one large study, a history of joint injury appears to increase the prevalence, but does not quicken the progression of the disease (Cooper et al. 2000). Specifically, injuries to the lower extremities have been found to positively correlate with subsequent development of OA, especially in the knee and hip (Gelber et al. 2000). These studies provide convincing evidence that high-intensity physical activity, direct joint impact, repetitive impact, twisting, and higher risk of joint trauma all combined can account for the higher prevalence rates in athletes when compared to the general population (Kuijt et al. 2012, Takeda et al. 2011).

Further evidence for the impact of repetitive movement comes from studies on the occupational risks associated with kneeling, squatting, heavy lifting, and climbing stairs or ladders in the development of OA of the knee. In a 2000 study, Coggon and colleagues compared over 500 patients awaiting surgical treatment of their knee OA with over 500 control subjects from the same communities and found that there is strong evidence linking the occupational risk factors listed above with the development of knee OA (Coggon et al. 2000). More specifically, the association between knee OA and occupational lifting, kneeling, and squatting were each found to be statistically significant when analyzed separately (Coggon et al. 2000).

2.4. Osteoarthritis and Archaeology

Bioarchaeologists have been studying OA in archaeological skeletal remains for over eight decades (see Hooton 1930 for one of the earliest studies). The practice of reconstructing activity patterns based on the prevalence, severity, and patterning of OA truly began in the 1960s and 70s, when studies such as those conducted by Angel (1966, 1971), Wells (1962, 1963, 1972), and

Ortner (1968) were published. These early studies often oversimplified the aetiology of the disease, and overemphasized the role that mechanical stress plays in its development and progression. Additionally, they were often unsystematic in the application of their methodology, often times focusing only on severe or extraordinary cases (Ortner 1968, Wells 1962, 1963). They did, however, provide thorough descriptions of the visual degenerative changes to the bones, and comparisons between other known archaeological populations. These early scholars were pioneers in reconstructing activity patterns of ancient populations based on degenerative changes to the skeleton. Ortner (1968), being a prime example, used degenerative changes to the humerus to compare the upper limb activities of two distinct archaeological populations.

By the late 1970s and early 80s, studies had become more systematic and rigorous in their methodology (e.g., Jurmain 1978, Merbs 1983, Thould and Thould 1983). A study by C.F. Merbs (1983) is often heralded as one of the best and earliest examples from this period of time of a systematic study of pathological changes to the skeleton associated with OA, inter-vertebral disc disease, vertebral compression, spondylolysis, and anterior tooth loss, subsequently linking those changes with ethnographically known activities of the Sadlermiut Inuit. Merbs theorized a list of 20 specific activities, such as harpoon throwing, paddling, and lifting, carrying or dragging heavy objects that he believed could leave an "imprint" on the skeleton. He concluded that male skeletons had clear evidence of both harpoon throwing and kayak paddling based on arthritic patterning in the shoulder and elbow. Greater severity through the acromioclavicular joint and the olecranon fossa was thought to be associated with full extension of the arm, a repetitive movement associated with harpoon throwing. Merbs found greater severity in the left side pivot portion of the elbow and wrist, as well as a pattern of broken styloid processes of the ulnae, which he interpreted as evidence of a unique style of left handed pivot style Sadlermiut paddling. In female skeletons, known movements involving repetitive flexion and extension of the elbow joint were visible on the remains. Severity was greater on the right side, indicative of the handedness preference when scraping skins, which was known to be a female activity (Merbs 1983). This type of detailed and thorough analysis remains a large part of archaeological studies on OA.

Since then, bioarchaeological studies that focused on the use of OA for activity reconstruction have continued to be published and continue to be a part of current academic publications (e.g. Bridges 1991, Dabbs 2011, Derevenski 2000, Hodges 1991, Hukuda et al. 2000, Jurmain 1990, Lovell and Dublenko 1999, Molnar et al. 2011, Novak and Slaus 2011, Rando and

Waldron 2012, Schrader 2012, Walker and Hollimon 1989, Watkins 2012, Woo and Sciulli 2013). These studies all fall under the same banner but differ greatly in their methodology, especially in regards to a uniform method of recording data. Many scholars choose to create their own system (e.g. Walker and Hollimon 1989, and Derevinski 2000), or modify an existing one to suit their particular research needs (e.g. Hodges 1991). Perhaps the most common method currently in use can be found in Buikstra's and Ubelaker's (1994) *Standards for Data Collection from Human Skeletal Remains* (e.g., Woo and Sciulli 2013, Schrader 2012, this study). This method is highly detailed and records both the severity and extent of osteophyte formation (lipping), porosity, and eburnation (sclerosis) as three separate categories. Despite detailed recording of the osteoarthritic data, more often than not this complete data set is rarely analyzed in other studies. Typically, the data are converted into presence and absence data (e.g. Derevenski 2000, Lieverse et al 2007a), or the severity scores are used without the inclusion of the extent scores (e.g. Woo and Sciulli 2013).

The current study is heavily influenced by the methodology employed by Walker and Hollimon (1989) in their study on OA in Southern Californian Indians, while incorporating the Buikstra and Ubelaker (1994:115-123) data collection methods. Walker and Hollimon's study was of particular interest because of the comprehensive inclusion of severity rates in their data analysis. They devised a relatively simple 5-point scale for grading the severity of OA and recorded each articular surface separately. Following the recording of this data they proceeded to create arthritis indices as described below.

> "A total arthritis score was calculated for each joint of an individual by summing the scores of all articular surfaces contributing to that joint. An arthritis index was then generated by dividing the sum of arthritis scores (SAS) by the total number of joint surfaces examined (NJS). For example, if a skeleton was complete, the arthritis scores of the distal femora and proximal tibiae were added and divided by four to generate the arthritis index for the knee" (Walker and Hollimon 1989; 174).

Their detailed approach incorporated severity data into one number per joint, allowing for further statistical analyses to be conducted on these arthritis indices. Walker and Hollimon (1989) incorporated both archaeological and ethnographic literature as a basis for understanding what specific activities could account for the severity and patterning of OA that they found. They compared two temporally distinct skeletal collections and controlled for both age and sex. They were able to show that the joints of the lower limb (hip, knee, ankle, and foot), for both men and women, had greater severity in the later period, which they interpreted as a "result of increased travel by foot due to the shift toward greater dependence on resource exchange during the late period" (Walker and Hollimon 1989; 180). Their method of creating severity indices was expanded upon and modified to suit this study, while the Buikstra and Ubelaker (1994:115-123) scoring method used to record the data initially. Details on how this was done will be presented in Chapter Three.

2.5. Degenerative Changes on the Skeleton

During the OA disease process, there is a loss of the dynamic equilibrium between damage and repair of the joint, after which the underlying subchondral bone surfaces come into direct contact with one another (Nuki 1999). In regards to bony changes, osteoarthritis can cause bone formation, bone destruction or both together. Bone formation, called osteophytes or lipping, generally takes place along the joint surfaces and margins. In severe cases, these bony outgrowths can form an osseous connection resulting in fusion or ankylosis of the joint (Jurmain and Kilgore 1995, Roberts and Manchester 2007, Sinkov and Cymet 2003). The processes that produce porosity remain poorly understood, although a number of possibilities exist. Bone destruction can produce porosity through the erosion of the subchondral bone, exposing underlying trabeculae. Porosity may also be the result of reactive trabecular bone formation, which also contributes to cartilage loss (Jurmain and Kilgore 1995, Nuki 1999, Sinkov and Cymet 2003). Subsequent bone-to-bone contact produces eburnation or a polishing of the bone surface and eventually results in a grooved joint surface (Jurmain and Kilgore 1995, Nuki 1999, Roberts and Manchester 2007, Sinkov and Cymet 2003). Eburnation is generally considered the best indicator of severe OA and its presence means that, while the cartilage was destroyed or damaged in life, the joint was still functional and active at the time of death (Jurmain 1999, Larsen 1997, Rogers and Waldron 1987, 1995).

While the above description of the bony response to osteoarthritis is generally well accepted, dissenting opinions do exist. This is especially true in regards to the use of porosity as an indicator of osteoarthritis, as new evidence suggests that porosity may not be part of the disease process. Jurmain (1999) describes three possible causes of the porosity on the articular surfaces of joints: 1) the above-mentioned thinning of the articular plate and exposure of the trabeculae, 2) vascular invasion of calcified cartilage and, 3) trabecular perforation through the articular plate subsequent to eburnation. This last cause implies that porosity would only be seen in more advanced cases of OA where eburnation was visible on the articular surface. Some scholars are cautious about using porosity as an indicator of osteoarthritis, especially in the absence of eburnation, which is viewed as the best indicator of severe OA in skeletal remains (e.g. Jurmain 1999, Rogers and Waldron 1995, Rothschild 1997). Others (see Bridges 1991, Croft et al. 1992, Derevenski 2000, Hodges 1991, Klaus et al. 2009, Larsen 1997, Lieverse et al. 2007a, Lovell 1994, Merbs 1983) are not as quick to dismiss porosity as a useful indicator of OA. The view taken here is that when porosity is present with another indicator of OA, it is a useful criterion to be included in a comprehensive study of OA. Following the lead of other scholars (Buikstra and Ubelaker 1994:115-123, Jurmain 1999), porosity is scored separately and, in the absence of another indicator of OA, those joint surfaces exhibiting only porosity are considered absent for OA.

2.6. Degenerative Changes in the joints under study

Synovial joint regions selected for this study are the temporomandibular joint, shoulder, elbow, wrist, hip, knee, ankle, and first metatarsophalangeal joint, which represent all major locations that can be afflicted by OA. Smaller synovial joints such as those in the wrist and foot were not included due to poor preservation of those remains. Degenerative changes to the vertebral column were also included. While the superior and inferior articular facets on vertebrae are synovial joints and, as such, are classified as OA, the joints of the vertebral bodies are cartilaginous. Although technically not osteoarthritis, the pathological response on the bone is virtually identical and as such they will be included here (Lovell 1994, Ortner 2003). A description of each joint, as well as information about its utility for activity reconstruction can be found below.

2.6.1. Temporomandibular Joint

The temporomandibular joint (TMJ) is a unique synovial joint of the body and a non-weight bearing joint. The articular surface of the joint is covered with fibrocartilage rather than hyaline cartilage, as is the case in normal synovial joints (Hodges 1991, Levangie and Norkin 2001). Fibrocartilage is designed for strength and is able to remodel and repair itself, something hyaline cartilage cannot do (Levangie and Norkin 2001). Additionally, the TMJ is a complex, compound joint insofar as the two bony portions of the joint typically do not contact one another, and instead, contact a non-ossified articular disc that sits in between them (Okeson 2008). This makes it possible to see evidence of the disease on the mandibular fossa and not the mandibular condyle, or vice versa (Okeson 2008, Rando and Waldron 2012). Due to its uniqueness, the clinical diagnosis of TMJ osteoarthritis is often based on changes to the soft tissue including splitting of the fibrocartilage and damage to the disc (Blackwood 1969, Hodges 1991). For archaeologists working with skeletal populations, soft tissue is generally not available for study and, as such, irregularities in the bony surfaces of the joint are used to identify the condition. These include: surface erosion, osteophyte formation, alterations to the joint contour and, eburnation (Hodges 1991, Rando and Waldron 2012). Factors that may affect the development of OA of the TMJ include dental attrition, antemortem tooth loss, sex, and age-at-death (Hodges 1991). No general consensus has been reached in regards to the significance of these factors, as studies have found both positive and negative associations between each factor and the development of TMJ OA (Rando and Waldron 2012, Hodges 1991). Studies on dental attrition in the Lake Baikal remains have been used to reconstruct activity (see Lieverse et al. 2007b, Waters-Rist et al. 2010); however, no work has yet been done in regards to OA of the TMJ in the remains.

2.6.2. Shoulder

The shoulder is a complex joint with vast range of motion. The entire shoulder complex is comprised of three joints: the glenohumeral joint, the acromioclavicular joint, and the sternoclavicular joint. The glenohumeral joint, consisting of the humeral head and the glenoid fossa of the scapula, is the ball and socket type joint often referred to as the "shoulder joint" (Ortner 2003, Roberts and Manchester 2007, Watkins 1999:181). The acromioclavicular joint, which joins the acromion process on the scapula with the clavicle, is a sliding synovial joint that aids the arm in movement and stability (Ortner 2003, Roberts and Manchester 2007). The sternoclavicular joint, which joins the clavicle to the manubrium of the sternum, has a much smaller range of motion, allowing for the shoulders to raise and move forward (Watkins 1999:183). Clinically speaking, shoulder OA appears on radiographs as a loss of joint space, sclerosis of the subchondral bone, morphological changes to the humeral head and glenoid fossa such as humeral head flattening, and lipping or osteophytes on the margin of the humeral head and glenoid (Buttaci et al. 2004, Norris and Iannotti 2002).

Nearly all modern patients treated for shoulder OA can recall a specific injury or event after which they began feeling pain in their shoulder. These injuries generally involve direct contact, dislocation, bone fracture, or damage to the rotator cuff, which is often accompanied by a clicking or popping sound (Blevins 1996, Buttaci et al. 2004, Crusher 2000, Norris and Iannotti 2002). In fact, dislocation can increase the risk of developing shoulder OA by as much as 10 to 20 times (Wolf and Amendoala 2005).

The effects of long-term repetitive motions are well documented for the shoulder. Clinical evidence suggests that marathon paddlers, such as those who canoe or kayak competitively, are at increased risk of mechanically irritating the shoulder during the paddling cycle (Hagemann et al. 2004). Shoulder injuries comprise more than 50% of all injuries to paddlers and they can be the result of traumatic injury or chronic overuse (Hagemann et al. 2004). The most notable bony change linked to paddling is the formation of bony spurs on the acromioclavicular joint (Hagemann et al. 2004, Merbs 1983). The effects of throwing on the shoulders of athletes are the result of the extreme motion and torque needed to perform the activity. For example, "little league shoulder" is similar to "little league elbow" (discussed below) insofar as it is most commonly seen in individuals who began pitching at an early age (O'Neill and Micheli 1988, Osbahr et al. 2010). Mechanical stress placed on the joint during overhead throwing is immense, especially when the epiphyseal plates are not fully developed or fused. These factors, when combined with a genetic predisposition, poor pitching technique, and low muscle strength significantly increase the risk of developing OA in the shoulder (O'Neill and Micheli 1988, Osbahr et al. 2010).

2.6.3. Elbow

The elbow consists of two synovial joints: the humero-ulnar (hinge) joint, and the humero-radial (pivot) joint. The former is designed for flexion and extension of the elbow, while the latter pivots or rotates during pronation and supination, and is also involved in flexion and extension (Hay and Reid 1988: 82, Northrip et al. 1983:146, Watkins 1999:186). Degenerative changes to the elbow joint appear less linked to advancing age than is the case for many other joints, being associated more with cumulative stress and activity patterns (Weiss and Jurmain 2007). Adams (1965) termed the presence of unilateral elbow OA in baseball pitchers "little league elbow" and, because it reflects cumulative stress over decades of use, it has particular utility to archaeological samples. Angel (1966), for example, found similar patterning of elbow OA (i.e., bilateral asymmetry) in archaeological populations who used atlatls, and termed this "atlatl elbow". Studies of archaeological Inuit populations have also found evidence of "atlatl elbow" (Jurmain 1978, Merbs 1983, Ortner 1968), resulting from the cumulative effects of hunting with this style of weapon, and having being trained in the technique starting at a relatively young age. Use of the bow and arrow has also been shown to degenerate the elbow over the course of time; however, unlike with atlatl use, both sides are similarly affected, and the shoulder joint is also involved (Angel 1966, Larsen 1997:174).

2.6.4. Wrist

The wrist is a complex series of joints that includes the distal radius and ulna, the adjoining articulating surfaces on the scaphoid, lunate, and triquetrum, and an articular disc that sits between the distal ulna and the lunate and triquetrum (Watkins 1999:187). The distal radius directly articulates with the scaphoid and lunate. These three surfaces (distal radius and corresponding surfaces on the scaphoid and lunate), as well as the distal ulna were used to evaluate wrist OA for this study. The midcarpal joint, which consists of a series of synovial joints between the proximal and distal rows of carpals (but not included in this study), forms the remainder of the wrist complex (Watkins 1999:187). OA of the wrist seems to strongly correlate with both age and genetics making its prevalence and severity in archaeological populations useful as an indicator of past health and genetic heritability (Jurmain 1999, Rossignol et al. 2005).

2.6.5. Hip

The hip is a major weight-bearing synovial joint of the body. The head of the femur articulates with the acetabulum, forming a ball and socket type joint (Watkins 1999:189). The deep acetabulum, along with the cylindrically shaped joint capsule and its ligaments, make for a very stable joint. With this stability comes a decreased predisposition to dislocations, but also a loss of flexibility when compared to the shoulder (also a ball and socket joint) (Watkins, 1999:190). Typically, OA of the hip has higher prevalence in females than in males; the hip is one of the joints believed to be more heavily influence by genetic factors (Jurmain and Weiss 2007, Sambrook et al. 1999, Spector and MacGregor 2004, Spector et al. 1996a). Beyond these risk factors, there is also a link between repetitive weight bearing activities and an increase in hip OA prevalence (Spector et al. 1996b). Modern epidemiological studies have shown that the risk of developing hip OA among farmers is nine times greater than for the general population. The exact reasons for this remain unclear, but it has been suggested that a heavy physical workload, and/or vibrations from heavy equipment may be responsible (Croft et al. 1992, Rogers and Waldron 1995, Rossingnol et al. 2005, Vingard et al. 1991, Waldron 1997). Another possible explanation is the early age that farmers begin their physically demanding lifestyle. During adolescence, the hip joint has not fully developed and it is during this stage that it is most susceptible to physical stress or trauma (Croft et al. 1992, Jurmain 1999). What is useful to note about these modern studies is that a heavy physical workload beginning early in life is one of the more probable, non-genetic determinants for the development of hip OA, and these are conditions that are likely to have existed for ancient populations (Vingard et al. 1991, Waldron 1997).

2.6.6. Knee

The knee consists of the tibiofemoral (hinge) and patellofemoral (gliding) joints, both contained within one joint capsule. The knee is a weight bearing joint that lacks skeletal stability, thus putting it at great risk of injury during dynamic movement, such as during sports and activities involving heavy lifting or squatting (Watkins 1999:191). Osteoarthritis of the knee is prevalent in modern elderly populations and is more common in women than men (Anderson and Felson 1988, Felson 2006, Slemenda et al. 1997). Current clinical perspectives list increasing age, atrophy of the quadriceps muscle, obesity, knee injuries, and occupational bending and lifting as factors affecting knee OA (Anderson and Felson 1988, Felson 2006, Slemenda et al. 1997). OA of the knee generally affects all portions of the joint but can be more severe in either the tibiofemoral or the patellofemoral compartments (Jurmain and Weiss 2007, Kujala et al. 1995). Destruction of the hyaline cartilage, bony remodeling of the patella, distal femur, and proximal tibia, stretching of the joint capsule, and muscle weakness all contribute to the destabilization of the joint (Felson 2006). Once the joint reaches a state of malalignment, breakdown of the cartilage leads to inflammation of the synovial membrane (lining of the joint) and the further breakdown of the joint eventually leads to joint failure (Dunlop et al. 2011, Felson 2006).

The knee is particularly useful in archaeological reconstructions of past health and activity because knee OA appears to be less correlated with age and genetics, and more correlated with activity, than are other joint regions such as the vertebrae, shoulder, and hip (Jurmain 1999). Sports related studies support these assertions, revealing an increase in tibiofemoral OA in soccer players and an increase in patellofemoral OA among weight lifters (Lequesne et al. 1997; Kujala et al. 1995). Based on these results, it would seem that, under certain conditions, upright locomotion would affect the more posterior portion of the knee joint (i.e., tibiofemoral) and that squatting, bending and lifting would increase the pressure on the anterior portion of the joint (i.e., patellofemoral).

2.6.7. Ankle

The "true" ankle joint is comprised of the articulating surfaces of three bones: the superior trochlear surface of the talus, the inferior surface of the distal tibia, and the distal fibula. The tibia and the talus are the two major weight bearing bones of the ankle during standing and locomotion, as the weight is transferred down the leg to this portion of the joint (Northrip et al. 1983:87). The articular cartilage in the ankle joint is relatively thin when compared to other joints but seems to retain its strength into later life, which is why primary OA (that is, OA that develops as part of the regular aging process and not a result of injury/trauma or an underlying disease) is typically less common in the ankle than in other joints in the body such as the hip and vertebral column (Saltzman et al. 2005, Valderrabano et al. 2008).

The ankle joint allows for plantar flexion and dorsiflexion of the foot, whereas the subtalar joint (between the talus and calcaneus) allows for pronation and supination of the foot (Watkins 1999:206). Clinical studies on the etiology of ankle OA suggest that the main risk factor is previous traumatic injury to the ankle joint (Saltzman et al. 2005, Valderrabano et al. 2008). The most common types of traumatic injury that seem to increase the risk of developing ankle OA are fractures to the distal tibia or fibula and damage to the ankle ligaments (Saltzman et al. 2005, Valderrabano et al. 2008). Due to the fact that ankle OA is influenced less by age than many other joints, it is particularly useful for determining ancient health and activity patterns. High levels of ankle OA in an ancient population could be indicative a high degree of ankle trauma.

2.6.8. First Metatarsophalangeal Joint

The big toe joint or the first metatarsophalangeal joint (1st MPJ) is a weight bearing joint in the body that receives a large amount of stress during tasks like walking, running, squatting, and lifting, that can lead to degenerative changes (Zammit et al. 2010). This joint consists of the distal articular surface of MT1 and the corresponding (proximal) surface on the first proximal pedal phalanx. Dorsiflexion of the toes, which would be common during travel over mountainous terrain, for example, can also increase the destruction of the joint, leading to OA. Osteophyte formation on the head of the metatarsal and on the proximal surface of the proximal phalanx is common (Zammit et al. 2010).

2.6.9. Vertebral Osteoarthritis

Significant associations between age-at-death and osteoarthritis are widely accepted (Weiss 2005). This is especially true for osteoarthritis of the vertebral column, in particular degeneration of the lumbar segment, which is nearly ubiquitous in modern populations (Seki et al. 2005). Bipedal locomotion puts undue pressure on the vertebral column and contributes to the prevalence of the disease in human populations (Weiss and Jurmain 2007). While genetic and anatomical factors certainly play a role in vertebral OA, activity-induced stress and mechanical loading can increase the severity of OA in particular regions of the vertebral column (Bridges 1994, Merbs 1983). The superior and inferior articular facets, which are synovial joints, are especially responsive to added repetitive pressure on the joint, resulting in the remodeling of the facets (Rojas-Sepulveda 2008; Derevinski 2000).

Vertebral osteophytosis refers to the formation of osteophytes along the superior and/or inferior margins of the vertebral bodies (or centra). While these joints are technically cartilaginous joints that connect to one another via intervertebral discs, the bony response (i.e, the formation of marginal osteophytes) is virtually identical to OA and, as such, they are typically included in the analyses of vertebral OA (Rogers and Waldron 1995). As Derevinski (2000) points out, the process of osseous remodeling in the vertebral column may well serve as a reliable indicator of activity. More specifically, two studies published in 1994, one by Lovell and one by Bridges, suggested that high prevalence rates of cervical OA may have been caused by carrying heavy loads on top of the head or with the aid of a tumpline, while high prevalence in the thoracic and lumbar regions may indicate high levels of load bearing stress to the mid and low back. While the efficacy of using vertebral OA to reconstruct activity remains debatable, the importance of being able to compare the patterns of vertebral involvement among prehistoric groups improves not only our understanding of ancient health and lifestyle but also our understanding of the disease as it affects modern populations (Jurmain 1990, Lovell 1994, Weiss and Jurmain 2007). For this study, care was taken to avoid categorizing other spinal pathologies such as ankylosing spondylitis and spina bifida as OA and individuals exhibiting traits consistent with these pathologies were excluded from the vertebral samples.

Schmorl's nodes, which appear as centralized depressions on the superior and inferior endplates of the vertebral bodies, are not directly related to the OA disease process. However, they are indicative of herniation or damage to the intervertebral discs, and can be caused by congenital weakening of the vertebral body, trauma, an underlying pathological condition, or degenerative disc disease (Resnick and Niwayama 1978). While Schmorl's nodes are often included in studies on OA, they are not included here as they were already examined for these populations in Macintosh's (2011) study on post-cranial metric traits.

2.7. Concluding Remarks: Osteoarthritis in the Cis-Baikal

Osteoarthritis is a complex disease that results when a joint fails to maintain equilibrium between damage and repair. With a complex aetiology, understanding the pathogenesis behind OA is difficult. Modern clinical studies inform bioarchaeologists on the complexities of the disease, and have contributed to its continued use in the field of ancient activity reconstruction. A comprehensive understanding of the severity and patterning of osteoarthritis can greatly improve our knowledge of ancient health and physical activity levels. Furthermore, unique patterns of severity can be the result of specific types of activities repetitively performed over an extended period of time. Clinical studies have shown that non-drug therapies are as effective as surgical interventions and that physical therapy focused on building muscle to stabilize the arthritic joint, coupled with weight loss is very effective at combating the pain and stiffness associated with OA (Kirkley et al. 2008). For the Cis-Baikal inhabitants, we have evidence that they lived physically active, if not strenuous lifestyles, that they maintained healthy body weights, and had well developed muscle tone (Lieverse et al. 2007a, 2009, 2011, 2013, Stock et al. 2010, Waters-Rist et al. 2006, Weber and Goriunova 2013). These factors amount to somewhat of an ancient treatment program for OA and, for all but the most severe cases, would most likely have kept pain and stiffness at tolerable levels.

The positive link between joint trauma and OA is of particular utility when studying ancient populations. The inhabitants of the Cis-Baikal would have been regularly engaged in physically demanding activities such as those listed by Lieverse and colleagues (2011): transporting goods over long distances and difficult terrain, manufacturing tools, hunting and processing game, setting up and taking down of campsites, and likely, propelling and portaging watercraft. It is reasonable to suggest that this lifestyle would have resulted in injury rates closer to those of elite athletes than the modern general population, and this could lead to an increase in the overall prevalence rates for the region. Furthermore, activities such as heavy lifting, kneeling, and squatting are classified today as part of a heavy labor job were likely common daily activities for many of the Cis-Baikal hunter-gatherers. This would have compounded their risk of developing OA. Clinical studies have suggested that the combination of high joint-loading sporting activities coupled with heavy labor jobs nearly doubled the risk when compared to high-joint loading sports alone (Vingard et al. 1993, 1998). Steep and rocky terrain, such as is seen in the Lake Baikal region would only serve to further destabilize the weight bearing joints and potentially increase the severity of OA present in these joints, especially that of the knee (Weber and Bettinger 2010).

3. Chapter Three: Materials and Methods

3.1. Cemetery Sites

Three collections of human remains were used in this research, two representing the Early Neolithic period (EN), and one the Late Neolithic and Early Bronze Age (LN-EBA). The EN cemetery of Lokomotiv (LOK; n=99) is one of the largest and most typical Kitoi cemeteries found in the Cis-Baikal. Located in the modern-day city of Irkutsk, at the conflux of the Angara and Irkut rivers, the cemetery has been excavated numerous times beginning in 1927 (Bazaliiskii 2010). The site was excavated throughout the late 1940s and 1950s, and then most recently by the Irkutsk State University in the 1980s and 90s (Bazaliiskii 2010, Weber et al. 2002). Radiocarbon dating of this site began in the 1980s by Mamonova and Sulerzhitskii (1989), who published seven dates, and BHAP scholars published a subsequent 98 dates that all suggest the cemetery was used for around a thousand years, between 8000 – 7000/6800 cal BP (Weber et al. 2006).

The other EN cemetery included in this study is Shamanka II (SHA; n=155), and this site has been radiocarbon dated to approximately coincide with LOK (Weber et al. 2006). SHA is located on a narrow peninsula at the southwestern tip of Lake Baikal. The site was first discovered in 1962, and initial excavations began in the 1990s under the direction of the Irkutsk State Technical University (Turkin and Kharinskii 2004). Systematic excavations continued at the site between 2000 until 2008 under the direction of V.I. Bazaliiskii of Irkutsk State University (Weber and Bettinger 2010). Excavations at SHA have yielded a total of 155 EN individuals. Additionally, 10 EBA individuals and one Iron Age individual have been excavated from this site; however, due to the small size of these samples, they were not included in this study (Weber and Bettinger 2010, Weber et al. 2016).

The entire LN-EBA sample for this research comes from the site of Ust'-Ida I (UID; n=67), which is located 150 km north of LOK, along the coast of the Angara river, near the mouth of the Ida river. A.P. Okladnikov originally recorded the site in the 1950s when a grave eroded out of the riverbank. Systematic excavations were done at the site between 1987 and 1996 under the direction of V.I. Bazaliiskii from the Irkutsk State University. These excavations produced a total of 31 Isakovo graves and 19 Glaskovo ones, distinguished by the south-oriented heads of the former, and north-oriented heads of the latter graves. Artifacts made of white nephrite or copper/bronze also allowed for the classification of the 19 Glaskovo graves (Bazaliiskii 2010, Weber et al. 2006). Radiocarbon dating at the site places its use between 6000/5800 – 4000 cal BP (Weber et al. 2006, Weber and Bettinger 2010).

3.2. Sex determination and age-at-death estimations

Sex determination and estimation of age-at-death were based on the standards outlined by Buikstra and Ubelaker (1994:15-47), and were conducted most recently by Lieverse and colleagues (e.g., Lieverse, 2005; Lieverse et al., 2017). Sex determination was based on examination of both the pelvis and cranium, when available (Acsádi and Nemeskéri 1970, Buikstra and Mielke 1985, Milner 1992, Phenice 1969). The greater sciatic notch, ventral arc, subpubic concavity, ischiopubic ramus, preauricular sulcus, iliac auricular surface, and sacral alae were all used when possible, as were cranial features such as the nuchal crest, mastoid process, supraorbital margin, glabella, and mental eminence. If none of these elements were preserved, postcranial metric traits were used following Bass (1995), and Bennett's (1993) methods (Lieverse, 2005, Lieverse et al., n.d.). Due to poor preservation, some skeletons could not be sexed at all. These remains were unable to be included in this study as all comparisons done here controlled for sex.

Age-at-death for adult individuals (20 years of age and older) was estimated following the standards by Buikstra and Ubelaker (1994:21-38), which use numerous methods for each individual in order to increase accuracy. These methods included analysis of age-related changes to the pubic symphysis, palatal sutures, iliac auricular surface, and ectocranial sutures (Brooks and Suchey 1990, Mann et al. 1987, Meindl and Lovejoy 1985, 1989, Suchey and Katz 1986). For the purposes of this study adult individuals were placed into one of two categories: younger adult (20-34 years) and older adult (35+ years). These groupings are commonly used in bioarchaeology (e.g., Buikstra and Ubelaker 1994), and thus facilitate comparison with data from other studies (including other BHAP literature). Because of small sample size, individuals classified here as over fifty years of age at death were grouped together with the older adult category (35+) due to the small sample size of this group.

A number of clearly adult skeletons existed (as evidenced by complete fusion of all preserved skeletal elements, and/or the complete eruption of adult dentition) whose age-at-death could not be more precisely categorized (Lieverse, 2005, Lieverse et al., n.d). These individuals occupy a third category (labeled "20+ years") and, in the portions of this study where age-at-death categories were combined, these individuals were also included.

Notably, both age-at-death determination and the assessment of OA severity are based on skeletal degeneration, creating potential issues with the demographic categories employed in this study. While this is more problematic for attempts to determine age-at-death at more fine-grained scales (as opposed to the broad age categories employed here), it is still important to note the potential impact of this issue on the interpretive potential of this study.

3.3. Methods

An individual's inclusion in this study had three requirements. (1) *Confident sex determination*: In order to control for sex-based differences in OA severity rates, only individuals that could be confidently sexed were included in this study. (2) *Adult age-at-death determination*: Osteoarthritis (OA) is a disease known to progress with advancing age, and for this reason, juvenile remains, which are unlikely to exhibit any sign of the disease, were not included in this study. (3) *Preservation*: Adequate preservation of the joint surfaces was required in order for an individual to be included in this study. Individuals that met requirements 1 and 2 were also required to possess at least one articular surface that was at least 50% complete (including at least 50% of the joint margin). The articular surfaces included in this study are outlined in Table 3.1.

TABLE 3.1: Articular Surfaces on the Joint Regions Selected to be Included in This Study.

Joint region	Articular surfaces
Vertebral Column	Cervical, thoracic, and lumbar 1) superior left intervertebral facet, 2) superior right intervertebral facet, 3) inferior left intervertebral facet, 4) inferior right intervertebral facet, 5) superior osteophytes of vertebral body, 6) inferior osteophytes of the vertebral body
TMJ	1) Mandibular fossa of the skull, 2) Occipital condyle of the skull, 3) mandibular condyle of the mandible
Shoulder	1) Humeral head, 2) glenoid fossa, 3) acromial facet of the clavicle, 4) acromial-clavicular facet of the scapula
Elbow	1) Trochlea, 2) capitulum of the humerus, 3) radial head on the ulna, 4) trochlear and radial notches on the ulna
Wrist	1) Distal radius, 2) head of the ulna, 3) articulating surfaces on the scaphoid and lunate
Hip	1) Femoral head, 2) acetabulum
Knee	1) Medial condyle of the distal femur, 2) lateral condyle of the distal femur and 3) medial condyle of the proximal tibia, 4) lateral condyle of the proximal tibia, the 5) lateral facet of the patella, 6) medial facet of the patella, 7) patellar surface of the femur
Ankle	1) Inferior articular surface on the distal tibia, 2) the articular surface of the lateral malleolus of fibula, 3) the superior surface of the trochlea of the talus including the facets for the medial malleolus and lateral malleolus on the talus
MPJ	1) Head of MT1 2) proximal articular surface of first proximal pedal phalanx

Two main age categories were employed in this study: younger adults (20-34 years at death) and older adults (35+ years at death). A third age category included adult individuals that could only be identified as 20+ years at death. These individuals were only included in analyses that combined the two younger and older adult categories together (e.g. bilateral asymmetry tests).

The scoring methods for OA of the intervertebral facets (VOA) were based on the Buikstra and Ubelaker method (1994:121-122) combined with the method developed and described by Derevinski (2000). This new combined method accounts for both the remodeling of the surface area of the facet as well as porosity as indicated in Table 3.2. The scoring method used for the vertebral bodies was based on osteophyte formation along the margin of the body. Osteophytosis of the vertebral bodies (OVB) were graded on a four-point scale (Table 3.3), following the standards set out by Buikstra and Ubelaker (1994:121).

TABLE 3.2: Scoring Method for Superior and Inferior Vertebral Facets (after Derevenski 2000, Buikstra and Ubelaker 1994; 121-123)

Remodeling	Porosity (degree)	Porosity (extent)
0=absence of remodeling	0=absence of porosity	0=absent or pits covering less than 10% of the surface area of the joint
1=remodeling and an increase in the surface area of the facet	1=small pinpoint sized holes	1=porosity present but on less than 50% of the surface area
2=the presence of a bony shelf on the lamina and the extension of the facet towards the vertebral notch	2=larger than pinpoint sized holes	2=porosity present on 50% surface area or more
–	3=both large and small pits	–

TABLE 3.3: Scoring of Vertebral Bodies (after Buikstra and Ubelaker 1994; 121-123)

Osteophytes
0=absent/no osteophyte formation
1=barely discernable
2=elevated ring of bone
3=curved spicules or well-formed bony spurs
4=fusion or ankyloses

The remaining paired joints were scored based on the standards outlined by Buikstra and Ubelaker (1994:122-123), which consider lipping, surface porosity, and eburnation separately. The scores for each (lipping, surface porosity, and eburnation) were subsequently graded based on both degree of severity and the extent of the circumference or surface area affected. Table 3.4 presents a complete outline of this scoring method. A total of six scores were recorded for each articular surface: degree of severity and extent (or surface area covered) were recorded for each of the three indicators of OA, those being lipping (osteophytes), porosity (pitting), and eburnation.

TABLE 3.4: Scoring Breakdown for All Joints Other Than Those of the Vertebral Column (after Buikstra and Ubelaker 1994:121-123)

Lipping (degree)	Lipping (extent)	Porosity (degree)	Porosity (extent)	Eburnation (degree)	Eburnation (extent)
0=no lipping	0=no lipping	0=no porosity	0=no porosity	0=no eburnation	0=no eburnation
1=barely discernible	1=less than 1/3 the circumference showed lipping	1=small pinpoint sized holes	1=less than 1/3 surface area had pitting	1=barely discernible	1=less than 1/3 surface area had eburnation
2=sharp ridge with curved spicules	2=1/3 to 2/3 circumference showed lipping	2=larger, coalesced holes	2=between 1/3 and 2/3 surface area had pitting	2=polish only	2=between 1/3 and 2/3 surface area had pitting
3=extensive spicule formation	3=more than 2/3 circumference had lipping	3=both large and small holes present	3=more than 2/3 surface area had pitting	3=polish with grooves	3=more than 2/3 surface area had pitting
4=ankylosis of the joint	–	–	–	–	–

3.3.1. Index creation

Because this study recorded a large number of data points for each joint (e.g., seven articular surfaces of the knee, multiplied by the six scores per surface, for a total of 42 potential data points for each observable knee), a method was needed that allowed for all of these data to be combined and included in further analysis (Appendices A-L). Following the approach devised by Walker and Holliman (1989), a method to compile indices was employed for both the paired joints and the vertebral column. The extent scores represent the surface area that was covered with each indicator of OA (i.e., lipping, porosity, and eburnation). Prior to using this index formula, the extent scores (other than zero) were converted from 1, 2, and 3 to 0.33, 0.67, and 1.00, respectively for all paired (i.e., non-vertebral) joints and the vertebral articular facet extent scores were converted from 1 and 2 to 0.50 and 1.00, respectively. These better represent the percentage or fraction of surface area covered by lipping, porosity or eburnation. In other words, this approach provided a standardized way of discussing articular surfaces of bones regardless of their completeness. In addition, the index formula used here enabled comparison with other workds employing published standards commonly used in bioarchaeology.

The following formula (Equation 3.1) was used to create an index for each articular surface of paired joints that represents the level of OA severity in that articular surface:

$$\text{Index for articular surface} = (\text{lipping degree} * \text{lipping extent}) + (\text{porosity degree} * \text{porosity extent}) + (\text{eburnation degree} * \text{eburnation extent}) \quad (3.1)$$

One articular surface index was needed for an individual to be included in the statistical analyses of a given joint. The index for each paired joint was then calculated by averaging the indices of articular surfaces for that joint (e.g. up to seven for each knee). This index is a numerical representation of the severity of OA in that joint for each individual under study. The paired joint indices could range from 0 (minimum) to 10 (maximum). The elbow and knee joint analyses involved creating additional indices for components within each joint—humeral-ulnar and humeral-radial for the elbow and medial, lateral, and anterior/patellofemoral for the knee—and were calculated by averaging each component's articular surface indices. These indices also had a maximum possible value of 10 and served to illuminate possible patterns and intricacies in the data not seen as vividly with the regular joint indices.

The severity of VOA was also represented by an index. Although the formula used for intervertebral facets differed slightly from that above, it follows the same concept (Equation 3.2). An index was created for each articular facet of each vertebra using the following formula:

$$\text{Vertebral articular facet index} = \text{remodeling score} + (\text{porosity degree} * \text{porosity extent}) \quad (3.2)$$

The four possible vertebral articular facet indices per vertebra were then averaged to create an index for that vertebra (e.g. C5). The analyses of the vertebral column (VOA and OVB) were conducted by segment: cervical, thoracic, and lumbar/sacral. Only one articular facet was needed to create an index for a given vertebra (it must have been at least 50% intact and observable for OA), but at least half the total vertebrae per segment were needed for an individual to be included. This meant at least four cervical vertebrae, at least six thoracic, and at least three lumbar (including S1 of the sacrum). A "segment index" was created for those individuals with enough vertebrae to be included by averaging the indices of each vertebra present. The minimum score for the vertebral articular facet index was 0, and the maximum was 5. The analysis of OVB on the vertebral bodies followed the same minimum for observable vertebrae as above (four cervical, six thoracic, three lumbar/sacral). If enough vertebrae were present, a vertebral body index was calculated by averaging the osteophyte scores present in each segment (0 minimum to 4 maximum, Table 3.3).

3.3.2. Statistical Analyses

Non-parametric tests were conducted on the indices in order to test the three main hypotheses outlined at the end of Chapter One. Wilcoxon Pairs tests were used to test for bilateral asymmetry, Kruskal-Wallis ANOVA tests were used for inter-site comparisons, and Mann-Whitney tests were used for intra-site comparisons. For intra-joint comparisons of the elbow, I used Wilcoxon pairs tests for the hinge and pivot components from each individual. For comparisons of the knee components (anterior, medial, and lateral) from the same individual, I used Friedman ANOVA tests. The significant p-value used was 0.05 for all of these tests.

To test for bilateral asymmetry, Wilcoxon Pairs tests (the non-parametric equivalent to paired t-tests) were conducted for each paired joint (i.e., all joints except for those of the vertebral column) for each site, controlling for sex. Individuals included in this portion of the analysis were required to have left and right sides present and scored. If no statistically significant differences were found, then left and right indices were pooled (i.e., averaged) to create one index for the joint. When pooling of the sides was possible (i.e., no statistically significant difference existed between the sides) individuals with only one side (left or right) present were also included in all further analyses. If pooling was not possible (i.e., there was a statistically significant difference between the left and right sides), individuals with only one side present could only be included in the analysis of that (left or right) side. These tests aimed to illuminate handedness preferences among the populations that can be indicative of specific tasks such as those involved in throwing weapons during hunting. In joints such as the elbow, where a right-handed preference would be expected, a non-significant result could indicate a strenuous activity that applied high amounts of pressure or loading on both sides of the body to such an extent that an "evening-out" effect would occur (e.g. paddling).

Kruskal-Wallis ANOVA (non-parametric equivalent to one-way ANOVA) tests were conducted for each joint (and each joint component, for the elbow and knee), controlling for sex, age, and side (when significant bilateral differences were noted) in a paired joint. These tests compared SHA, LOK, and UID, and respective sub-groups (age- and sex-specific) to one another in order to identify inter-site differences. Mann-Whitney tests (non-parametric equivalent to unpaired t-tests) were conducted for each joint controlling for both sex and age-at-death. These intra-site comparisons between males and females and between the younger and older adult age categories help illustrate different activity patterns between the sexes, and between the two age groups.

4. Chapter Four: Results

4.1. Introduction

In this chapter, the results of all non-parametric statistical analyses are presented. All tests were performed on the indices created by combining all recorded data on marginal lipping or osteophytes, porosity, and eburnation (see Chapter Three for more detail). Separate osteoarthritis (OA) severity indices were calculated for the left and right side of each paired joint (TMJ, shoulder, elbow, wrist, hip, knee, ankle, MT1-1st proximal phalanx). Severity indices were also created for OA of the intervertebral facets (VOA) and for osteophytosis of the vertebral bodies (OVB). Tests for bilateral asymmetry (Wilcoxon Pairs tests) were used to determine if indices for the left and right sides could be pooled (i.e., averaged) in order to increase sample size. For the unpaired vertebral joints, the analysis was conducted separately for VOA and OVB for each of the three major sections of the vertebral column (cervical, thoracic, and lumbar/sacral). Non-parametric statistical tests include Mann-Whitney tests for comparisons of two independent samples, Kruskal-Wallis tests for comparisons of three independent samples (i.e., comparisons among the three cemeteries of Shamanka II, Lokomotiv, Ust'-Ida I [SHA, LOK, and UID]). For the additional analysis conducted on the knee (see knee component data below), Friedman ANOVA tests were conducted for comparisons of three dependent samples (i.e., comparisons of the three components of one individual). Boxplots were used to visually depict the data.

The adult males and females from each cemetery were further separated into two age groups: younger adults (20-34) and older adults (35+). Boxplots show the minimum and maximum values for each group, quartile one (Q1, the lower box), quartile three (Q3, the upper box), the median (middle line separating Q1 and Q3), and the mean line (in red). The interquartile range (IQR)—the "spread" of the data—is shown as the entire vertical height of the box. A corresponding table for each boxplot lists the descriptive statistics for each joint. P-values are reported to three decimal places and can be found in multiple tables at the end of the chapter. In the sections below, the highest index that was recorded for each joint is provided, along with other relevant results. The highest possible index value was 10 for the TMJ, shoulder, elbow, wrist, hip, knee, ankle, and MT1-1st proximal phalanx. For VOA the highest possible index value was 5, and for OVB, the highest possible value was 4. In no instance was the maximum value actually observed.

4.2. Bilateral Asymmetry

Wilcoxon Pairs tests were conducted to determine if there was statistically significant asymmetry between the left and right sides for the paired joints of the TMJ, shoulder, elbow, wrist, hip, knee, ankle, and MT1-1st proximal phalanx joints. The results of these paired tests showed significant side differences only for the shoulder and wrist (Table 4.1). Both the SHA males and the LOK females exhibited significant differences between the left and right shoulders, and the latter also had a significant result for the wrist (p-values < 0.05, Table 4.1). Further analyses of the wrist and shoulder were undertaken separately for the left and right side data at all sites. For the remaining joints, the left and right side data were pooled (i.e., averaged when an individual had both sides present) into one index per individual using the method described in Chapter Three. Below I describe the results of each joint separately.

TABLE 4.1: Results of Wilcoxon Pairs Tests for Bilateral Asymmetry in Paired Joint Regions (p-values listed in upper left of each cell, sample size listed in lower right)

Site and sex class	TMJ	Shoulder	Elbow	Wrist	Hip	Knee	Ankle	MT1
Shamanka II females	0.317 *(18)*	1 *(15)*	0.116 *(14)*	1 *(14)*	0.317 *(17)*	1 *(17)*	0.18 *(19)*	0.59 *(17)*
Shamanka II males	0.18 *(46)*	**0.049** *(42)*	0.186 *(48)*	0.458 *(46)*	0.584 *(45)*	0.868 *(45)*	0.156 *(54)*	0.382 *(47)*
Lokomotiv females	n/a *(13)*	**0.043** *(16)*	0.05 *(17)*	**0.041** *(15)*	0.655 *(22)*	0.101 *(17)*	0.345 *(15)*	0.109 *(11)*
Lokomotiv males	0.893 *(17)*	0.478 *(20)*	0.14 *(22)*	0.066 *(15)*	0.317 *(19)*	0.279 *(20)*	0.345 *(20)*	0.361 *(11)*
Ust'-Ida I females	n/a *(3)*	0.18 *(5)*	0.317 *(4)*	0.18 *(2)*	0.317 *(5)*	n/a *(3)*	n/a *(2)*	n/a *(0)*
Ust'-Ida I males	n/a *(10)*	0.144 *(13)*	0.401 *(9)*	0.674 *(9)*	0.317 *(12)*	0.5 *(9)*	0.715 *(9)*	0.317 *(3)*

Significant values in bold.

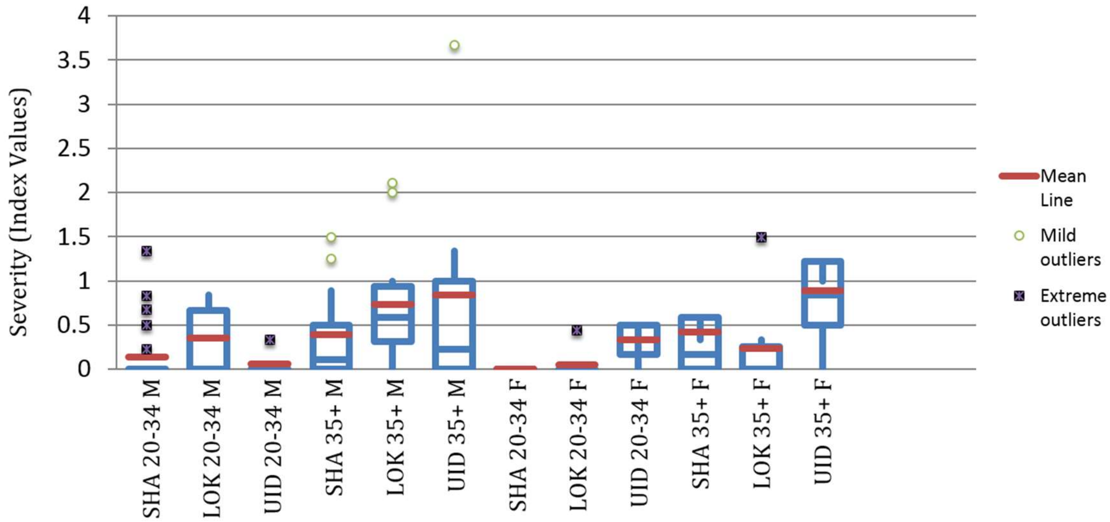
4.3. The Appendicular Skeleton

4.3.1. The Upper Limb

4.3.1.1. Shoulder

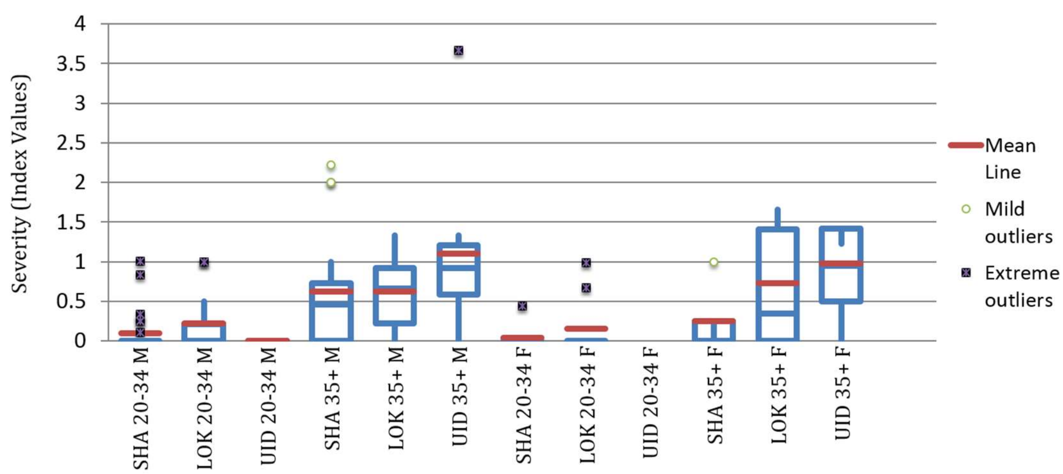
As mentioned above, Wilcoxon Pairs tests for bilateral asymmetry produced significant results requiring separate analysis of left and right sides. The SHA males and LOK females both had significant results (p-values of 0.049 and 0.043 respectively, Table 4.1). Both the males from SHA and the females from LOK showed significantly more severe OA in the right shoulder when compared to the left (Tables 4.1, 4.4, 4.5).

Severity indices ranged from 0 to 3.67 for the left shoulder, although the majority of individuals had values below 1.5 (Figure 4.1 and Table 4.4). The individual with an index of 3.67 was an older male from UID (Burial 54.1.1). For the right shoulder, indices exhibited the same range of 0 to 3.67 (Figure 4.2 and Table 4.5), with the same individuals accounting for the highest score. It is worth noting that all older adults from UID showed more severe shoulder OA than the older adults from the other two sites; this was true for both sides (Figures 4.1 and 4.2). Despite this difference, there were no statistically significant differences among the three sites (all p-values > 0.05, Table 4.2). This was true for both the left and right shoulders.



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.1: Left shoulder osteoarthritis severity boxplot



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.2: Right shoulder boxplot

TABLE 4.2: Results of Kruskal-Wallis and Mann-Whitney Tests for Inter- and Intra-Site Statistical Differences in TMJ, Shoulder, Elbow, Wrist, Hip, Knee, Ankle, and MT1-1st Proximal Phalanx by Age and Sex Subgroups (p-values)

Kruskal-Wallis Tests- Inter-site tests										
Site, age group (in years), and sex	TMJ	Left Shoulder	Right Shoulder	Elbow	Left Wrist	Right Wrist	Hip	Knee	Ankle	MT1-1st
SHA-LOK-UID/20-34 F	0.97	0.51	0.879	0.182	0.421	**0.022**	0.597	0.058	0.298	0.82*
SHA-LOK-UID/35+ F	0.741	0.302	0.375	0.419	0.18	0.268	0.759	0.271	0.686	0.796 *
SHA-LOK-UID/20-34 M	0.988	0.522	0.5	0.116	0.678	0.278	0.828	0.694	0.403	0.594
SHA-LOK-UID/35+ M	0.283	0.271	0.364	0.375	**0.011**	0.224	0.481	0.927	0.159	0.234
Mann-Whitney Tests- Intra-site tests										
SHA 20-34 F vs 20-34 M	0.874	0.346	0.535	0.407	0.336	0.276	0.616	0.382	0.122	0.236
LOK 20-34 F vs 20-34 M	0.685	0.199	0.538	0.564	0.54	0.298	0.52	0.173	0.538	0.874
UID 20-34 F vs 20-34 M	n/a	0.405	n/a	0.079	n/a	0.817	0.569	0.699	0.317	n/a
SHA 35+ F vs 35+ M	0.642	0.969	0.287	1	0.136	0.195	0.929	0.104	0.678	**0.031**
LOK 35+ F vs 35+ M	0.537	**0.039**	1	0.64	0.704	0.155	0.269	0.753	0.329	0.697
UID 35+ F vs 35+ M	0.739	0.508	1	0.884	0.897	0.561	1	0.909	0.569	n/a
SHA 20-34 F vs 35+ F	0.85	0.146	0.585	**0.027**	0.624	0.296	0.457	0.206	0.261	0.482
LOK 20-34 F vs 35+ F	0.418	0.414	0.091	**0.047**	0.064	0.869	0.173	0.543	0.35	0.782
UID 20-34 F vs 35+ F	n/a	0.355	n/a	0.121	n/a	0.245	0.882	0.386	1	n/a
SHA 20-34 M vs 35+ M	0.49	0.08	**0.003**	0.052	**0.01**	**0.002**	0.35	0.001	0.453	**0.002**
LOK 20-34 M vs 35+ M	0.188	0.176	0.074	0.201	**0.048**	**0.04**	0.52	0.065	0.29	0.342
UID 20-34 M vs 35+ M	0.439	0.175	**0.02**	0.862	**0.008**	0.066	0.298	0.167	**0.032**	1

SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male. The p-values for the first three MT1 inter-site comparisons (indicated by asterisks) are Mann-Whitney tests done only between SHA and LOK due to the lack of sample at UID.
Significant Values in Bold.
Samples sizes for TMJ, left and right shoulders, elbow, left and right wrists, hip, knee, ankle, and MT1 1st proximal phalanx are located in Tables 4.24, 4.4, 4.5, 4.6, 4.12, 4.13, 4.14, 4.15, 4.22, and 4.23, respectively.
For post-hoc tests for groups exhibiting significant results, see Table 4.3.

TABLE 4.3: Results of Post-Hoc Mann-Whitney Tests for Significant Results from Table 4.2 (p-values)

	Left Wrist	Right Wrist	Knee	Thoracic VOA	
	35+ M	20-34 F	20-34 F	20-34 F	20-34 M
SHA vs LOK	0.105	**0.005**	**0.018**	**0**	**0.022**
SHA vs UID	**0.004**	0.374	0.411	n/a	0.474
LOK vs UID	0.122	0.693	0.622	n/a	0.201

SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.
Significant results in bold.
Sample sizes for left and right wrists, knee, and thoracic VOA can be found in Tables 4.12, 4.13, 4.15, and 4.28, respectively.

TABLE 4.4: Left Shoulder Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	26	0.14	0	0	0	0
LOK 20-34 M	10	0.35	0	0	0.66	0.66
UID 20-34 M	6	0.06	0	0	0	0
SHA 35+ M	20	0.39	0	0.11	0.5	0.5
LOK 35+ M	12	0.73	0.31	0.58	0.94	0.63
UID 35+ M	7	0.84	0	0.22	1	1
SHA 20-34 F	12	0	0	0	0	0
LOK 20-34 F	10	0.04	0	0	0	0
UID 20-34 F	2	0.34	0.17	0.34	0.5	0.34
SHA 35+ F	4	0.42	0	0.17	0.58	0.58
LOK 35+ F	9	0.23	0	0	0.25	0.25
UID 35+ F	4	0.89	0.5	0.84	1.22	0.72

Corresponds to Fig. 4.1 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range.

TABLE 4.5: Right Shoulder Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	28	0.1	0	0	0	0
LOK 20-34 M	12	0.22	0	0	0.21	0.21
UID 20-34 M	6	0	0	0	0	0
SHA 35+ M	18	0.62	0	0.46	0.73	0.73
LOK 35+ M	11	0.63	0.22	0.67	0.92	0.7
UID 35+ M	8	1.1	0.58	0.92	1.21	0.62
SHA 20-34 F	12	0.04	0	0	0	0
LOK 20-34 F	11	0.15	0	0	0	0
UID 20-34 F	1	0	0	0	0	0
SHA 35+ F	4	0.25	0	0	0.25	0.25
LOK 35+ F	8	0.73	0	0.35	1.41	1.41
UID 35+ F	4	0.97	0.5	0.95	1.42	0.91

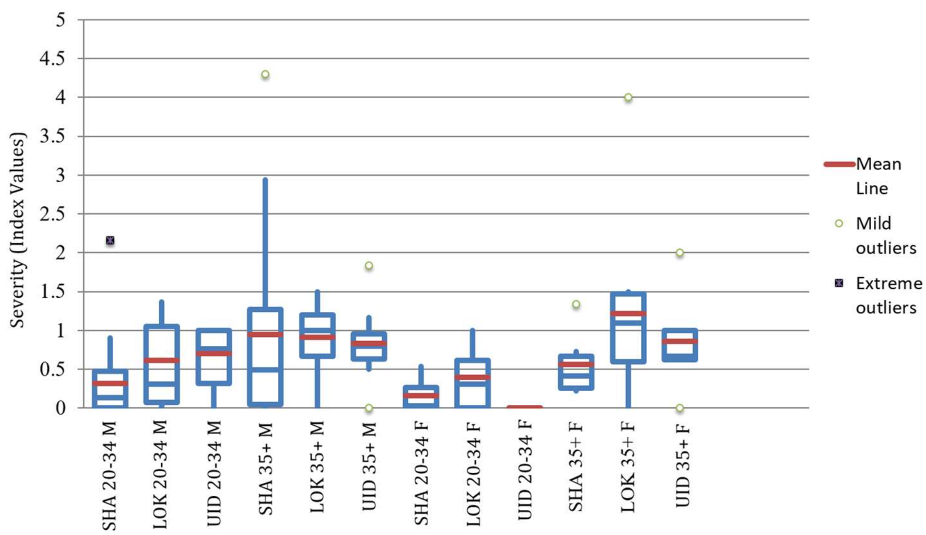
corresponds to Fig. 4.2 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range.

Intra-site analysis of OA severity of the shoulder revealed several significant differences. Older females and older males at LOK differed significantly for the left shoulder, with males having overall more severe OA than contemporary females (p-value=0.039, with median values of 0 and 0.5825 respectively, Tables 4.2 and 4.4). On the right shoulder, this comparison produced a non-significant result (p-value=1.00, Table 4.2). For males at two of the three sites considered (SHA and UID), OA severity of the right shoulder increased significantly with age (p-values=0.003 and 0.02 respectively, Table 4.2). For males at LOK, this trend was also visible, although the result of the statistical test was not significant (p-value=0.074, Table 4.2). No other groups were found to increase significantly with age for the shoulder.

4.3.1.2. Elbow

The range of severity indices for the elbow was 0 to 4.30. The elbow was a common joint to be affected by OA, and relatively high severity scores were regularly seen at all sites (Figures 4.3, 4.4, 4.5, Table 4.6). Two individuals exhibited very high severity indices: one older male from SHA (Burial 65.1, score: 4.30), and one older female from LOK (L7.1 score: 4.00). The severity rates at all three sites were fairly uniform and no statistically significant differences were found between the three sites for elbow OA (p-values > 0.05, Table 4.2).

Intra-site analysis did produce some significant results. At both SHA and LOK, severity increased significantly with age for females (p-values=0.027 and 0.047 respectively, Table 4.2). No other intra-site comparisons produced significant results, however, for both mean and median severity scores. The females from LOK notably surpassed not only the rest of the female sample, but also all male groups. For further analysis of the elbow, see the elbow components section below.



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.3: Boxplot of elbow osteoarthritis severity

Figure 4.4: Osteoarthritis of the distal right humerus showing eburnated surface on the capitulum, anterior view (SHA_2003.027.01; male, 35-50 years)

Figure 4.5: Osteoarthritis on the proximal right ulna, showing osteophytic lipping of the joint margins, anterior view (SHA_2003.027.01; male, 35-50 years)

TABLE 4.6: Elbow Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	31	0.31	0	0.13	0.48	0.48
LOK 20-34 M	12	0.62	0.08	0.31	1.05	0.98
UID 20-34 M	7	0.7	0.32	0.77	1	0.68
SHA 35+ M	22	0.95	0.05	0.49	1.27	1.22
LOK 35+ M	13	0.91	0.67	1	1.2	0.54
UID 35+ M	8	0.83	0.63	0.8	0.96	0.33
SHA 20-34 F	11	0.16	0	0.03	0.27	0.27
LOK 20-34 F	12	0.39	0	0.31	0.61	0.61
UID 20-34 F	2	0	0	0	0	0
SHA 35+ F	6	0.56	0.26	0.42	0.67	0.41
LOK 35+ F	9	1.22	0.6	1.1	1.47	0.87
UID 35+ F	5	0.86	0.62	0.67	1	0.38

corresponds to Fig. 4.3 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range.

4.3.1.2.1. Elbow Components

As was discussed in the methods section (Chapter Three), the elbow was analyzed again by separating the ulnar-humeral "hinge" component (trochlea of humerus and trochlear notch of ulna) and the radio-ulnar "pivot" component (as mentioned in Chapter Two, I note that the "pivot" component of the elbow – which includes the capitulum of humerus, radial notch of ulna, and radial head of radius – does also play a role in flexion and extension). Wilcoxon Pairs tests were used to compare the hinge and pivot components within the same individual (comparing two dependent samples), and these tests revealed several significant differences. Older females at LOK had significantly more severe OA in the hinge than the pivot component (p-value=0.028, Table 4.8). No other females differed significantly between the two portions of the elbow (p-values > 0.05, Table 4.8). The males, by contrast, had many significant differences between the hinge and pivot components. Four of the six comparisons yielded significant results (Table 4.8): younger males at SHA (p-value=0.028), older males at LOK (p-value=0.038), and both younger (p-value=0.043) and older males at UID (p-value=0.043). In all cases, the hinge portion had higher median severity values than the pivot portion (Table 4.7). Two individuals had exceedingly high severity index values over 5: one from an older male from SHA with a pivot index of 5.09 (Burial 65.1), and the other from an older female from LOK with a hinge index of 6.17 (Burial L7.1). These are the same two individuals that stood out in the regular elbow analysis.

TABLE 4.7: Elbow Component Descriptive Statistics

Site, age group (in years), and sex	Humeral-ulnar			Humeral-radial	
	N	Median	IQR	Median	IQR
SHA 20-34 M	30	0.12	0.5	0.06	0.37
LOK 20-34 M	12	0.67	0.88	0.	1.04
UID 20-34 M	6	0.88	0.87	0.22	0.46
SHA 35+ M	22	0.75	1.35	0.25	1.26
LOK 35+ M	11	1.	0.75	0.67	0.93
UID 35+ M	8	0.92	0.5	0.75	0.28
SHA 20-34 F	11	0.	0.5	0.	0.19
LOK 20-34 F	12	0.42	0.94	0.08	0.49
UID 20-34 F	2	0.	0.	0.	0.
SHA 35+ F	6	0.84	0.46	0.06	0.28
LOK 35+ F	8	1.38	0.85	0.75	1.05
UID 35+ F	4	1.	0.5	0.71	0.94

SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male
N=sample size, IQR=interquartile range.

TABLE 4.8: P-values for Dependent Component Data from the Elbow

		Elbow Component
Site, age group (in years), and sex	N	HU vs. HR
SHA 20-34 M	30	**0.028**
LOK 20-34 M	12	0.123
UID 20-34 M	6	**0.043**
SHA 35+ M	22	0.366
LOK 35+ M	11	**0.038**
UID 35+ M	8	**0.043**
SHA 20-34 F	11	0.116
LOK 20-34 F	12	0.063
UID 20-34 F	2	n/a
SHA 35+ F	6	0.116
LOK 35+ F	8	**0.028**
UID 35+ F	4	0.317

SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; HU=humeral-ulnar; HR=humeral-radial
Wilcoxon pairs tests for the elbow data.
Significant results in bold.

In addition to the above “paired” analysis comparing the hinge and pivot components of the elbow, inter- and intra-site analyses were done for these components separately. Inter-site testing revealed significant differences in severity of the hinge portion of the elbow when younger males from all three cemeteries were compared (p-value=0.017, Table 4.9). Post-hoc testing showed that the significant difference was between the younger males from SHA and UID (p-value=0.012, Table 4.10). The same trend was seen in the comparison between younger males at SHA and LOK, where the p-value approached significance (p-value=0.053, Table 4.10). The hinge portions of the younger males from SHA were consistently less severe than the younger males at the other two sites, which could suggest that the strenuous activities that ultimately contribute to OA began earlier in life for the males at UID and LOK. Inter-site testing for the pivot portion of the elbow revealed no significant differences in severity for any of the groups under study (p-values > 0.05, Table 4.9).

TABLE 4.9: P-values for Inter-Site Kruskal-Wallis Tests on Elbow Component Data

	Elbow component	
SHA vs LOK vs UID	HU	HR
20-34 F	0.18	0.446
35+ F	0.51	0.397
20-34 M	**0.017**	0.927
35+ M	0.706	0.601

HU=humeral-ulnar; HR=humeral-radial. Subsequent post-hoc testing conducted on significant results can be found in Table. 4.10.
Significant results in bold. Sample sizes can be found in Table 4.7.

TABLE 4.10: Post-Hoc Mann-Whitney Tests for the Inter-Site Comparisons of Elbow Component Data

	Elbow HU younger males
SHA vs LOK	0.053
SHA vs UID	**0.012**
LOK vs UID	0.487

HU=humeral-ulnar; HR=humeral-radial
Significant results in bold. Sample sizes can be found in Table 4.7.

Intra-site analyses that compared males to females at the same site showed no statistically significant differences between the sexes for either the hinge or pivot component (all p-values < 0.05, Table 4.11). The remaining intra-site comparisons on age-related severity changes did produce some significant results. The younger Early Neolithic (EN) females from both SHA and LOK differed significantly from their older female contemporaries in the severity of the hinge (p-values=0.008 and 0.045 respectively, Table 4.11). Severity scores rose from a median of 0 for younger females to a median of 0.84 for older females at SHA and from 0.42 to 1.38 at LOK (Table 4.7). Younger males (median value 0.12) also differed significantly from their older contemporaries (median value 0.75) for the hinge portion at SHA (p-value=0.03, Table 4.11), which was not the case at the other two cemeteries. The IQR for older males at SHA was the largest of all groups under study, for both the hinge and pivot portions of the elbow (Table 4.7). The results of the hinge portion of the elbow are particularly interesting as they more prominently display differences among and within sites that were seen when the elbow was analyzed as one unit.

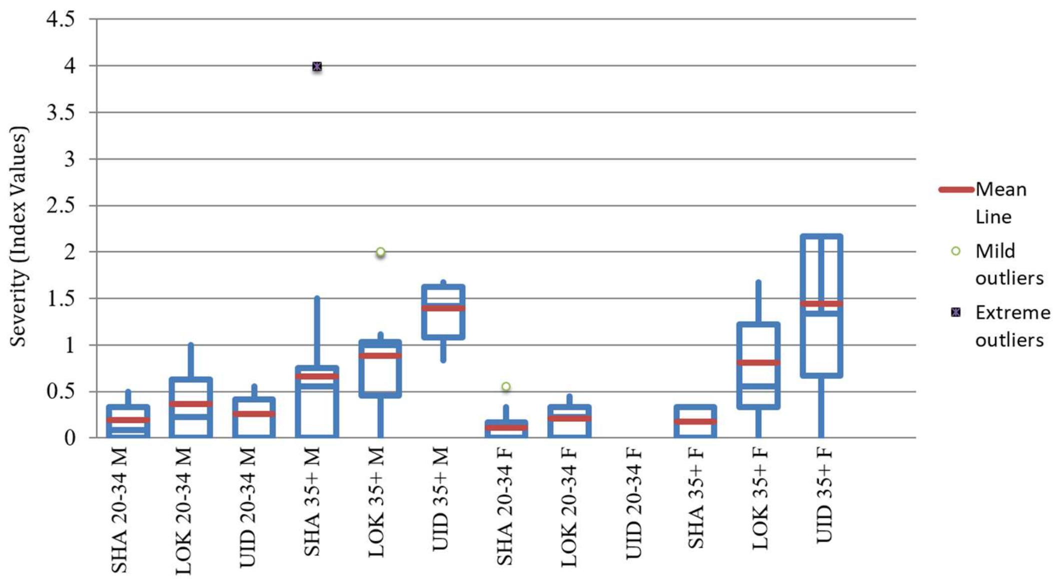
TABLE 4.11: Results of Intra-Site Mann-Whitney Tests on Elbow Component Data (p-values)

	Elbow Component	
	Hinge	Pivot
SHA 20-34 F vs. 20-34 M	0.648	0.427
LOK 20-34 F vs. 20-34 M	0.47	0.954
UID 20-34 F vs. 20-34 M	0.068	0.317
SHA 35+ F vs. 35+ M	0.737	0.341
LOK 35+ F vs. 35+ M	0.563	0.68
UID 35+ F vs. 35+ M	0.671	0.865
SHA 20-34 F vs. 35+ F	**0.008**	0.58
LOK 20-34 F vs. 35+ F	**0.045**	0.105
UID 20-34 F vs. 35+ F	0.165	0.165
SHA 20-34 M vs. 35+ M	**0.03**	0.101
LOK 20-34 M vs. 35+ M	0.295	0.281
UID 20-34 M vs. 35+ M	0.958	0.081

SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I
Significant results in bold.
Sample sizes can be found in Table 4.7.

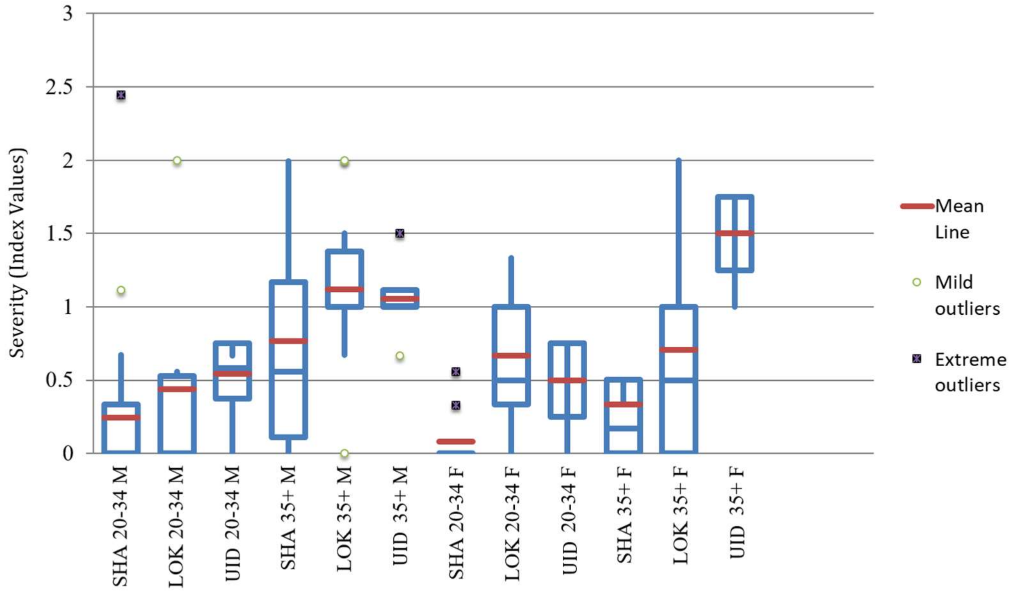
4.3.1.3. Wrist

For the wrist, Wilcoxon Pairs tests for bilateral asymmetry produced a significant result for the LOK females (p-value=0.041, Table 4.1), with more severe OA on the right side when compared to the left side. Due to this difference between the left and right sides, separate analysis of each side was required. The range of severity indices for the left wrist was 0 to 3.995 and 0 to 2.447 for the right wrist. For both wrists, OA severity scores for most individuals fell between 0 and 2.00 (Tables 4.12 and 4.13). Both of the highest index scores came from males at SHA. An older male from this site (burial 58.1) was an extreme outlier with the value of 3.995 for the left wrist (Figure 4.6), and a younger male (SHA, Burial 46.1) had the value of 2.447 for the right wrist (Figure 4.7).



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.6: Boxplot of left wrist osteoarthritis severity



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.7: Boxplot of right wrist osteoarthritis severity

TABLE 4.12: Left Wrist Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	28	0.19	0	0.08	0.33	0.33
LOK 20-34 M	10	0.36	0	0.22	0.62	0.62
UID 20-34 M	6	0.26	0	0	0.42	0.42
SHA 35+ M	19	0.66	0	0.55	0.75	0.75
LOK 35+ M	12	0.88	0.46	1	1.03	0.57
UID 35+ M	6	1.39	1.08	1.42	1.63	0.54
SHA 20-34 F	10	0.11	0	0	0.17	0.17
LOK 20-34 F	9	0.2	0	0.22	0.34	0.34
UID 20-34 F	1	0	0	0	0	0
SHA 35+ F	5	0.18	0	0	0.33	0.33
LOK 35+ F	7	0.81	0.33	0.56	1.22	0.89
UID 35+ F	3	1.45	0.67	1.34	2.17	1.5

corresponds to Fig. 4.4 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range.

TABLE 4.13: Right Wrist Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	30	0.24	0	0	0.33	0.33
LOK 20-34 M	7	0.44	0	0	0.53	0.53
UID 20-34 M	4	0.54	0.38	0.58	0.75	0.37
SHA 35+ M	21	0.77	0.11	0.56	1.17	1.06
LOK 35+ M	10	1.12	1	1	1.38	0.38
UID 35+ M	5	1.06	1	1.01	1.11	0.11
SHA 20-34 F	11	0.08	0	0	0	0
LOK 20-34 F	11	0.67	0.33	0.5	1	0.67
UID 20-34 F	2	0.5	0.25	0.5	0.75	0.5
SHA 35+ F	4	0.33	0	0.17	0.5	0.5
LOK 35+ F	8	0.71	0	0.5	1	1
UID 35+ F	2	1.5	1.25	1.5	1.75	0.5

corresponds to Fig. 4.5 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range.

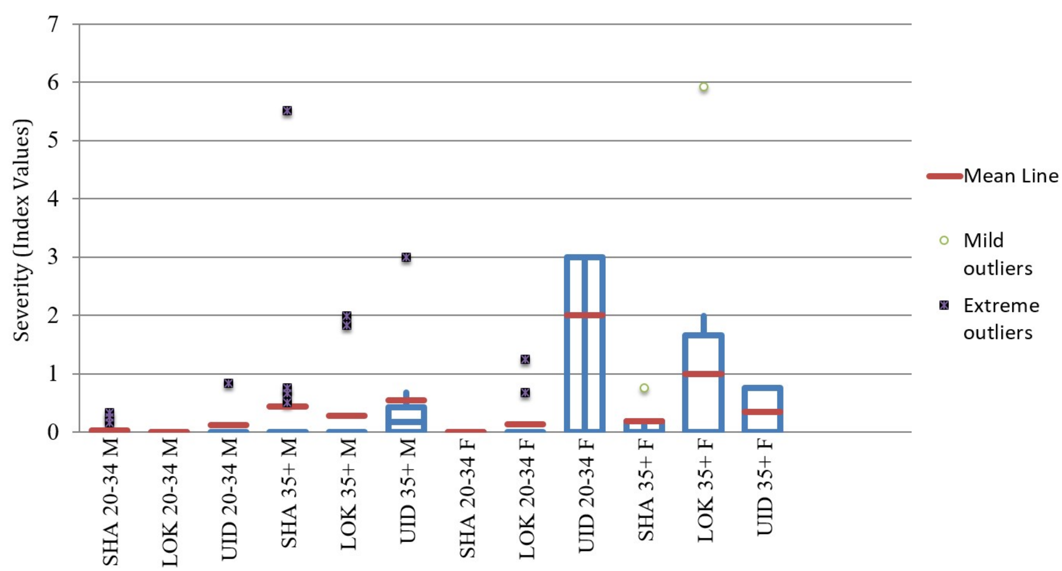
Inter-site tests revealed significant differences among younger females at the three sites for the right wrist (p-value=0.022, Tables 4.2, 4.13). Post-hoc testing revealed that this was attributable to the higher degree of severity among younger females at LOK compared to younger females at SHA; median values for the right wrist were 0 and 0.5 respectively (p-value=0.005, Tables 4.3, Figure 4.7). A significant difference was found in left wrist OA between older males from each of the three sites (p-value=0.011, Table 4.2) and can be attributed to the higher severity levels at UID when compared to SHA (p-value=0.004, Table 4.2). No other significant inter-site differences were found for wrist OA (p-values >0.05, Table 4.2).

The results of the intra-site testing of the wrist revealed no significant differences between the sexes, however wrist OA often increased significantly with age. Wrist OA increased significantly with age for nearly all males. At SHA and LOK older males had significantly more severe OA in both the left and right wrists than their younger male contemporaries (p-values all < 0.05, Table 4.2). At UID, the left wrist differed significantly with age while the right wrist did not, although it did approach significance (p-value=0.066, Table 4.2). For both the left and right wrists, the sample sizes for females at UID were relatively small and they were unable to be included in most of this analysis (Tables 4.12 and 4.13). Unlike wrist OA in the male populations that increased significantly with age for the most part, none of these comparisons produced significant results for any of the females that were able to be included (p-values >0.05, Table 4.2).

4.3.2. The Lower Limb

4.3.2.1. Hip

Severity indices for the hip ranged from 0 to 5.92 (Figure 4.8). Despite this large range, OA severity in the hip was low overall (as compared to many of the other joints under study here) for all groups at all sites. Median scores were 0 for all groups except for older males at UID (Table 4.14). Older females at all three sites had a third quartile severity score over zero as did the older males at UID (Table 4.14). In addition, the highest third quartile severity score was the younger females at UID (Q3=3.00, Table 4.14). Hip OA severity scores for all but two individuals ranged from 0 to 3 (Figure 4.8). An older male at SHA had a value of 5.505 (Burial 61.2, Figure 4.9), and an older female at LOK had a value of 5.92 (Burial L18.1). Both inter-site tests and intra-site tests showed no statistically significant differences for the hip joint at all sites (Table 4.2).



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.8: Boxplot of hip osteoarthritis severity

Figure 4.9: Osteoarthritis of the left acetabulum, lateral view (SHA_2005.061.02; male, 35-45 years)

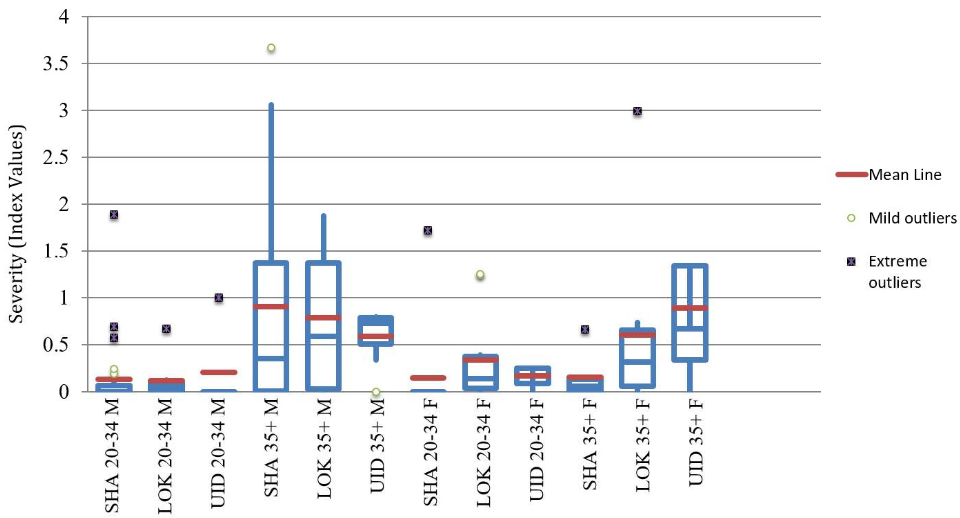
TABLE 4.14: Hip Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	32	0.02	0	0	0	0
LOK 20-34 M	14	0	0	0	0	0
UID 20-34 M	7	0.12	0	0	0	0
SHA 35+ M	17	0.44	0	0	0	0
LOK 35+ M	14	0.27	0	0	0	0
UID 35+ M	8	0.54	0	0.17	0.42	0.42
SHA 20-34 F	14	0	0	0	0	0
LOK 20-34 F	14	0.14	0	0	0	0
UID 20-34 F	3	2	0	0	3	3
SHA 35+ F	4	0.19	0	0	0.19	0.19
LOK 35+ F	12	0.99	0	0	1.66	1.66
UID 35+ F	5	0.35	0	0	0.75	0.75

corresponds to Fig. 4.6 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range.

4.3.2.2. Knee

Severity indices for the knee ranged from 0 to 3.6. Despite the relatively small range, knee OA was common at three sites and relatively severe OA was far from rare. Inter-site analysis showed no significant differences among the sites for males. For the females, inter-site analyses showed a significant difference between the younger females at SHA and those of the same age group from LOK (p-value=0.018, Table 4.2). Median values of 0 for SHA and 0.1365 for LOK illustrate this difference (Figures 4.10, 4.11, Table 4.15). The older females from both LOK and UID had mean and median severity scores similar to older males (at all sites). However, the older females from SHA were conspicuously lower in overall severity, as represented by median, mean and IQR, than all others within the 35+ age category. Their values were within the range of the younger 20-34 sample from the other sites (Table 4.15). The older females along with the older males at UID had the highest median values of all the groups.



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.10: Boxplot of knee osteoarthritis severity

Figure 4.11: Osteoarthritis on the distal left and right femora, anterior views (SHA_2000.008; male, 35-40 years)

TABLE 4.15: Knee Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	29	0.13	0	0	0.07	0.07
LOK 20-34 M	8	0.12	0	0.03	0.09	0.09
UID 20-34 M	5	0.2	0	0	0	0
SHA 35+ M	22	0.91	0.01	0.35	1.36	1.36
LOK 35+ M	14	0.79	0.02	0.59	1.36	1.34
UID 35+ M	7	0.59	0.5	0.73	0.79	0.28
SHA 20-34 F	12	0.14	0	0	0	0
LOK 20-34 F	11	0.33	0.03	0.14	0.38	0.34
UID 20-34 F	2	0.17	0.08	0.17	0.25	0.17
SHA 35+ F	6	0.15	0	0.06	0.13	0.13
LOK 35+ F	9	0.6	0.06	0.31	0.65	0.6
UID 35+ F	3	0.89	0.34	0.67	1.34	1

corresponds to Fig. 4.7 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range.

Intra-site testing revealed no significant differences between the males and females of similar ages at any of the three sites. Likewise, OA did not increase significantly with age for the females at any of the three sites. Figure 4.10 illustrates the differences in severity indices of younger males and females compared to older males and females at all three sites. Despite not finding a significant difference, for the females at LOK and UID there was an increase in OA severity with age. Interestingly, the females from SHA showed almost no increase in severity rates in the knee with age, which has implications for overall behavioral reconstruction to be discussed in the following chapter. For the older males, the median and IQR values at each site increased when compared to their younger male contemporaries, and males at SHA exhibited a significant difference when younger and older age classes were compared (Figure 4.12, p-value=0.001, Table 4.2). The knee data were subsequently analyzed by components, similar to the elbow data, the results of which further illuminated the differences among and within the sites for this joint.

Figure 4.12: Osteoarthritis on the distal right femur showing surface eburnation, anterior view (SHA_2005.065; male, 50+ years)

4.3.2.2.1. Knee Components

The three components of the knee—the anterior knee (patellar surface of femur, lateral and medial facets of the patella), medial knee (medial condyles of the distal femur and proximal tibia), and lateral knee (lateral condyles of the distal femur and proximal tibia)—were analyzed separately to further illuminate the results of the knee joint. These analyses compared the three components within an individual to show where OA of the knee was typically most and/or least severe. Further analyses compared each component among and within the sites as was done for the full joints. When the three components of the knee were compared from within the same individual, several important differences in severity became apparent. The anterior knee was most severely affected when compared to the medial and lateral components at all three sites and for all sex and age groups. This difference was significant for younger females and older males at LOK and for both younger and older males at SHA (all p-values < 0.05, Tables 4.16 and 4.17).

TABLE 4.16: P-values for Dependent Component Data from the Knee

		Knee Component
Site, age group (in years), and sex	N	Anterior vs Medial vs Lateral
SHA 20-34 M	27	**0.002**
LOK 20-34 M	6	0.174
UID 20-34 M	2	n/a
SHA 35+ M	16	**0**
LOK 35+ M	14	**0.003**
UID 35+ M	4	0.523
SHA 20-34 F	9	n/a
LOK 20-34 F	10	**0.004**
UID 20-34 F	1	n/a
SHA 35+ F	4	0.097
LOK 35+ F	8	0.072
UID 35+ F	1	n/a

SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male
Friedman ANOVA for the knee data.
Significant results in bold.
For post-hoc tests for groups exhibiting significant results, see Table 4.18.

TABLE 4.17: Knee Component Descriptive Statistics

		Anterior		Medial		Lateral	
Site, age group (in years), and sex	N	Median	IQR	Median	IQR	Median	IQR
SHA 20-34 M	27	0.00	0.06	0.00	0.00	0.00	0.00
LOK 20-34 M	6	0.08	0.25	0.00	0.00	0.00	0.00
UID 20-34 M	2	0.00	0.00	0.00	0.00	0.00	0.00
SHA 35+ M	16	0.47	1.66	0.04	0.52	0.25	0.75
LOK 35+ M	14	1.00	1.49	0.08	0.73	0.42	1.19
UID 35+ M	4	0.83	0.13	0.84	0.25	0.38	0.81
SHA 20-34 F	9	0.00	0.00	0.00	0.00	0.00	0.00
LOK 20-34 F	10	0.25	0.40	0.00	0.12	0.00	0.31
UID 20-34 F	1	n/a	n/a	n/a	n/a	n/a	n/a
SHA 35+ F	4	0.25	0.37	0.00	0.08	0.17	0.12
LOK 35+ F	8	0.55	0.92	0.00	0.08	0.00	0.02
UID 35+ F	1	n/a	n/a	n/a	n/a	n/a	n/a

SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male
N=sample size and IQR=interquartile range.

Inter-and intra-site analyses of the anterior portion of the knee tended to follow the same trends seen in the complete knee analysis but with more significant differences. Median values for all groups ranged from 0 to 1 (Table 4.17). Older males from all three sites, especially the EN sites of SHA and LOK, had large IQRs most notably for the anterior portion (Table 4.17). The older females from LOK had the most severe OA in the anterior portion of the knee when compared to the other females. The median value for the anterior knee of older females from LOK was 0.555, while the younger contemporaries had a median severity value of 0.251, the same as the older females from SHA (Table 4.17).

TABLE 4.18: Results of Wilcoxon Pairs Post-Hoc Testing of Dependent Knee Components (following Table 4.16)

	Anterior vs Medial	Anterior vs Lateral	Lateral vs Medial
LOK 20-34 F	**0.018**	**0.028**	0.285
SHA 20-34 M	**0.018**	**0.018**	0.655
SHA 35+ M	**0.002**	**0.019**	0.673
LOK 35+ M	**0.022**	**0.047**	**0.046**

Post-hoc testing conducted on knee component data when Friedman ANOVA (Table 4.16) produced significant results. Significant results in bold. Sample sizes can be found in Table 4.16.

Inter-site comparisons showed that younger females from LOK had significantly more severe OA in the anterior knee than the younger females from SHA (p-value=0.01, Table 4.19). These results are consistent with those from the overall knee scores. No other inter-sites tests produced significant results for any of the three knee components (Table 4.20).

TABLE 4.19: Post-Hoc Mann-Whitney Tests for the Inter-Site Comparisons of Knee Component Data

	Anterior knee younger females
SHA vs LOK	**0.01**
SHA vs UID	n/a
LOK vs UID	n/a

Significant results in bold. Sample sizes can be found in Table 4.16.

TABLE 4.20: P-values for Inter-Site Kruskal-Wallis Tests on Knee Component Data

	Knee Component		
SHA vs LOK vs UID	Anterior	Medial	Lateral
20-34 F	**0.015**	0.526	0.526
35+ F	0.434	0.911	0.316
20-34 M	0.523	0.887	0.988
35+ M	0.901	0.467	0.88

Post-hoc testing conducted on significant results can be found in Table 4.19.
Significant results in bold.
Sample sizes can be found in Table 4.16.

Intra-site comparisons of males and females produced no statistically significant results. However, OA severity often increased significantly with age. The females at SHA showed a significant increase in OA severity with age in both the anterior and lateral components of the knee (p-value=0.037 for both, Table 4.21), while the females at LOK did not show any significant increase with age in any of the three knee components. The female sample from UID was too small to be analyzed. The males from SHA showed a significant increase with age in all three knee components (p-values all < 0.05, Table 4.21). At LOK, younger and older males showed a significant increase in OA severity only for the lateral portion of the knee (p-value=0.048, Table 4.21) and not in the anterior or medial portions, although those portions did show a strong trend of increased severity with age. At UID, there was no significant increase in OA severity with age among the males, despite the lack of significant results here, a strong trend of increased severity with age in all portions.

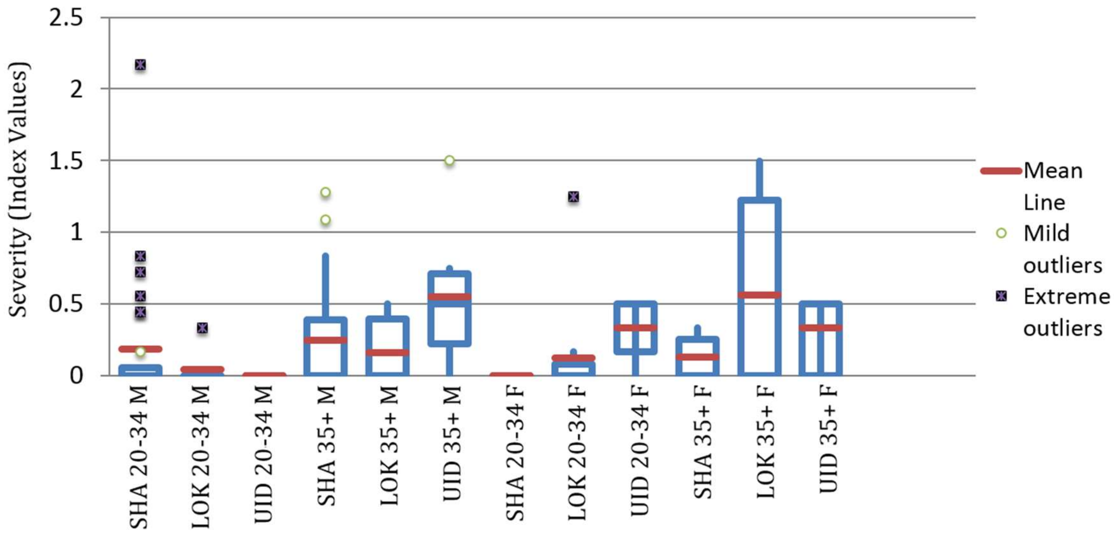
TABLE 4.21: Results of Intra-Site Mann-Whitney Tests on Knee Component Data (p-values)

	Knee Component		
	Anterior	Medial	Lateral
SHA 20-34 F vs. 20-34 M	0.25	0.869	0.869
LOK 20-34 F vs. 20-34 M	0.386	0.625	0.329
UID 20-34 F vs. 20-34 M	n/a	n/a	n/a
SHA 35+ F vs. 35+ M	0.422	0.345	0.671
LOK 35+ F vs. 35+ M	0.394	0.232	0.088
UID 35+ F vs. 35+ M	n/a	n/a	n/a
SHA 20-34 F vs. 35+ F	**0.037**	0.487	**0.037**
LOK 20-34 F vs. 35+ F	0.477	0.929	0.756
UID 20-34 F vs. 35+ F	n/a	n/a	n/a
SHA 20-34 M vs. 35+ M	**0.002**	**0.01**	**0.004**
LOK 20-34 M vs. 35+ M	0.083	0.161	**0.048**
UID 20-34 M vs. 35+ M	0.064	0.165	0.355

SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I
Significant results in bold.
Sample sizes can be found in Table 4.16.

4.3.2.3. Ankle

Ankle OA was much less commonly seen at all three sites than was knee OA and severity levels overall were low. Most severity values for OA of the ankle fell between 0 and 0.5 (Figures 4.13 and 4.14). The top of the range was 2.17 for this joint (SHA, Burial 10.1). Older females at LOK stood out amongst the other females, with the highest mean, median and IQR values (Figure 4.13, Table 4.22). No significant differences were found in the inter-site analysis for the ankle (p-values > 0.05, Table 4.2). The intra-site analysis also yielded largely non-significant results, with the exception being between the younger and older males from UID (p-value=0.032, Table 4.2). Median values for the younger males were 0 while the older males were 0.5025 (Figure 4.13, Table 4.22).



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.13: Boxplot of osteoarthritis severity for ankle joint

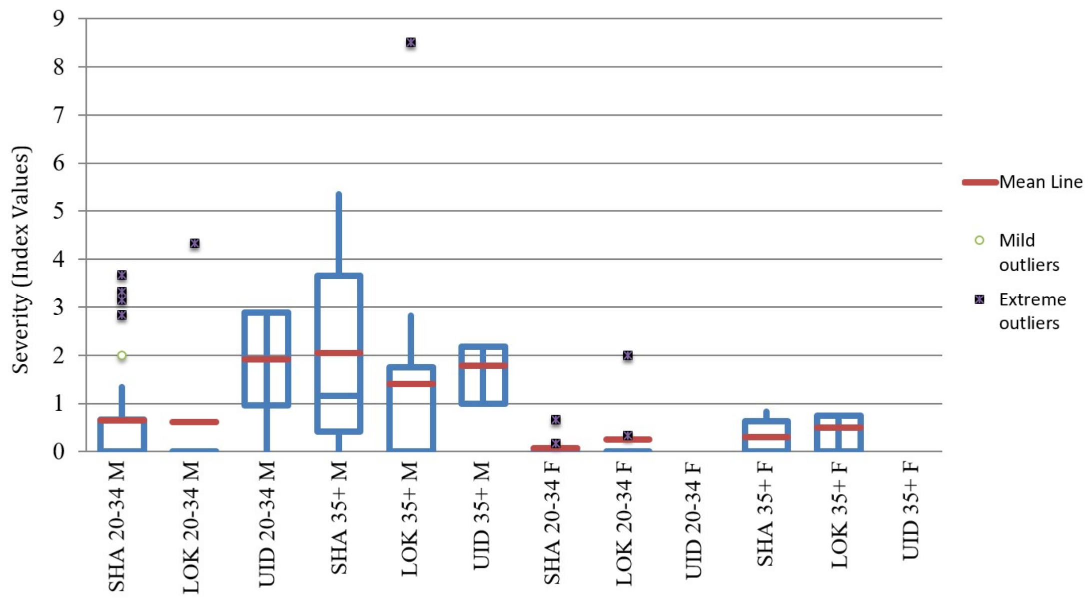
TABLE 4.22: Ankle Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	29	0.19	0	0	0.06	0.06
LOK 20-34 M	8	0.04	0	0	0	0
UID 20-34 M	6	0	0	0	0	0
SHA 35+ M	24	0.24	0	0	0.39	0.39
LOK 35+ M	14	0.16	0	0	0.39	0.39
UID 35+ M	7	0.55	0.22	0.50	0.71	0.49
SHA 20-34 F	12	0	0	0	0	0
LOK 20-34 F	13	0.12	0	0	0.08	0.08
UID 20-34 F	2	0.34	0.17	0.34	0.5	0.34
SHA 35+ F	6	0.13	0	0	0.25	0.25
LOK 35+ F	9	0.56	0	0	1.22	1.22
UID 35+ F	3	0.33	0	0	0.5	0.5

corresponds to Fig. 4.8 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range

4.3.2.4. MT1-1st Proximal Phalanx

Most individuals had severity indices between 0 and 3 for this joint (Figure 4.14, Table 4.23), but one individual, an older male from LOK (Burial L11.1.1), was an extreme outlier with an index of 8.505, the top of the range. No female skeletons from UID contained this element, and as a result, inter-site tests for females were conducted only between SHA and LOK. None of these tests produced significant results. Similarly, inter-site tests for males at SHA, LOK, and UID also proved insignificant. Intra-site testing showed significant results only at the site of SHA. The older males had significantly more severe OA in this joint than their younger male contemporaries, as well as their contemporary older females (p-values=0.031 and 0.002 respectively, Table 4.2).



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.14: MT1-1st boxplot of osteoarthritis severity for proximal phalanx

TABLE 4.23: MT1-1st Proximal Phalanx Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	28	0.65	0	0	0.67	0.67
LOK 20-34 M	7	0.62	0	0	0	0
UID 20-34 M	2	1.92	0.96	1.92	2.88	1.92
SHA 35+ M	23	2.04	0.42	1.17	3.67	3.25
LOK 35+ M	11	1.41	0	0	1.75	1.75
UID 35+ M	3	1.78	1	1	2.17	1.17
SHA 20-34 F	11	0.08	0	0	0	0
LOK 20-34 F	9	0.26	0	0	0	0
UID 20-34 F	0	0	0	0	0	0
SHA 35+ F	6	0.31	0	0	0.62	0.62
LOK 35+ F	3	0.5	0	0	0.75	0.75
UID 35+ F	0	0	0	0	0	0

Corresponds to Fig. 4.9 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range

4.4. The Axial Skeleton

4.4.1. Temporomandibular Joint (TMJ)

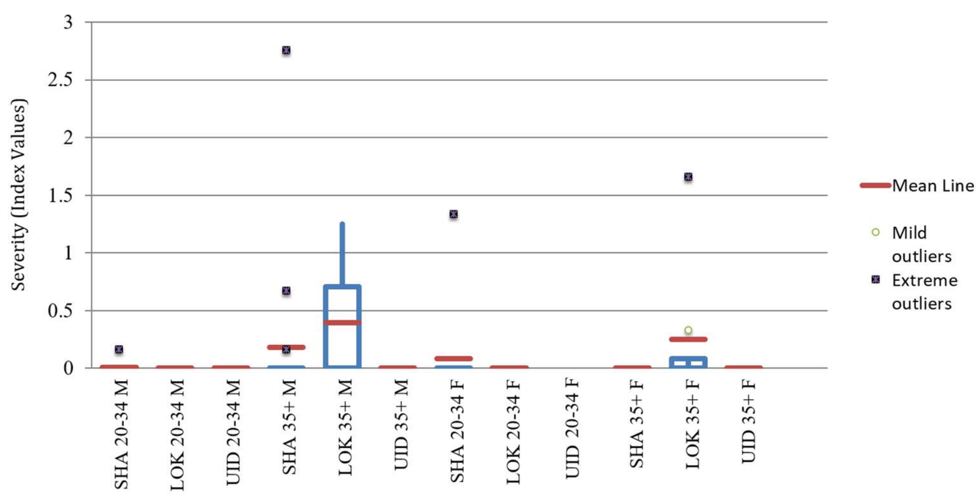
Severity indices for the TMJ ranged from 0 to 2.78 across all samples. This joint was not commonly affected by OA. For the TMJ, LOK stands out as the site with the most severe OA overall (Table 4.24). This is true for both males and females and the mean, median, and IQRs for the older adults are the highest among all groups under study (Table 4.24). Aside from this site, the severity levels of OA for this joint were negligible.

TABLE 4.24: TMJ: Descriptive Statistics for Severity Indices

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	28	0.01	0	0	0	0
LOK 20-34 M	5	0	0	0	0	0
UID 20-34 M	3	0	0	0	0	0
SHA 35+ M	20	0.18	0	0	0	0
LOK 35+ M	12	0.40	0	0	0.71	0.71
UID 35+ M	6	0	0	0	0	0
SHA 20-34 F	16	0.08	0	0	0	0
LOK 20-34 F	7	0	0	0	0	0
UID 20-34 F	1	0	0	0	0	0
SHA 35+ F	4	0	0	0	0	0
LOK 35+ F	8	0.25	0	0	0.08	0.08
UID 35+ F	2	0	0	0	0	0

Corresponds to Fig. 4.10 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range

Despite the differences noted above at the site of LOK, the inter-site statistical analysis for the TMJ produced no significant results (p-values all > 0.05, see Table 4.2). At the site of LOK, severity for the older males ranged from 0 to 1.25 with an IQR of 0.71, and the older females ranged from 0 to 1.66 with an IQR of 0.08 (Table 4.24). The most severe case observed was an older male at SHA (Burial 65.1) who had a severity score higher than any other individual in the study (2.755, Figures 4.15 and 4.16).



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

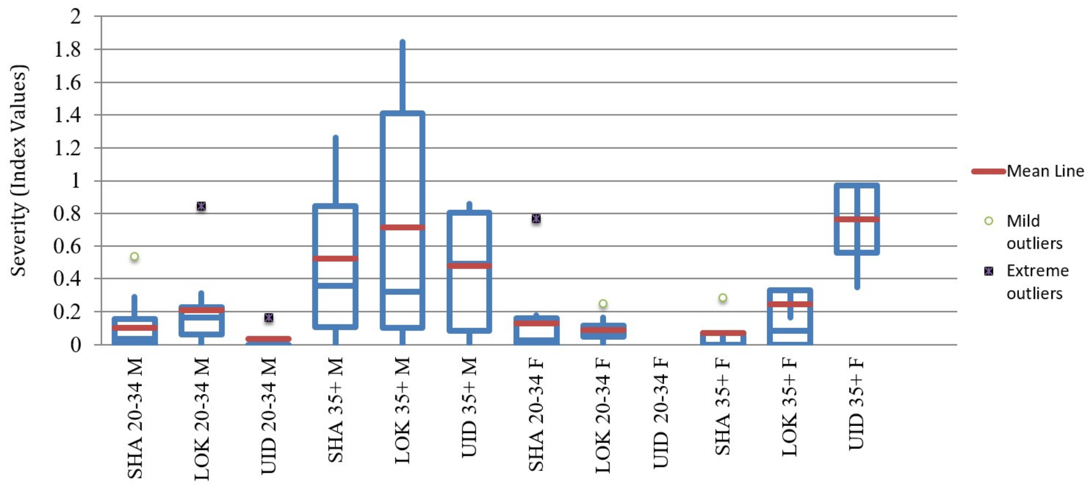
Figure 4.15: Boxplot of osteoarthritis severity for TMJ

Figure 4.16: Osteoarthritis on the right TMJ (SHA_2005.065; male, 50+ years)

No statistically significant differences were found in the intra-site statistical analysis (p-values all > 0.05, see Table 4.2). The small sample size for younger females (age 20-34) at UID did not allow for their inclusion in statistical analysis, and they were unable to be displayed in the boxplot (Figure 4.15).

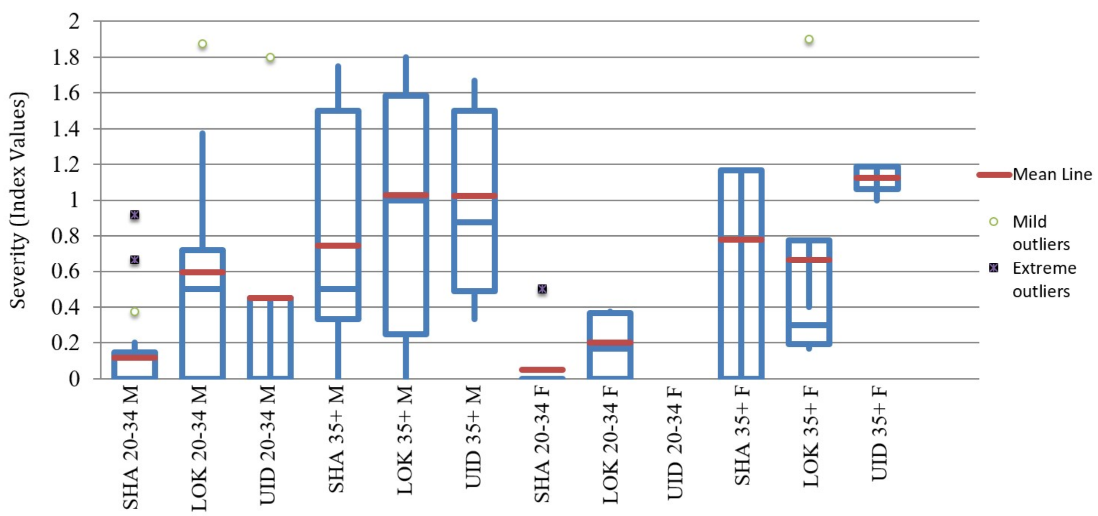
4.4.2. The Vertebral Column

The younger female sample from UID was limited or absent for all portions of the vertebral column. As such, they were not able to be included in any of the following analyses. Additionally, for the thoracic bodies, the older females from both UID and SHA were unable to be included in the analysis (n=1 in both cases). All sample size information can be found in Tables 4.25 to 4.30 (these groups are not pictured in the box plots in Figures 4.17 – 4.22). All p-values for inter-and intra-site statistical tests can be found below in Table 4.25.



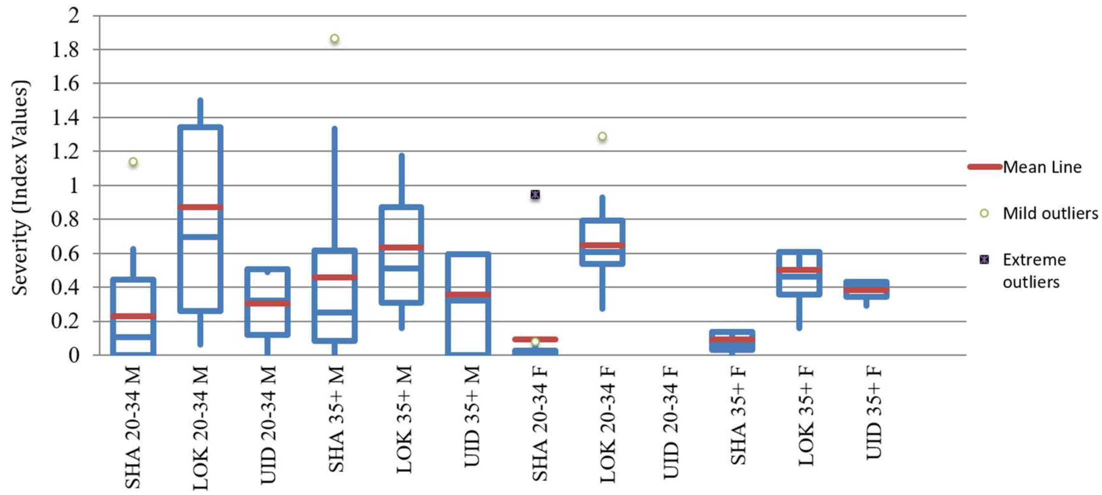
Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.17: Boxplot of osteoarthritis severity for cervical VOA



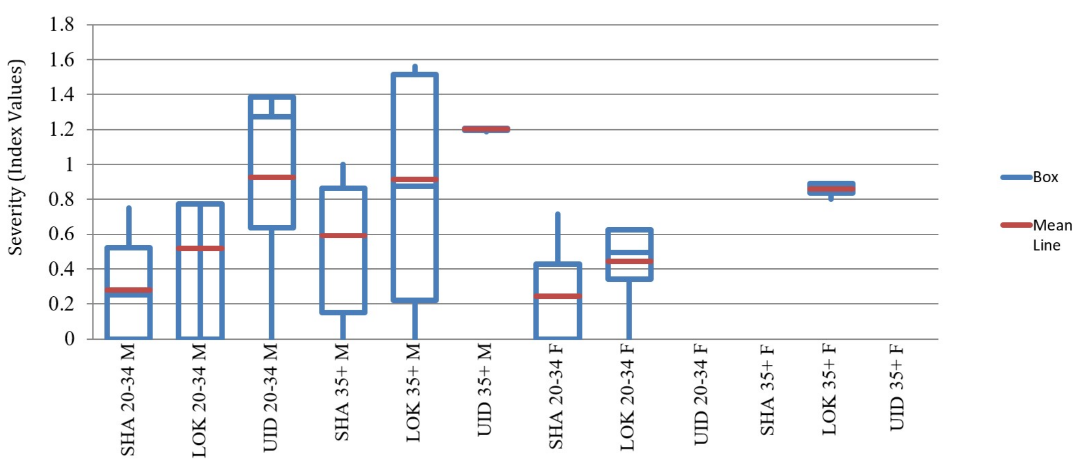
Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.18: Boxplot of osteoarthritis severity for cervical OVB



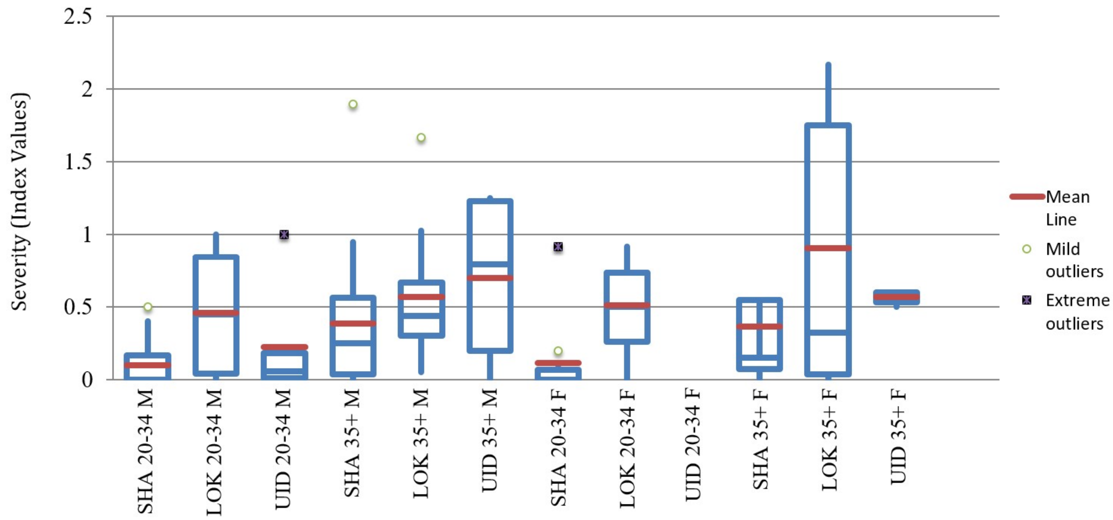
Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.19: Boxplot of osteoarthritis severity for thoracic VOA



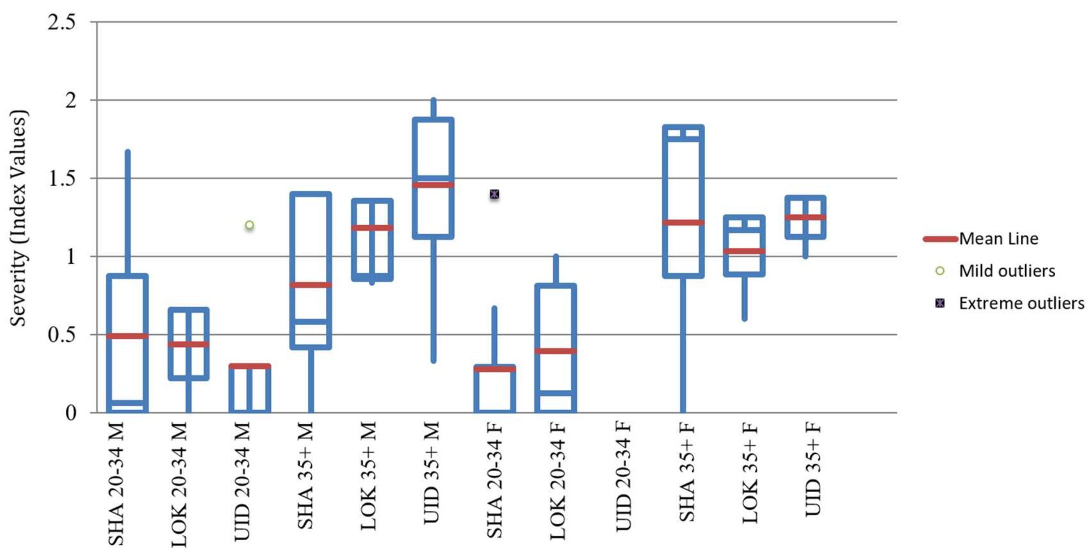
Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.20: Boxplot of osteoarthritis severity for thoracic OVB



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.21: Boxplot of osteoarthritis severity for lumbar VOA



Boxplot with severity values shown categorized by sex, age, and site. SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I.

Figure 4.22: Boxplot of osteoarthritis severity for lumbar OVB

TABLE 4.25:

Results of Kruskal-Wallis and Mann-Whitney Tests for Inter- and Intra-Site Statistical Differences in Cervical, Thoracic, and Lumbar VOA and OVB by Age and Sex Subgroups (p-values)

Kruskal-Wallis Tests Inter-site tests						
	Cervical VOA	Thoracic VOA	Lumbar VOA	Cervical OVB	Thoracic OVB	Lumbar OVB
SHA-LOK-UID/20-34 F*	0.657*	**0.0004***	**0.003***	0.212*	0.289*	0.651*
SHA-LOK- UID /35+ F	0.159	0.089	0.789	0.607	n/a	0.707
SHA-LOK- UID /20-34 M	0.12	0.062	0.08	0.216	0.568	0.769
SHA-LOK- UID /35+ M	0.853	0.245	0.311	0.57	0.399	0.203
Mann-Whitney Tests Intra-site tests						
SHA 20-34 F vs 20-34 M	0.913	**0.03**	0.631	0.36	0.655	0.501
LOK 20-34 F vs 20-34 M	0.29	0.925	0.699	0.245	0.606	0.868
UID 20-34 F vs 20-34 M	n/a	n/a	n/a	n/a	n/a	n/a
SHA 35+ F vs 35+ M	0.05	0.132	0.955	0.634	n/a	0.362
LOK 35+ F vs 35+ M	0.225	0.724	0.768	0.643	1	0.827
UID 35+ F vs 35+ M	0.38	0.882	1	0.617	n/a	0.617
SHA 20-34 F vs 35+ F	0.621	0.312	0.276	0.499	n/a	0.185
LOK 20-34 F vs 35+ F	0.932	0.275	0.725	0.286	**0.02**	0.071
UID 20-34 F vs 35+ F	n/a	n/a	n/a	n/a	n/a	n/a
SHA 20-34 M vs 35+ M	**0.009**	0.078	**0.021**	**0.001**	0.114	0.193
LOK 20-34 M vs 35+ M	0.145	0.664	0.596	0.336	0.302	0.386
UID 20-34 M vs 35+ M	**0.042**	0.807	0.109	0.136	0.564	**0.033**

SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; UID had no observable younger (20-34 years) female sample.

* These comparisons were two way comparisons done between Shamanka II and Lokomotiv only.

Significant results in bold.

Sample sizes for cervical, thoracic, and lumbar VOA, and cervical, thoracic, and lumbar OVB can be found in Tables 4.26, 4.28, 4.30, 4.27, 4.29, 4.31, respectively.

TABLE 4.26: Cervical VOA Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	25	0.1	0	0.04	0.15	0.15
LOK 20-34 M	9	0.21	0.06	0.17	0.23	0.17
UID 20-34 M	5	0.03	0	0	0	0
SHA 35+ M	18	0.52	0.11	0.36	0.84	0.74
LOK 35+ M	12	0.72	0.1	0.32	1.41	1.31
UID 35+ M	7	0.48	0.08	0.49	0.8	0.72
SHA 20-34 F	10	0.13	0	0.03	0.16	0.16
LOK 20-34 F	8	0.09	0.05	0.07	0.12	0.07
UID 20-34 F	0	0	0	0	0	0
SHA 35+ F	4	0.07	0	0	0.07	0.07
LOK 35+ F	4	0.24	0	0.08	0.33	0.33
UID 35+ F	2	0.76	0.56	0.76	0.97	0.41

corresponds to Fig. 4.11 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range

TABLE 4.27: Cervical OVB Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	22	0.12	0	0	0.15	0.15
LOK 20-34 M	8	0.59	0	0.5	0.72	0.72
UID 20-34 M	4	0.45	0	0	0.45	0.45
SHA 35+ M	17	0.74	0.33	0.5	1.5	1.17
LOK 35+ M	9	1.03	0.25	1	1.58	1.33
UID 35+ M	6	1.03	0.49	0.88	1.5	1.01
SHA 20-34 F	10	0.05	0	0	0	0
LOK 20-34 F	6	0.2	0	0.17	0.36	0.36
UID 20-34 F	0	0	0	0	0	0
SHA 35+ F	3	0.78	0	0	1.17	1.17
LOK 35+ F	4	0.67	0.19	0.3	0.78	0.58
UID 35+ F	2	1.13	1.06	1.13	1.19	0.13

corresponds to Fig. 4.12 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range

TABLE 4.28: Thoracic VOA Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	23	0.23	0	0.1	0.45	0.45
LOK 20-34 M	6	0.87	0.26	0.69	1.34	1.08
UID 20-34 M	4	0.3	0.12	0.32	0.51	0.39
SHA 35+ M	18	0.46	0.08	0.25	0.62	0.53
LOK 35+ M	10	0.64	0.31	0.51	0.87	0.56
UID 35+ M	5	0.36	0	0.32	0.59	0.59
SHA 20-34 F	12	0.09	0	0	0.03	0.03
LOK 20-34 F	12	0.65	0.54	0.61	0.79	0.25
UID 20-34 F	1	0	0	0	0	0
SHA 35+ F	3	0.09	0.03	0.06	0.14	0.1
LOK 35+ F	4	0.5	0.36	0.46	0.61	0.25
UID 35+ F	3	0.38	0.34	0.4	0.43	0.09

Corresponds to Fig. 4.13 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range

TABLE 4.29: Thoracic OVB Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	15	0.28	0	0.25	0.52	0.52
LOK 20-34 M	3	0.52	0	0	0.77	0.77
UID 20-34 M	3	0.92	0.64	1.27	1.39	0.75
SHA 35+ M	9	0.59	0.15	0.59	0.86	0.71
LOK 35+ M	6	0.91	0.22	0.88	1.52	1.3
UID 35+ M	2	1.2	1.19	1.2	1.21	0.01
SHA 20-34 F	9	0.25	0	0	0.43	0.43
LOK 20-34 F	6	0.44	0.34	0.49	0.63	0.28
UID 20-34 F	0	0	0	0	0	0
SHA 35+ F	1	0	0	0	0	0
LOK 35+ F	3	0.86	0.84	0.88	0.89	0.05
UID 35+ F	1	0	0	0	0	0

Corresponds to Fig. 4.14 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range

TABLE 4.30: Lumbar Intervertebral VOA Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	25	0.1	0	0	0.17	0.17
LOK 20-34 M	10	0.46	0.04	0.45	0.84	0.8
UID 20-34 M	6	0.22	0.01	0.06	0.18	0.17
SHA 35+ M	16	0.39	0.04	0.25	0.56	0.52
LOK 35+ M	9	0.57	0.3	0.44	0.67	0.37
UID 35+ M	6	0.7	0.2	0.79	1.23	1.03
SHA 20-34 F	11	0.11	0	0	0.07	0.07
LOK 20-34 F	11	0.51	0.26	0.5	0.74	0.48
UID 20-34 F	0	0	0	0	0	0
SHA 35+ F	3	0.37	0.08	0.15	0.55	0.48
LOK 35+ F	6	0.91	0.04	0.33	1.75	1.71
UID 35+ F	2	0.57	0.53	0.57	0.6	0.07

corresponds to Fig. 4.15 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range

4.4.2.1. Cervical Vertebrae – Intervertebral Facets (VOA)

The range of indices for cervical VOA was 0 to 1.84 (Table 4.26, Figure 4.17). Median severity was highest for the older females from UID at 0.76. Aside from the older female group from UID, the older males from all three sites had the highest median severity scores of all groups as well as the three largest IQRs, which are visible on the box plot (Figure 4.17). Inter-site tests revealed no statistically significant differences among the sites.

Intra-site testing between the sexes was also not statistically significant. It is worth noting, however, that the older males at both EN sites had more severe OA of the cervical facets than contemporary older females (Figure 4.23). This difference closely approached significance at SHA (p-value=0.05, Table 4.25). When age categories were compared, the older males at both SHA and UID had significantly more severe cervical VOA than contemporary younger males (p-values=0.008 and 0.004 respectively, Table 4.25). This comparison at LOK did not prove to be significant. No other significant results or trends were found in the intra-site comparisons.

Figure 4.23: Osteoarthritis (VOA) on the inferior articular facets of the C7 vertebra, inferior view (SHA_2000.008; male, 35-40 years)

4.4.2.2. Cervical Vertebrae – Vertebral Bodies (OVB)

Severity indices for cervical OVB ranged from 0 to 1.9 (Table 4.27, Figure 4.18). The older males from all three sites, the older females from UID, as well as the younger males at LOK all had similarly high median severity values (Table 4.27). For cervical OVB, the overall disparity between the severity of older males and females at both SHA and LOK was much smaller than was seen in the cervical VOA data (Figures 4.17 and 4.18). No significant differences were found among the sites in severity of OA of the cervical OVB (p-values > 0.05, Table 4.25), and only one significant difference was found with the intra-site testing, which was between older and younger males at SHA (p-value=0.001, Table 4.25).

4.4.2.3. Thoracic Vertebrae – Intervertebral Facets (VOA)

Severity for thoracic VOA ranged from 0 to 1.5 (Figures 4.19 and 4.24, Table 4.28). The males from LOK – both younger and older – had the two highest median severity values among all the male groups (0.69 and 0.51 respectively, Table 4.28). The same was true for females at LOK, who had the two highest median values among all female groups (0.605 for younger and 0.4625 for older females, Table 4.28).

Figure 4.24: Osteoarthritis (VOA) on the superior articular facets of the thoracic vertebrae, posterior view (SHA_2003.027.01; male, 35-50 years)

Inter-site analysis showed that the younger females at LOK had significantly more severe thoracic VOA than younger females at SHA (p-value=0.0004, Table 4.25); comparisons with younger females at UID were not possible due to a sample size of 1 for that site. No other significant inter-site differences were found.

Intra-site testing produced mostly non-significant results save one from SHA that revealed that younger males had significantly more severe thoracic VOA than contemporary younger females (p-value=0.03, Table 4.25). These tests indicate overall low severity of OA in the females from SHA when compared to the males from the same site and the females from LOK (Figure 4.19). No other intra-site differences were found to be significant.

4.4.2.4. Thoracic Vertebrae – Vertebral Bodies (OVB)

Severity indices for thoracic OVB ranged from 0 to 1.56 (Table 4.29, Figure 4.20). The male groups (both younger and older) from all sites had large IQRs when compared to the females (Figure 4.20). The largest IQR was the older males from LOK at 1.3. As was previously mentioned, sample sizes were too small or absent entirely for the older females at SHA, and both groups of females at UID for them to be included in any analysis (Table 4.29). Inter-site analyses for the groups that were able to be conducted showed no statistical differences between any of the sites.

Intra-site analyses found no significant differences between the sexes within any of the sites. The comparisons of age within the sites produced one significant result for the females at LOK. The older females had significantly more severe thoracic OVB than their younger female contemporaries (p-value=0.02, Table 4.25). The older females had a small IQR (0.055), and a large Q1 (0.84) meaning that all older females had similarly high severity levels. No other intra-site differences were found to be significant.

4.4.2.5. Lumbar Vertebrae – Intervertebral Facets (VOA)

Severity indices for lumbar VOA ranged from 0 to 2.167 for the entire sample, which is the largest range among all portions of the vertebral column (Table 4.30, Figure 4.21). Inter-site testing showed that younger females at LOK had significantly more severe OA in this region than the younger females from SHA. No other inter-site tests proved to be significant.

Intra-site analysis revealed that the older males had significantly more severe OA in this region than their younger male contemporaries at SHA. No other significant differences were found within the sites (Table 4.30). Males and females at LOK had similar median severity for both the younger and older age classes. This is not the case at either of the other two sites, where the median scores for males were higher than the females, making LOK, and their female population in particular, and unique (see Table 4.30, Figure 4.21). The LOK females are of particular interest as they stand out as having particularly severe lumbar VOA. Explanations for why this may be the case will be discussed in the next chapter.

4.4.2.6. Lumbar Vertebrae – Vertebral Bodies (OVB)

Severity indices for lumbar OVB ranged from 0 to 2.00 among all observable individuals (Table 4.31, Figures 4.22 and 4.25). The results of inter-site analysis showed no significant differences between the sites (p-values > 0.05, Table 4.25). Intra-site tests showed no significant differences between the sexes, and only one significant age related difference. The older males at UID had significantly more severe OA than their younger male contemporaries (p-value=0.033).

The older males from both SHA and LOK had higher median severity and Q1 values from each of their younger male contemporaries, although these differences were not statistically significant (Table 4.31). Overall severity levels for lumbar OVB were relatively high (when compared to other vertebral severity levels) among older adults at all sites.

Figure 4.25: Osteoarthritis (OVB) on lumbar vertebral bodies (SHA_2003.027.01; male, 35-50 years)

TABLE 4.31: Lumbar OVB Descriptive Statistics

Site, age group (in years), and sex	N	Mean	Q1	Median	Q3	IQR
SHA 20-34 M	16	0.49	0	0.06	0.88	0.88
LOK 20-34 M	2	0.44	0.22	0.44	0.66	0.44
UID 20-34 M	4	0.3	0	0	0.3	0.3
SHA 35+ M	7	0.82	0.42	0.58	1.4	0.98
LOK 35+ M	3	1.18	0.85	0.88	1.35	0.5
UID 35+ M	6	1.46	1.13	1.5	1.88	0.75
SHA 20-34 F	8	0.28	0	0	0.29	0.29
LOK 20-34 F	6	0.4	0	0.13	0.81	0.81
UID 20-34 F	0	0	0	0	0	0
SHA 35+ F	3	1.22	0.88	1.75	1.83	0.95
LOK 35+ F	3	1.03	0.88	1.17	1.25	0.37
UID 35+ F	2	1.25	1.13	1.25	1.38	0.25

Corresponds to Fig. 4.16 above; SHA=Shamanka II, LOK=Lokomotiv, UID=Ust'-Ida I; F=female; M=male; N=sample size, Q1=quartile 1, Q3=quartile 3, IQR=interquartile range

The data presented above have the potential to provide considerable insight into termporal, sex-based, and geographic differences in behavioral adaptations among middle Holocene hunter-gatherers in the Cis-Baikal region. At the same time, it is important to note that repeated sampling (using repeated measures) may in some cases have increased the likelihood of a “type I error” occurring. In this sense, repeated measures used here affected the robustness of the results of the current study by creating “false positives.” Cases in which multiple significant results were detected and were all consistent with a given interpretation (e.g., from different joints that are relevant to a single process or behavior) are particularly valuable in this respect. In the next chapter, I identify patterns in these data, focusing on testing the hypotheses outlined in Chapter One.

5. Chapter Five: Discussion

5.1. Introduction

This thesis compared the severity of osteoarthritis (OA) in the three middle Holocene cemeteries of Shamanka II (SHA), Lokomotiv (LOK), and Ust'-Ida I (UID). Examination of these three cemeteries enabled comparison of OA severity during two periods: the Early Neolithic (EN) Kitoi—as represented by SHA and LOK—and the Late Neolithic-Early Bronze Age (LN-EBA) Isakovo-Serovo-Glaskovo (ISG)—as represented by UID. Furthermore, this study examined the severity of OA across two of the micro-regions of the Cis-Baikal region of Siberia, with SHA located in South Baikal and LOK and UID located in the Angara River Valley. The three hypotheses of this study are 1) that the Early Neolithic (EN) Kitoi groups were likely to have had higher OA severity scores when compared to the LN-EBA groups, especially for the males; 2) that a higher disparity between the OA severity rates of the males and the females would likely have been found in the EN samples when compared to the LN-EBA sample; and 3) that micro-regional specific physical activity levels and behaviors existed in the Cis-Baikal.

In particular, comparisons of the contemporaneous sites of SHA and LOK offered a unique opportunity to investigate similarities and differences between two genetically and culturally related populations (Mooder et al. 2010, Movsesian et al. 2014, Weber and Bettinger 2010, Weber et al. 2002) living in differing areas with potentially different lifestyles. In contrast, UID and LOK represent temporally, culturally, and potentially genetically distinct populations that occupied the same region at different times (6000/5800 – 4000/3400 cal BP and 8000 – 7000/6800 cal BP, respectively; Movsesian et al. 2014, Weber and Bettinger 2010). A comparison of these sites thus offers insights into diachronic cultural change within the Angara River Valley. OA data were also used here to reveal differences between activity patterns of males and females, and thus related to the gendered division of labor. While the use of OA as an indicator of sex-specific activities must be applied cautiously, it is still useful to discuss clear trends and significant results in the data, as several successful studies have demonstrated (Bridges 1991, Derevenski 2000, Jurmain 1999).

Previous BHAP scholars have investigated topics such as prehistoric activity patterns, health, diet, and mobility by employing a variety of methods. These methods include studies of entheseal changes in the upper and lower limbs (Lieverse et al. 2009, 2013), skeletal morphology of long bones (Lieverse et al., 2011, Stock et al. 2010), disease, trauma rates, and physiological stress levels (Lieverse 2010, Waters-Rist et al. 2011), non-metric postcranial traits (Macintosh 2010), non-metric cranial traits (Movsesian et al. 2014), carbon, nitrogen, and strontium isotopic data (Katzenberg et al. 1999, 2009, 2010, 2012, Lieverse et al. 2011, Waters-Rist et al. 2011, Weber and Goriunova 2013, Weber et al. 2011), and numerous dental indicators of diet, health, and mouth use (Clarke, 2015, Lieverse et al. 2007b, Waters-Rist et al. 2006, 2010). All these lines of evidence are consistent with suggestions made by Weber and colleagues (2002, Weber and Bettinger 2010) that EN Kitoi occupants of the South Baikal and Angara River Valley micro-regions lived in larger groups with smaller territorial ranges than later populations that inhabited the Cis-Baikal during the LN-EBA (Weber et al. 2002, Weber and Bettinger 2010). EN populations appear to have followed a logistical foraging pattern (Weber et al. 2002, after Binford 1980). Logistical forays most likely played an important role in EN groups' mobility practices, as these groups appear to have employed relatively small annual foraging ranges (when compared to the region's LN-EBA hunter-gatherers; Weber and Bettinger 2010). Data on entheseal changes, OA prevalence data, postcranial traits, and skeletal cross-sectional geometry have been used to suggest that logistical forays were undertaken more frequently by EN males, in particular (Lieverse et al. 2007a, 2009, 2013, Macintosh 2010, Stock et al. 2010).

However, a recent publication by Lieverse and colleagues (2013) suggests greater complexity when multiple contemporaneous sites are compared. Distinct activity patterns for males and females were most visible at the South Baikal cemetery of SHA, with males exhibiting higher levels of lower limb entheseal changes than females. At the Angara River Valley cemetery of LOK, females exhibited higher levels of entheseal changes on the lower limbs than their female contemporaries at SHA. This pattern suggests a differing lifestyle for those females living on the lakeside (SHA) versus along the Angara River (LOK). These differences are particularly interesting considering that, both culturally (via evidence on grave treatments, and grave goods) and genetically (via evidence from aDNA, and non-metric cranial traits), these two populations appear to have been closely related (Bazaliiskii 2010, Mooder et al. 2005, 2006, 2010, Movsesian et al. 2014). The inclusion of individuals from both SHA and LOK in this study enables an investigation of synchronic variability during the EN Cis-Baikal.

LN-EBA hunter-gatherer groups in the Cis-Baikal appear to have lived in smaller communities that placed greater emphasis on terrestrial game and may have employed larger annual rounds and greater residential mobility (Weber et al. 2002, Weber and Bettinger 2010). These groups developed a rather large population living in the Little Sea region (north coast of Lake Baikal), as well as the upper Lena River (to the north and west of Lake Baikal), although the population density in the latter region never seemed to approach that of the other three areas, likely due to the less productive nature of fisheries there (Weber and Bettinger 2010; Weber et al. 2011). LN-EBA individuals included in this study (UID) enable a comparison of EN and LN-EBA mobility practices as well as broader activity patterns among chronologically separated populations inhabiting the same area (the Angara River Valley). Below, I discuss patterns in the OA data I collected for each joint at the intra-joint (for the elbow and the knee only), intra-site, and inter-site levels, in order to illuminate chronological and geographic patterns of activity among Cis-Baikal hunter-gatherer communities.

5.2. The Temporomandibular Joint (TMJ)

Overall severity rates of TMJ OA were low across all sites and within all age and sex groups. LOK stands out as the site with the highest levels of TMJ OA, especially among older individuals of both sexes. While these results were not statistically significant, a clear trend was visible in the TMJ data that warrants discussion and adds to an already robust body of literature put forth by BHAP scholars. Current epidemiological data suggest that TMJ OA increases with age, and there is a tendency for females to be preferentially affected (Flores-Mir et al 2006, Goaz and White 2001, Sato et al. 1996). Data on the frequencies of dental occlusal and interproximal grooves presented by Waters-Rist and colleagues (2010) suggested a variation in fishing practices between groups living on the lakeshore versus the riverside. The groups located on the shores of the Angara River exhibited a higher prevalence of occlusal grooves when compared to lakeside communities (such as SHA). These authors proposed that “groups who occupied the Angara River region used their teeth more frequently or intensively in the production of material culture items that formed grooves, perhaps to improve the acquisition of unique riverine resources" (Waters-Rist et al. 2010:10). Ethnographic and archaeological evidence presented by Waters-Rist and colleagues suggested that these occlusal grooves were the result of repetitive friction between the teeth and plant fibers and sinew, likely used to manufacture cordage and fishing netting.

Furthermore, Lieverse and colleagues (2007b) studied the dental attrition patterning between riverine and lakeside communities in the Cis-Baikal. They found that riverine communities (i.e., UID and LOK) showed more severe anterior attrition and lower posterior attrition when compared to the lakeside communities (i.e., SHA). They suggested that this was due to the use of the anterior teeth and mouth for non-masticatory tasks. New evidence from dental calculus, presented by Clarke (2015), suggests that these fibers may in fact have been animal-based sinew rather than plant-based.

Coupled with the evidence on occlusal grooves and dental attrition, results of the TMJ OA analyses conducted here suggest that the inhabitants buried at LOK were engaged in unique or more strenuous non-masticatory mouth use, including, perhaps, the manufacturing of cordage for fishing nets and other items. The single male outlier found at SHA furthers this point, as his elevated OA severity (almost double those of anyone else under study here) are likely due to injuries, genetics, and/or behavior at an individual level rather than the group level. The individuals at LOK were clearly using their mouths in unique ways, leaving occlusal grooves that are frequent and visually distinctive, anterior dental attrition levels that are heightened when compared to sites along the lake's coast, and having the highest overall severity levels of TMJ OA of all groups under study here, with the LOK males having the most severe rates, followed closely by the LOK females. In terms of the hypotheses outlined in Chapter One, clear differences in TMJ OA were observed between the EN sample from the Angara River (LOK) and the LN-EBA sample from the same micro-region (UID), suggesting diachronic change (hypothesis 1). In addition, with respect to the TMJ, it also appears possible that different intensities or different activities altogether may have characterized the EN populations of the Angara River Valley and the South Baikal (hypothesis 3).

5.3. The Vertebral Column

The utility of using OA on the intervertebral facets (VOA) and osteophytosis of the vertebral bodies (OVB) to reconstruct past activity patterns has been subject to much debate within the archaeological literature (Jurmain 1990, Knüsel et al. 1997, Rogers and Waldron 1995). Its efficacy in reconstructing past lifestyles and biomechanical stresses has at times been overlooked due to a belief that the "normal" curvature of the human vertebral column associated with bipedality, coupled with the effects of aging, can account for the development of vertebral OA (Nathan 1962, Shore 1934-35). Clinical analyses have shown that the natural curvature of the vertebral column allows the body to moderate and transfer weight or stress downward, with the more caudal portions (e.g., lower thoracic, lumbar, and sacral vertebrae) receiving most of the load (Knüsel et al. 1997, Nathan 1962, Shore 1934-35).

While these factors do impact vertebral OA, many studies (see Bridges 1994, Derevenski 2000, Hukuda 2000, Lieverse 2007a, Lovell 1994, Merbs 1983) have shown that VOA and OVB can be useful indicators of behavior and activity. Lieverse (2007a) pointed out that the most likely explanation for differences in vertebral OA that cannot be accounted for by sex and age-at-death is variation in activity patterns. Further, Derevenski (2000) was able to use vertebral OA data from two ethnographically and historically well-documented populations to correlate levels of vertebral OA—especially VOA—to known activities that these groups performed. Derevenski (2000) suggested that the biomechanical forces leading to facet remodeling (VOA) might make it one of the most reliable indicators of load-bearing activities in past populations.

5.3.1. Vertebrae: Inter-Site Comparisons

The results of both the younger and older male groups showed overall high OA severity levels at all three sites. This was true for both VOA and OVB. More specifically, younger males at LOK exhibited higher VOA in both the thoracic and lumbar segments than the younger males at the other two sites, and while these comparisons are not statistically significant, they do approach significance (p-values 0.062 and 0.08, Table 4.21). An inter-site comparison shows that the females at LOK (both younger and older) had higher VOA in both thoracic and lumbar vertebrae than females (both younger and older) at the other sites, and these comparisons were often significant or approached significance (Table 4.21). Based on Derevenski's (2000) compelling case for the utility of VOA in activity reconstruction, these results suggest a noticeable difference in the load-bearing stresses on the lower backs of both males and females from LOK when compared to the corresponding group at each of the other two sites. Interestingly, OVB severity was relatively uniform across the three sites.

The cervical vertebrae showed no significant inter-site differences for either VOA or OVB, and overall severity rates were relatively stable across all the sites. Other scholars (see Bridges 1994, Lovell 1994) have found unique patterns of cervical OA in their samples. Lovell (1994) and Bridges (1994) found that the frequency and severity of cervical OA was greater in their samples than in the thoracic and lumbar regions, with ankylosis of the cervical vertebrae being relatively common. They have suggested that this pattern of heightened cervical involvement is often the result of some combination of extension and compression of the neck from carrying heavy loads on the heads through the use of devices such as creels or tumplines. The OA data presented here, as well as the prevalence data presented by Lieverse and colleagues (2007a), suggests that heavy loads were carried in a manner that placed the majority of the load on the lower back.

5.3.2. Vertebrae: Intra-Site Comparisons

Sex differences in the levels of VOA and OVB at each site indicate that severity levels for males and females at LOK and UID did not differ significantly. At SHA, both the younger and older females had lower OA compared to the corresponding male group. This was most obvious in the VOA comparisons, where they differed significantly in both thoracic and cervical VOA (Table 4.21). These data may suggest that SHA females experienced significantly less biomechanical stress to the vertebral column than the SHA males, as well as compared to both the males and females from the other two sites.

Overall, VOA and OVB severity suggest that the lifestyle and workload for inhabitants along the Angara River (LOK and UID) resulted in a similar pattern of vertebral OA despite the temporal gap between them (hypothesis 3). In contrast, the results from SHA suggest a gendered division of labor that left a pattern of vertebral OA distribution that distinguished the sexes from one another. The EN males from SHA were likely responsible for the majority of hard physical labor that affected the vertebrae, including logistical forays that would have involved hauling heavy loads across rugged landscapes. These activities would likely have resulted in the elevated severity levels of VOA seen in the males when compared to the SHA females (hypothesis 2; Weber and Bettinger 2010).

5.4. The Upper Limb

The non-weight bearing upper limb joints provide useful insights into prehistoric activity patterns in the Cis-Baikal. As was previously mentioned in Chapter Two, the effects of long term repetitive motions are well documented for the upper limb and suggest that intensive activities such as paddling and overhead throwing (e.g., during hunting) would likely increase the severity of OA in the upper limb joints, especially if those activities began at a young age (Hagemann et al. 2004, O'Neill and Micheli 1988, Osbahr et al. 2010). Overall, we observed bilateral symmetry, which was surprising given that we would expect to see evidence of right-handedness in the form of higher OA severity in the joints of the upper right limb. More specifically, only the shoulder and wrist exhibited bilateral asymmetry, and only for some groups (SHA males and LOK females). While OA severity is not a direct reflection of handedness, higher severity on the right side is consistent with right-handedness (Stirland 1993). Overall trends towards bilateral asymmetry favoring the right side of upper limb joints were not uncommon, but the shoulder for SHA males and the wrist for LOK females were the only joints that showed a statistically significant preference on the right side, which is consistent with right-handedness.

The elbow, one of the most reliable sources of activity reconstruction (Weiss and Jurmain 2007) showed no evidence of asymmetry and suggests that rigorous two-handed tasks were likely undertaken regularly and were strenuous enough to even out a natural right-handed dominance. This echoes the skeletal robusticity results from Stock and colleagues (2010) that showed high levels of mechanical demands on the upper limb and little by way of asymmetry suggestive of consistent and symmetric loading of the upper limbs. They proposed that the use of watercraft was plausible given comparisons to other marine adapted hunter-gatherer groups (Stock et al. 2010). While no archaeological evidence has been recovered of boats or paddles in the Cis-Baikal region at these time periods, indirect osteological support for watercraft usage do exist in the Cis-Baikal in the form of morphological changes to muscle attachments (entheses) in the upper limbs as well as the above mentioned skeletal robusticity data (Lieverse et al. 2009, Lieverse et al. 2011, Stock et al. 2010).

5.4.1. Upper Limb: Inter-Site Comparisons

OA severity rates in the upper limb (shoulder, elbow, and wrist) were relatively constant across all three sites, with very few statistically significant inter-site differences. Most comparisons showed that, for the female groups, those from LOK had the highest OA severity, while the SHA females had much lower rates, with the UID females intermediate but often close to those at LOK. For the males, there was much less disparity between the sites, and a more even OA severity across the entire Cis-Baikal, although males at SHA often exhibited lower severity than those at the other two sites. This trend of lower OA severity in the upper limb for both the female and male groups from SHA had not been observed in analyses of other activity markers such as entheseal changes or cross-sectional geometry (Lieverse et al. 2009, Lieverse et al. 2011, Stock et al. 2010). This could be an indicator of unique micro-regional activity patterns that distinguish the South Baikal from the Angara River Valley (hypothesis 3). A more intensive and laborious lifestyle among inhabitants of both sexes of the Angara River Valley could account for these subtle yet clear trends in the OA severity data.

5.4.2. Upper Limb: Intra-Site Comparisons

Relatively few intra-site differences were found to be significant for the upper limb. While most statistical tests comparing males to females for the upper limb joints did not yield significant results, an established trend—using comparisons of mean and median OA severity values for the wrist, elbow, and shoulder—was visible in the lower severity rates of the SHA females versus the higher ones of the SHA males. This trend was not seen at the other two sites, where male and female mean severities were closer together, implying less gender differentiation in upper limb activity at LOK and UID when compared to SHA.

5.4.3. Upper Limb: Intra-Joint Comparisons

The intra-joint comparisons for the elbow illuminated a few interesting trends in both inter- and intra-site differences. Across the entire Cis-Baikal, the hinge (i.e., humeral-ulnar) portion of the elbow was more severely affected by OA than the pivot (i.e., humeral-radial) portion. This finding suggests that flexion and extension of the elbow were more rigorous and repetitively used than pronation and supination (rotation) of the forearm.

Activities that may have contributed to OA in the hinge portion of the elbow include chopping, cutting, and scraping (all of which may have been involved in food preparation and tool manufacture), as well as paddling, overhead throwing, and bow-and-arrow use. Archaeological remains such as spear points, harpoons, lithic chopping and scraping tools, and arrowheads have been documented in middle Holocene burials and at habitation sites throughout the Cis-Baikal, (Weber et al. 2002), and may explain this intra-joint difference in OA severity. Similarly, the use of watercraft may represent another source of OA disease progression in the hinge portion of the elbow (Bazaliiskii 2010, Lieverse et al. 2011). Repeated and strenuous flexion and extension at the hinge portion of the elbow joint during paddling would likely have contributed to the development of OA and the severity seen in these populations (Hay and Reid 1988, Merbs 1982, Northrip et al. 1983, Watkins 1999). While the pivot portion of the elbow joint is still involved during paddling, most paddling styles favor flexion and extension (Merbs 1983, Watkins 1999). Notably, Merbs (1983) identified a unique pivot style of paddling among Sadlermiut Inuit groups, in which he found greater severity in the radio-humeral portion of the elbow and the corresponding wrist joint. The results from this study suggest that paddling in the middle Holocene Cis-Baikal favored flexion and extension of the hinge portion most heavily.

Much like the overall upper limb results, the elbow hinge shows a clear trend toward lower OA severity in this portion of the joint at SHA when compared to the other two sites. This is most easily recognizable in the younger males, with those from SHA exhibiting significantly lower OA severity than those at UID, and closely approaching significance when compared to LOK. Once again, the LOK females stand out among the other female groups as having the highest mean and median severity values for both the hinge and pivot portions of the elbow, with SHA on the lower end, and UID intermediate. This divergence between SHA and LOK suggests that different activity patterns may have characterized groups inhabiting the Angara River Valley and the South Baikal (hypothesis 3).

5.5. The Lower Limb

While activity reconstruction for the upper limb can reflect a variety of different types of movement, those for the lower limb generally reflect weight-bearing tasks employing both limbs simultaneously or in close coordination. No cases of bilateral asymmetry in terms of OA severity were found for any of the joints of the lower limb in this dataset, most likely a result of their simultaneous use during these activities. Clinical research, as discussed in Chapter Two, has shown positive correlations between occupational stressors such as lifting, kneeling, and squatting with elevated levels of OA in the knee (Coggon et al. 2000). Injuries to the lower body have been shown to have a positive correlation with the development of OA, notably for the hip, knee, and ankle joints (Gelber et al. 2000, Kuigt et al. 2012, Nuki 1999, Takeda et al. 2011, Wolf and Amendola 2005). Trauma, coupled with rigorous biomechanical stressors placed on these joints, can lead to the development of OA in the lower limb.

5.5.1. Lower Limb: Inter-Site Comparisons

Other biomechanical indicators of activity patterns (most notably robusticity, skeletal morphology, and lower limb entheseal data) have all suggested a general trend towards decreased lower limb strain and mechanical loading in the LN-EBA when compared to the EN (Lieverse et al. 2011, Lieverse et al. 2013, Stock et al. 2010). OA prevalence data suggested that overall physical activity levels were relatively stable throughout the Cis-Baikal during both the EN and the LN-EBA, but that prevalence for knee OA was higher for EN males when compared to both contemporary females and later ISG groups (Lieverse et al. 2007a). OA severity of the lower limb remained relatively stable through the EN and LN-EBA, and echoed what was found in the OA prevalence data with the knee results, indicating a slight decrease in strain on the lower limb from the EN to the LN-EBA. One possible interpretation of this reduction in lower limb strain is that terrestrial mobility may have decreased over time. Interestingly, in the data considered here, this trend did not hold true for the site of LOK, where the results were unique and suggestive of a different lifestyle at this site, particularly among the female inhabitants.

The females from LOK exhibited high lower limb OA severity when compared to the females at SHA, and with only one exception (the knee), this was also true when compared to UID. Lower limb entheseal data (Lieverse et al., 2013) also identified the uniqueness of LOK insofar as individuals at this site exhibited higher aggregate scores than the other cemeteries under study. Based on assertions made by Weber et al. (2002), Lieverse and colleagues (2013) proposed that this pattern could be due to high population densities during the EN in the Angara River Valley, which would likely have caused an increase in competition for resources. The exact nature of EN competition on the Angara River may have taken many forms, with individuals travelling long distances to procure resources themselves (e.g., by hunting, fishing, gathering, etc.). Population pressure during this period may also have created incentives for individuals to travel long distances in order to procure resources indirectly, through exchange with other groups.

For example, in an analysis of OA severity data from the Southern California Channel Islands, Walker and Holliman (1989) interpreted an increase in lower limb OA severity from the early to the late period as a the result of increased travel by foot due to a greater dependence on resource exchange and the related expansion of the exchange system. According to Walker and Holliman, this reliance on long-distance networks likely resulted in more terrestrial travel than previous periods. It is possible that during the EN in the Angara River Valley, population densities were relatively high (as suggested by Weber et al. [2002, see also Weber and Bettinger 2010]), prompting not just competition for resources but the development of systems of exchange between groups, requiring regular movement across great distances in order to facilitate exchange. Although it is beyond the scope of this thesis to investigate the precise activities responsible for producing OA severity markers under study here, I note that either direct procurement or long distance movement for exchange purposes would have involved repetitive and potentially strenuous use of the lower limb joints. In either case, these activities would have produced elevated mechanical strain and regular injuries to the joints of the lower limb, thereby systematically increasing the severity of OA in these individuals.

5.5.2. Lower Limb: Intra-Site Comparisons

Comparisons of OA severity between males and females within each of the three sites under study here hint at aspects of community organization while also suggesting differences that may have existed at the regional scale. At the EN site of SHA, located in the South Baikal, OA severity scores for the lower limb differed for males and females, with males exhibiting elevated scores relative to females. This pattern suggests that males interred at SHA engaged in activities producing greater physical strain on the lower limb than the activities that females at the site performed. In this sense, lower limb OA severity data are consistent with previous work arguing that EN groups employed logistical foraging strategies, with males traveling long distances to procure resources (hypothesis 2). In contrast, OA severity rates for the lower limb among males and females at the EN site of LOK were similar. This pattern implies that both males and females at LOK—and perhaps in the Angara River Valley more broadly— experienced similar levels of mechanical strain on the lower limb during this period. It is possible that population pressure in the EN Angara River Valley may have caused both groups to participate equally in logistical forays. However, it is also possible that EN males and females undertook entirely different types of activities that happened to produce similar strain on the lower limb. Finally, the LN-EBA site of UID also showed minimal difference between OA severity scores for the joints of the lower limb between males and females. This lack of difference between males and females with respect to lower limb strain is consistent with the hypothesis that LN-EBA groups employed residential foraging strategies (with residential moves undertaken equally by males and females).

5.5.3. Lower Limb: Intra-Joint Comparisons

The knee component results offer several unique insights into behavioral reconstruction in the Cis-Baikal. At the broadest level, it is noteworthy that, for all three sites and for all groups included in this study, the anterior knee component showed more severe OA than the medial or lateral components. Clinical literature (discussed in Chapter Two) suggests multiple scenarios that may have produced this pattern, all involving repetitive and intensive squatting, bending, and lifting (Coggon et al. 2000, Gelber et al. 2000). Some behaviors requiring these types of movements could have included moving over steep or rocky terrain while carrying heavy loads such as large animal carcasses or watercraft. In their culture-historic syntheses of Cis-Baikal prehistory, both Okladnikov (1950, 1955) and Khlobystin (1987) suggested a long period during which the region's hunter-gatherer occupants employed relatively heavy dugout canoes before the eventual adoption of birch bark watercraft. Although the precise timing of this technological change remains poorly understood for a number of reasons, including a lack of direct evidence for watercraft usage (see discussion of problems with Okladnikov's chronology in Chapter One), I note here that Khlobystin (1987:333) particularly emphasized the physical strain that would have been involved in portaging dugout canoes prior to the development of construction techniques for the lighter birch bark variant. This physical strain would have been particularly pronounced for the anterior portion of the knee.

5.6. Age-Related Patterning and Concluding Remarks

While not explicitly addressed in the above discussion, these data also enabled an analysis of OA patterning with respect to age. In Chapter Two, I discussed the correlation between advancing age and the occurrence of OA seen in both clinical and archaeological data (Adatia et al. 2012, Cook et al. 2007, Garstang et al. 2006, Haq et al. 2003, Hodges 1991, Hunter and Felson 2006, Jurmain 1977, Jurmain and Kilgore 1995, Sokolove and Lepus 2013). Middle Holocene Cis-Baikal groups under study here exhibited an increase in OA severity with age in almost every intra-site comparison, and in many cases, these increases were statistically significant (Tables 4.2 and 4.21). Intra-site age comparisons of the right shoulder, elbow, left and right wrist, ankle, and MT1-1st proximal phalanx exhibited statistical significance for either male or female groups from at least one of the sites under study here (Table 4.2). However, age-related differences in OA severity were most pronounced for the vertebrae, especially the lumbar and cervical regions. High OA severity (as well as disc degeneration and herniation) are often seen with increasing age, at least in part due to the natural curvature of the spine and pressure of upright posture on the lower back (Prescher 1998).

Vertebral OA data also pointed to the high severity of OA among the LOK females (Tables 4.22 – 4.27). Older females from this site exhibited pronounced increases in severity when compared to their younger female contemporaries, which is suggestive of strenuous physical activity levels coupled with the expected effects of advancing age (i.e., increased OA severity with age). Most comparisons of OA severity for other joints (upper and lower limb joints) between the females from the three sites under study here showed that LOK females exhibited relatively high severity scores (compared to SHA females, who exhibited relatively low scores, and UID females, who featured intermediate values). Together, these findings are consistent with the interpretation that LOK females engaged in particularly strenuous physical activity relative to other females in the middle Holocene Cis-Baikal. It is also important to note that articular surfaces on the elbow and knee were "resampled" for individual component analyses, thereby increasing the changes of a false positive (type I error) in tests of statistical significance. These increases in the likelihood of type I error had the effect of lowering the robustness of interpretations involving these joints.

The discussion above has focused on identifying trends in the OA severity data and offering suggestions for types of behaviors and lifestyles that were most likely to have caused them. To do so, I examined three broad hypotheses concerning (1) OA severity changes between the EN and LN-EBA, (2) sex-based differences in OA severity, and (3) micro-regional or geographic differences in physical activity levels. In the next Chapter, I offer concluding remarks on the discussion sections above, provide an overview of the merits of the methodology used in this study for both collecting and analyzing OA severity data, and raise several possible areas of future research that build on the findings of this thesis.

6. Chapter Six: Conclusion

6.1. Summary

The aim of this study was to add to the growing body of literature being published by Baikal-Hokkaido Archaeology Project (BHAP) scholars all over the world. More specifically, I sought to investigate both similarities and differences in behavioral adaptation at three cemeteries (Shamanka II [SHA], Lokomotiv [LOK], and Ust'-Ida I [UID]) using data I collected and analyzed on osteoarthritis (OA) distribution and OA severity rates. More broadly, these data also have the potential to contribute to current understandings of diversity in hunter-gatherer lifeways and to the study of social organization among prehistoric human groups.

In order to accomplish these goals, I developed a detailed method for data collection that recorded the severity of osteoarthritis in each joint. I also developed a method (see Chapter Three) to incorporate each data point (via the creation of indices) into the analysis with the hope that this would provide a nuanced picture of OA in the Cis-Baikal and enable identification of subtle trends concerning OA severity in the middle Holocene. Previous studies of OA presence/absence were not sensitive to these subtleties. While time-consuming, the method of data collection that I developed enabled a thorough analysis of nuances in the distribution of OA throughout the prehistoric Cis-Baikal.

The data from these three sites were used to investigate differences and similarities in the behavior and lifeways of the inhabitants of the Cis-Baikal during the middle Holocene. In Chapter One, I introduced the three main hypotheses that drove this research. Hypothesis 1 suggested that Early Neolithic (EN) Kitoi groups (especially males) were likely to have had higher OA severity scores when compared to LN-EBA groups. This hypothesis was based on the theory that EN Kitoi groups practiced lower residential, but higher logistical mobility, especially the males from the EN cemeteries of SHA, and LOK (Weber et al. 2002, Weber and Bettinger 2010). It was theorized that the higher logistical mobility would likely have resulted in greater stress and overall activity levels, resulting in higher OA severity scores when compared to the LN-EBA groups. Hypothesis 2 suggested that a higher disparity between the OA severity rates of the males and the females would likely have been found in the EN samples when compared to the LN-EBA sample. Residential mobility strategies were theorized to have had a flattening effect on OA severity rates between the sexes, whereby both sexes were equally involved in high levels of physical activity. Hypothesis 3 tested micro-regional specific physical activity levels and behaviors. Isotopic levels had suggested that a heavier reliance was placed on aquatic resources during the EN along the Angara River (Weber et al. 2002, 2011). Furthermore, demographic data have suggested that the population density along the Angara River may have been significantly denser than in the South Baikal, which would have increased competition for resources in this area and perhaps led to an increase in physical activities levels during the EN (Lieverse et al. 2011, Weber and Bettinger 2010).

The results for the LOK females offered insights into all three of these hypotheses, and suggest fruitful areas for future research. The trend of lower residential, higher logistical mobility during the EN was visible in the OA severity levels for the site of SHA, where the males tended to have more severe OA than the females. The EN site of LOK showed a previously less visible trend towards increased physical activity by females (especially older females) when compared to SHA. This trend of increased activity among the LOK females had also been detected in lower limb entheseal data by Lieverse and colleagues (2013), but had yet to be detected elsewhere. The OA severity data presented here offer another identification of this trend. The trend toward increased activity among LOK females was not only seen in the lower limb, but was also detectable in OA severity scores for the upper limb, vertebral column, and the TMJ. While the results from the LOK females do not necessarily suggest that this EN group practiced residential rather than logistical mobility, they do suggest that females at this site regularly engaged in more strenuous physical activity and behaviors than females at SHA. This raises new questions about diversity in EN lifeways, and more specifically, whether the LOK or SHA females were an anomaly among groups of women during this period. This question could be answered by collecting and analyzing data from more EN sites from along the Angara River (and any future sites located in the South Baikal).

The LOK females continued to offer surprising and interesting results in terms of sex-based differences in severity levels that allowed comparisons with the other sites under study here. While the results for the SHA females were consistent with expectations based on hypothesis 2 (i.e., lower severity rates for females when compared to males from the same site), the LOK females were much closer in overall severity to the LOK males than the SHA females were to the SHA males. A similar lack of sexual disparity was visible in the results from UID. This suggests that micro-regional lifestyle differences played a major role in behavioral differences that may have led to the OA severity rates seen in this study. Both UID and LOK are located along the Angara River, and both sites showed lower levels of sexual disparity in OA severity rates than were seen at SHA. These results offer significant evidence that supports hypothesis 3, namely that micro-regional environmental differences likely had a large effect on behaviours and lifestyles. These micro-regional differences could be further explored by looking at more sites from these micro-regions to help form a fuller picture of the OA severity rates throughout the entire Cis-Baikal.

6.2. Directions for Future Research

A few suggestions could be made for future studies on OA severity that would streamline data collection while still providing accurate scoring of severity for each joint. These modifications to the method used in this study would also provide the same utility during data analysis, but would significantly lower the time investment per skeleton during data collection in the field. The method I employed for this thesis required taking six data points for each joint portion. The utility of the scores for both degree of severity and surface area covered by each of the three indicators of OA (lipping, porosity, and eburnation) became apparent during the analysis process, as each data point offered unique insight into the progression of the disease in that particular individual, and contributed to the robustness of the index values. However, articular surfaces that were scored separately (Table 3.1) were often redundant (i.e., the scores for two separate articular surfaces were exactly the same), and many of them could have been combined and scored as one discreet unit.

A streamlined version of the approach employed in the current study would involve recording one set of six scores for the proximal tibia and another set of six scores for the distal femur, rather than recording separate sets for the lateral and medial condyles of both the femur and tibia (thereby reducing the total number of data points in this example from 24 to 12). Data collection for the vertebrae could similarly be made more efficient by recording only one set of scores for the two superior intervertebral facets, and recording one set for the two inferior intervertebral facets. These changes would greatly reduce the time required to collect data for each skeleton, and would result in no loss of data for most joints.

However, the elbow and knee joints – which were analyzed as whole joints as well as in separate component analyses – represent exceptions that would not benefit from the use of the streamlined method. In fact, the application of the proposed streamlined method to the elbow and knee would result in a loss of meaningful data, as the results of separate component analyses for these two joints enhanced and highlighted trends visible in the overall joint analyses. For example, younger females at LOK exhibited significantly greater OA severity in the anterior knee than did the younger females from SHA. This finding demonstrated differences that were not statistically significant in data for the knee as a whole (although, as stated above, resampling of multiple articular surfaces on the knee increased the likelikhood of type I error, or false positives, in statistical tests for this joint). Therefore, while a streamlined method of data collection would likely be effective for most joints in the body, separate component analyses for the elbow and knee appear to be particularly useful. Both of these joints are especially complex, and serve as robust indicators of behavioral adaptations, nuances of which are visible through the more detailed approach that I developed for this thesis (as discussed in Chapters Two and Three).

The use of the streamlined method, involving more rapid data collection for most joints, would likely have allowed time for the inclusion of additional cemetery populations in this analysis. Many other skeletal collections were housed in the same storage facility as those used in this study, and these additional samples could have enabled a broader discussion of hunter-gatherer adaptations in the middle Holocene Cis-Baikal. For example, materials from the upper Lena and Little Sea, as well as from additional sites located along the Angara River were available, and could have provided important comparative data addressing all three of the hypotheses I explored in this thesis.

6.3. Concluding Remarks

Despite the absence of these additional sites in my analysis, the OA severity data I collected from the three large cemeteries of Shamanka II (SHA), Lokomotiv (LOK), and Ust'-Ida I (UID) were sufficient to test three hypotheses that I outlined above in Chapter One, regarding temporal variation in hunter-gatherer lifeways (hypothesis 1), sex-based division of labor (hypothesis 2), and micro-regional differences in activity patterns (hypothesis 3). I also made several suggestions for areas of future research. First, I suggested small but potentially important changes to the method I employed in this thesis (for joints other than the knee and elbow), which would improve efficiency in the field without any loss of meaningful data. Second, the collection and analysis of OA data from additional, previously-excavated sites (i.e., in the Little Sea, the upper Lena, and along the Angara River) would add to both the EN and LN-EBA samples. The inclusion of sites from the Little Sea and upper Lena would also offer new micro-regions for comparison, while additional sites from the Angara River and any future sites to be found in the South Baikal—especially from the EN—would be useful in adding further resolution to this discussion of micro-regional trends in OA severity. If other EN sites along the Angara were to produce results similar to the LOK females examined in this study, for example, this would offer a complementary suite of data suggestive of an intensive and physically taxing lifestyle throughout the Angara River micro-region during this time period. If the results from these other sites were different from the LOK females, this would indicate that females interred at this site exhibited uniquely taxing lifestyles. In either case, these data and the activity reconstructions they enable will continue to contribute to current efforts by BHAP researchers to investigate the diverse lifeways of the Cis-Baikal's middle Holocene hunter-gatherers.

7. Bibliography

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APPENDIX A. ANKLE INDICES

Individual	Cemetery	Sex	Age	Ankle Index
22-1	SHA	M	19-22	0.0000
17-2	SHA	M	20-22	0.0000
83 (a-robust)	SHA	M	20-22	0.0000
51-1	SHA	M	20-25	0.0000
53-1	SHA	M	20-25	0.0000
29-1	SHA	M	20-30	0.0000
46-1	SHA	M	25-29	0.0000
50-2	SHA	M	25-29	0.4458
63-1	SHA	M	25-29	0.0000
75-1	SHA	M	25-29	0.0000
18-1	SHA	M	25-29	0.0000
14-1	SHA	M	25-30	0.0550
19-1	SHA	M	25-30	0.0000
21-1	SHA	M	25-30	0.0550
21-2	SHA	M	25-30	0.0000
27-2	SHA	M	25-30	0.0000
45-1	SHA	M	25-34	0.0000
50-1	SHA	M	25-34	0.4433
63-2	SHA	M	25-34	0.7217
15-1	SHA	M	25-34	0.0000
10-1	SHA	M	25-34	2.1700
108-3	SHA	M	25-34	0.0000
112-1	SHA	M	25-34	0.0000
41-1	SHA	M	30-39	0.0000
64-1	SHA	M	30-39	0.5567
50-3	SHA	M	30-40	0.0000
17-1	SHA	M	30-40	0.8333
11-2	SHA	M	30-40	0.0000
52-1	SHA	PM	20-24	0.1667
55-1	SHA	M	35-39	0.0000
59-1	SHA	M	35-39	0.0000
8-1	SHA	M	35-40	0.0000
32-1	SHA	M	35-45	0.1667
33-1	SHA	M	35-45	0.2233
34-1	SHA	M	35-45	0.3333
58-1	SHA	M	35-45	0.0000
61-2	SHA	M	35-45	0.0000

Individual	Cemetery	Sex	Age	Ankle Index
62-2	SHA	M	35-45	0.0000
71-1	SHA	M	35-45	0.0000
27-1	SHA	M	35-50	0.5550
30-1	SHA	M	35-50	0.0000
13-2	SHA	M	35-50	1.0850
108-1	SHA	M	35-50	0.6683
39-1	SHA	M	40-44	0.0000
70-1	SHA	M	40-50	0.0000
68-1	SHA	M	45-49	0.0000
62-5	SHA	M	45-59	0.5542
65-1	SHA	M	50 +	0.8317
48-1	SHA	M	50+	0.0000
53-2	SHA	M	50+	0.0000
60-1	SHA	M	50+	0.1667
23-1 (23 BR)- box 1/2	SHA	PM	35-45	0.0000
44-1	SHA	PM	50+	1.2783
62-4	SHA	PM	20+	0.0000
26-2	SHA	PM	20+	0.0000
54-1	SHA	F	17-21	0.0000
25-1	SHA	F	20-22	0.0000
47-1	SHA	F	20-25	0.0000
69-2	SHA	F	20-25	0.0000
14-2	SHA	F	20-25	0.0000
61-1	SHA	F	25-29	0.0000
66-1	SHA	F	25-34	0.0000
69-1	SHA	F	25-34	0.0000
104-1	SHA	F	25-34	0.0000
96-2	SHA	F	30-34	0.0000
7-1	SHA	PF	20-30	0.0000
13-1	SHA	PF	25-34	0.0000
42-2	SHA	F	50+	0.0000
62-1	SHA	PF	35-45	0.0000
43-1	SHA	PF	35-50	0.4400
79-1	SHA	PF	35-50	0.0000
60-2	SHA	F	40-44	0.0000
42-1	SHA	F	40-45	0.3350
62-3	SHA	PF	20+	0.0000
26-1	SHA	PF	20+	0.0000

Individual	Cemetery	Sex	Age	Ankle Index
23-2	SHA	PF	20+	0.0000
25-3	SHA	PF	20+	0.0000
16-1	SHA	U	20-25	0.0000
12-1	SHA	U	20-34	0.0000
44-2	SHA	U	20+	0.6700
23-4	SHA	U	20+	2.0000
23-5	SHA	U	20+	0.0000
108-2	SHA	U	20+	0.0000
78- Leg Set #1 (arthritic ind)	SHA			0.2500
78-Leg Set #2	SHA			0.0000
L-10-1	LOK	M	20-25	0.0000
L-10-2	LOK	M	20-25	0.3333
L-22-2 (labelled 22D)	LOK	M	20-25	0.0000
L-22-3 (labelled 22K2)	LOK	M	20-25	0.0000
L-23-1	LOK	M	20-25	0.0000
L-15-1	LOK	M	20-34	0.0000
L-31-2-1	LOK	M	25-30	0.0000
L-44-2	LOK	M	30-39	0.0000
R-6-1-1	LOK	M	35-39	0.5000
R-6-2-1	LOK	M	35-39	0.0000
L-30-1-1	LOK	M	35-40	0.0000
L-30-2-1	LOK	M	35-40	0.0000
L-33-1	LOK	M	35-45	0.5017
L-20-2	LOK	M	35-50	0.0000
L-24-2	LOK	M	40-45	0.0000
L-8-1	LOK	M	40-45	0.4150
L-42-1	LOK	M	40-50	0.0000
L-24-5-2	LOK	M	45-50	0.5000
L-16-1-1	LOK	M	45-55	0.3342
L-11-1-1	LOK	M	50+	0.0000
L-19-1	LOK	M	50+	0.0000
R-7-1	LOK	M	50+	0.0000
L-12-1	LOK	F	18-22	0.0000
L-25-2	LOK	F	20-22	0.0000
L-36-1	LOK	F	20-25	1.2500
L-39-1	LOK	F	20-25	0.0825
R-11-1	LOK	F	20-25	0.0000
L-20-1	LOK	F	20-29	0.1667

Individual	Cemetery	Sex	Age	Ankle Index
L-43-2	LOK	F	20-29	0.0000
L-37-1-1	LOK	F	25-29	0.0000
L-14-1	LOK	F	25-30	0.0000
L-2-3	LOK	F	25-34	0.0000
L-24-6	LOK	F	25-34	0.1100
L-25-3	LOK	F	25-34	0.0000
L-29-1	LOK	PF	30-40	0.0000
L-38-1	LOK	PF	50+	0.6667
L-25-1	LOK	F	35-40	0.0000
L-28-1	LOK	F	35-40	0.0000
L-25-4	LOK	F	35-45	0.0000
L-38-2	LOK	F	35-45	0.0000
L-4-1	LOK	F	35-50	1.6600
L-7-1	LOK	F	40-45	1.4967
L-17-1	LOK	F	45-55	0.0000
L-21-1	LOK	F	50+	1.2233
L-2-1-1	LOK	U	20-25	0.0000
L-41-3	LOK	U	20+	0.0000
L-2-4	LOK	U	25-34	0.0000
L-2-2	LOK	U	35-39	0.0000
39-1-1	UID	F	25-34	0.6700
20-2	UID	F	30-40	0.0000
30-1-1	UID	F	50+	0.0000
42-1-1	UID	F	50+	0.0000
52-1-1	UID	F	60+	1.0000
20-1	UID	M	18-24	0.0000
43-1	UID	M	19-25	0.0000
45-1	UID	M	22-30	0.0000
16-1-1	UID	M	25-34	0.0000
19-1	UID	M	30-34	0.0000
47-1-1	UID	M	30-40	0.0000
38-1	UID	M	35-45	0.7500
41-1-1	UID	M	35-50	0.4450
12-1-1	UID	M	35-50	0.0000
6-1-1-	UID	M	35-50	1.5000
48-1	UID	M	50+	0.6700
54-1-1	UID	M	50+	0.0000
29-1-1	UID	M	50+	0.5025

APPENDIX B. ELBOW INDICES

Individual	Cemetery	Sex	Age	Elbow Index	Elbow Hinge Index	Elbow Pivot Index
54-1	SHA	F	17-21	0.0000	0.0000	0.0000
25-1	SHA	F	20-22	0.1250	0.5000	0.0000
47-1	SHA	F	20-25	0.0000	0.0000	0.0000
69-2	SHA	F	20-25	0.0000	0.0000	0.0000
14-2	SHA	F	20-25	0.0000	0.0000	0.0000
61-1	SHA	F	25-29	0.0330	0.0000	0.0550
66-1	SHA	F	25-34	0.4000	0.5000	0.3333
69-1	SHA	F	25-34	0.5330	0.6675	0.4433
104-1	SHA	F	25-34	0.5340	0.5000	0.5567
96-2	SHA	F	30-34	0.0000	0.0000	0.0000
60-2	SHA	F	40-44	0.5000	1.0000	0.0000
42-1	SHA	F	40-45	0.2340	0.4175	0.1117
42-2	SHA	F	50+	0.2250	0.5000	0.0000
22-1	SHA	M	19-22	0.0000	0.0000	0.0000
17-2	SHA	M	20-22	0.0000	0.0000	0.0000
83 (a-robust)	SHA	M	20-22	0.0000	0.0000	0.0000
51-1	SHA	M	20-25	0.1000	0.2500	0.0000
53-1	SHA	M	20-25	0.0670	0.1675	0.0000
29-1	SHA	M	20-30	0.0000	0.0000	0.0000
46-1	SHA	M	25-29	0.2000	0.0000	0.3333
50-2	SHA	M	25-29	0.1340	0.1675	0.1117
63-1	SHA	M	25-29	0.0000	0.0000	0.0000
75-1	SHA	M	25-29	0.2660	0.0000	0.4433
18-1	SHA	M	25-29	0.0000	0.0000	0.0000
14-1	SHA	M	25-30	0.1320	0.0825	0.1650
19-1	SHA	M	25-30	0.1670	0.1675	0.1667
21-1	SHA	M	25-30	0.0660	0.1650	0.0000
21-2	SHA	M	25-30	0.0000	0.0000	0.0000
27-2	SHA	M	25-30	0.3015	0.5025	0.1117
45-1	SHA	M	25-34	0.0000	0.0000	0.0000
50-1	SHA	M	25-34	0.0000	0.0000	0.0000
63-2	SHA	M	25-34	0.4000	0.4175	0.3883
85-1	SHA	M	25-34	0.9000	1.0000	0.8333
15-1	SHA	M	25-34	0.0000	0.0000	0.0000
24-1	SHA	M	25-34	0.7340	0.8350	0.6667
10-1	SHA	M	25-34	2.1600		2.1600
108-3	SHA	M	25-34	0.4000	0.5000	0.3333

Individual	Cemetery	Sex	Age	Elbow Index	Elbow Hinge Index	Elbow Pivot Index
112-1	SHA	M	25-34	0.6233	0.8350	0.5008
41-1	SHA	M	30-39	0.0000	0.0000	0.0000
64-1	SHA	M	30-39	0.8000	1.7500	0.1667
50-3	SHA	M	30-40	0.9000	1.0000	0.8333
17-1	SHA	M	30-40	0.8290	1.0000	0.8283
11-2	SHA	M	30-40	0.0000	0.0000	0.0000
55-1	SHA	M	35-39	1.9990	1.7500	2.1650
59-1	SHA	M	35-39	0.5000	1.0000	0.1667
8-1	SHA	M	35-40	0.0000	0.0000	0.0000
32-1	SHA	M	35-45	0.9320	1.4125	0.6117
33-1	SHA	M	35-45	0.0000	0.0000	0.0000
34-1	SHA	M	35-45	0.5000	1.0000	0.1667
58-1	SHA	M	35-45	1.3823	1.1700	1.4417
61-2	SHA	M	35-45	0.4330	0.6675	0.2767
62-2	SHA	M	35-45			
71-1	SHA	M	35-45	0.4830	0.0000	0.7217
27-1	SHA	M	35-50	2.9337	2.5000	3.2783
30-1	SHA	M	35-50	0.0000	0.0000	0.0000
108-1	SHA	M	35-50	2.6000	3.0025	2.3317
39-1	SHA	M	40-44	0.6660	0.9150	0.5000
70-1	SHA	M	40-50	0.2500	0.5000	0.0000
68-1	SHA	M	45-49	0.0000	0.0000	0.0000
62-5	SHA	M	45-59	0.3320	0.1675	0.4417
65-1	SHA	M	50 +	4.3013	3.2500	5.0850
48-1	SHA	M	50+	0.5340	0.8375	0.2200
53-2	SHA	M	50+	0.2000	0.5000	0.0000
60-1	SHA	M	50+	0.0000	0.0000	0.0000
7-1	SHA	PF	20-30	0.1340	0.3350	0.0000
62-1	SHA	PF	35-45	0.3350	0.6700	0.0000
43-1	SHA	PF	35-50	0.7258	1.3400	0.3350
79-1	SHA	PF	35-50	1.3360	1.0000	1.5600
52-1	SHA	PM	20-24	0.5567	0.6700	0.5000
23-1 (23 BR)- box 1/2	SHA	PM	35-45	2.8550	2.6650	3.0233
44-1	SHA	PM	50+	0.0000	0.0000	0.0000
16-1	SHA	U	20-25	0.0000	0.0000	0.0000
12-1	SHA	U	20-34	0.2500	0.5000	0.0000
44-2	SHA	U	20+	0.0000		0.0000

Individual	Cemetery	Sex	Age	Elbow Index	Elbow Hinge Index	Elbow Pivot Index
L-10-1	LOK	M	20-25	0.2500	0.5000	0.0000
L-10-2	LOK	M	20-25	0.0000	0.0000	0.0000
L-10-3	LOK	M	25-30	0.0000	0.0000	0.0000
L-10-4	LOK	M	30-34	0.3670	0.8350	0.0550
L-11-1-1	LOK	M	50+	0.8773	1.0000	0.8050
L-12-1	LOK	F	18-22	0.0000	0.0000	0.0000
L-13-1	LOK	M	25-30	1.2088	1.2500	1.1675
L-14-1	LOK	F	25-30	1.1000	1.0000	1.1667
L-15-1	LOK	M	20-34	1.0000	1.0000	1.0000
L-16-1-1	LOK	M	45-55	1.2010	0.9175	1.3900
L-17-1	LOK	F	45-55	0.6000	1.0000	0.3333
L-19-1	LOK	M	50+	0.8471	1.7500	0.2500
L-2-1-1	LOK	U	20-25	0.0000	0.0000	0.0000
L-2-3	LOK	F	25-34	1.0000	1.0000	1.0000
L-2-4	LOK	U	25-34	0.3350	0.3350	0.0000
L-20-1	LOK	F	20-29	0.3670	0.5000	0.2783
L-20-2	LOK	M	35-50	1.5000	1.8325	1.2783
L-21-1	LOK	F	50+	1.3458	1.5000	1.2758
L-22-3 (labelled 22K2)	LOK	M	20-25	0.1250	0.2500	0.0000
L-23-1	LOK	M	20-25	0.0000	0.0000	0.0000
L-24-2	LOK	M	40-45	1.0829	1.2500	0.8325
L-24-5-2	LOK	M	45-50	1.6600	1.6600	
L-24-6	LOK	F	25-34	0.5425	1.0850	0.0000
L-25-1	LOK	F	35-40	0.0000	0.0000	0.0000
L-25-2	LOK	F	20-22	0.0000	0.0000	0.0000
L-25-3	LOK	F	25-34	0.2475	0.3300	0.1650
L-28-1	LOK	F	35-40	1.4680	1.5825	1.3917
L-30-2-1	LOK	M	35-40	0.0000	0.0000	0.0000
L-31-1-1	LOK	U	35-50	0.5000	1.0000	0.0000
L-33-1	LOK	M	35-45	1.0025	1.0025	
L-34-1	LOK	F	35-45	1.5000	1.5000	
L-34-1	LOK	U	20+	0.6667	1.0000	0.0000
L-36-1	LOK	F	20-25	0.8310	0.9150	0.7750
L-37-1-1	LOK	F	25-29	0.5020	0.6700	0.3900
L-38-1	LOK	PF	50+	1.0990	1.6650	0.7217
L-38-2	LOK	F	35-45	0.9670	1.2500	0.7783
L-39-1	LOK	F	20-25	0.1340	0.3350	0.0000

Individual	Cemetery	Sex	Age	Elbow Index	Elbow Hinge Index	Elbow Pivot Index
L-42-1	LOK	M	40-50	0.0000	0.0000	0.0000
L-44-1	LOK	M	30-39	2.3330	1.7500	2.7217
L-44-2	LOK	M	30-39	0.1000	0.2500	0.0000
L-6-1	LOK	M	20+	1.0000	1.0000	
L-7-1	LOK	F	40-45	4.0015	6.1725	2.3600
L-8-1	LOK	M	40-45	1.3980	1.5000	1.3300
R-1-1-1	LOK	M	30-34	1.3660	1.6650	1.1667
R-11-1	LOK	F	20-25	0.0000	0.0000	0.0000
R-14-1	LOK	M	30-39	0.6667	1.0000	0.0000
R-15-1	LOK	F	20-34	0.0000	0.0000	0.0000
R-15-2	LOK	F	35-40	0.0000	0.0000	0.0000
R-6-1-1	LOK	M	35-39	1.0000	1.5000	0.6667
R-6-2-1	LOK	M	35-39	0.6658	0.8325	0.0000
R-7-1	LOK	M	50+	0.5988	0.6675	0.5800
40-1	UID	F	25-30	0.0000	0.0000	0.0000
20-2	UID	F	30-40	0.0000	0.0000	0.0000
11-1-1	UID	F	35-50	0.6700		0.6700
36-1-2	UID	F	40-50	1.0000	1.0000	1.0000
30-1-1	UID	F	50+	0.0000	0.0000	0.0000
42-1-1	UID	F	50+	0.6217	1.0000	0.4158
52-1-1	UID	F	60+	2.0000	2.0000	2.0000
20-1	UID	M	18-24	0.0670	0.1675	0.0000
43-1	UID	M	19-25	1.0000	1.0000	0.0000
45-1	UID	M	22-30	1.5000	2.0000	1.0000
16-1-1	UID	M	25-34	0.0000	0.0000	0.0000
16-2-1	UID	M	25-34	0.7663	1.2500	0.4717
19-1	UID	M	30-34	0.5660	0.7500	0.4433
47-1-1	UID	M	30-40	1.0000	1.0000	
38-1	UID	M	35-45	0.7330	0.9175	0.6100
41-1-1	UID	M	35-50	0.5000	0.5000	0.5000
56-1	UID	M	35-50	0.0000	0.0000	0.0000
12-1-1	UID	M	35-50	1.8350	2.0025	1.0000
6-1-1-	UID	M	35-50	0.8690	0.9200	0.8350
48-1	UID	M	50+	0.6700	0.6700	0.6700
54-1-1	UID	M	50+	0.8900	1.0000	0.8350
29-1-1	UID	M	50+	1.1670	1.5000	0.9450

APPENDIX C. CERVICAL VOA INDICES

Individual	Cemetery	Sex	Age	Cervical VOA Index
32-1	SHA	M	35-45	0.8393
33-1	SHA	M	35-45	0.0000
34-1	SHA	M	35-45	0.8571
39-1	SHA	M	40-44	0.8452
41-1	SHA	M	30-39	0.1429
42-1	SHA	F	40-45	0.2857
42-2	SHA	F	50+	0.0000
43-1	SHA	PF	35-50	0.0000
45-1	SHA	M	25-34	0.1548
46-1	SHA	M	25-29	0.5357
47-1	SHA	F	20-25	0.0500
48-1	SHA	M	50+	0.4286
50-1	SHA	M	25-34	0.0000
51-1	SHA	M	20-25	0.0000
53-1	SHA	M	20-25	0.0000
53-2	SHA	M	50+	0.0714
54-1	SHA	F	17-21	0.0000
55-1	SHA	M	35-39	0.7917
58-1	SHA	M	35-45	0.2857
59-1	SHA	M	35-39	0.0357
60-1	SHA	M	50+	0.0000
61-1	SHA	F	25-29	0.0000
61-2	SHA	M	35-45	0.0000
63-1	SHA	M	25-29	0.2500
63-2	SHA	M	25-34	0.0000
64-1	SHA	M	30-39	0.0179
65-1	SHA	M	50 +	1.2639
66-1	SHA	F	25-34	0.1071
69-1	SHA	F	25-34	0.7679
69-2	SHA	F	20-25	0.0000
70-1	SHA	M	40-50	1.5714
71-1	SHA	M	35-45	0.2500
75-1	SHA	M	25-29	0.0000
79-1	SHA	PF	35-50	0.0000
85-1	SHA	M	25-34	0.0417
96-2	SHA	F	30-34	0.0000
14-1	SHA	M	25-30	0.1071

Individual	Cemetery	Sex	Age	Cervical VOA Index
15-1	SHA	M	25-34	0.0000
17-1	SHA	M	30-40	0.0556
18-1	SHA	M	25-29	0.0000
19-1	SHA	M	25-30	0.0000
21-1	SHA	M	25-30	0.2857
22-1	SHA	M	19-22	0.0357
24-1	SHA	M	25-34	0.2917
27-1	SHA	M	35-50	0.2500
29-1	SHA	M	20-30	0.2857
30-1	SHA	M	35-50	0.7500
14-2	SHA	F	20-25	0.0000
21-2	SHA	M	25-30	0.1429
27-2	SHA	M	25-30	0.0000
7-1	SHA	PF	20-30	0.1786
8-1	SHA	M	35-40	1.0000
11-2	SHA	M	30-40	0.1563
12-1	SHA	U	20-34	1.1875
104-1	SHA	F	25-34	0.1786
108-1	SHA	M	35-50	0.2083
108-3	SHA	M	25-34	0.0000
83 (a-robust)	SHA	M	20-22	0.0000
L-10-1	LOK	M	20-25	0.0625
L-10-4	LOK	M	30-34	0.2292
L-11-1-1	LOK	M	50+	1.8438
L-12-1	LOK	F	18-22	0.0000
L-13-1	LOK	M	25-30	0.1071
L-16-1-1	LOK	M	45-55	0.3214
L-19-1	LOK	M	50+	0.1071
L-2-3	LOK	F	25-34	0.0625
L-20-1	LOK	F	20-29	0.0714
L-20-2	LOK	M	35-50	0.6071
L-22-3 (labelled 22K2)	LOK	M	20-25	0.0000
L-23-1	LOK	M	20-25	0.0000
L-24-5-2	LOK	M	45-50	2.2667
L-24-6	LOK	F	25-34	0.2500
L-25-3	LOK	F	25-34	0.1667
L-28-1	LOK	F	35-40	0.0000
L-29-1	LOK	PF	30-40	0.1000

Individual	Cemetery	Sex	Age	Cervical VOA Index
L-30-2-1	LOK	M	35-40	0.1250
L-31-2-1	LOK	M	25-30	0.1667
L-33-1	LOK	M	35-45	0.0714
L-37-1-1	LOK	F	25-29	0.0000
L-38-1	LOK	PF	50+	0.1667
L-38-2	LOK	F	35-45	0.0000
L-39-1	LOK	F	20-25	0.0714
L-42-1	LOK	M	40-50	0.0000
L-44-1	LOK	M	30-39	0.3125
L-7-1	LOK	F	40-45	0.8125
L-8-1	LOK	M	40-45	1.4688
R-1-1-1	LOK	M	30-34	0.8438
R-14-1	LOK	M	30-39	0.1750
R-6-1-1	LOK	M	35-39	0.0833
R-6-2-1	LOK	M	35-39	0.3214
R-7-1	LOK	M	50+	1.3889
36-1-2	UID	F	40-50	0.3500
38-1	UID	M	35-45	1.0893
41-1-1	UID	M	35-50	0.0000
43-1	UID	M	19-25	0.0000
45-1	UID	M	22-30	0.1667
48-1	UID	M	50+	0.1071
52-1-1	UID	F	60+	1.1786
54-1-1	UID	M	50+	0.4917
12-1-1	UID	M	35-50	0.7500
20-1	UID	M	18-24	0.0000
16-1-1	UID	M	25-34	0.0000
16-2-1	UID	M	25-34	0.0000
29-1-1	UID	M	50+	0.8571
6-1-1-	UID	M	35-50	0.0625

APPENDIX D. CERVICAL OVB INDICES

Individual	Cemetery	Sex	Age	Cervical OVB Index
32-1	SHA	M	35-45	1.7500
33-1	SHA	M	35-45	0.0000
34-1	SHA	M	35-45	1.6250
39-1	SHA	M	40-44	1.5000
41-1	SHA	M	30-39	0.9167
42-1	SHA	F	40-45	2.3333
42-2	SHA	F	50+	0.0000
46-1	SHA	M	25-29	0.0000
47-1	SHA	F	20-25	0.0000
48-1	SHA	M	50+	1.9167
50-1	SHA	M	25-34	0.0000
51-1	SHA	M	20-25	0.0000
53-1	SHA	M	20-25	0.0000
53-2	SHA	M	50+	0.5833
54-1	SHA	F	17-21	0.0000
55-1	SHA	M	35-39	1.0000
58-1	SHA	M	35-45	1.5833
59-1	SHA	M	35-39	0.3333
60-1	SHA	M	50+	0.4167
61-1	SHA	F	25-29	0.0000
61-2	SHA	M	35-45	0.0000
63-2	SHA	M	25-34	0.0000
64-1	SHA	M	30-39	0.0000
65-1	SHA	M	50 +	0.3750
66-1	SHA	F	25-34	0.0000
69-1	SHA	F	25-34	0.5000
69-2	SHA	F	20-25	0.0000
70-1	SHA	M	40-50	0.6667
71-1	SHA	M	35-45	0.0000
75-1	SHA	M	25-29	0.0000
79-1	SHA	PF	35-50	0.0000
85-1	SHA	M	25-34	0.2000
96-2	SHA	F	30-34	0.0000
14-1	SHA	M	25-30	0.0000
15-1	SHA	M	25-34	0.6667
17-1	SHA	M	30-40	0.3750
18-1	SHA	M	25-29	0.0000

Individual	Cemetery	Sex	Age	Cervical OVB Index
19-1	SHA	M	25-30	0.0000
21-1	SHA	M	25-30	0.0833
22-1	SHA	M	19-22	0.0000
24-1	SHA	M	25-34	0.2000
27-1	SHA	M	35-50	0.5000
29-1	SHA	M	20-30	0.1667
14-2	SHA	F	20-25	0.0000
21-2	SHA	M	25-30	0.0000
27-2	SHA	M	25-30	0.0000
7-1	SHA	PF	20-30	0.0000
8-1	SHA	M	35-40	0.4000
104-1	SHA	F	25-34	0.0000
108-1	SHA	M	35-50	0.0000
108-3	SHA	M	25-34	0.0000
83 (a-robust)	SHA	M	20-22	0.0000
L-10-1	LOK	M	20-25	0.0000
L-10-4	LOK	M	30-34	1.8750
L-12-1	LOK	F	18-22	0.0000
L-13-1	LOK	M	25-30	0.5000
L-16-1-1	LOK	M	45-55	0.8333
L-19-1	LOK	M	50+	0.2500
L-2-3	LOK	F	25-34	0.3750
L-20-1	LOK	F	20-29	0.0000
L-20-2	LOK	M	35-50	1.5833
L-22-3 (labelled 22K2)	LOK	M	20-25	0.0000
L-23-1	LOK	M	20-25	0.0000
L-24-5-2	LOK	M	45-50	2.5000
L-24-6	LOK	F	25-34	0.3333
L-28-1	LOK	F	35-40	0.2000
L-31-2-1	LOK	M	25-30	0.5000
L-33-1	LOK	M	35-45	0.0000
L-37-1-1	LOK	F	25-29	0.5000
L-38-1	LOK	PF	50+	0.4000
L-38-2	LOK	F	35-45	0.1667
L-39-1	LOK	F	20-25	0.0000
L-42-1	LOK	M	40-50	1.0000
L-7-1	LOK	F	40-45	1.9000
R-1-1-1	LOK	M	30-34	1.3750

Individual	Cemetery	Sex	Age	Cervical OVB Index
R-14-1	LOK	M	30-39	0.5000
R-6-1-1	LOK	M	35-39	1.3000
R-6-2-1	LOK	M	35-39	0.0000
R-7-1	LOK	M	50+	1.8000
36-1-2	UID	F	40-50	1.2500
38-1	UID	M	35-45	1.6667
41-1-1	UID	M	35-50	0.7500
45-1	UID	M	22-30	1.8000
48-1	UID	M	50+	0.3333
52-1-1	UID	F	60+	1.0000
54-1-1	UID	M	50+	0.4000
20-1	UID	M	18-24	0.0000
16-1-1	UID	M	25-34	0.0000
16-2-1	UID	M	25-34	0.0000
29-1-1	UID	M	50+	2.0000
6-1-1	UID	M	35-50	1.0000

APPENDIX E. HIP INDICES

Individual	Cemetery	Sex	Age	Hip Index
54-1	SHA	F	17-21	0.0000
25-1	SHA	F	20-22	0.0000
47-1	SHA	F	20-25	0.0000
69-2	SHA	F	20-25	0.0000
14-2	SHA	F	20-25	0.0000
57-1	SHA	F	25-29	0.0000
61-1	SHA	F	25-29	0.0000
66-1	SHA	F	25-34	0.0000
69-1	SHA	F	25-34	0.0000
78-2	SHA	F	25-34	0.0000
104-1	SHA	F	25-34	0.0000
96-2	SHA	F	30-34	0.0000
13-1	SHA	FP	25-34	0.0000
7-1	SHA	FP	20-30	0.0000
42-1	SHA	F	40-45	0.7500
42-2	SHA	F	50+	0.0000
62-1	SHA	FP	35-45	0.0000
43-1	SHA	FP	35-50	0.0000
62-3	SHA	FP	20+	0.0000
23-2	SHA	FP	20+	0.0000
16-1	SHA	U	20-25	0.0000
23-3	SHA	U	20+	0.0000
78- Leg Set #1 (arthritic ind)	SHA	U		0.0000
78-Leg Set #2	SHA	U		0.0000
22-1	SHA	M	19-22	0.0000
17-2	SHA	M	20-22	0.0000
83 (a-robust)	SHA	M	20-22	0.0000
51-1	SHA	M	20-25	0.0000
53-1	SHA	M	20-25	0.0000
78-3	SHA	M	20-25	0.0000
29-1	SHA	M	20-30	0.0000
46-1	SHA	M	25-29	0.0000
50-2	SHA	M	25-29	0.1650
63-1	SHA	M	25-29	0.0000
75-1	SHA	M	25-29	0.0000
18-1	SHA	M	25-29	0.0000
14-1	SHA	M	25-30	0.0000

Individual	Cemetery	Sex	Age	Hip Index
19-1	SHA	M	25-30	0.0000
21-1	SHA	M	25-30	0.0000
21-2	SHA	M	25-30	0.0000
27-2	SHA	M	25-30	0.0000
45-1	SHA	M	25-34	0.3350
50-1	SHA	M	25-34	0.0000
63-2	SHA	M	25-34	0.2500
85-1	SHA	M	25-34	0.0000
15-1	SHA	M	25-34	0.0000
24-1	SHA	M	25-34	0.0000
10-1	SHA	M	25-34	0.0000
108-3	SHA	M	25-34	0.0000
112-1	SHA	M	25-34	0.0000
41-1	SHA	M	30-39	0.0000
64-1	SHA	M	30-39	0.0000
50-3	SHA	M	30-40	0.0000
17-1	SHA	M	30-40	0.0000
11-2	SHA	M	30-40	0.0000
52-1	SHA	MP	20-24	0.0000
55-1	SHA	M	35-39	0.0000
8-1	SHA	M	35-40	0.0000
32-1	SHA	M	35-45	0.0000
33-1	SHA	M	35-45	0.0000
34-1	SHA	M	35-45	0.0000
58-1	SHA	M	35-45	0.6600
61-2	SHA	M	35-45	5.5050
71-1	SHA	M	35-45	0.0000
27-1	SHA	M	35-50	0.0000
108-1	SHA	M	35-50	0.0000
39-1	SHA	M	40-44	0.0000
70-1	SHA	M	40-50	0.7500
62-5	SHA	M	45-59	0.0000
65-1	SHA	M	50 +	0.5025
48-1	SHA	M	50+	0.0000
53-2	SHA	M	50+	0.0000
60-1	SHA	M	50+	0.0000
62-4	SHA	MP	20+	0.0000
L-12-1	LOK	F	18-22	0.0000

Individual	Cemetery	Sex	Age	Hip Index
L-25-2	LOK	F	20-22	0.0000
L-36-1	LOK	F	20-25	0.0000
L-39-1	LOK	F	20-25	0.0000
R-11-1	LOK	F	20-25	0.0000
L-20-1	LOK	F	20-29	0.0000
L-43-2	LOK	F	20-29	0.0000
L-37-1-1	LOK	F	25-29	0.0000
L-14-1	LOK	F	25-30	0.0000
L-22-6 (labelled 22A)	LOK	F	25-30	0.0000
L-2-3	LOK	F	25-34	0.0000
L-24-6	LOK	F	25-34	0.0000
L-25-3	LOK	F	25-34	1.2450
L-29-1	LOK	FP	30-40	0.6700
L-25-1	LOK	F	35-40	0.0000
L-28-1	LOK	F	35-40	0.0000
R-15-2	LOK	F	35-40	0.0000
L-25-4	LOK	F	35-45	1.9900
L-34-1	LOK	F	35-45	0.0000
L-38-2	LOK	F	35-45	0.6700
L-4-1	LOK	F	35-50	1.6650
L-7-1	LOK	F	40-45	1.6600
L-17-1	LOK	F	45-55	0.0000
L-18-1	LOK	F	50+	5.9200
L-21-1	LOK	F	50+	0.0000
L-38-1	LOK	FP	50+	0.0000
L-2-1-1	LOK	U	20-25	0.0000
L-2-4	LOK	U	25-34	0.0000
L-2-2	LOK	U	35-39	0.0000
L-31-1-1	LOK	U	35-50	0.0000
L-10-1	LOK	M	20-25	0.0000
L-10-2	LOK	M	20-25	0.0000
L-22-2 (labelled 22D)	LOK	M	20-25	0.0000
L-22-3 (labelled 22K2)	LOK	M	20-25	0.0000
L-23-1	LOK	M	20-25	0.0000
L-15-1	LOK	M	20-34	0.0000
L-10-3	LOK	M	25-30	0.0000
L-13-1	LOK	M	25-30	0.0000
L-31-2-1	LOK	M	25-30	0.0000

Individual	Cemetery	Sex	Age	Hip Index
R-1-1-1	LOK	M	30-34	0.0000
L-10-4	LOK	M	30-34	0.0000
L-44-1	LOK	M	30-39	0.0000
L-44-2	LOK	M	30-39	0.0000
R-14-1	LOK	M	30-39	0.0000
R-6-1-1	LOK	M	35-39	0.0000
R-6-2-1	LOK	M	35-39	0.0000
L-30-1-1	LOK	M	35-40	0.0000
L-30-2-1	LOK	M	35-40	0.0000
L-33-1	LOK	M	35-45	0.0000
L-20-2	LOK	M	35-50	0.0000
L-24-2	LOK	M	40-45	0.0000
L-8-1	LOK	M	40-45	0.0000
L-42-1	LOK	M	40-50	0.0000
L-24-5-2	LOK	M	45-50	1.9900
L-16-1-1	LOK	M	45-55	0.0000
L-11-1-1	LOK	M	50+	0.0000
L-19-1	LOK	M	50+	0.0000
R-7-1	LOK	M	50+	1.8325
L-40-1	LOK	M	20+	0.0000
40-1	UID	F	25-30	0.0000
39-1-1	UID	F	25-34	6.0000
20-2	UID	F	30-40	0.0000
11-1-1	UID	F	35-50	0.0000
36-1-2	UID	F	40-50	1.0000
30-1-1	UID	F	50+	0.0000
42-1-1	UID	F	50+	0.7500
52-1-1	UID	F	60+	0.0000
1-1	UID	F	20+	0.0000
20-1	UID	M	18-24	0.0000
43-1	UID	M	19-25	0.0000
45-1	UID	M	22-30	0.0000
16-1-1	UID	M	25-34	0.0000
16-2-1	UID	M	25-34	0.0000
19-1	UID	M	30-34	0.0000
47-1-1	UID	M	30-40	0.8350
38-1	UID	M	35-45	0.0000
41-1-1	UID	M	35-50	0.0000

Individual	Cemetery	Sex	Age	Hip Index
56-1	UID	M	35-50	3.0000
12-1-1	UID	M	35-50	0.0000
6-1-1-	UID	M	35-50	0.3325
48-1	UID	M	50+	0.0000
54-1-1	UID	M	50+	0.3350
29-1-1	UID	M	50+	0.6700

APPENDIX F. KNEE INDICES

Individual	Cemetery	Sex	Age	Knee Index	Anterior Knee Index	Medial Knee Index	Lateral Knee Index
54-1	SHA	F	17-21	0.0000	0.0000	0.0000	0.0000
25-1	SHA	F	20-22	0.0000	0.0000	0.0000	0.0000
47-1	SHA	F	20-25	0.0000	0.0000	0.0000	0.0000
69-2	SHA	F	20-25	0.0000	0.0000	0.0000	0.0000
14-2	SHA	F	20-25	0.0000	0.0000	0.0000	0.0000
61-1	SHA	F	25-29	0.0000	0.0000	0.0000	
66-1	SHA	F	25-34	0.0000	0.0000	0.0000	0.0000
69-1	SHA	F	25-34	1.7217	2.0825	1.0000	
104-1	SHA	F	25-34	0.0000	0.0000	0.0000	0.0000
96-2	SHA	F	30-34	0.0000	0.0000	0.0000	0.0000
7-1	SHA	PF	20-30	0.0000	0.0000	0.0000	0.0000
13-1	SHA	PF	25-34	0.0000			
62-1	SHA	PF	35-45	0.1340	0.3350	0.0000	0.1675
43-1	SHA	PF	35-50	0.6614	0.9933	0.3300	0.4950
79-1	SHA	PF	35-50	0.0000	0.0000		
60-2	SHA	F	40-44	0.0000	0.0000		
42-1	SHA	F	40-45	0.1193	0.1667	0.0000	0.1675
42-2	SHA	F	50+	0.0000	0.0000	0.0000	0.0000
62-3	SHA	PF	20+	0.0000	0.0000	0.0000	0.0000
23-2	SHA	PF	20+	0.0000	0.0000	0.0000	0.0000
25-3	SHA	PF	20+	0.0000			
22-1	SHA	M	19-22	0.0000	0.0000	0.0000	0.0000
17-2	SHA	M	20-22	0.0000	0.0000	0.0000	0.0000
83 (a-robust)	SHA	M	20-22	0.0000	0.0000	0.0000	0.0000
51-1	SHA	M	20-25	0.0000	0.0000	0.0000	0.0000
53-1	SHA	M	20-25	0.0000	0.0000	0.0000	0.0000
29-1	SHA	M	20-30	0.0000	0.0000	0.0000	0.0000
46-1	SHA	M	25-29	0.0000	0.0000	0.0000	0.0000
50-2	SHA	M	25-29	0.0000	0.0000	0.0000	0.0000
63-1	SHA	M	25-29	0.0660	0.1100	0.0000	0.0000
75-1	SHA	M	25-29	0.0000	0.0000	0.0000	0.0000
18-1	SHA	M	25-29	0.0000	0.0000	0.0000	0.0000
14-1	SHA	M	25-30	0.0000	0.0000	0.0000	0.0000
19-1	SHA	M	25-30	0.0000	0.0000	0.0000	0.0000
21-1	SHA	M	25-30	0.2371	0.3867	0.2500	0.0000
21-2	SHA	M	25-30	0.0000	0.0000	0.0000	0.0000

Individual	Cemetery	Sex	Age	Knee Index	Anterior Knee Index	Medial Knee Index	Lateral Knee Index
27-2	SHA	M	25-30	0.0000	0.0000	0.0000	0.0000
45-1	SHA	M	25-34	0.0000	0.0000	0.0000	0.0000
50-1	SHA	M	25-34	0.0000	0.0000	0.0000	0.0000
63-2	SHA	M	25-34	0.0670	0.1117	0.0000	0.0000
15-1	SHA	M	25-34	0.0957	0.2233	0.0000	0.0000
10-1	SHA	M	25-34	1.8867	2.8300		0.0000
108-3	SHA	M	25-34	0.5714	1.0000	0.0000	0.5000
112-1	SHA	M	25-34	0.0000	0.0000	0.0000	0.0000
41-1	SHA	M	30-39	0.1914	0.4467	0.0000	0.0000
64-1	SHA	M	30-39	0.0000	0.0000	0.0000	0.0000
50-3	SHA	M	30-40	0.0000	0.0000	0.0000	0.0000
17-1	SHA	M	30-40	0.0000		0.0000	0.0000
11-2	SHA	M	30-40	0.6907	0.9450	0.0000	0.0000
52-1	SHA	PM	20-24	0.0000	0.0000	0.0000	0.0000
55-1	SHA	M	35-39	0.0330	0.0550	0.0000	0.0000
59-1	SHA	M	35-39	0.0000	0.0000		
8-1	SHA	M	35-40	2.8720	5.7900	0.5850	1.5850
32-1	SHA	M	35-45	0.3680	0.1667	0.0000	1.3400
33-1	SHA	M	35-45	0.2857	0.3883	0.1675	0.2500
34-1	SHA	M	35-45	1.4857	1.8333	1.7500	1.0000
58-1	SHA	M	35-45	2.4975	3.3300		0.0000
61-2	SHA	M	35-45	0.0000	0.0000	0.0000	0.0000
62-2	SHA	M	35-45	0.0000		0.0000	0.0000
71-1	SHA	M	35-45	0.1900	0.4433	0.0000	0.0000
27-1	SHA	M	35-50	0.4459	0.6942	0.0825	0.3325
13-2	SHA	M	35-50	3.6700	3.6700		
108-1	SHA	M	35-50	0.5000	1.0000	0.5000	0.2500
39-1	SHA	M	40-44	0.0000	0.0000	0.0000	0.0000
70-1	SHA	M	40-50	2.3121	4.7283	0.5000	0.5000
62-5	SHA	M	45-59	0.0000	0.0000	0.0000	0.0000
65-1	SHA	M	50 +	3.0542	4.2767	1.8300	1.2525
48-1	SHA	M	50+	1.0000	1.6600	0.6700	0.6700
53-2	SHA	M	50+	0.0000	0.0000	0.0000	0.0000
60-1	SHA	M	50+	0.2136	0.4983	0.0000	0.0000
23-1 (23 BR)- box 1/2	SHA	PM	35-45	0.6650	0.6650		
44-1	SHA	PM	50+	0.3325	0.3325		
62-4	SHA	PM	20+	0.0000	0.0000	0.0000	0.0000

Individual	Cemetery	Sex	Age	Knee Index	Anterior Knee Index	Medial Knee Index	Lateral Knee Index
26-2	SHA	PM	20+	0.0000	0.0000	0.0000	0.0000
16-1	SHA	U	20-25	0.0714	0.1667	0.0000	0.0000
12-1	SHA	U	20-34	0.0000	0.0000		
23-3	SHA	U	20+	1.3333	2.0000	1.0000	1.0000
23-5	SHA	U	20+	0.0000			0.0000
108-2	SHA	U	20+	0.0000	0.0000		
L-12-1	LOK	F	18-22	0.0000	0.0000	0.0000	0.0000
L-25-2	LOK	F	20-22	0.0957	0.2233	0.0000	0.0000
L-36-1	LOK	F	20-25	1.2421	1.7217	1.0825	1.0825
L-39-1	LOK	F	20-25	0.1363	0.2217	0.1650	0.0000
R-11-1	LOK	F	20-25	0.0670	0.3350	0.0000	0.0000
L-20-1	LOK	F	20-29	0.3857	0.5000	0.0000	0.5000
L-37-1-1	LOK	F	25-29	0.0000	0.0000	0.0000	0.0000
L-14-1	LOK	F	25-30	0.0000	0.0000	0.0000	0.0000
L-24-6	LOK	F	25-34	0.1384	0.2783	0.0000	0.0000
L-25-3	LOK	F	25-34	0.3650	0.6700	0.2475	0.4150
L-29-1	LOK	PF	30-40	1.2500	1.5000		1.0000
L-25-1	LOK	F	35-40	0.0000	0.0000	0.0000	0.0000
L-28-1	LOK	F	35-40	0.0413	0.0000	0.0000	0.0825
R-15-2	LOK	F	35-40	0.3333	1.0000	0.0000	0.0000
L-38-2	LOK	F	35-45	0.0558	0.1117	0.0000	0.0000
L-4-1	LOK	F	35-50	0.6543	0.7767	0.6650	0.0000
L-7-1	LOK	F	40-45	2.9950	2.9950		
L-17-1	LOK	F	45-55	0.3143	1.0000	0.0000	0.0000
L-21-1	LOK	F	50+	0.7340	1.4450	0.3350	0.0000
L-38-1	LOK	PF	50+	0.2857	0.3333	0.0000	0.5000
L-10-1	LOK	M	20-25	0.1193	0.2783	0.0000	0.0000
L-10-2	LOK	M	20-25	0.0000	0.0000	0.0000	0.0000
L-22-2 (labelled 22D)	LOK	M	20-25	0.0000		0.0000	0.0000
L-23-1	LOK	M	20-25	0.0670	0.0000	0.1675	0.0000
L-13-1	LOK	M	25-30	0.6663	0.7500	0.0000	0.0000
L-31-2-1	LOK	M	25-30	0.0000			0.0000
L-44-1	LOK	M	30-39	0.0838	0.1675	0.0000	0.0000
L-44-2	LOK	M	30-39	0.0000	0.0000	0.0000	0.0000
R-6-1-1	LOK	M	35-39	0.0957	0.2233	0.0000	0.0000
R-6-2-1	LOK	M	35-39	0.5770	1.6117	0.1675	0.1675

Individual	Cemetery	Sex	Age	Knee Index	Anterior Knee Index	Medial Knee Index	Lateral Knee Index
L-30-1-1	LOK	M	35-40	0.0000	0.0000	0.0000	0.0000
L-30-2-1	LOK	M	35-40	0.1429	0.3333	0.0000	0.0000
L-33-1	LOK	M	35-45	0.8608	1.0000	0.7500	0.6650
L-20-2	LOK	M	35-50	0.0000	0.0000	0.0000	0.0000
L-24-2	LOK	M	40-45	0.5990	1.3300	0.0000	0.8325
L-8-1	LOK	M	40-45	1.8738	4.3250	0.5000	1.3350
L-42-1	LOK	M	40-50	0.0000	0.0000	0.0000	0.0000
L-24-5-2	LOK	M	45-50	1.5688	1.0000	1.4950	3.6700
L-16-1-1	LOK	M	45-55	0.9986	1.2200	0.6650	1.0000
L-11-1-1	LOK	M	50+	2.8000	9.0000	1.2500	1.2500
L-19-1	LOK	M	50+	0.0000	0.0000	0.0000	0.0000
R-7-1	LOK	M	50+	1.4865	1.6633	1.2500	1.5000
L-40-1	LOK	M	20+	0.0000	0.0000	0.0000	0.0000
L-2-1-1	LOK	U	20-25	0.0000	0.0000	0.0000	0.0000
L-2-2	LOK	U	35-39	0.0000	0.0000	0.0000	0.0000
L-31-1-1	LOK	U	35-50	0.1650	0.1650		
40-1	UID	F	25-30	0.0000	0.0000		
20-2	UID	F	30-40	0.3333	1.0000	0.0000	0.0000
11-1-1	UID	F	35-50	0.6700	0.6700		
30-1-1	UID	F	50+	0.0000	0.0000	0.0000	0.0000
52-1-1	UID	F	60+	2.0000	2.0000		
20-1	UID	M	18-24	0.0000	0.0000	0.0000	0.0000
43-1	UID	M	19-25	0.0000		0.0000	0.0000
45-1	UID	M	22-30	1.0000	1.0000		
16-1-1	UID	M	25-34	0.0000	0.0000		0.0000
19-1	UID	M	30-34	0.0000	0.0000	0.0000	0.0000
38-1	UID	M	35-45	0.7286	1.1667	1.0000	0.0000
41-1-1	UID	M	35-50	0.7938	0.8350	0.8350	1.0000
12-1-1	UID	M	35-50	0.3350	0.6700	0.0000	0.0000
6-1-1-	UID	M	35-50	0.8058	0.8333	0.8350	0.7500
48-1	UID	M	50+	0.6700		0.6700	
54-1-1	UID	M	50+	0.0000	0.0000		
29-1-1	UID	M	50+	0.7783	0.7783		

APPENDIX G. LUMBAR VOA INDICES

Individual	Cemetery	Sex	Age	Lumbar VOA Index
33-1	SHA	M	35-45	0.2000
34-1	SHA	M	35-45	0.0000
39-1	SHA	M	40-44	0.0500
41-1	SHA	M	30-39	0.0000
42-1	SHA	F	40-45	0.1500
42-2	SHA	F	50+	0.0000
43-1	SHA	PF	35-50	0.9500
45-1	SHA	M	25-34	0.1667
46-1	SHA	M	25-29	0.0000
47-1	SHA	F	20-25	0.0000
48-1	SHA	M	50+	0.6667
50-1	SHA	M	25-34	0.0000
50-2	SHA	M	25-29	0.0625
50-3	SHA	M	30-40	0.2000
51-1	SHA	M	20-25	0.0000
53-1	SHA	M	20-25	0.0000
53-2	SHA	M	50+	0.0833
54-1	SHA	F	17-21	0.0000
55-1	SHA	M	35-39	0.0000
57-1	SHA	F	25-29	0.0500
59-1	SHA	M	35-39	0.0000
60-1	SHA	M	50+	0.0500
61-1	SHA	F	25-29	0.0000
61-2	SHA	M	35-45	0.0000
62-5	SHA	M	45-59	0.5417
63-1	SHA	M	25-29	0.2917
63-2	SHA	M	25-34	0.0000
64-1	SHA	M	30-39	0.1000
65-1	SHA	M	50 +	1.9000
66-1	SHA	F	25-34	0.0833
69-1	SHA	F	25-34	0.9167
69-2	SHA	F	20-25	0.0000
70-1	SHA	M	40-50	0.5000
71-1	SHA	M	35-45	0.3083
75-1	SHA	M	25-29	0.3000
85-1	SHA	M	25-34	0.0000
96-2	SHA	F	30-34	0.2000

Individual	Cemetery	Sex	Age	Lumbar VOA Index
14-1	SHA	M	25-30	0.2500
18-1	SHA	M	25-29	0.0000
21-1	SHA	M	25-30	0.5000
22-1	SHA	M	19-22	0.1667
24-1	SHA	M	25-34	0.4000
27-1	SHA	M	35-50	0.9500
29-1	SHA	M	20-30	0.0000
14-2	SHA	F	20-25	0.0000
21-2	SHA	M	25-30	0.0625
27-2	SHA	M	25-30	0.0000
7-1	SHA	PF	20-30	0.0000
8-1	SHA	M	35-40	0.3000
10-1	SHA	M	25-34	0.0000
104-1	SHA	F	25-34	0.0000
108-1	SHA	M	35-50	0.6250
108-3	SHA	M	25-34	0.0000
112-1	SHA	M	25-34	0.0000
83 (a-robust)	SHA	M	20-22	0.0000
L-10-1	LOK	M	20-25	0.0000
L-10-2	LOK	M	20-25	0.0000
L-10-3	LOK	M	25-30	0.5250
L-10-4	LOK	M	30-34	1.0000
L-11-1-1	LOK	M	50+	0.1667
L-12-1	LOK	F	18-22	0.0000
L-13-1	LOK	M	25-30	0.3750
L-16-1-1	LOK	M	45-55	0.6667
L-17-1	LOK	F	45-55	0.0000
L-19-1	LOK	M	50+	0.3250
L-2-1-1	LOK	U	20-25	0.0000
L-2-3	LOK	F	25-34	0.6250
L-2-4	LOK	U	25-34	0.8125
L-20-1	LOK	F	20-29	0.2500
L-20-2	LOK	M	35-50	1.0250
L-22-3 (labelled 22K2)	LOK	M	20-25	0.9167
L-23-1	LOK	M	20-25	0.0000
L-24-6	LOK	F	25-34	1.0250
L-25-1	LOK	F	35-40	0.0000
L-25-2	LOK	F	20-22	0.2083

Individual	Cemetery	Sex	Age	Lumbar VOA Index
L-25-3	LOK	F	25-34	0.9167
L-26-1	LOK	M	20+	0.3333
L-28-1	LOK	F	35-40	0.1500
L-29-1	LOK	PF	30-40	0.8500
L-30-2-1	LOK	M	35-40	0.4375
L-31-1-1	LOK	U	35-50	0.0000
L-33-1	LOK	M	35-45	0.5000
L-36-1	LOK	F	20-25	0.2667
L-37-1-1	LOK	F	25-29	0.4000
L-38-1	LOK	PF	50+	2.1667
L-38-2	LOK	F	35-45	0.5000
L-39-1	LOK	F	20-25	0.5000
L-44-1	LOK	M	30-39	0.1667
L-7-1	LOK	F	40-45	2.6250
L-8-1	LOK	M	40-45	1.6667
R-1-1-1	LOK	M	30-34	0.6250
R-11-1	LOK	F	20-25	0.5556
R-14-1	LOK	M	30-39	1.0000
R-6-1-1	LOK	M	35-39	0.3000
R-6-2-1	LOK	M	35-39	0.0500
38-1	UID	M	35-45	1.1667
41-1-1	UID	M	35-50	0.0000
42-1-1	UID	F	50+	0.6333
45-1	UID	M	22-30	1.0000
47-1-1	UID	M	30-40	0.2222
48-1	UID	M	50+	0.1250
52-1-1	UID	F	60+	0.5000
54-1-1	UID	M	50+	1.2500
12-1-1	UID	M	35-50	0.4167
19-1	UID	M	30-34	0.0625
20-1	UID	M	18-24	0.0000
16-1-1	UID	M	25-34	0.0000
16-2-1	UID	M	25-34	0.0500
29-1-1	UID	M	50+	1.2500

INDEX 8. LUMBAR OVB INDICES

Individual	Cemetery	Sex	Age	Lumbar OVB Index
33-1	SHA	M	35-45	0.0000
34-1	SHA	M	35-45	0.5833
41-1	SHA	M	30-39	0.7500
42-1	SHA	F	40-45	1.9000
42-2	SHA	F	50+	0.0000
43-1	SHA	PF	35-50	1.7500
46-1	SHA	M	25-29	1.6667
47-1	SHA	F	20-25	0.6667
50-1	SHA	M	25-34	0.0000
50-2	SHA	M	25-29	0.0000
50-3	SHA	M	30-40	1.8750
54-1	SHA	F	17-21	0.0000
57-1	SHA	F	25-29	0.1667
60-1	SHA	M	50+	1.5000
64-1	SHA	M	30-39	0.1250
66-1	SHA	F	25-34	0.0000
69-1	SHA	F	25-34	1.4000
69-2	SHA	F	20-25	0.0000
71-1	SHA	M	35-45	0.3333
75-1	SHA	M	25-29	0.0000
14-1	SHA	M	25-30	0.0000
18-1	SHA	M	25-29	0.3333
21-1	SHA	M	25-30	0.0000
24-1	SHA	M	25-34	0.2000
27-1	SHA	M	35-50	1.4000
29-1	SHA	M	20-30	1.6250
21-2	SHA	M	25-30	0.0000
7-1	SHA	PF	20-30	0.0000
8-1	SHA	M	35-40	1.4000
10-1	SHA	M	25-34	1.2500
104-1	SHA	F	25-34	0.0000
108-1	SHA	M	35-50	0.5000
108-3	SHA	M	25-34	0.0000
83 (a-robust)	SHA	M	20-22	0.0000
L-10-2	LOK	M	20-25	0.0000
L-11-1-1	LOK	M	50+	1.8333
L-12-1	LOK	F	18-22	0.0000

Individual	Cemetery	Sex	Age	Lumbar OVB Index
L-13-1	LOK	M	25-30	0.8750
L-16-1-1	LOK	M	45-55	0.8750
L-17-1	LOK	F	45-55	0.6000
L-20-1	LOK	F	20-29	1.0000
L-20-2	LOK	M	35-50	0.8333
L-24-6	LOK	F	25-34	0.2500
L-28-1	LOK	F	35-40	1.3333
L-36-1	LOK	F	20-25	1.1250
L-37-1-1	LOK	F	25-29	0.0000
L-38-1	LOK	PF	50+	1.1667
L-39-1	LOK	F	20-25	0.0000
38-1	UID	M	35-45	2.0000
41-1-1	UID	M	35-50	1.0000
42-1-1	UID	F	50+	1.0000
48-1	UID	M	50+	0.3333
52-1-1	UID	F	60+	1.5000
54-1-1	UID	M	50+	2.4000
12-1-1	UID	M	35-50	1.5000
19-1	UID	M	30-34	0.0000
20-1	UID	M	18-24	0.0000
16-1-1	UID	M	25-34	0.0000
16-2-1	UID	M	25-34	1.2000
29-1-1	UID	M	50+	1.5000

APPENDIX H. MT1-1ST PROXIMAL PHALANX INDICES

Individual	Cemetery	Sex	Age	MT1-1st Proximal Phalanx Index
54-1	SHA	F	17-21	0.0000
25-1	SHA	F	20-22	0.0000
47-1	SHA	F	20-25	0.0000
69-2	SHA	F	20-25	0.0000
14-2	SHA	F	20-25	0.0000
61-1	SHA	F	25-29	0.0000
66-1	SHA	F	25-34	0.0000
69-1	SHA	F	25-34	0.0000
104-1	SHA	F	25-34	0.6700
96-2	SHA	F	30-34	0.0000
7-1	SHA	FP	20-30	0.1650
60-2	SHA	F	40-44	0.0000
42-1	SHA	F	40-45	1.0000
42-2	SHA	F	50+	0.0000
62-1	SHA	FP	35-45	0.0000
43-1	SHA	FP	35-50	0.0000
79-1	SHA	FP	35-50	0.8300
62-3	SHA	FP	20+	3.5050
26-1	SHA	FP	20+	1.5050
23-2	SHA	FP	20+	0.0000
16-1	SHA	U	20-25	0.5000
12-1	SHA	U	20-34	0.0000
44-2	SHA	U	20+	0.1650
23-4	SHA	U	20+	3.0000
23-5	SHA	U	20+	0.0000
108-2	SHA	U	20+	0.0000
78- Leg Set #1 (arthritic ind)	SHA			3.6700
22-1	SHA	M	19-22	0.0000
17-2	SHA	M	20-22	0.0000
83 (a-robust)	SHA	M	20-22	0.0000
51-1	SHA	M	20-25	0.0000
53-1	SHA	M	20-25	0.0000
29-1	SHA	M	20-30	0.0000
46-1	SHA	M	25-29	3.1550
50-2	SHA	M	25-29	0.3300
63-1	SHA	M	25-29	0.0000

Individual	Cemetery	Sex	Age	MT1-1st Proximal Phalanx Index
75-1	SHA	M	25-29	0.0000
18-1	SHA	M	25-29	0.0000
14-1	SHA	M	25-30	0.0000
19-1	SHA	M	25-30	0.0000
21-1	SHA	M	25-30	0.0000
21-2	SHA	M	25-30	0.1650
27-2	SHA	M	25-30	0.0000
45-1	SHA	M	25-34	0.0000
50-1	SHA	M	25-34	0.0000
63-2	SHA	M	25-34	0.6700
15-1	SHA	M	25-34	0.6650
108-3	SHA	M	25-34	1.3300
112-1	SHA	M	25-34	0.0000
41-1	SHA	M	30-39	2.8300
64-1	SHA	M	30-39	0.0000
50-3	SHA	M	30-40	3.3250
17-1	SHA	M	30-40	1.9950
11-2	SHA	M	30-40	3.6700
52-1	SHA	MP	20-24	0.1650
55-1	SHA	M	35-39	0.3350
59-1	SHA	M	35-39	0.0000
8-1	SHA	M	35-40	1.0000
32-1	SHA	M	35-45	3.6600
33-1	SHA	M	35-45	0.0000
34-1	SHA	M	35-45	1.1650
58-1	SHA	M	35-45	5.3500
61-2	SHA	M	35-45	0.0000
62-2	SHA	M	35-45	3.6700
71-1	SHA	M	35-45	3.6600
27-1	SHA	M	35-50	2.8250
30-1	SHA	M	35-50	0.6650
13-2	SHA	M	35-50	0.6700
108-1	SHA	M	35-50	1.3350
39-1	SHA	M	40-44	4.8450
70-1	SHA	M	40-50	0.0000
68-1	SHA	M	45-49	0.0000
62-5	SHA	M	45-59	4.5000

Individual	Cemetery	Sex	Age	MT1-1st Proximal Phalanx Index
65-1	SHA	M	50 +	4.0100
53-2	SHA	M	50+	5.5200
60-1	SHA	M	50+	1.0000
23-1 (23 BR)- box 1/2	SHA	MP	35-45	2.1600
44-1	SHA	MP	50+	0.5000
62-4	SHA	MP	20+	3.0050
26-2	SHA	MP	20+	0.0000
L-12-1	LOK	F	18-22	0.0000
L-36-1	LOK	F	20-25	0.0000
L-39-1	LOK	F	20-25	0.0000
R-11-1	LOK	F	20-25	0.3350
L-20-1	LOK	F	20-29	0.0000
L-37-1-1	LOK	F	25-29	0.0000
L-14-1	LOK	F	25-30	0.0000
L-24-6	LOK	F	25-34	0.0000
L-25-3	LOK	F	25-34	1.9950
L-7-1	LOK	F	40-45	1.5000
L-17-1	LOK	F	45-55	0.0000
L-38-1	LOK	PF	50+	0.0000
L-41-3	LOK	U	20+	0.6600
L-2-2	LOK	U	35-39	0.0000
L-10-1	LOK	M	20-25	0.0000
L-10-2	LOK	M	20-25	0.0000
L-22-2 (labelled 22D)	LOK	M	20-25	0.0000
L-15-1	LOK	M	20-34	0.0000
L-31-2-1	LOK	M	25-30	0.0000
L-10-4	LOK	M	30-34	4.3300
L-44-2	LOK	M	30-39	0.0000
R-6-1-1	LOK	M	35-39	1.0000
R-6-2-1	LOK	M	35-39	2.4950
L-30-1-1	LOK	M	35-40	0.0000
L-33-1	LOK	M	35-45	0.6650
L-20-2	LOK	M	35-50	0.0000
L-25-5	LOK	M	35-50	0.0000
L-24-2	LOK	M	40-45	0.0000
L-42-1	LOK	M	40-50	0.0000
L-16-1-1	LOK	M	45-55	2.8250

Individual	Cemetery	Sex	Age	MT1-1st Proximal Phalanx Index
L-11-1-1	LOK	M	50+	8.5050
L-19-1	LOK	M	50+	0.0000
20-1	UID	M	18-24	0.0000
19-1	UID	M	30-34	3.8400
38-1	UID	M	35-45	1.0000
41-1-1	UID	M	35-50	3.3400
6-1-1	UID	M	35-50	1.0000

APPENDIX I. SHOULDER INDICES

Individual	Cemetery	Sex	Age	Left Shoulder Index	Right Shoulder Index
54-1	SHA	F	17-21	0.0000	0.0000
25-1	SHA	F	20-22		0.0000
47-1	SHA	F	20-25	0.0000	0.0000
69-2	SHA	F	20-25	0.0000	0.0000
14-2	SHA	F	20-25	0.0000	0.0000
57-1	SHA	F	25-29	0.0000	0.0000
61-1	SHA	F	25-29	0.0000	0.0000
57-2	SHA	F	25-34	0.0000	
66-1	SHA	F	25-34	0.0000	0.0000
69-1	SHA	F	25-34	0.0000	0.4433
104-1	SHA	F	25-34	0.0000	0.0000
96-2	SHA	F	30-34	0.0000	0.0000
7-1	SHA	FP	20-30	0.0000	0.0000
60-2	SHA	F	40-44	0.0000	0.0000
42-1	SHA	F	40-45	0.3333	1.0000
42-2	SHA	F	50+	1.3300	0.0000
79-1	SHA	FP	35-50	0.0000	0.0000
16-1	SHA	U	20-25	0.0000	
12-1	SHA	U	20-34	0.0000	0.0000
108-2	SHA	U	20+	0.0000	
22-1	SHA	M	19-22	0.0000	0.0000
17-2	SHA	M	20-22	0.0000	0.0000
83 (a-robust)	SHA	M	20-22	0.0000	0.0000
51-1	SHA	M	20-25	0.0000	0.0000
53-1	SHA	M	20-25	0.0000	0.0000
29-1	SHA	M	20-30	0.0000	0.0000
46-1	SHA	M	25-29	0.0000	0.2500
50-2	SHA	M	25-29	0.0000	
63-1	SHA	M	25-29	0.0000	0.0000
75-1	SHA	M	25-29	0.0000	0.0000
18-1	SHA	M	25-29	0.0000	0.0000
14-1	SHA	M	25-30	0.0000	0.0000
19-1	SHA	M	25-30	0.2233	0.0000
21-1	SHA	M	25-30	0.0000	0.0000
21-2	SHA	M	25-30	0.6700	1.0050
27-2	SHA	M	25-30	0.0000	0.0000

Individual	Cemetery	Sex	Age	Left Shoulder Index	Right Shoulder Index
45-1	SHA	M	25-34	0.0000	0.0000
50-1	SHA	M	25-34	0.0000	0.0000
63-2	SHA	M	25-34	0.0000	0.0000
85-1	SHA	M	25-34	0.0000	0.0000
15-1	SHA	M	25-34	1.3333	0.0000
24-1	SHA	M	25-34		0.2475
10-1	SHA	M	25-34	0.5000	
108-3	SHA	M	25-34	0.0000	0.0000
112-1	SHA	M	25-34		0.0000
41-1	SHA	M	30-39	0.0000	0.0000
64-1	SHA	M	30-39	0.0000	0.0000
50-3	SHA	M	30-40	0.8300	0.8350
17-1	SHA	M	30-40		0.3333
11-2	SHA	M	30-40		0.1100
55-1	SHA	M	35-39	0.0000	1.0000
59-1	SHA	M	35-39	0.0000	0.0000
8-1	SHA	M	35-40	0.3333	0.7500
32-1	SHA	M	35-45	0.2200	0.6625
33-1	SHA	M	35-45	0.0000	0.0000
34-1	SHA	M	35-45	0.0000	0.2500
58-1	SHA	M	35-45	0.5000	0.5000
61-2	SHA	M	35-45	1.2525	2.2233
71-1	SHA	M	35-45	0.0000	0.2500
27-1	SHA	M	35-50	0.4150	0.6675
30-1	SHA	M	35-50	0.0000	
108-1	SHA	M	35-50	1.4975	2.0000
39-1	SHA	M	40-44	0.0000	0.0000
70-1	SHA	M	40-50	0.5000	0.0000
62-5	SHA	M	45-59	0.0000	0.4175
65-1	SHA	M	50 +	0.8867	
48-1	SHA	M	50+	0.2500	0.5000
53-2	SHA	M	50+	0.0000	0.0000
60-1	SHA	M	50+	0.0000	0.0000
23-1 (23 BR)-box 1/2	SHA	MP	35-45	2.0000	2.0000
L-12-1	LOK	F	18-22	0.0000	0.0000
L-25-2	LOK	F	20-22	0.0000	
L-36-1	LOK	F	20-25	0.0000	0.0000

Individual	Cemetery	Sex	Age	Left Shoulder Index	Right Shoulder Index
L-39-1	LOK	F	20-25	0.0000	0.0000
R-11-1	LOK	F	20-25	0.0000	0.0000
L-20-1	LOK	F	20-29		0.0000
R-15-1	LOK	F	20-34		0.0000
L-37-1-1	LOK	F	25-29	0.0000	0.0000
L-14-1	LOK	F	25-30	0.0000	0.0000
L-2-3	LOK	F	25-34	0.0000	0.6667
L-24-6	LOK	F	25-34	0.0000	0.0000
L-25-3	LOK	F	25-34	0.4433	0.9900
L-25-1	LOK	F	35-40	0.0000	
L-28-1	LOK	F	35-40	0.0000	0.0000
R-15-2	LOK	F	35-40	0.0000	0.0000
L-38-2	LOK	F	35-45	0.0000	0.0000
L-4-1	LOK	F	35-50		1.3300
L-7-1	LOK	F	40-45	1.4950	2.1700
L-17-1	LOK	F	45-55	0.2500	0.2500
L-18-1	LOK	F	50+	0.0000	
L-21-1	LOK	F	50+	0.0000	1.6600
L-38-1	LOK	FP	50+	0.3350	0.4467
L-2-1-1	LOK	U	20-25	0.0000	
L-2-4	LOK	U	25-34	0.0000	0.3350
L-10-1	LOK	M	20-25		0.0000
L-10-2	LOK	M	20-25	0.0000	0.0000
L-22-2 (labelled 22D)	LOK	M	20-25	0.0000	0.0000
L-22-3 (labelled 22K2)	LOK	M	20-25		0.0000
L-23-1	LOK	M	20-25	0.0000	0.0000
L-10-3	LOK	M	25-30	0.0000	0.0000
L-31-2-1	LOK	M	25-30	0.8350	0.0000
R-1-1-1	LOK	M	30-34	0.6600	1.0000
L-10-4	LOK	M	30-34	0.0000	0.0000
L-44-1	LOK	M	30-39	0.6650	0.1100
L-44-2	LOK	M	30-39	0.0000	0.5000
R-14-1	LOK	M	30-39	1.3300	1.0000
R-6-1-1	LOK	M	35-39	2.0000	0.0000
R-6-2-1	LOK	M	35-39	0.7500	1.0000
L-30-2-1	LOK	M	35-40	0.0000	

Individual	Cemetery	Sex	Age	Left Shoulder Index	Right Shoulder Index
L-20-2	LOK	M	35-50	0.9150	1.5000
L-25-5	LOK	M	35-50		0.0000
L-24-2	LOK	M	40-45	0.4150	0.6650
L-8-1	LOK	M	40-45	0.6650	1.3300
L-42-1	LOK	M	40-50	0.0000	
L-24-5-2	LOK	M	45-50	1.0000	0.4433
L-16-1-1	LOK	M	45-55	0.4175	0.6675
L-11-1-1	LOK	M	50+	0.0000	0.4433
L-19-1	LOK	M	50+	0.5000	0.0000
R-7-1	LOK	M	50+	2.1133	0.8350
39-1-1	UID	F	25-34	0.6700	
20-2	UID	F	30-40	0.0000	0.0000
11-1-1	UID	F	35-50	0.6700	0.6700
36-1-2	UID	F	40-50	0.0000	0.0000
42-1-1	UID	F	50+	1.0000	1.2233
52-1-1	UID	F	60+	1.8867	2.0000
20-1	UID	M	18-24	0.0000	0.0000
43-1	UID	M	19-25	0.0000	0.0000
45-1	UID	M	22-30	0.0000	0.0000
16-1-1	UID	M	25-34	0.0000	0.0000
16-2-1	UID	M	25-34	0.0000	0.0000
19-1	UID	M	30-34	0.3333	0.0000
38-1	UID	M	35-45	0.0000	0.0000
41-1-1	UID	M	35-50	0.0000	0.0000
56-1	UID	M	35-50		1.0000
12-1-1	UID	M	35-50	1.3333	1.3333
6-1-1-	UID	M	35-50	0.6667	1.1650
48-1	UID	M	50+	0.0000	0.7767
54-1-1	UID	M	50+	3.6700	3.6700
29-1-1	UID	M	50+	0.2233	0.8350

SHOULDER 11. THORACIC VOA INDICES

Individual	Cemetery	Sex	Age	Thoracic VOA Index
33-1	SHA	M	35-45	0.0000
34-1	SHA	M	35-45	0.0000
39-1	SHA	M	40-44	0.1250
41-1	SHA	M	30-39	0.1042
42-1	SHA	F	40-45	0.2083
42-2	SHA	F	50+	0.0625
46-1	SHA	M	25-29	0.0000
47-1	SHA	F	20-25	0.0795
48-1	SHA	M	50+	0.5000
50-1	SHA	M	25-34	0.0000
51-1	SHA	M	20-25	0.0000
53-1	SHA	M	20-25	0.0000
53-2	SHA	M	50+	1.3333
54-1	SHA	F	17-21	0.0000
55-1	SHA	M	35-39	0.1250
57-1	SHA	F	25-29	0.0000
57-2	SHA	F	25-34	0.0000
58-1	SHA	M	35-45	0.2222
59-1	SHA	M	35-39	0.0455
60-1	SHA	M	50+	0.5313
61-1	SHA	F	25-29	0.0000
61-2	SHA	M	35-45	0.0648
63-1	SHA	M	25-29	0.0313
63-2	SHA	M	25-34	0.1042
64-1	SHA	M	30-39	0.4773
65-1	SHA	M	50 +	0.8182
66-1	SHA	F	25-34	0.0000
69-1	SHA	F	25-34	0.9444
69-2	SHA	F	20-25	0.0000
70-1	SHA	M	40-50	0.6458
71-1	SHA	M	35-45	0.0682
75-1	SHA	M	25-29	0.1750
79-1	SHA	PF	35-50	0.0000
85-1	SHA	M	25-34	0.0500
96-2	SHA	F	30-34	0.0000
17-1	SHA	M	30-40	0.4286
18-1	SHA	M	25-29	0.0000

Individual	Cemetery	Sex	Age	Thoracic VOA Index
19-1	SHA	M	25-30	0.1500
21-1	SHA	M	25-30	0.0909
22-1	SHA	M	19-22	0.0625
24-1	SHA	M	25-34	0.6136
27-1	SHA	M	35-50	1.8646
29-1	SHA	M	20-30	0.6250
30-1	SHA	M	35-50	1.1500
14-2	SHA	F	20-25	0.0000
21-2	SHA	M	25-30	1.1389
27-2	SHA	M	25-30	0.0000
7-1	SHA	PF	20-30	0.0500
8-1	SHA	M	35-40	0.2955
10-1	SHA	M	25-34	0.4643
11-2	SHA	M	30-40	0.6250
104-1	SHA	F	25-34	0.0208
108-1	SHA	M	35-50	0.2750
108-3	SHA	M	25-34	0.1364
23-1 (23 BR)- box 1/2	SHA	PM	35-45	0.1481
83 (a-robust)	SHA	M	20-22	0.0000
L-10-2	LOK	M	20-25	0.0625
L-10-3	LOK	M	25-30	0.1705
L-10-4	LOK	M	30-34	2.1042
L-11-1-1	LOK	M	50+	0.2917
L-12-1	LOK	F	18-22	0.4545
L-16-1-1	LOK	M	45-55	0.1563
L-17-1	LOK	F	45-55	0.1591
L-19-1	LOK	M	50+	1.1742
L-2-1-1	LOK	U	20-25	0.9167
L-2-3	LOK	F	25-34	0.5694
L-2-4	LOK	U	25-34	0.2222
L-20-1	LOK	F	20-29	1.2879
L-20-2	LOK	M	35-50	0.5000
L-24-5-2	LOK	M	45-50	1.4500
L-24-6	LOK	F	25-34	0.7917
L-25-2	LOK	F	20-22	0.7955
L-25-3	LOK	F	25-34	0.6042
L-28-1	LOK	F	35-40	0.9219
L-29-1	LOK	PF	30-40	0.9306

Individual	Cemetery	Sex	Age	Thoracic VOA Index
L-30-2-1	LOK	M	35-40	0.5208
L-33-1	LOK	M	35-45	0.2500
L-36-1	LOK	F	20-25	0.2727
L-37-1-1	LOK	F	25-29	0.6136
L-38-1	LOK	PF	50+	0.4250
L-38-2	LOK	F	35-45	0.5000
L-39-1	LOK	F	20-25	0.6071
L-43-2	LOK	F	20-29	0.2917
L-44-1	LOK	M	30-39	1.5000
L-44-2	LOK	M	30-39	0.5238
L-8-1	LOK	M	40-45	0.9107
R-1-1-1	LOK	M	30-34	0.8636
R-11-1	LOK	F	20-25	0.5667
R-6-1-1	LOK	M	35-39	0.3500
R-6-2-1	LOK	M	35-39	0.7500
36-1-2	UID	F	40-50	0.4643
41-1-1	UID	M	35-50	0.0000
42-1-1	UID	F	50+	0.2917
45-1	UID	M	22-30	0.5625
48-1	UID	M	50+	0.0000
52-1-1	UID	F	60+	0.3958
54-1-1	UID	M	50+	0.8698
12-1-1	UID	M	35-50	0.3229
19-1	UID	M	30-34	0.4875
20-2	UID	F	30-40	0.0000
16-1-1	UID	M	25-34	0.0000
16-2-1	UID	M	25-34	0.1591
29-1-1	UID	M	50+	0.5938

APPENDIX J. THORACIC OVB INDICES

Individual	Cemetery	Sex	Age	Thoracic OVB Index
33-1	SHA	M	35-45	0.0000
34-1	SHA	M	35-45	0.5909
39-1	SHA	M	40-44	1.5714
41-1	SHA	M	30-39	0.6000
42-1	SHA	F	40-45	1.9583
46-1	SHA	M	25-29	0.2500
47-1	SHA	F	20-25	0.4286
50-1	SHA	M	25-34	0.0000
51-1	SHA	M	20-25	0.0000
54-1	SHA	F	17-21	0.0000
55-1	SHA	M	35-39	0.1429
57-1	SHA	F	25-29	0.7143
57-2	SHA	F	25-34	0.0000
61-2	SHA	M	35-45	1.0000
64-1	SHA	M	30-39	0.2500
66-1	SHA	F	25-34	0.0000
69-1	SHA	F	25-34	0.7500
69-2	SHA	F	20-25	0.3182
71-1	SHA	M	35-45	0.1500
75-1	SHA	M	25-29	0.0000
18-1	SHA	M	25-29	0.1429
19-1	SHA	M	25-30	0.4375
21-1	SHA	M	25-30	0.0000
24-1	SHA	M	25-34	0.2727
27-1	SHA	M	35-50	0.7083
29-1	SHA	M	20-30	0.7143
21-2	SHA	M	25-30	0.0417
7-1	SHA	PF	20-30	0.0000
8-1	SHA	M	35-40	0.8636
10-1	SHA	M	25-34	0.7500
11-2	SHA	M	30-40	0.7500
104-1	SHA	F	25-34	0.0000
108-1	SHA	M	35-50	0.2778
83 (a-robust)	SHA	M	20-22	0.0000
L-10-2	LOK	M	20-25	0.0000
L-10-3	LOK	M	25-30	0.0000
L-11-1-1	LOK	M	50+	2.0000

Individual	Cemetery	Sex	Age	Thoracic OVB Index
L-12-1	LOK	F	18-22	0.0000
L-16-1-1	LOK	M	45-55	0.3750
L-17-1	LOK	F	45-55	0.9091
L-19-1	LOK	M	50+	0.1667
L-20-1	LOK	F	20-29	0.6250
L-20-2	LOK	M	35-50	1.5625
L-24-6	LOK	F	25-34	0.3333
L-36-1	LOK	F	20-25	0.6250
L-37-1-1	LOK	F	25-29	0.3636
L-38-1	LOK	PF	50+	0.8000
L-38-2	LOK	F	35-45	0.8750
L-39-1	LOK	F	20-25	0.7143
R-1-1-1	LOK	M	30-34	1.5455
R-6-1-1	LOK	M	35-39	1.3750
R-6-2-1	LOK	M	35-39	0.0000
36-1-2	UID	F	40-50	1.1667
41-1-1	UID	M	35-50	1.2143
54-1-1	UID	M	50+	1.1875
19-1	UID	M	30-34	1.5000
16-1-1	UID	M	25-34	0.0000
16-2-1	UID	M	25-34	1.2727

APPENDIX K. TMJ INDICES

Individual	Cemetery	Sex	Age	TMJ Index
54-1	SHA	F	17-21	0.0000
47-1	SHA	F	20-25	0.0000
69-2	SHA	F	20-25	0.0000
14-2	SHA	F	20-25	0.0000
20-2	SHA	F	20-34	0.0000
57-1	SHA	F	25-29	0.0000
61-1	SHA	F	25-29	0.0000
57-2	SHA	F	25-34	0.0000
66-1	SHA	F	25-34	0.0000
69-1	SHA	F	25-34	1.3375
78-2	SHA	F	25-34	0.0000
104-1	SHA	F	25-34	0.0000
96-2	SHA	F	30-34	0.0000
7-1	SHA	FP	20-30	0.0000
20-3	SHA	FP	20-34	0.0000
13-1	SHA	FP	25-34	0.0000
60-2	SHA	F	40-44	0.0000
42-1	SHA	F	40-45	0.0000
42-2	SHA	F	50+	0.0000
78-4	SHA	FP	35-50	0.0000
12-1	SHA	U	20-34	0.0000
22-1	SHA	M	19-22	0.0000
51-1	SHA	M	20-25	0.0000
53-1	SHA	M	20-25	0.0000
78-3	SHA	M	20-25	0.0000
29-1	SHA	M	20-30	0.0000
46-1	SHA	M	25-29	0.0000
50-2	SHA	M	25-29	0.0000
63-1	SHA	M	25-29	0.0000
75-1	SHA	M	25-29	0.0000
14-1	SHA	M	25-30	0.0000
19-1	SHA	M	25-30	0.0000
21-1	SHA	M	25-30	0.0000
21-2	SHA	M	25-30	0.0000
35-1	SHA	M	25-34	0.0000
45-1	SHA	M	25-34	0.0000
50-1	SHA	M	25-34	0.0000

Individual	Cemetery	Sex	Age	TMJ Index
63-2	SHA	M	25-34	0.0000
85-1	SHA	M	25-34	0.0000
15-1	SHA	M	25-34	0.0000
24-1	SHA	M	25-34	0.0000
10-1	SHA	M	25-34	0.0000
108-3	SHA	M	25-34	0.0000
41-1	SHA	M	30-39	0.0000
64-1	SHA	M	30-39	0.0000
17-1	SHA	M	30-40	0.1650
11-2	SHA	M	30-40	0.0000
52-1	SHA	MP	20-24	0.0000
36-1	SHA	MP	25-34	0.0000
55-1	SHA	M	35-39	0.0000
8-1	SHA	M	35-40	0.0000
32-1	SHA	M	35-45	0.1650
33-1	SHA	M	35-45	0.0000
34-1	SHA	M	35-45	0.0000
58-1	SHA	M	35-45	0.0000
61-2	SHA	M	35-45	0.0000
71-1	SHA	M	35-45	0.0000
30-1	SHA	M	35-50	0.0000
13-2	SHA	M	35-50	0.0000
108-1	SHA	M	35-50	0.0000
39-1	SHA	M	40-44	0.0000
70-1	SHA	M	40-50	0.0000
62-5	SHA	M	45-59	0.0000
65-1	SHA	M	50 +	2.7550
48-1	SHA	M	50+	0.0000
53-2	SHA	M	50+	0.0000
23-1 (23 BR)- box 1/2	SHA	MP	35-45	0.0000
44-1	SHA	MP	50+	0.6700
20-1	SHA	M	30-60	0.0000
L-39-1	LOK	F	20-25	0.0000
L-20-1	LOK	F	20-29	0.0000
L-43-2	LOK	F	20-29	0.0000
R-15-1	LOK	F	20-34	0.0000
L-37-1-1	LOK	F	25-29	0.0000
L-14-1	LOK	F	25-30	0.0000

Individual	Cemetery	Sex	Age	TMJ Index
L-24-6	LOK	F	25-34	0.0000
L-28-1	LOK	F	35-40	0.0000
R-15-2	LOK	F	35-40	0.0000
L-34-1	LOK	F	35-45	0.0000
L-38-2	LOK	F	35-45	0.3300
L-4-1	LOK	F	35-50	0.0000
L-7-1	LOK	F	40-45	1.6600
L-18-1	LOK	F	50+	0.0000
L-21-1	LOK	F	50+	0.0000
L-10-1	LOK	M	20-25	0.0000
L-23-1	LOK	M	20-25	0.0000
L-13-1	LOK	M	25-30	0.0000
L-31-2-1	LOK	M	25-30	0.0000
R-14-1	LOK	M	30-39	0.0000
L-30-1-1	LOK	M	35-40	0.0000
L-30-2-1	LOK	M	35-40	0.0000
L-33-1	LOK	M	35-45	0.0000
L-1-1-1	LOK	M	35-50	0.0000
L-20-2	LOK	M	35-50	0.6650
L-25-5	LOK	M	35-50	0.8300
R-2-1-1	LOK	M	35-50	0.0000
L-8-1	LOK	M	40-45	1.2500
L-42-1	LOK	M	40-50	0.0000
L-16-1-1	LOK	M	45-55	1.5025
L-11-1-1	LOK	M	50+	0.4950
L-19-1	LOK	M	50+	0.0000
L-34-1	LOK	U	20+	0.6650
L-31-1-1	LOK	U	35-50	0.0000
20-2	UID	F	30-40	0.0000
11-1-1	UID	F	35-50	0.0000
30-1-1	UID	F	50+	0.0000
20-1	UID	M	18-24	0.0000
16-2-1	UID	M	25-34	0.0000
19-1	UID	M	30-34	0.0000
38-1	UID	M	35-45	0.0000
56-1	UID	M	35-50	0.0000
12-1-1	UID	M	35-50	0.0000
6-1-1-	UID	M	35-50	0.0000

Individual	Cemetery	Sex	Age	TMJ Index
48-1	UID	M	50+	0.0000
29-1-1	UID	M	50+	0.0000
7-1	UID	M	20+	0.0000

APPENDIX L. WRIST INDICES

Individual	Cemetery	Sex	Age	Left Wrist Index	Right Wrist Index
54-1	SHA	F	17-21	0.0000	0.0000
25-1	SHA	F	20-22	0.0000	0.0000
47-1	SHA	F	20-25	0.0000	0.0000
69-2	SHA	F	20-25	0.0000	0.0000
14-2	SHA	F	20-25	0.0000	0.0000
61-1	SHA	F	25-29		0.0000
66-1	SHA	F	25-34	0.0000	0.0000
69-1	SHA	F	25-34	0.3333	0.0000
104-1	SHA	F	25-34	0.5567	0.5567
96-2	SHA	F	30-34	0.0000	0.0000
7-1	SHA	PF	20-30	0.2200	0.3300
60-2	SHA	F	40-44	0.0000	
42-1	SHA	F	40-45	0.5567	0.3350
42-2	SHA	F	50+	0.0000	0.0000
43-1	SHA	PF	35-50	0.0000	0.0000
79-1	SHA	PF	35-50	0.3333	1.0000
16-1	SHA	U	20-25	0.0000	0.0000
12-1	SHA	U	20-34		0.0000
44-2	SHA	U	20+	0.0000	1.0000
108-2	SHA	U	20+	0.0000	0.0000
22-1	SHA	M	19-22	0.0000	0.0000
17-2	SHA	M	20-22	0.0000	0.0000
83 (a-robust)	SHA	M	20-22		0.0000
51-1	SHA	M	20-25	0.0000	0.0000
53-1	SHA	M	20-25	0.0000	0.0000
29-1	SHA	M	20-30	0.0000	0.0000
46-1	SHA	M	25-29	0.3333	2.4467
50-2	SHA	M	25-29	0.1650	0.3333
63-1	SHA	M	25-29	0.0000	0.0000
75-1	SHA	M	25-29	0.2200	0.3333
18-1	SHA	M	25-29	0.0000	0.0000
14-1	SHA	M	25-30	0.4467	0.0000
19-1	SHA	M	25-30	0.2233	0.2233
21-1	SHA	M	25-30	0.0000	0.0000
21-2	SHA	M	25-30	0.4433	0.4433
27-2	SHA	M	25-30	0.0000	0.0000
45-1	SHA	M	25-34	0.0000	0.0000

Individual	Cemetery	Sex	Age	Left Wrist Index	Right Wrist Index
50-1	SHA	M	25-34	0.3350	0.3350
63-2	SHA	M	25-34	0.0000	0.6700
85-1	SHA	M	25-34	0.0000	0.0000
15-1	SHA	M	25-34	0.3333	1.1133
10-1	SHA	M	25-34		0.0000
108-3	SHA	M	25-34	0.3333	0.3333
112-1	SHA	M	25-34	0.0000	0.0000
41-1	SHA	M	30-39	0.4467	0.5567
64-1	SHA	M	30-39	0.7767	0.0000
50-3	SHA	M	30-40	0.4467	0.2233
17-1	SHA	M	30-40	0.5000	0.0000
11-2	SHA	M	30-40	0.0000	0.0000
52-1	SHA	PM	20-24	0.3300	0.3300
55-1	SHA	M	35-39	0.0000	1.9950
59-1	SHA	M	35-39	0.6667	0.1100
8-1	SHA	M	35-40	0.0000	0.0000
32-1	SHA	M	35-45	0.5533	0.0000
33-1	SHA	M	35-45		0.0000
34-1	SHA	M	35-45	0.6667	0.5000
58-1	SHA	M	35-45	3.9950	1.7800
61-2	SHA	M	35-45	0.5533	0.5000
71-1	SHA	M	35-45	0.8350	0.5567
27-1	SHA	M	35-50	0.3350	1.0000
30-1	SHA	M	35-50	0.5000	0.5000
108-1	SHA	M	35-50	0.3333	0.5567
39-1	SHA	M	40-44	0.0000	0.0000
70-1	SHA	M	40-50	0.9967	1.6700
68-1	SHA	M	45-49	0.0000	0.0000
62-5	SHA	M	45-59	0.0000	1.0000
65-1	SHA	M	50 +	1.5000	2.0000
48-1	SHA	M	50+	0.8900	1.1700
53-2	SHA	M	50+	0.6700	0.4467
60-1	SHA	M	50+	0.0000	
23-1 (23 BR)- box 1/2	SHA	PM	35-45		1.0000
44-1	SHA	PM	50+		1.3400
L-12-1	LOK	F	18-22	0.0000	0.0000
L-36-1	LOK	F	20-25	0.3350	2.0000

Individual	Cemetery	Sex	Age	Left Wrist Index	Right Wrist Index
L-39-1	LOK	F	20-25	0.4467	0.3333
R-11-1	LOK	F	20-25	0.0000	0.0000
L-20-1	LOK	F	20-29		0.3333
R-15-1	LOK	F	20-34		
L-37-1-1	LOK	F	25-29	0.2233	0.5000
L-14-1	LOK	F	25-30	0.5000	1.0000
L-2-3	LOK	F	25-34		1.3350
L-24-6	LOK	F	25-34	0.0000	0.3333
L-25-3	LOK	F	25-34	0.3350	0.5000
L-29-1	LOK	PF	30-40	0.0000	1.0000
L-25-1	LOK	F	35-40		0.0000
L-28-1	LOK	F	35-40		0.5000
R-15-2	LOK	F	35-40	0.0000	0.0000
L-34-1	LOK	F	35-45	0.3350	0.0000
L-38-2	LOK	F	35-45	0.7767	2.0000
L-7-1	LOK	F	40-45	1.6700	
L-17-1	LOK	F	45-55	0.3333	0.6667
L-21-1	LOK	F	50+	2.0000	2.0000
L-38-1	LOK	PF	50+	0.5567	0.5000
L-2-1-1	LOK	U	20-25	0.0000	
L-2-4	LOK	U	25-34		1.0000
L-2-2	LOK	U	35-39	0.0000	0.0000
L-10-1	LOK	M	20-25	0.0000	0.0000
L-10-2	LOK	M	20-25	0.0000	0.0000
L-23-1	LOK	M	20-25		0.0000
L-15-1	LOK	M	20-34	0.0000	
L-10-3	LOK	M	25-30	0.6667	
L-13-1	LOK	M	25-30	1.0000	0.5567
L-31-2-1	LOK	M	25-30	0.0000	
R-1-1-1	LOK	M	30-34	0.4433	0.5000
L-10-4	LOK	M	30-34	0.0000	0.0000
L-44-1	LOK	M	30-39	0.5000	2.0000
R-14-1	LOK	M	30-39	1.0000	
R-6-1-1	LOK	M	35-39	2.0000	
R-6-2-1	LOK	M	35-39	0.0000	
L-30-2-1	LOK	M	35-40	1.0000	1.0000
L-33-1	LOK	M	35-45	0.6667	0.6700
L-20-2	LOK	M	35-50	0.3333	1.0000

Individual	Cemetery	Sex	Age	Left Wrist Index	Right Wrist Index
L-25-5	LOK	M	35-50		1.0000
L-24-2	LOK	M	40-45	2.0000	2.0000
L-8-1	LOK	M	40-45	0.5000	1.0000
L-42-1	LOK	M	40-50	0.0000	0.0000
L-16-1-1	LOK	M	45-55	1.0000	1.5000
L-11-1-1	LOK	M	50+	1.0000	1.9950
L-19-1	LOK	M	50+	1.1100	1.0000
R-7-1	LOK	M	50+	1.0000	
40-1	UID	F	25-30	0.3333	1.0000
20-2	UID	F	30-40		0.0000
11-1-1	UID	F	35-50		1.0000
30-1-1	UID	F	50+	0.0000	
42-1-1	UID	F	50+	1.3350	2.0000
52-1-1	UID	F	60+	3.0000	
20-1	UID	M	18-24	0.0000	0.0000
43-1	UID	M	19-25	0.0000	1.0000
16-1-1	UID	M	25-34	0.0000	
16-2-1	UID	M	25-34	0.5567	0.5000
19-1	UID	M	30-34	0.0000	0.6667
47-1-1	UID	M	30-40	1.0000	
38-1	UID	M	35-45	1.6700	0.6650
41-1-1	UID	M	35-50	0.8350	1.0050
12-1-1	UID	M	35-50	1.5000	1.0000
6-1-1-	UID	M	35-50	1.3350	1.1133
48-1	UID	M	50+	1.0000	
29-1-1	UID	M	50+	2.0000	1.5000