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BIOARCHAEOLOGY OF THE EVERYDAY: ANALYSIS OF ACTIVITY PATTERNS AND DIET IN THE NILE VALLEY

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of

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by

Sarah A. Schrader

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In memory of Professor Phillip L. Walker;

an inspiration, a mentor, and a friend

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TABLE OF CONTENTS

Page

Page

Page

Page

LIST OF TABLES

Appendix Table Page

Appendix Table Page

LIST OF FIGURES

ABSTRACT

Schrader, Sarah A. Ph.D., Purdue University, August 2013. Bioarchaeology of the Everyday: Analysis of Activity Patterns and Diet in the Nile Valley. Major Professor: Michele Buzon.

By employing a bioarchaeological perspective, this dissertation addresses how quotidian acts are altered during and as a consequence of sociopolitical change. Specifically, variation in day-to-day activities associated with the transition from the New Kingdom to the Napatan Periods in Ancient Nubia is explored. The focal site of the dissertation, Tombos, is located at the Third Cataract and was continuously inhabited throughout this instance of sociopolitical transition. An additional nine skeletal samples from Egypt and Nubia were also examined to investigate comparative variation in activity and diet throughout the Nile Valley. The methods of entheseal remodeling and osteoarthritis were used to broadly infer levels of manual labor. Stable isotope analysis of bone collagen and carbonate were examined to better understand dietary patterns. The theoretical perspectives of embodiment, structuration, and social identity were applied to illustrate the significance of quotidian action and further theoretical notions of the skeleton.

A distinct increase in activity (entheseal remodeling, osteoarthritis) was found between the New Kingdom Tombos and Napatan Tombos populations. This suggests that despite having social, political, and economic authority during

the Napatan Period, some Nubian populations were engaging in more physically strenuous activities than during the previous colonial Egyptian New Kingdom. Activities including farming, animal husbandry, and granite quarrying are possible explanations for this increase in activity. Dietary reconstruction suggests the Napatan Tombos sample was eating more C_3 plants than the New Kingdom Tombos population. This may be due to an environment of post-colonial transculturation and coexistence between Egyptians and Nubians. However, collagen analysis was not particularly successful. Possible reasons for these issues as well as proposed resolutions are put forward.

This dissertation is an example of the applicability of human skeletal remains to theoretically driven anthropological questions. From a regional history perspective, these new data suggests the daily lives, both physical and dietary, of Nubians significantly changed with the New Kingdom/Napatan transition.

CHAPTER 1. TOWARD A BIOARCHAEOLOGY OF THE EVERYDAY

1.1 Introduction

This dissertation draws attention to the significance of quotidian action and in doing so calls for a 'Bioarchaeology of the Everyday.' Several anthropological subdisciplines have broached the topic of day-to-day activities and have placed premier importance on the social, collective, and individual meaningfulness of these seemingly mundane movements (Franklin, 2003; Gibson and Rodan, 2005; Hill, 2005; Lavie and Swedenburg, 1996; McIafferty and Preston, 2010). Everyday actions, such as dancing, personal adornment, speech, popular culture, religious practices, as well as food and drink, define who we are and shape our social selves (Bourdieu, 1977; Ness, 1992; Prown, 1982; Spencer, 2008; Wilson, 2006). These movements not only reinforce identities, but also advertise our social reality to others.

Patterns of daily life become even more intriguing when examined diachronically (a distinct advantage of the archaeological perspective, discussed further below). With time, sociopolitical phenomena, such as invasion, conquest, globalization, and trade, can transform societies as cultures and populations interact. These events can and often do dramatically affect the everyday lives of local populations. However, it is important to bear in mind that these sociopolitical processes do not inherently control, dominate, and restrain those within these scenarios; individuals existing within this milieu always remain agentive.

When situated within a framework of structuration theory, the dichotomy between social systems and individuals is clarified. Structuration acknowledges the social structure as highly influential and governing of many aspects of life. Furthermore, the influence of social structure can escalate during periods of sociopolitical change. For example, in situations of imperial conquest, the empire may establish the political, economic, and social structural norms. However, individuals within these scenarios maintain the ability to express their views, react to these changes, and define their identities. As suggested by Giddens (1984), this is done through quotidian acts. These actions can voice identity, resistance, and positionality. In sum, the social structure is inevitably constraining, which can be intensified during periods of sociopolitical change. Individuals can communicate their opinions, no matter how confining the social system, by altering their day-to-day activities.

Anthropological archaeologists contend that these social principles are directly applicable to ancient populations (Hodder and Hutson, 2003). Thus, social structures of the ancient world were also limiting; however, individuals could likewise express self-identity through the quotidian. The examination of these social phenomena via the archaeological record presents the distinct advantage of long-term diachronic comparison. In many regions, millennia of prehistoric and historic artifacts, ecofacts, and features have been preserved. By examining extended periods of time, archaeologists have the ability to investigate the material record before, during, and after, significant sociopolitical events. Thus, it becomes the task of the archaeologist (and bioarchaeologist, see below) to identify, quantify, and interpret meaningful daily actions in the ancient past.

Bioarchaeology, the study of human skeletal remains and their archaeological context, has the ability to greatly inform our understanding of the everyday lives of past populations. Situated between cultural anthropology, biological anthropology, and archaeology, bioarchaeology combines theory, methodology, and anthropological interpretations from each of these perspectives. Archaeological examinations of households and communities have begun to address the quotidian in the ancient past (see Allison, 1999; Wilk and Rathje, 1982); however, these perspectives are limited to a relatively broad scope (i.e., community, household). Bioarchaeological investigations, on the other hand, are able to study individuals and address agentive action, social structure, and identity on a more refined scale (i.e., the individual; Stojanowski, 2005).

In the past, bioarchaeologists have frequently approached studies of sociopolitical change in terms of dramatic and sudden events (e.g., violence, forced relocation; Torres-Rouff, 2005; Tung, 2007). However, the much less provocative topic of everyday activities has been overlooked. Cultural anthropologists have addressed the role of the quotidian in social settings. For example, Asokaraj (2011) studied the reproduction of everyday life through the examination of children's social reality (e.g., family, peers, popular culture, and religious practices), in an Internally Displaced Persons Camp (IDPC) during the Sri Lankan Civil War. Gupta (1995) studied the quotidian of corruption within local bureaucracies, in lieu of participant observation, in his ethnography of the

Indian governmental state. Others have addressed how individuals/groups can use daily action as a form of resistance (de Certeau, 1988; Herndl, 1996; Scott, 1985). These same principals can, and should, be applied to our understanding of the ancient world. For this I turn to the examination of the New Kingdom/Napatan transition in Ancient Nubia.

1.2 Nubia in Sociopolitical Transition

Ancient Nubia, located in what is today southern Egypt and northern Sudan, was home to many diverse cultures spanning the Neolithic (*c*. 5,000-3,000 BC) to the Medieval Period (*c*. AD 500-1500; Figure 1.1). At times, Nubia's power grew to such an extent it threatened Ancient Egypt. The allure of Egyptian archaeology and 'Egyptomania' has often overshadowed the archaeology of Nubia (Adams, 1981; Trigger, 1994). However, the prehistory and history of Nubia should not be underemphasized; the peoples of Nubia played a large role in the development of Africa, Egypt, and the Near East.

Nubia has been referred to as the 'Corridor to Africa,' linking sub-Saharan Africa to Egypt, the Mediterranean and the wider world (Adams, 1977). This connection, in addition to valuable raw materials including gold, ivory, ebony, incense, and exotic animals, made Nubia an economic powerhouse. Furthermore, the wide floodplain, particularly south of the Third Cataract, gave local Nubians the ability to produce surplus agriculture and maintain a thriving pastoral economy (Trigger, 1976a).

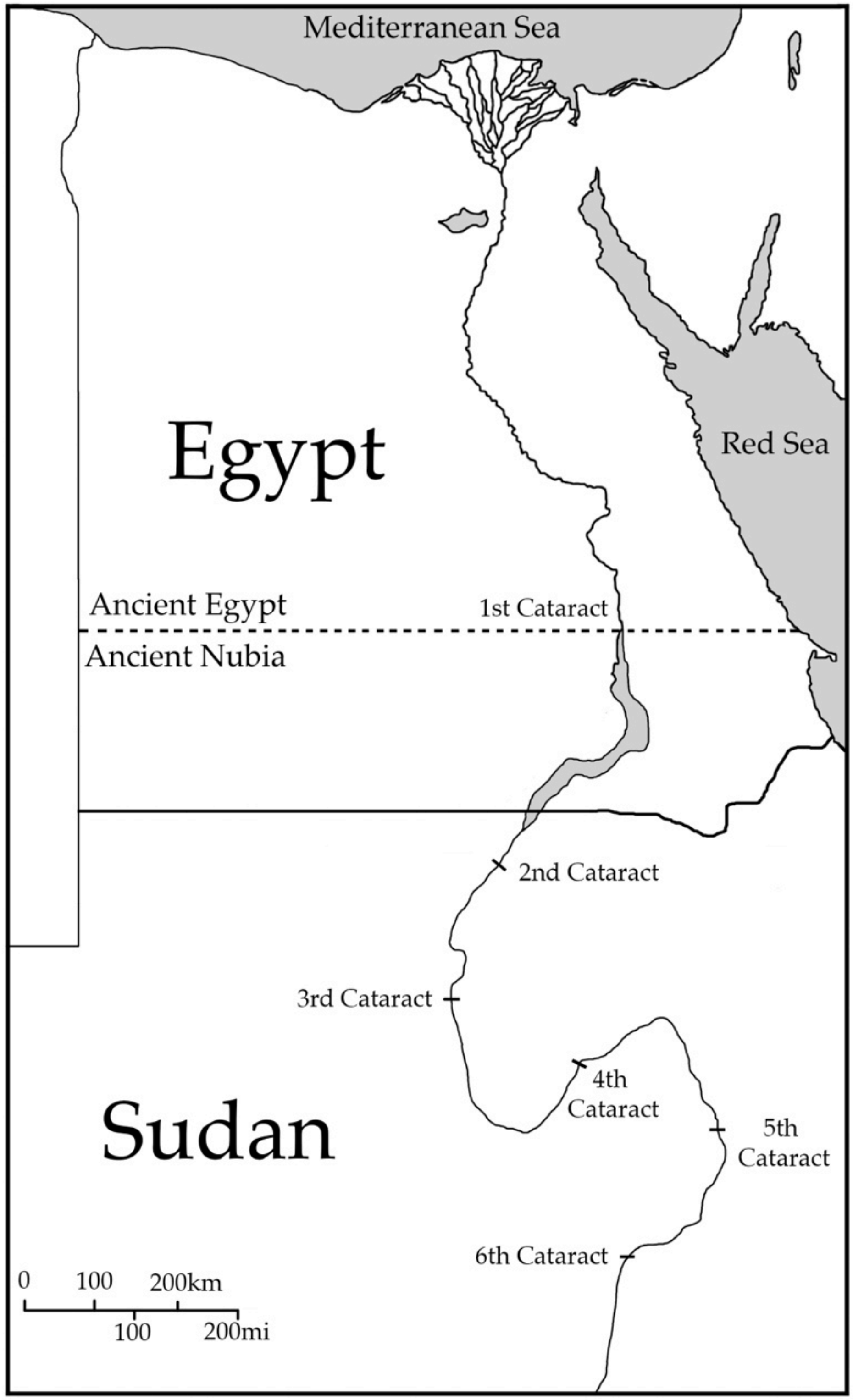

Figure 1.1 Map of the Nile Valley

Threatened by this growing power, Egypt conquered Nubia at the onset of the New Kingdom Period (*c.* 1,550 BC)[1]. Once Egypt had militarily subdued Nubia, the Empire began to colonize this new territory as a form of social, political, and economic authority (Adams, 1984; S.T. Smith, 1997; 1998). Imperial efforts were focused on incorporating local Nubian communities into the greater governmental structure via the construction of temple towns, the promotion of local administrators, and socioeconomic reorganization (Trigger et al., 1983). Colonization as an imperial tactic was successful; Nubian territories remained under the control of Egypt until the recession of the Empire (*c.* 1,070 BC; Edwards, 2004).

The decline of the New Kingdom has been attributed to internal weakening as well as external invasion, and may have been a product of both. According to Egyptian timelines, this political change initiates the 3rd Intermediate Period (*c.* 1,069-664 BC); however, within Nubian studies this time period is referred to as 'The Dark Ages' (Morkot, 1994; 1995b). In fact, little is known about Nubia during this time. Some have suggested Nubians reverted to a tribal or semi-nomadic lifestyle (Kendall, 1982; O'Connor, 1983). Others have argued that the foundations of a powerful state, Kush, had been established in the form of united polities and were quickly growing (Morkot, 2001). Certainly, by 850 BC Kush had expanded from its base near the Fourth Cataract (Napata)

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[1] However, this was not the first instance of Egyptian/Nubian conflict; a prior notable episode of conflict occurred during the Middle Kingdom Period (2,050-1,650 BC), when the Egyptian Empire expanded its borders into Nubian territory (see Chapter 2 for further detail)
[2] An administrative division within Ancient Egypt government
[3] Construction of the western Deffufa began during the Kerma Moyen, but wasn't complete until the Kerma Classique (Bonnet, 1984). The eastern Deffufas were built later, during the Kerma Classique Period (Ambridge, 2007).

and was rapidly gaining influence. Kush would go onto to successfully conquer Egypt and establish the 25th Dynasty of Pharaohs. Although Kush's power in Egypt was limited (760-656 BC), it continued in Nubia for centuries. However, the origins of this state remain obscure.

1.3 An Introduction to Tombos

Tombos, located near the Third Cataract, was an Egyptian colonial town that was established by the Empire during the New Kingdom. It likely served as an administrative center within Nubia, controlling trade, population movement, and also instituting Egyptian/Nubian coexistence. Recent excavations have also uncovered tombs dating to the subsequent Third Intermediate and Napatan Periods. While previous archaeological and bioarchaeological research has elucidated the role of Tombos as a component of the Egyptian Empire during the New Kingdom (see Buzon, 2006a; Buzon, 2006b; Schrader, 2012; S.T. Smith, 2003b), our understanding of Tombos and Nubian life during the 11th century BC and onward is incomplete (S.T. Smith, 2006; 2007; S.T. Smith and Buzon, in press; S.T. Smith and Buzon, in review). In fact, Tombos is one of few excavated sites that was continuously occupied from the New Kingdom Period through to the Napatan Period. Thus, the interpretation of Tombos artifacts and skeletal remains greatly improve our understanding of (1) the New Kingdom/Napatan transition in Nubia and (2) the significance of quotidian action during periods of sociopolitical change.

1.4 The Present Research

How can bioarchaeologists move beyond the limited examination of synchronic or episodic events (e.g., violence, relocation) to the examination of the diachronic events of daily life, which provide a more broadly meaningful interpretation of individual lifeways and agentive identities? The application of activity patterns (entheseal remodeling, osteoarthritis) and dietary reconstruction (isotope analysis) allow us to examine the long-term effects of sociopolitical change on the quotidian lives in ancient populations. Through the analysis of entheseal remodeling and osteoarthritis, broad levels of manual labor can be inferred. When applied to the skeletal remains of Napatan Tombos we can determine how physically active this population was. Then, these data can be contrasted with New Kingdom Tombos for a diachronic comparison, as well as various Nubian sites for a spatial comparison. Through stable isotope analysis bioarchaeologists can reconstruct dietary patterns of the ancient past. Carbon and nitrogen levels within bones can indicate what types of foods Nubians were eating during this period of change.

Thus, it is my goal to examine diachronic changes to physical activity and diet within Nubia during the New Kingdom/Napatan transition. Through the lens of structuration, physical activity and manual labor can be viewed as integral components to the socioeconomic structure (e.g., food production, craft production). These endeavors can elucidate what types of labor individuals were engaging in; however, they are more likely to be controlled, or at very least influenced by, political and social authorities and are, therefore, somewhat constrained. Using everyday activities, including the consumption of food, individuals can express their agentive views, define social identities, and react to the confining social structure.

Within the context of Tombos and Ancient Nubia, the analysis of activity will address many questions including: How did manual labor change between the New Kingdom and Napatan Periods at Tombos? How are these levels of manual labor contextualized within Nubia? Did Nubians revert to a tribal or semi-nomadic lifestyle? Is there any indication of Napatan political unification? What was the economic function of Napatan Tombos? Dietary reconstruction will examine the following queries: Did diet change between the New Kingdom and Napatan Periods at Tombos, indicating a response to a confining social structure? If so, can this response be interpreted anthropologically? If not, what other quotidian actions might Ancient Nubians have been using in an agentive manner? Is diet being used as a signal for social identity? Consequently, this dissertation research will make theoretical, methodological, and regional cultural history contributions to the discipline of anthropological thought.

1.5 Structure of the Dissertation

This dissertation is organized into eight chapters, each of which contributes to an understanding of everyday life in Ancient Nubia. Following this brief introduction, I provide a culture history of Nubia and contextualize Tombos in Chapter 2. I then present information on the skeletal samples included in this dissertation; I first address the Napatan Tombos sample, and then move onto New Kingdom Tombos, Saqqara, Qurneh, Shellal, Scandinavian Joint Expedition C-Group, Scandinavian Joint Expedition Pharaonic, Kerma, and

O16/P37. I also discuss the bioarchaeological methodologies used for aging and sexing skeletal remains, which were applied to the skeletal collections listed above. Chapter 4 focuses the theoretical orientation of this research and explores embodiment, structuration, social identity, as well as the anthropology of food. Research questions and hypotheses are also presented in this chapter.

Entheseal remodeling as an indicator of physically strenuous activity is discussed in Chapter 5. This chapter is organized to both stand alone, presenting interpretations of manual labor in ancient Nubia, and contribute to the broader theme of everyday life. Chapter 6 focuses on osteoarthritis as a bioarchaeological indicator of activity. First, the comparability of entheseal remodeling and osteoarthritis is addressed. Then, osteoarthritis is used as another means to interpret ancient day-to-day life. Chapter 7 presents stable isotope analysis data and a preliminary reconstruction of the Nubian diet. In the final chapter, Chapter 8, the hypotheses and results of each of the data chapters are revisited. The interconnectedness of these interpretations is discussed within the framework of a quotidian bioarchaeology. The implications of this dissertation and future research are also put forward.

CHAPTER 2. SITUATING TOMBOS IN A TRANSITIONAL SOCIOPOLITICAL LANDSCAPE: A CULTURE HISTORY OF NUBIA

2.1 Introduction

Characterized by mummies, pyramids, and pharaohs, the ancient history of the Nile Valley has captivated audiences for centuries. Specialists in archaeology, Egyptology, paleobotany, archaeozoology, geology, as well as numerous other disciplines, have all tried to probe further into the hidden past of Egypt and Nubia. Consequently, our understanding of the ancient Nile Valley has greatly improved since initial antiquarian efforts. Anthropological lines of questioning have recently delved into postmodern topics of identity, embodiment, and transculturation in the region (Buzon, 2006a; Hafsaas-Tsakos, 2009; Meskell, 2002; Meskell and Joyce, 2003; Richards, 2005; S.T. Smith, 2003b). With this dissertation, I hope to build on this legacy of postmodern inquiry by examining the quotidian livelihoods of Nubians during the New Kingdom/Napatan transition.

In this chapter I describe the unique geophysical context of the Nile Valley and outline the major historical events of ancient Egypt and Nubia. The aim of Chapter 2 is to provide the reader with the basic chronological and background information necessary to interpret the context of the analysis of activity patterns and diet during the New Kingdom/Napatan transition.

2.2 Geophysical Context

The distinct geophysical environs of Egypt and Nubia have greatly impacted the historical events described in this chapter. The headwaters of the Nile River originate in Uganda and Ethiopia; the Blue Nile (Ethiopia) and the White Nile (Uganda/South Sudan) flow northward and converge in Khartoum, Sudan. From there, the Nile courses through Sudan, into Egypt, and, ultimately, flows into the Mediterranean Sea (Trigger, 1976b). Extremely rich and fertile silts are transported via the Nile and are gradually deposited along its banks. This creates a particularly circumscribed environment; the 1.5 to 3.0 km along both banks of the River are typically green, lush, and promote habitation, which is greatly contrasted by the vast sandy deserts that characterize much of Northern Africa (Adams, 1977).

Six granite outcrops, otherwise known as cataracts, span from Aswan (modern Egypt) to the Shabaluka Gorge (modern Sudan) and characterize the Nubian landscape. These rocky stretches create rapids and impede the direct and seamless Nile flow that is present in Egypt. On multiple occasions, these cataracts served as natural barriers between Egypt and Nubia (Edwards, 2004). For much of the region's history, the First Cataract, just south of Aswan, served as the barrier between Egypt and Nubia. Even today, the First Cataract is seen as the ethnic border between Egyptians and Nubians (Horton, 1964). The area between the First and Second Cataract (now near Wadi Halfa), defines Lower Nubia. The area south of the Second Cataract is referred to as Upper Nubia; in the ancient past this region was termed 'Kush' (Dixon, 1958; Kendall, 1997). The *Batn el Hajar*, or Belly of the Rock, lies between the Second and Third Cataracts and is notorious for being particularly rocky and difficult to navigate. This exceptionally granite-rich landscape limits arable soil and, thus, this area was sparsely inhabited. The region between the Third and Fourth Cataracts is known as the Dongola Reach; the unusually wide floodplain of the Dongola Reach makes it the most fertile area throughout all of Nubia (north of the Fifth Cataract). Therefore, it is not surprising that the first Nubian State, centered at Kerma (3^{rd} Cataract), as well as the second Nubian State, centered at Napata (4^{th} Cataract), would originate from this region (Arkell, 1961; O'Connor, 1991). Less is known about the 5^{th} Cataract region of Nubia; recent excavations by the Sudan Research Society and the British Museum, entitled the Fifth Cataract Project, are greatly informing our understanding of this area (El-Amin and Edwards, 2000). Between the Fifth and Sixth Cataracts lies the ancient city of Meroë, which was the southern capital of Kush (*c.* 9^{th}-3^{rd} centuries BC; Morkot, 2000). Lastly, the Sixth Cataract is approximately 100km north of modern Khartoum (Edwards, 2004). Next I will briefly outline the major prehistoric/historic events and cultural traditions of the Nile Valley.

2.3 Nile Valley Chronology

I have broadly divided the chronology of the Nile Valley into five components: Pre-Dynastic/Early Dynastic, Old Kingdom and First Intermediate Period, Middle Kingdom and Second Intermediate Period, New Kingdom and Third Intermediate Period, and the Late Period and the Napatan State. This timeline is by no means comprehensive; it does, however, present a broad chronological overview of the Ancient Nile Valley.

Table 2.1 Chronology of Ancient Egypt and Nubia

<table>
<tr><th>Date B.C.</th><th>Egypt</th><th>Lower Nubia</th><th>Upper Nubia</th></tr>
<tr><td>3500-2600</td><td>Predynastic/ Early Dynastic</td><td>A-Group</td><td>Neolithic/ Pre-Kerma</td></tr>
<tr><td>2600-2150</td><td>Old Kingdom</td><td>?</td><td rowspan="2">Kerma Ancien</td></tr>
<tr><td>2150-2050</td><td>1st Intermediate Period</td><td rowspan="4">C-Group</td></tr>
<tr><td>2050-1650</td><td>Middle Kingdom</td><td>Kerma Moyen</td></tr>
<tr><td>1650-1550</td><td>2nd Intermediate Period</td><td rowspan="2">Kerma Classique</td></tr>
<tr><td>1550-1050</td><td>New Kingdom</td></tr>
<tr><td>1050-750</td><td>3rd Intermediate Period</td><td>?</td><td>Pre-Napata</td></tr>
<tr><td>750-332</td><td>Late Period</td><td>?</td><td>Napata</td></tr>
</table>

(Adapted from S.T. Smith, 1998)

2.3.1 Pre-Dynastic/Early Dynastic

The climate in North Africa began to dramatically change around 5,000 BC, becoming increasingly arid (Midant-Reynes, 2000). Human populations slowly began to settle near precious water sources; in Northeastern Africa, habitation zones were limited to the Nile Valley and to some extent desert oases. The regular flooding of the Nile River encouraged sedentism, as well as the domestication of plants and animals. Throughout the history of Egypt and Nubia, the Nile River was a lifeline in terms of a water resource, fertilization via silt deposits, transportation, and communication (Said, 1993). It is during this Neolithic period that distinct cultural traditions in Egypt and Nubia begin to appear (Table 2.1).

In Egypt, the Badarian culture (*c.* 5,000-4,000 BC) is one of the first distinct traditions to appear in the material record of the Nile Valley. Because the settlements of the Badarian culture were primarily ephemeral, most of what we know about this culture is derived from cemeteries. Badarian graves do possess some grave goods, namely small human figurines, jewelry, lithics, and ceramic vessels; however, for the most part, graves appear to be fairly egalitarian (Brunton and Caton-Thompson, 1928). The archaeological record suggests the Badarian people subsisted on animal husbandry, fishing, and limited agriculture. Storage pits from this time period have been found and are thought to reflect seasonal movement (Hendrickx and Vermeersch, 2000).

The A-Group, a distinctly indigenous Nubian culture, emerged in Lower Nubia during the 4th millennium BC (*c.* 3,500-2,600 BC; O'Connor, 1993). Adapted to a Nilotic environment, the A-Group peoples practiced hunting, gathering, and fishing, as well as limited cultivation and herding. There is evidence of domesticated wheat, barley, legumes, goat, and cattle during this time (Nordström, 1972). Interestingly, the A-Group peoples appear to have traded with Egypt; Egyptian wares including beads, wheel-made pottery, utensils, basketry, throwsticks, and palettes have all been found in A-Group contexts. However, no A-Group artifacts have been found in Egypt, suggesting they may have been trading perishables (e.g., cereals, livestock; O'Connor, 1993; Shinnie, 1996).

Archaeological evidence suggests that while the A-Group culture was initially egalitarian it gradually became increasingly complex and centralized (Williams, 1989). At the elite cemetery at Qustul, large graves filled with high status goods, such as gold and early pharaonic iconography, may be the burials of early A-Group rulers (Firth, 1927; Williams, 1986). Copper tools, such as fishhooks, adzes, needles, and knives, have also been discovered at A-Group sites (Gratien, 1978).

While the A-Group was thriving in Lower Nubia, the Pre-Kerma culture (*c.* 3,000-2,500 BC) was becoming increasingly sedentary and expansive in Upper Nubia (Bonnet, 1997; Honegger, 2006). The large floodplain in this region allowed for a dependence upon surplus grain agriculture. The primary Pre-Kerma settlement is located ~5km east of the modern Nile, near the city of Kerma. Researchers have proposed that paleochannels were once present directly aside this ancient habitation site (Marcolongo and Surian, 1993; 1997). Hundreds of pits, presumably used for storage of foodstuffs, measuring 70-120cm in diameter and 30-60cm deep, have been located at this Pre-Kerma settlement. Postholes (10-25cm in diameter) outline circular structures of three distinct sizes. The most common posthole arrangement forms a circular structure approximately 4.2m in diameter; Honegger (2004) has suggested that these constructions were houses. Larger (approximately 7m in diameter), presumably more specialized, circular structures have also been identified. These may have been places for community aggrandizement, houses of the socioeconomically elite, workshops, or stables. Ten smaller circular structures have also been found, which Honegger (2004) proposes are raised granaries. In addition to these buildings, diagnostic Pre-Kerma pottery, hearths, and ovens have also been excavated (Bonnet, 1988; Privati, 1988; Reinold, 1993).

The Naqada culture, contemporary with A-Group and Pre-Kerma, appeared in Upper Egypt around 4,000 BC. Unlike the A-Group and Pre-Kerma cultures, the Naqada culture shows marked differentiation in social strata, urban settlement, and territorial expansion (by 3,500 BC; Bard, 2000). Cities, namely Naqada, Hierakonpolis, and Abydos, became centers for labor, production, and trade. These cities formed the base of Upper Egypt (Bard, 1994). Around 3,100 BC Upper and Lower Egypt were unified, marking the emergence of an institutionalized bureaucracy and the dynastic tradition (Midant-Reyenes, 2000). It is no coincidence that directly after the establishment of the 1st Dynasty and the unification of Egypt that the A-Group of Lower Nubia collapses and disappears from the archaeological record. This may have been due to Egyptian military campaigns or slave-taking expeditions (H. Smith, 1991; S.T. Smith, 1998). Archaeological evidence, or lack thereof, suggests this region may have been uninhabited for the following two centuries.

2.3.2 Old Kingdom and First Intermediate Period

The Egyptian Old Kingdom (2,686-2,181 BC; Dynasties 3-6) marks the establishment of a more widespread pharaonic culture, a unified religious system, an expanding bureaucracy, and a complex funerary ideology that would prompt the construction of the pyramids (Malek, 2000). This is considered to be a relatively long period of economic prosperity and political unity within Egypt.

It was around this time that the paleochannels that fed the Upper Nubian Pre-Kerma settlement shifted westward; thus, the primary Kerma habitation site was relocated from the previous settlement. Centered upon the type-site Kerma, this culture is generally divided into three phases: Kerma Ancien (2,500-2,050), Kerma Moyen (2,050-1,650 BC), and Kerma Classique (1,650-1,500 BC; Gratien, 1978). Several other Kerman urban centers, including Sai and Bugdumbush, also flourished (Emery and Kirwan, 1935; Firth, 1927; Vercoutter, 1958). These towns facilitated trade between Egypt and central Africa (Bonnet, 1997). Ancient Egyptian texts suggest that Kerma had a unified ruler during Kerma Ancien; the merchant, Harkhuf (*c.* 2,200 BC), describes his voyages to foreign southern lands and a principal leader who allowed Egyptian trade (Breasted, 1962; Shinnie, 1996). With centralized production, structured trade, and consolidated power, Kerma would expand and pose a serious threat to the Egyptian Empire.

Appearing slightly later than Kerma, the Lower Nubian C-Group (*c.* 2,400-1,650 BC) is a distinct cultural tradition that reinhabited what was once A-Group territory (i.e., between the First and Second Cataracts; Bietak, 1986). The C-Group peoples may have been decedents of the A-Group that moved southward during the initial Old Kingdom (Säve-Söderbergh, 1989). Research into the relationship between the A-Group and C-Group is underway; several lines of material evidence support a cultural relationship between the two groups (e.g., rimmed pottery, tomb type, grave goods; Geus, 1991; Williams, 1977). The bioarchaeological examination of cranial nonmetric traits also indicates a biological relationship between the A- and C-Groups (Prowse and Lovell, 1995). However, dental nonmetric traits suggest the C-Group was particularly distinct from both A-Group and Kerma (Irish, 2005). Interestingly, a recent bioarchaeological study of craniometrics suggests the C-Group and Kerma groups may be biologically linked (Buzon, 2011). Both the biological and cultural association between the A-Group, C-Group, and Kerma has yet to be well defined.

Politically organized as chiefdoms, the primary mode of subsistence for the C-Group peoples was agriculture and animal husbandry, which was supplemented by hunting, gathering, and fishing (Beckett and Lovell, 1994; S.T. Smith, 1998). There appears to be a strong pastoral component to the C-Group culture; rock drawings, leather artifacts, animal burials, and evidence of extensive domesticated livestock all characterize this period in Lower Nubia (Shinnie, 1996; Williams, 1977). This has promoted the academic discussion of the existence of cattle cults within Nubia (Brass, 2003; Williams, 1986).

Due to a combination of factors, including an increasingly arid environment and sociopolitical fragmentation, the end of the third millennium BC is characterized by the gradual loss of centralized power in Egypt. During Egypt's First Intermediate Period (2,181-2,055 BC; Dynasties 9-11), nomarchs, leaders of local nomes[2], gained a substantial amount of power, creating small and oftentimes aggressively competitive provincial power bases. While Egyptians were dealing with these internal issues, the C-Group continued to thrive and Kerma gained a substantial degree of power during this period. Thus, it is not surprising that one of the primary goals for the Pharaohs of the reunited Middle Kingdom was to curtail these growing polities (Adams, 1984; S.T. Smith, 1997).

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[2] An administrative division within Ancient Egypt government

2.3.3 Middle Kingdom and Second Intermediate Period

Once nomarch disputes were resolved and Egypt was reunited as the Middle Kingdom (2,055-1,650; Dynasties 11-13), the construction of multiple fortresses within Nubia began. Initiated by Senusret I and continued by Senusret II and Senusret III, a total of 17 military fortresses were built in the Second Cataract region from 1,943-1,843 BC (from Elephantine to Semna; Trigger, 1976b; Watterson, 1997). These were massive mudbrick structures, complete with dry moats and thick walls, which were occupied by Egyptian administrators and military personnel. The archaeological record suggests the C-Group peoples of Lower Nubia were allowed to continue a traditional existence despite an Egyptian military presence; however, cultural interaction between the Egyptians and the C-Group peoples was minimal at this time (O'Connor, 1993).

These fortresses are an important component to understanding the relationship between Egypt and Nubia during the Middle Kingdom (S.T. Smith, 1995; 1998). Not only would these structures have had the obvious ideological message of advertising Egypt's authority, but they also served the very practical function of protection and control of the Nile River (e.g., trade goods, communication, population movement). Furthermore, these forts clearly defined Egyptian control from the Second Cataract to the Mediterranean. Each of these forts would have been very costly in terms of construction and maintenance; the fact that Egypt ultimately built 17 forts suggests that there was a strong motivating factor and a distinct purpose to these outposts (Emery, 1965; Trigger, 1976b).

The growing power of Kerma was a principal concern for the Egyptian Empire and likely justified these fort endeavors. During the Kerma Moyen Period (2,050-1,650 BC), Kerma became increasingly centralized and developed natural resources reserves, trade route connections, and a powerful urban center. The city of Kerma expanded its city limits, developed its infrastructure, and intensified fortifications (i.e., walls, ditches, gates, towers; Bonnet, 1994). With this expansion, the Kingdom of Kerma effectively controlled the region between the Fourth Cataract and the *Batn el Hajar* (Trigger, 1976a).

The Kerma religious ideology and funerary culture were also refined during the Kerma Moyen. Massive structures unique to Nubian architecture, Deffufas, were constructed for religious purposes (Bonnet, 1992; Trigger, 1976a). Three Deffufas were built in Kerma, each approximately 20m tall; a western Deffufa was constructed in the town and two eastern Deffufas were constructed at the site of a nearby cemetery[3] (Bard, 2007). This cemetery was designed as the final resting place for the rulers and elite of Kerma, and interestingly, was located atop the primary Pre-Kerma settlement discussed in Section 2.3.1 (for further information see Chapter 3; Bonnet, 1990). When excavated in 1916-1921, George Reisner estimated there were a total of 30,000-40,000 inhumations in the eastern cemetery. Some of these burials, particularly those in the larger, latter tumuli[4], have been interpreted to be sacrificial burials (Kendall, 1997; Reisner, 1923a; 1923b). When the skeletal remains of the 'sacrificial victims' were

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[3] Construction of the western Deffufa began during the Kerma Moyen, but wasn't complete until the Kerma Classique (Bonnet, 1984). The eastern Deffufas were built later, during the Kerma Classique Period (Ambridge, 2007).
[4] A tumulus is a mounded burial structure that is often outlined by a ring of rocks

analyzed, no osteological indicators of perimortem trauma were identified; however, these individuals may have willingly and non-violently accompanied their rulers to the afterlife (Buzon and Judd, 2008; Judd, 2004; Judd and Irish, 2009).

Grave goods associated with Kerma tumuli inhumations include: funerary beds, ivory hooks, alabaster vessels, cattle hides, stone tools, mica insets for clothing, ivory inlays for furniture, bronze knives, and bread molds (Bonnet, 1994). The traditional Nubian practice of animal burial is also substantially amplified during this time. Goats, sheep, and particularly cattle are frequently associated with many of the graves at the Kerma necropolis. As many as 4,000 cattle bucrania[5] have been found associated with a single inhumation (Chaix, 2004). These animals clearly played a significant role in Kerma ideology; many had undergone horn modification, were decorated with red ochre, draped in feather headdresses, and adorned with pendants dangling from pierced horns (Bonnet, 1991).

The complexity and centralized power of Kerma as an independent state, the second oldest state in Africa, cannot be underestimated (O'Connor, 1993). Kerma likely posed a serious threat to the Egyptian Empire, thereby justifying the construction and maintenance of the Second Cataract forts. As stated above, these forts would not only have served the economic function of controlling trade along the Nile, but would have housed a military force capable of defending Egypt's borders from Kerma if necessary (Bourriau, 1991).

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[5] Bucrania are the skulls of bovids

Throughout the Middle Kingdom, there was a dramatic influx of Near Eastern populations into Egypt, particularly in the eastern Nile Delta. As these immigrants, later referred to as the Hyksos, became increasingly united, centralized power of the Egyptian state declined. Thus, the Second Intermediate Period (1,650-1,550 BC; Dynasties 14-17) is characterized by foreign Hyksos rule at Avaris (Northeastern Delta) and the retreat of Egyptian rulers to the dwindling power base at Thebes in the south (Bietak, 1996; 1997). There is also some indication of a Kerma/Hyksos alliance against the remaining Egyptian presence at Thebes (Callender, 2000).

Scholars have begun to think of Nile Valley polities from the perspective of Nubia (Török, 1995). Morkot has asserted that:

> The rise of powerful states in Nubia was seen as dependent on Egypt's phases of internal weakness and hence inability to interfere. So it became customary to say that when Egypt was weak, Nubia *became* strong. Nubia's strength has rarely, if ever, been seen as a contributory factor in Egypt's weakness (2000:60-61).

In this light, the rising power of Kerma, supported by political and military alliances with the Hyksos, may have contributed to the deterioration of the Egyptian Middle Kingdom (Morkot, 2000; S.T. Smith, 1997). It was during the Kerma Classique Period (1,650-1,500 BC), that Kerma reached the height of its power, both economically and territorially (Bonnet, 1990). At this time, the city of Kerma expanded beyond the walls of the Kerma Moyen fortifications. It is estimated that the city size grew from 6 to 25 hectares during the Kerma Classique Period (Bonnet, 1994). Concurrent with the decline of Egyptian power, the Second Cataract forts gradually fell into disrepair. However, many Egyptian expatriates continued to inhabit the region and cultural interaction between the Egyptian population and the local C-Group population greatly increased. Furthermore, Kerma actively traded and interacted with this Second Cataract population, allowing for dramatic growth and expansion (S.T. Smith, 1995). Kerma had grown to an unprecedented level and was then, more than ever, a threat to Egypt. Thus, the first Pharaohs of the New Kingdom surpassed the control and influence of Second Cataract forts of the Middle Kingdom by implementing a foreign policy that would permanently eliminate Kerma as a competitive power (Frandsen, 1979).

2.3.4 New Kingdom and Third Intermediate Period

The New Kingdom Period (1,550-1,069 BC; Dynasties 18-20), also known as Egypt's Golden Age, is considered to be the height of Egypt's political power, economy, and culture. Some of the best-known Pharaohs of Egypt's past, including Tutankhamun, Hatshepsut, and Ramesses II, date to the New Kingdom. This great period of prosperity for Egypt was founded on territorial expansion in both Nubia as well as Syro-Palestine.

Pharaoh Ahmose (1,550-1,525 BC) began his reign by reclaiming control of the Lower Nubian forts and reestablishing the border with Nubia at the Second Cataract (Emery, 1965; S.T. Smith, 1991a). Thutmosis I (1,504-1,492 BC) and Thutmosis III (1,479-1,425 BC) continued these efforts by expanding the southern border of Egypt even farther. Armed with the chariots, introduced by the Hyksos, Egypt virtually annihilated the city of Kerma and the southern political boundary of Egypt was established at the Fourth Cataract of the Nile

River (Breasted, 1962; O'Connor, 1993). Stelae and Egyptian monuments were built throughout Nubia, including at Tombos, proclaiming this victory over 'Wretched Kush' (see Figure 5.4; S.T. Smith, 2003b). By *c.* 1,400 BC the majority of Nubia was under the direct control of Egypt with an imposed administrative center at Napata (Shaw, 2000).

With this territorial expansion, Egypt was faced with another problem; how would the Empire consolidate these foreign lands into the imperial regime to avoid another foreign invasion (i.e., Hyksos), or a resurgence of Kerma power? Egypt addressed this issue using various economic, political, social, and ideological methods (Kemp, 2006; S.T. Smith, 1992b). New towns centered on Egyptian temples were constructed throughout Nubia (Gebel Barkal, Soleb, Amara, Sesibi, Sai; Bard, 1999). These temple towns not only promoted Egyptian religion and facilitated Egyptian/Nubian coexistence, but also served as economic centers of redistribution (Trigger, 1976b).

Egyptian civil officials, priests, artisans, and more generally, colonizers are known to have moved from Egypt to Nubia (Kemp, 1978; 2006). New political offices such as the "King's Son of Kush," "Viceroy of Kush," "Overseer of Foreign Lands,"[6] and "Deputy of Wawat" were introduced and are referred to in the bureaucratic texts of Ancient Egypt (Emery, 1965; O'Connor, 1983). Furthermore, it has been suggested that local leaders may have been conscripted into positions of power to promote the unification of imperial rule (Edwards, 2004). Egyptian colonial policy during the New Kingdom encouraged the

[6] Not exclusively used for Nubia; also applies to Egyptian rule of Syro-Palestine (Zertal and Higgenbotham, 2008)

cultural assimilation of Nubians (particularly in Lower Nubia; Morkot, 1995a). The adoption of Egyptian culture may have been vital to local Nubians advancing within government (S.T. Smith, 2003b); there is evidence to suggest that Nubians who maintained more traditional customs tended to belong to lower socioeconomic statuses and did not have ranking positions (Ward, 1994).

Egyptian-style artifacts increasingly dominate the material record in New Kingdom Nubia. In the past Egyptologists and archaeologists have assumed this reflects acculturation of local Nubians (Breasted, 1909; Emery, 1965). However, recent research suggests this process was much more complex, and bidirectional. Stuart Tyson Smith demonstrates that through a process of transculturation local Nubians actively blended cultural traits during this time; in other words, Nubians maintained agency in this colonial encounter. There is evidence to suggest that Nubians had the option of (1) assimilating to Egyptian cultural norms per imperial instruction, (2) selectively adopting Egyptian characteristics, or (3) maintaining a more traditional Nubian social identity (S.T. Smith, 2003b).

Egypt continued this socioeconomic foothold in Nubia until, due to foreign invasion, environmental stressors, and the increasingly powerful priesthood of Amun at Thebes, the New Kingdom became politically fragmented (Third Intermediate Period; 1,069-664 BC). This period in Nubian history remains somewhat unclear. Ancient Egyptian texts provide an interesting account of the Viceroy of Kush, Panehsy, which is particularly telling of Egyptian/Nubian relations during this time. Egypt was experiencing what was coined 'the year of the hyena'; drought, famine, ransacking Libyans, and the disunity of the Priesthood/Pharaoh led to a period of chaos and disorder, particularly at Thebes

(Wilkinson, 2007). Concerned by these increasing problems, the last Pharaoh of the New Kingdom, Ramesses XI (1,107-1,078 BC), requested the military and leadership services of Panehsy. As the Pharaoh's primary representative in Nubia, Panehsy accepted this mission and, with his army, restored order in Thebes. However, Panehsy saw this period of governmental weakness as an opportunity and waged war against Egypt. Ramesses XI responded with military force; under the Egyptian general Paiankh, Panehsy's army was pushed back and he retreated to Nubia (Thijs, 2003). Panehsy would live a long and relatively prosperous life in Nubia and was later buried at Aniba (Lower Nubia). This anecdote not only describes the tone of political relations between Egypt and Nubia at the end of the New Kingdom Period, but also suggests that Nubia was relatively unified and possessed strong local leaders. By *c.* 850 BC Nubia had undergone the process of state formation, and was unified as the Second Kingdom of Kush, centered at Napata (Fourth Cataract); Kush would go on to conquer and rule Egypt as the 25th Dynasty (760-656 BC). However, it is the gap between 1,069-850 BC that remains particularly vague in Nubia's history.

It was once thought that after the Egyptian Empire withdrew from Nubia, local Nubians either completely abandoned their territories (i.e., Lower Nubia), or they reverted to tribal and semi-nomadic lifestyles (i.e., Upper Nubia; Kendall, 1982; O'Connor, 1983). These lifeways allegedly persisted until *c.* 850 BC with the appearance of, what was considered to be, a Napatan 'Chiefdom' (Griffith, 1916; 1917; 1929; Reisner, 1920a). If this were the case, rapid expansion would have had to occur to develop the Kushite royal lineage (buried at el-Kurru and Nuri), religious ideology (manifest at Gebel Barkal), and extent of territorial control (extending the central Sudanese savanna, spanning the Second to Sixth Cataracts) that was well developed by the emergence of the 25th Dynasty (Adams, 1964; Dixon, 1964).

This perspective, however, is rooted in the ethnocentric and, oftentimes, racist tendencies of 19th and early 20th century archaeologists. In early Egyptological texts, Napatan Nubia was rarely discussed; when the subject of Kush was broached, these early works typically praised the 25th Dynasty for being 'Egyptianized' (Trigger, 1994; see section 2.3.5). After the 25th Dynasty, Adams claims Nubians "… became progressively less Egyptian and more barbarous in character" (1964:109). These arguments do not acknowledge local Nubians as being economically independent, politically strong, and militarily savvy, and instead passively deem them as members of a backward periphery (Morkot, 2001).

With continued excavation efforts, the depopulation argument is becoming less plausible (Williams, 1990). Excavations at Tombos and other contemporary sites, such as Amara West, show continued occupation from the New Kingdom, through the Third Intermediate Period, and into the Napatan Period (S.T. Smith, 2006; 2007; S.T. Smith and Buzon, in press; Spencer, 2002). In line with recent Nubian-centered perspectives (Morkot, 2000; S.T. Smith, 2006; S.T. Smith and Buzon, in press; Török, 1995), it is plausible that Nubia was organized into a series of polities or was even operating as a successor state during the questionable period of 1,069-850 BC. The tale of Panehsy further supports this argument; Panehsy's ability to (1) produce a Nubian army that was both willing and able to attack Egyptian forces[7], and (2) retreat to Nubia unharmed, where he was presumably protected, suggests Nubia was not completely devastated by Egyptian withdrawal and may have been, at least to some degree, unified.

Archaeological evidence from the Napatan Period is limited; however, this can be primarily attributed to the need for further excavation. Edwards supports this idea "…there is no reason to suspect that the mysteries surrounding the origins of the Napatan state are anything other than a reflection of inadequate fieldwork" (2004:116). Tombos is one of few excavated sites that was occupied during this transition and, thus, is vitally important to the archaeological understanding of the New Kingdom/Napatan quotidian.

2.3.5 Late Period and the Napatan State (Kush)

The 25th Dynasty of Egypt (760-656 BC), characterized by Kushite rule, was the last dynasty of the Third Intermediate Period (1,069-664 BC). The rulers of the 25th Dynasty legitimized their power by portraying themselves as 'saviors' of the Egyptian civilization (Joffe, 2002; Morkot, 1999)[8]. Pharaohs, including Kashta, Shabaka, and Taharqo, emulated many aspects of Ancient Egyptian culture (e.g., clothing, art, architecture). The restoration of the Egyptian tradition was not an exact imitation; instead, many Nubian cultural elements and

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[7] Panehsy's army was initially successful in battle; after usurping power at Thebes, Panehsy successfully defeated the town of Hardai (Middle Egypt). This victory was short-lived; Panehsy was soon overpowered by Ramesses XI's royal army, led by Paiankh (Wilkinson, 2007)

[8] There was an increasing Libyan cultural presence in Egypt, beginning in the latter New Kingdom Period (Taylor, 2000)

symbolism were entwined with Egyptian elements, creating a hybrid material culture. Despite a fairly prosperous dynasty, Kush was ousted from Egyptian rule by the Assyrians, which ushered in the Late Period (664-332 BC; Dynasties 26-31; Taylor, 2000). However, this did not reduce Kush's power within Nubia. Major cities of Kush, including Kawa, Napata, el Kurru, and Meroë would continue to thrive during the Napatan Period. In fact, the Napatan state continued as a centralized power in Nubia until *c.* AD 400 centered at Meroë (S.T. Smith, 1998).

2.4 Tombos in Context

Located at the Third Cataract of the Nile, the town of Tombos was established at the start of the New Kingdom. Archaeological and bioarchaeological evidence suggests this community was inhabited by Egyptians and Nubians and likely served as an imperial administrative center (Buzon, 2006a; S.T. Smith, 2003b). The geopolitical positioning of Tombos is an important consideration. Located on the rocky Third Cataract of the Nile River, Tombos would have made an ideal location for a riverine point of control. Here, trade, communication, and population movement could have all been monitored. This region is also considered to be a border between contrasting territorial and hegemonic Egyptian colonial strategies (S.T. Smith, 2003b). To the north, many Egyptian colonies were created (e.g., Amara, Sesebi, Sai, Soleb), bringing about direct interaction and coexistence between Egyptians and Nubians (i.e., territorial colonial strategy). These sites are characterized by being strongly culturally Egyptian. However, south of Tombos, the Egyptian Empire took a more hegemonic approach and was primarily concerned with using the pre-existing infrastructure to encourage economic productivity with minimal imperial intervention (Doyle, 1986). The Egyptian Empire enforced a similar hegemonic approach in Syro-Palestine (Higginbotham, 2000; Redford, 1992). Thus, it is not surprising that sites south of Tombos are more culturally Nubian. This may be a consequence of the hegemonic imperial approach; alternatively, this strong Upper Nubian culture could explain why a territorial imperial strategy would not have been effective in this region (S.T. Smith, 2003b).

The ethnic and biological identity of the inhabitants of Tombos has been addressed through bioarchaeological methods. The funerary style of Tombos varies diachronically and fluidly blends both Nubian and Egyptian elements. The traditional Egyptian burial style was to have the body in a supine position within a coffin (if the deceased's family could afford it; Baines and Lacovara, 2002). This is contrasted to the traditional Nubian burial style, which is characterized by the body being placed in a flexed position on a burial bed (Säve-Söderbergh, 1989). During the New Kingdom Period, the majority of burials at Tombos are in the Egyptian style. However, there are a few inhumations (n=4), all of which are female, that are buried in the traditional Nubian flexed position. With time, particularly during the 3rd Intermediate and Napatan Periods, there is an increasing fusion of Egyptian and Nubian burial traditions. For example, the appearance of burials in coffins on beds emerges. Similarly, multi-interment pyramid (elite) and chamber tomb (non-elite) superstructures, both of which are Egyptian in style, were both used in the New Kingdom Tombos cemetery. During the Napatan Period, the traditional Nubian single (or double) inhumation tumuli burials were used. The pyramid tradition also continues into the Napatan Period as well. Furthermore, a cultural mix of grave goods (jewelry, amulets, scarabs), and ceramics, has also been found (S.T. Smith, 2003b).

Using craniometric and strontium isotope analyses, Buzon has shown that the biological and geographic origins of people at Tombos were both local (i.e., Nubian) and foreign (i.e., Egyptian; Buzon, 2006a; Buzon et al., 2007; Buzon and Simonetti, 2013). Furthermore, the biological identity of the Tombos population changed through time. In the New Kingdom Period, Buzon's research indicates the presence of both foreign Egyptians and local Nubians. During the latter Napatan Period, the majority of Tombos inhabitants were local (Buzon and Simonetti, 2013). Thus, in synthesizing these data, there is evidence to suggest that both Nubians and Egyptians inhabited this site and were actively engaging in both Egyptian and Nubian traditions.

Archaeological evidence from the cemetery at Tombos indicates prosperous administrators occupied this town. In 2000, the pyramid tomb of Siamun, a high-ranking administrator was excavated (Figures 2.1 and 2.2). Funerary cones, which would have lined the façade of the pyramid entrance, were inscribed with his title: "Honored by Osiris and Anubis, Master of the Divine Pavilion, the Scribe of the Treasury, Overseer of Foreign Lands, Siamun, and his [mother] the Mistress of the House Weren" (S.T. Smith, 2003b:141). This title reflects a third-level administrator, a position that would have been held in high regard in an Egyptian colony. Siamun's title, in addition to the general size and grandeur of the tomb, indicate he was appointed by the Egyptian Empire and represented an elite socioeconomic status. Furthermore, multiple pyramid tombs, similar to Siamun's pyramid, have been identified at Tombos. Future excavation of these tombs will certainly elucidate additional administrative roles and broaden our understanding of this community.

Figure 2.1 Remains of Siamun's Pyramid at Tombos

(Photo courtesy of S.T. Smith)

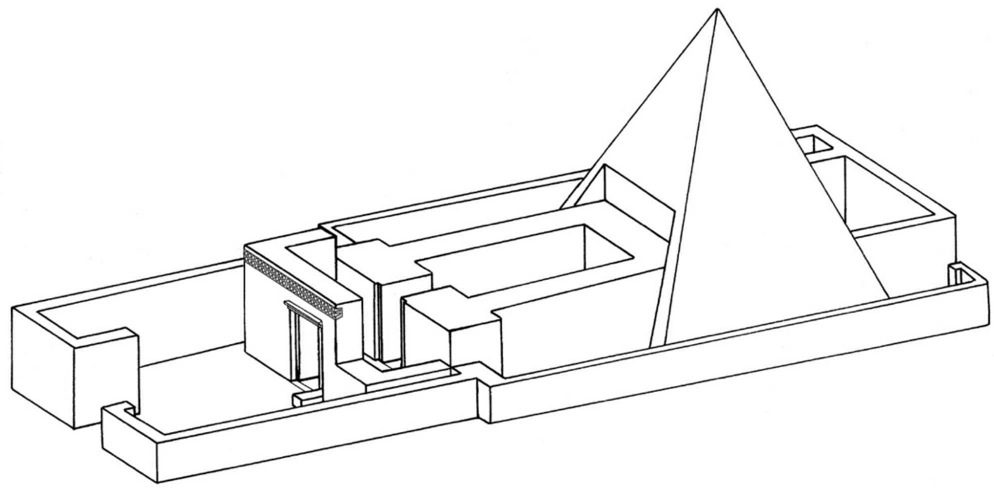

Figure 2.2 Recreation of Siamun's Pyramid at Tombos

(Illustration courtesy of S.T. Smith)

In addition to these elite tombs, there is also a significant middle-class/non-elite component to Tombos. Several chamber tombs, excavated in 2000 and 2002, were found to contain multiple inhumations (Figure 2.3). The tombs themselves were larger and more elaborate than similar tombs from this period, suggesting an elevated socioeconomic status. Furthermore, grave goods, such as scarabs, amulets, jewelry, coffins, imported ceramic vessels[9] and ushabtis[10] were also included with the deceased. These burial contexts suggest these individuals were not as high ranking as Siamun, but also were not markedly poor. This middle-class population of Tombos may have engaged in activities such as scribes, prosperous servants, and artisans (Buzon and Richman, 2007).

[9] Vessels imported from as far as Mycenae have been found at Tombos (S.T. Smith, 2003a)

[10] Ushabtis are funerary figurines that, according to Ancient Egyptian religious beliefs, could be evoked in the afterlife to perform manual labor. Ushabtis, in particular, are reflective of elite status (S.T. Smith, 1992a)

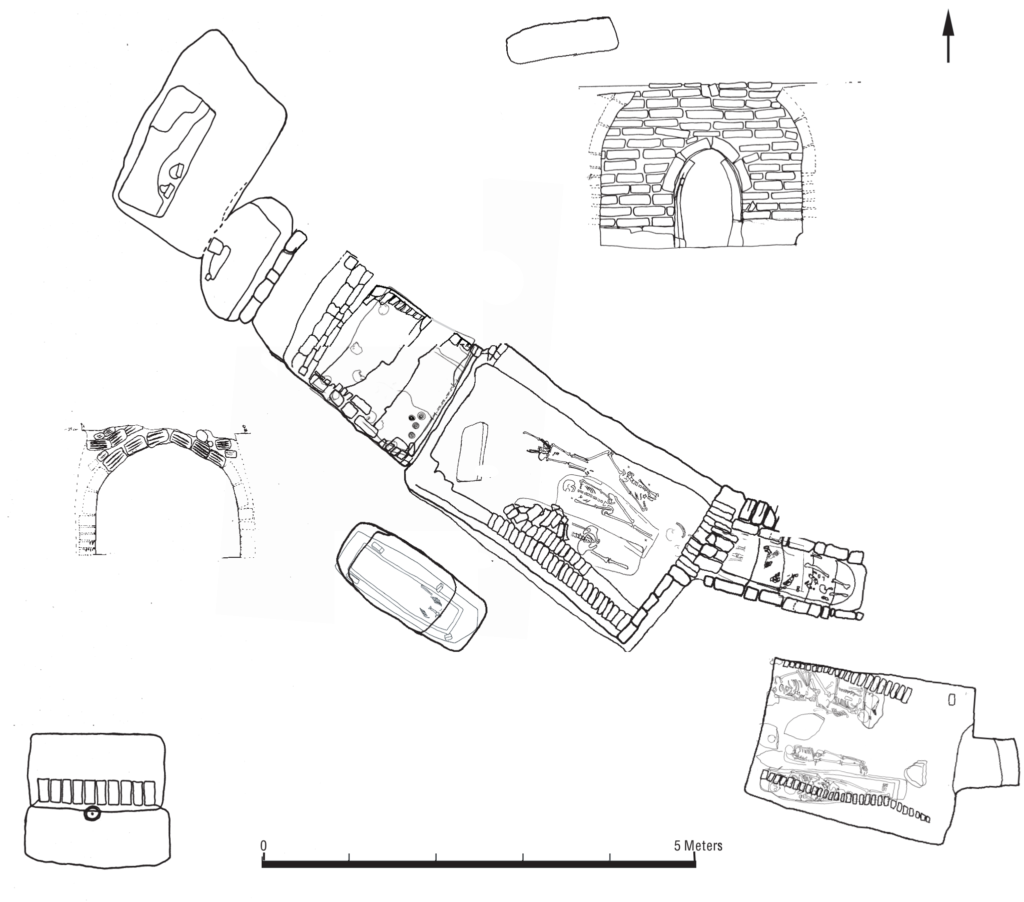

Figure 2.3 Non-Elite Chamber Tombs at Tombos

(Units 6 and 7; Illustration by Nadejda Reshetnikova, courtesy of S.T. Smith)

The bioarchaeological examination of skeletal remains from New Kingdom Tombos further supports the idea that this community was composed of middle to upper socioeconomic status individuals who were administering the Third Cataract and Upper Nubia (Schrader, 2010; 2012). When skeletal remains were analyzed for osteoarthritis and entheseal markers, both indicators of physically stressful manual labor, the Tombos sample had particularly low frequencies of each condition. These data were then compared with various Nile

Valley populations. The Tombos sample consistently had the lowest levels of both osteoarthritis and entheseal markers than any comparative sample. Thus, this bioarchaeological investigation of activity supports the archaeological material record.

From these archaeological and bioarchaeological investigations, a great deal has been elucidated about New Kingdom Tombos. However, much less is known about the subsequent Third Intermediate and Napatan Periods at Tombos. As discussed in section 2.3, this phase of history remains obscure throughout Nubia, and, because of this, has been referred to as a 'Dark Age' (Morkot, 1994; 1995b). Tombos is one of few sites that was continuously inhabited from the New Kingdom to the Napatan Period and is, thus, crucially important to the archaeological decipherment of this social, political, and economic transition.

2.5 Summary

This chapter has examined the cultural history of the Nile Valley from the Neolithic (*c.* 5,000 BC) to the Late Period (*c.* 332 BC). More attention was given to the Nubian cultures of the Nile Valley (e.g., A-Group, C-Group, Kerma) than the Egyptian Periods (e.g., Old Kingdom, Middle Kingdom, New Kingdom) because of the direct relevance to this research. Furthermore, the intense phases of interaction between these two cultures (i.e., Middle Kingdom forts, Kerma growth and expansion, New Kingdom colonization) were also discussed. The context of Tombos is situated within this complex history of entanglement, as Egyptians and Nubians coexisted within this colonial center. The ethnic identities of this community have been shown to be fluid and dynamic. Further examination of diet and activity during the New Kingdom/Napatan transition will elucidate the everyday experience of local Egyptian/Nubian populace during this transition.

CHAPTER 3. SKELETAL SAMPLES OF THE NEW KINGDOM-NAPATAN TRANSITION: TOMBOS AND COMPARABLE COLLECTIONS

3.1 Introduction

In order to address the quotidian activities of the inhabitants of Napatan Tombos, 76 individuals from this population were analyzed (Table 3.4). In addition to this core sample, 540 individuals from various Nile Valley archaeological sites were also examined. These comparative sites are located throughout Ancient Nubia (Figure 3.1) and range chronologically from the Kerma Ancien (2,500-2,050 BC) to the Napatan Period (850-650 BC). This chapter examines the archaeological context of each of these samples and identifies how many individuals were analyzed from each collection.

First, the archaeological and skeletal material from Napatan Tombos will be described. Then, the comparative material, including New Kingdom Tombos, Saqqara, Qurneh, Shellal, Scandinavian Joint Expedition C-Group, Scandinavian Joint Expedition Pharaonic, Amara West, Kerma, and O16/P37 will be addressed. Finally, the methods used to determine age at death and sex of the skeletal remains will also be discussed in this chapter. These methods were used to age and sex all skeletal material discussed in this dissertation.

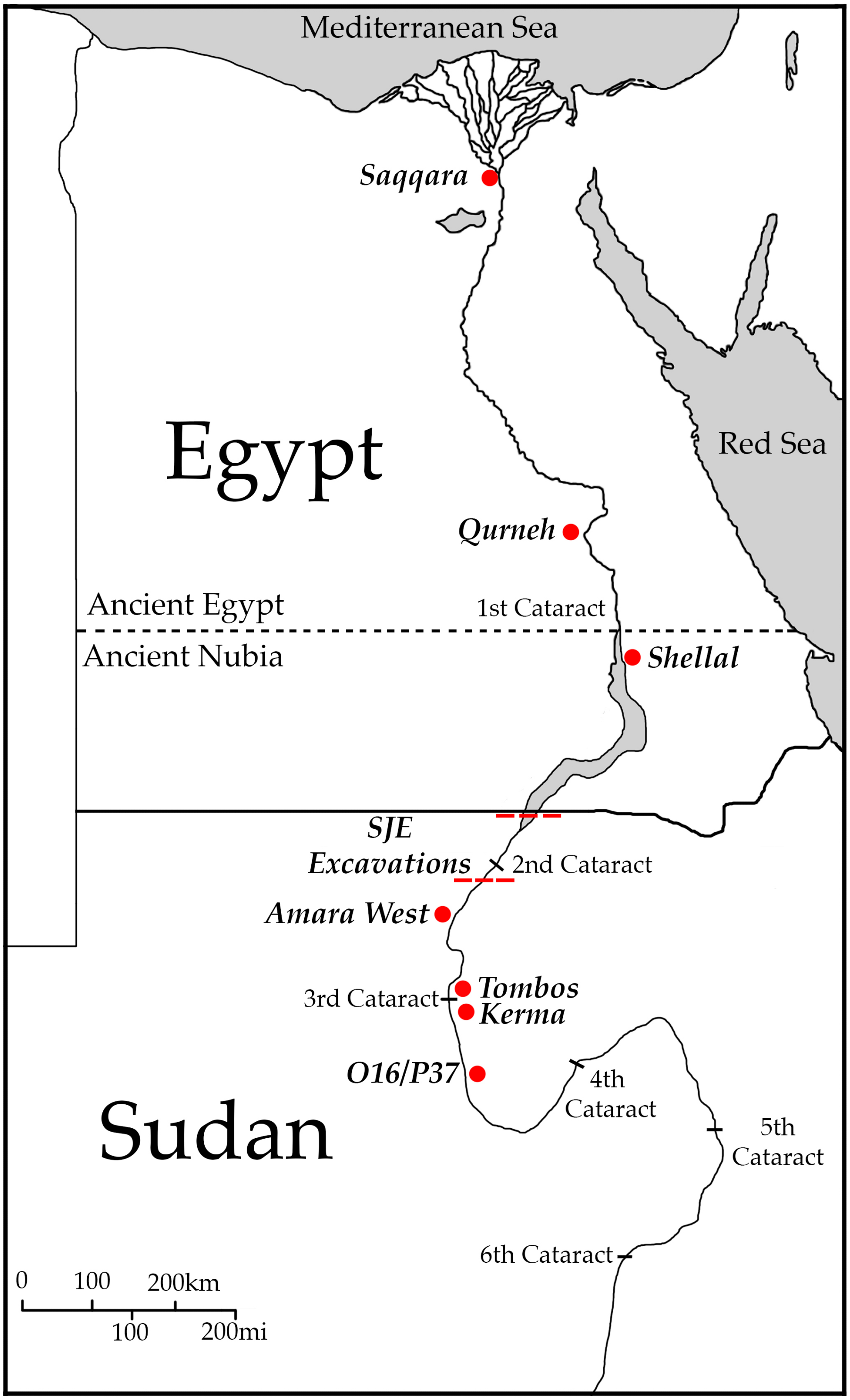

Figure 3.1 Map of Skeletal Collection Excavation Sites

3.2 Sampling

This dissertation research, focused on the site of Tombos, addresses the consequences of sociopolitical change associated with the New Kingdom/Napatan transition on quotidian activity patterns. Thus, comparative samples from Egypt and Nubia that are roughly contemporary to Tombos were selected. A primary goal of sampling was to achieve a varied representation of life during this time. Thus, archaeological collections with spatial, chronological, cultural, and socioeconomic status variation were ideal. In doing so, a broad range of Ancient Egyptian and Nubian lifeways are examined.

As discussed in Chapter 2, few archaeological sites and cemeteries dating to the Napatan Period have been excavated. This makes analysis of Tombos particularly important to elucidating the New Kingdom/Napatan transition. However, this also means we must look to other time periods for comparative material. First and foremost, the New Kingdom skeletal sample from Tombos serves as an excellent point of comparison by directly addressing the effects of sociopolitical change, diachronically. The Egyptian cemeteries of Saqqara and Qurneh date to the New Kingdom and are an interesting Egyptian corollary to contemporary New Kingdom Tombos. Shellal, also dating to the New Kingdom, borders Upper Egypt and Lower Nubia and, thus, reflects a mixed Egyptian and Nubian populace. The Scandinavian Joint Expedition sample consists of a C-Group and Pharaonic (New Kingdom) component (discussed in more detail below). The C-Group sample is an example of a more characteristically Nubian population, while the Pharaonic sample comes from Egyptian-style tombs and is presumably composed of Egyptian expatriates and assimilated Nubians. Amara

West is an Egyptian colony within Nubia, like New Kingdom Tombos, and is another example of pre-Napatan imperial town. Kerma, located 20km south of Tombos, is a pre-Egyptian Empire sample within Upper Nubia. The spatial closeness of these two sites is particularly interesting and partially controls for environmental variances. O16/P37 is a Kerma culture site that is thought to have been composed of people of lower socioeconomic status who were likely engaging in strenuous physical labor associated with agriculture. O16/P37 is an interesting socioeconomic comparison to the more prosperous and affluent Tombos. These samples will help us better understand what everyday life was like in Ancient Egypt and Nubia before the Napatan Period. Results of these analyses will then be compared to the Napatan Tombos activity pattern and dietary reconstruction data.

3.3 Napatan Tombos

Tombos is located at the Third Cataract of the Nile River. Excavations at Tombos began in 2000, under the direction of Stuart Tyson Smith (University of California, Santa Barbara) and are still underway (in collaboration with Michele Buzon, Purdue University). Further information regarding the context and archaeology of Tombos can be found in Chapter 2. The Napatan component of the Tombos cemetery consists of tumuli, pyramid tombs, and chamber tombs. A tumulus is a burial structure, which, at Tombos, is typically designed for one or two inhumations. The superstructure of these tombs is a mound of earth, oftentimes lined with large stones. Owing to deterioration over time, these mounds are now barely discernible and the stones are often displaced. The substructure of the tumulus tombs consist of a shaft (~2-3m deep) with a burial niche, almost exclusively on the north side, at the bottom of the shaft. Many of these tumuli appear to have been reused, with one burial often atop another. The tumuli burials examined in this study include: Units 2, 3, 10, 14, 16, 17, 18, 19, 20, 22, 25, 27, 28, 32, 33, and 34.

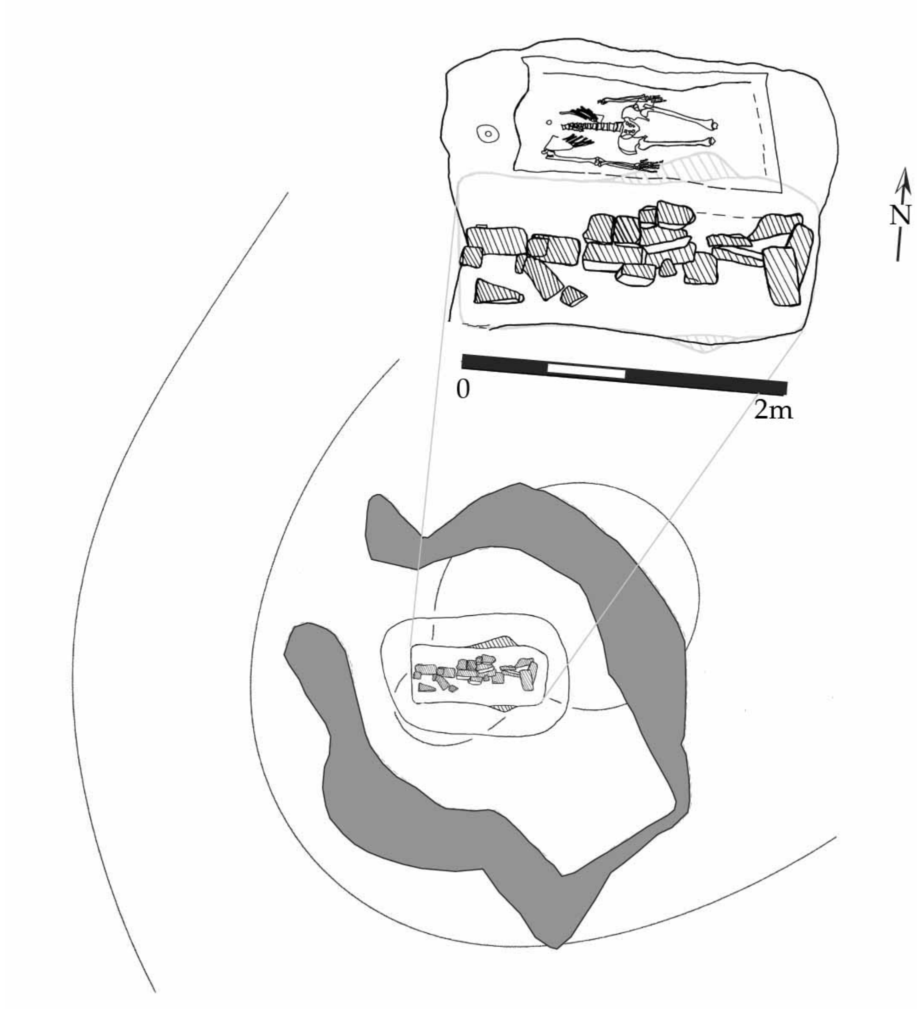

Figure 3.2 Napatan Tumulus at Tombos

(Unit 3; Illustration by Nadejda Reshetnikova, courtesy of S.T. Smith)

To date, three non-tumuli Napatan tombs have been excavated at Tombos (pyramids: Unit 9, Unit 23; chapel: Unit 15)[11]. The superstructures of these pyramids/chapel did not stand the test of time; a foundation, a few mudbricks high, is all that remains of these once prominent structures. The substructures of these pyramids consist of a deep shaft (~3-4m deep) with one or more chambers at the bottom of the shaft. These chambers vary in size, but are typically 3-4m^2. A particularly unique pyramid, Unit 9, which was excavated in 2011, was found to have one central chamber with five subsidiary chambers emanating therefrom. It is evident that these pyramid tombs were constructed with the intention of burying several individuals within the subterranean chambers. Unfortunately, both Napatan pyramids were looted in antiquity; however, when the minimum number of individuals (MNI) was calculated for each of these units it is clear that many people were interred within (MNI Unit 9: 23, MNI Unit 23: 8 (excavation incomplete), MNI Unit 15: 19).

Many of the Tombos burials were looted in antiquity for their valuable grave goods. In this process, many of the burials became disarranged, or commingled. Consequently, it is impossible to identify isolated individuals within this context. However, using bioarchaeological analysis, an MNI can be determined. This provides an estimate of how many people were buried within a

[11] It should be noted, there is significant evidence to suggest that some of the Napatan pyramid and chapel tombs were initially constructed during the New Kingdom Period and reused during the Third Intermediate and Napatan Periods (i.e., Unit 15, Unit 23). For example, a Ramesses II scarab (New Kingdom) was found near the bottom of the eastern chamber of Unit 23; however, multiple lines of evidence including diagnostic ceramic vessels, C^{14} testing, and another scarab (found in an upper locus) all indicate this pyramid was in use during the Napatan Period.

single tomb. Commingled bones remain valuable sources of information regarding ancient lifeways. The entheseal changes and osteoarthritis on these bones makes it possible to detect strenuous labor within this population. However, considering the context of these finds, these skeletal elements cannot be associated with a sex or age at death due to the lack of an associated skull and/or os coxae. Thus, commingled remains are included in a broad examination of activity at Tombos, however, the interpretation of these data are cautionary owing to the fact that sex and age could not be associated.

The skeletal remains from Tombos have been transported from Sudan to Purdue University and are curated in the Department of Anthropology by Dr. Michele Buzon. For this study I examined 76 individuals (18 females, 8 males, MNI 50 commingled remains) from the Napatan segment of the Tombos cemetery (Table 3.4). This sample was used in the analysis of entheseal markers, osteoarthritis, and dental carbonate stable isotope ratios.

3.4 Comparative Samples

The following section describes the Nile Valley skeletal collections that were used to compare to and contrast with the Napatan Tombos sample.

3.4.1 New Kingdom Tombos

In addition to the Napatan burials at Tombos, there is also a substantial New Kingdom component to the cemetery. As discussed in Chapter 2, this colonial town likely served the Egyptian Empire as an administrative center. Furthermore, archaeological evidence suggests this population included both an upper class as well as a middle class[12]. Upper class individuals were buried in elite pyramid tombs, with the valuable and rare grave goods (e.g., ushabtis, jewelry, scarabs, coffins). The middle class component of the cemetery includes the underground chamber tombs, where many people were buried and lower quality grave goods were present. However, these individuals were by no means of low socioeconomic status; the chamber tomb context in addition to moderate grave goods, suggests these individuals had some degree of wealth (S.T. Smith, 2003b).

The New Kingdom Tombos sample was previously analyzed for entheseal changes and osteoarthritis (Schrader, 2010; 2012). Therefore, these previous studies will serve as diachronic points of comparison to the Napatan material. I examined a total of 108 individuals (18 female, 12 male, MNI 78 commingled remains) from New Kingdom Tombos (Table 3.4). These specimens were used in the examination of entheseal remodeling and osteoarthritis as well as dietary reconstruction (dental carbonate, bone collagen). The skeletal material from New Kingdom Tombos, in addition to the Napatan material, is housed at Purdue University and is curated by Dr. Michele Buzon.

3.4.2 Saqqara

The ancient cemetery of Saqqara is located approximately 19km south of the modern city of Cairo. Saqqara is the primary necropolis of Ancient Memphis, which served as a major city and nome capital throughout much of Ancient

[12] Nearly all of the bones examined here originate from the middle class component of the Tombos cemetery (see Schrader 2010; 2012 for further detail)

Egyptian history (Martin, 1991). Very little is known about the provenance of this material. This collection was a gift to the Duckworth Laboratory (Department of Anthropology, University of Cambridge), where it continues to be housed. Museum records indicate these samples date to the New Kingdom Period and, more specifically, may be from the 18th Dynasty (*c*. 1,539-1,292 BC). Samples from the Saqqara collection were used for dental carbonate stable isotope analysis (Table 3.4).

3.4.3 Qurneh

The site of Qurneh is located in Upper Egypt and is best known for being the primary necropolis of Thebes. Like the Saqqara sample, very little is known about the provenance of these specimens. E.A. Wallis Budge gave these samples to the Duckworth Laboratory (Department of Biological Anthropology, University of Cambridge) in the late 1880's. Collection records indicate these specimens date to the New Kingdom Period; however, this is difficult to verify. The skeletal remains do show indications of mummification (e.g., the presence of resin), which was an indicator of high socioeconomic standing (S.T. Smith, 1991b). Specimens from the Qurneh sample were used for dental carbonate stable isotope analysis (Table 3.4). The Qurneh collection remains curated at the Duckworth Laboratory in the Department of Anthropology at the University of Cambridge.

3.4.4 Shellal

The cemetery at Shellal, located at the border between Ancient Egypt and Ancient Nubia, dates to the New Kingdom Period (1,550-1,068 BC; James, 1982). According the original excavators, most inhumations were in an Egyptian style (Smith and Jones, 1908). However, because Shellal was badly plundered, this is difficult to establish. Samples from Shellal were used here as comparative material for dental carbonate stable isotope analysis (Table 3.4). The Shellal skeletal collection is currently housed at the Duckworth Laboratory in the Department of Biological Anthropology at the University of Cambridge.

3.4.5 Scandinavian Joint Expedition: C-Group and Pharaonic

Both the C-Group and Pharaonic samples studied here were collected as a part of the Scandinavian Joint Expedition to Sudanese Nubia (1963-1964; Säve-Söderbergh, 1989). In preparation for the imminent flooding due to the construction of the Aswan High Dam, multiple salvage expeditions, including the Scandinavian Joint Expedition (SJE), were assembled. Focusing on the region from the Egyptian border to 60km south, the SJE excavated hundreds of archaeological sites. The skeletal remains excavated by the SJE are now housed at the Panum Institute (University of Copenhagen, Denmark) and curated by Dr. Niels Lynnerup.

Many of these sites relate to the C-Group culture (*c.* 2,000-1,600 BC). The C-Group thrived in this region, concurrent with the Egyptian First Intermediate

Period, Middle Kingdom, Second Intermediate Period, and the New Kingdom[13]. Despite cohabiting Lower Nubia with Egyptians for centuries, the C-Group culture maintained unique cultural traditions and represent an indigenous Nubian culture (Bietak, 1986; Vagn Nielsen, 1970). A total of 152 C-Group individuals, buried at 17 separate sites, were examined here (Table 3.1; Table 3.4). Specimens from SJE C-Group sites were used in the analysis of entheseal remodeling, osteoarthritis, and dental carbonate.

Table 3.1 SJE C-Group Skeletal Remains Examined

Cemetery Number	Site	Date (BC)	*n*
24	Shirfadik	1,650-1,550	3
35	Nag' el-Leithi	1,550-1,450	3
47	Nag' el-Leithi	1,650-1,500	3
65	Komangana	2,150-1,550	7
95	Amintobirki	1,600-1,450	5
97	Kashkush	2,050-1,600	42
99	Kashkush	?	1
170	Nag' el-Leithi	2,000-1,600	7
179	Shirfadik	2,150-1,550	55
183	Ikhtiariy	1,650-1,550	2
184	Debeira	1,650-1,600	1
193	Shirfadik	2,000-1,600	1
197	Shirfadik	2,000-1,600	1
201	Nag' Iryan	1,550-1,500	3
220	Bintibirra	1,550-1,500	8
246	Shartematti	2,050-1,550	4
262	Shirgondi	1,650-1,550	6

[13] The majority of specimens examined here date to the Second Intermediate and New Kingdom Periods (see Table 3.1 for further detail)

In addition to C-Group remains excavated by the SJE, dozens of Pharaonic sites were also unearthed. Pharaonic sites, as defined by the SJE, were cemeteries in use from *c.* 1,550-1,300 and were in the Egyptian style. In fact, some of the C-Group and Pharaonic sites chronologically overlap because the SJE differentiated C-Group and Pharaonic burials based on their funerary tradition. Many of these individuals would have lived side-by-side yet they maintained unique cultural practices (Vagn Nielsen, 1970). For this study, 31 Pharaonic individuals (17 females, 14 males), from five sites, were analyzed (Table 3.2; Table 3.4). These samples were used in the analysis of entheseal remodeling, osteoarthritis, and dental carbonate.

Table 3.2 SJE Pharaonic Skeletal Remains Examined

Cemetery Number	Site	Date (BC)	*n*
185	Hillet Fadrus	1,550-1,300	17
280	Shirfadik	1,450-1,300	3
309	Kashkush	1,450-1,300	1
318	Komangana	1,550-1,400	1
400	Wadi Serra	1,480-1,425	10

3.4.6 Amara West

The town of Amara West, located approximately 180km north of Tombos, was the Egyptian administrative capital of Upper Nubia for much of the New Kingdom period (1,550-1,069 BC; Spencer, 1997; 2002). Like Tombos, there was a large Egyptian population living at Amara West; however, there were likely indigenous Nubians living there as well. Excavations led by Dr. Neal Spencer (Keeper, Department of Ancient Egypt and Sudan, The British Museum) began in 2006 and are still underway (Binder et al., 2011; Parkinson and Spencer, 2009; N. Spencer, 2009). In collaboration with Dr. Spencer and Michaela Binder (bioarchaeologist, University of Durham) dental carbonate samples from Amara West were analyzed for stable isotope ratios. The Amara West skeletal material is housed at the British Museum and is curated by Dr. Daniel Antoine.

3.4.7 Kerma

The ancient city of Kerma, typesite for the Kerma culture, is located 20km south of Tombos. As discussed in Chapter 2, beginning with the Pre-Kerma settlement (3,000-2,500 BC), native Nubians settled and began exploiting the wide floodplain of this region. Kerma would continue to grow and expand into the Kingdom of Kush and is the second instance of state formation in Africa (O'Connor, 1993).

The skeletal material examined here originates from Kerma's immense cemetery, located east of the city. Excavated in 1913-1916 by George A. Reisner, the cemetery covered an expanse of 80-90 hectares (195-200 acres) and is estimated to have contained thousands of inhumations and two monumental deffufas (mud brick temple; Adams, 1984). A series of massive tumuli were constructed to bury local leaders. The largest of these tumuli, KIII, measures 90m in diameter and has a surface area of 6,358m^2 (Reisner, 1923a; 1923b). In sum, Reisner excavated 7 large tumuli, 16 small tumuli, and 112 independent graves, spanning the Kerma Ancien, Moyen, and Classique periods (Figure 3.3).

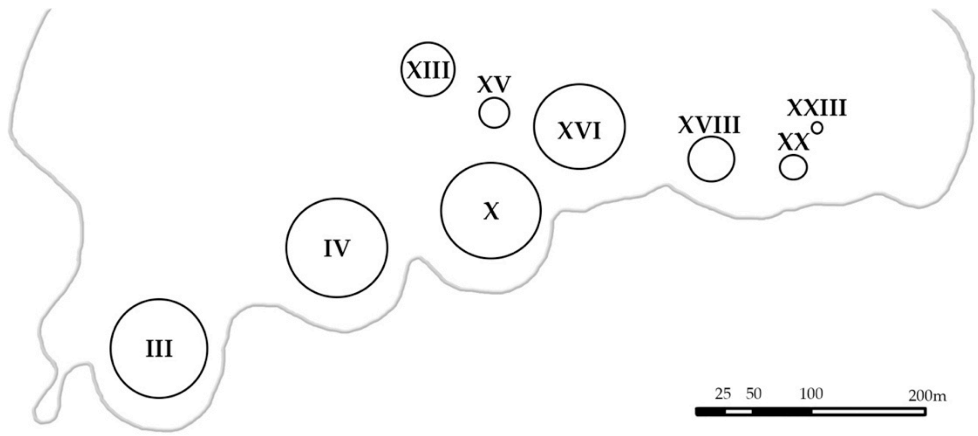

Figure 3.3 Subset of Kerma Tumuli Included in Present Study

(Adapted from Reisner, 1923a)

Unfortunately, the principal interments of the large tumuli, presumably the most elite and/or royal individuals of Kerma (buried in central apartments), were all looted in antiquity[14] (Figure 3.4). However, within the main corridors that bisected each of the large tumuli, hundreds of bodies were found. Reisner interpreted these burials to be victims of sacrifice, because of their quantity and burial position. Reisner theorized these individuals were members of the chief's harem, family, and bodyguards, who, either willingly or forcibly, accompanied their leader to death *en masse* (Kendall, 1997). Subsidiary burials were later cut into the surface of the tumuli and were likely designed to inhume the Kerma elite.

[14] However, the principal interments of the smaller tumuli were preserved and included here (entitled 'chiefs,' a term applied to these burials by Reisner).

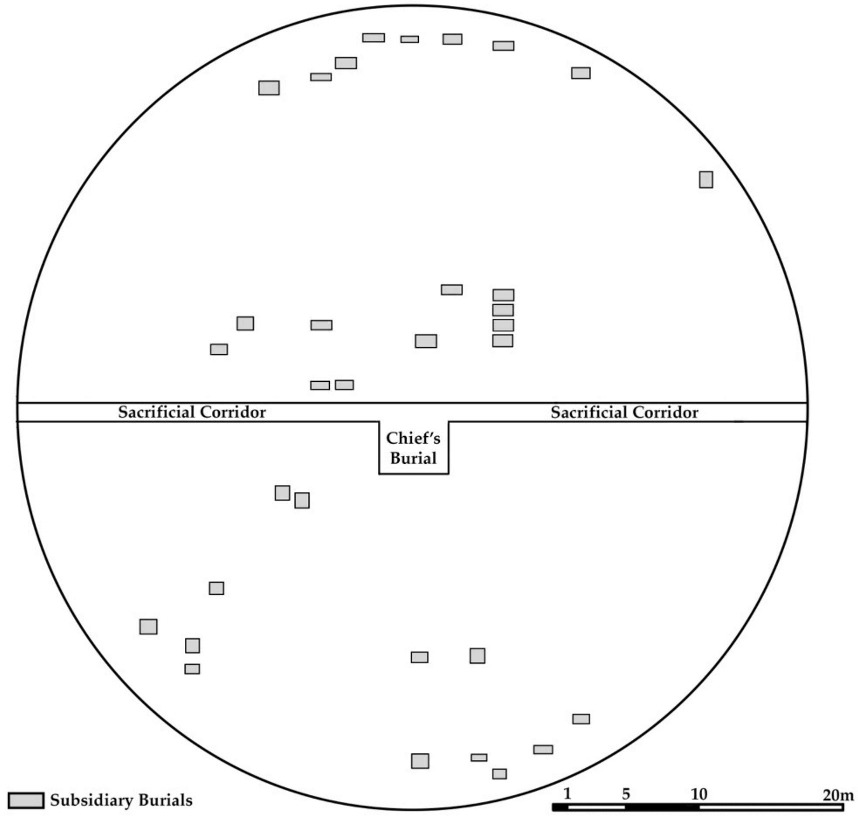

Figure 3.4 Plan of Tumulus KIII

Adapted from Reisner, 1923a)

I examined 207 individuals from Kerma (107 females, 99 males; Table 3.5.1). These individuals were buried in the following tumuli: KIII, KIV, KX, KXIII, KXV, KXVI, KXVIII, KXX, KXXIII, which all date to the Kerma Classique Period (1,650-1,500 BC). Chiefs, sacrificial, and subsidiary burials were all included in analyses (see Table 3.3). Skeletal samples from the Kerma collection were used in the analysis of entheseal remodeling, osteoarthritis, and dental enamel carbonate[15]. This material is housed in the Duckworth Collection in the Department of Biological Anthropology at the University of Cambridge.

Table 3.3 Distribution of the Kerma Burial Types Examined Here

	Chief	**Sacrificial Burials**	**Subsidiary Burials**
n	15	139	43

3.4.8 O16/P37

The sites O16 and P37 were excavated during the Northern Dongola Reach Survey project (1993-1997; Judd, 2001; Welsby, 2001). Located near the modern town of Dongola, the two sites are near one another (P37 is approximately 3km south of O16) and chronologically overlap. A total of 11 skeletons from the Kerma Ancien period (2,500-2,050 BC) were excavated from O16. At P37, 46 individuals were excavated that dated from the Kerma Ancien to the Kerma Moyen (2,500-1,650 BC; Judd, 2001). Because of their temporal and spatial proximity, these sites have been considered as a single unit in previous bioarchaeological research (see Judd, 2002), and therefore are also paired together in this dissertation. O16/P37 is considered to be a rural sample, particularly when compared to the contemporary urban center of Kerma (70km north).

[15] Previously published data from Kerma was used as a point of comparison for bone collagen stable isotope analysis (Iacumin et al., 1996; Thompson et al., 2008)

For this study, I examined 42 individuals (11 females, 15 males, 16 indeterminate sex) from O16/P37 (Table 3.4). Analysis of entheseal remodeling and osteoarthritis was performed on the O16/P37 sample. The skeletal remains of O16/P37 are housed at the British Museum and are currently curated by Dr. Daniel Antoine.

3.5 Sex and Age Determination

Standard bioarchaeological os coxae and cranial indicators were used to sex and age human skeletal remains (Buikstra and Ubelaker, 1994). Morphological indicators such as the ventral arc, sciatic notch, mastoid process, and supra-orbital margin are, in combination, accepted methods of determining the sex of a skeleton. Sex could not be determined for commingled remains because they were not associated with os coxae or crania. Body size variation, as a product of sexual dimorphism, can also be used as an osteological means for differentiating males and females (Buzon, 2004; Buzon and Richman, 2007). However, this method was not employed here because body size can be a factor in the development of muscle attachment sites. Body size is controlled for in the analysis of entheseal remodeling and, therefore, could not be used to infer sex.

The crania and os coxae were also used to determine the age at death (Buikstra and Ubelaker, 1994). When possible degenerative changes to the pubic symphysis and auricular surface (os coxae) were preferentially used to determine age. However, when these indicators were absent, tooth wear and cranial suture closure were used to infer age (Buikstra and Ubelaker, 1994; Walker et al., 1991). Only remains from adults were included in this study. Age categories included young adults (18-29 years), middle adults (30-45 years), and old adults (46+ years). Because commingled remains were not associated with os coxae or crania, age could not be determined beyond adult.

Table 3.4 Sex Distribution of Samples

	Female	Male	Indeterminate	Total
Tombos Napatan*	18	8	50	**76**
Tombos New Kingdom*	18	12	78	**108**
C-Group	86	66	0	**152**
Pharaonic	17	14	0	**32**
Kerma	107	99	0	**206**
O16/P37	11	15	16	**42**

(The indeterminate individuals for Napatan and New Kingdom Tombos include the minimum number of individuals for commingled remains; see sections 3.2 and 3.3.1 for further details.)

3.6 Summary

This chapter has presented background information on the principal sample of this dissertation, Napatan Tombos, as well as several comparative collections. Comparative samples include: New Kingdom Tombos, Saqqara, Qurneh, Shellal, SJE C-Group, SJE Pharaonic, Amara West, Kerma, and O16/P37. When compared with Napatan Tombos, each of these collections will provide a unique point of comparison and greatly inform our understanding of the New Kingdom/Napatan transition. The bioarchaeological methods used for aging and sexing skeletal remains was also presented. These are standard bioarchaeological techniques and were applied to all skeletal collections discussed above. When the theoretical framework of embodiment, structuration, and identity are applied to these bioarchaeological methods, inquiries concerning the significance of quotidian actions can be addressed.

CHAPTER 4. THE EMBODIED SKELETON, THE STRUCTURED STATE, AND THE AGENTIVE INDIVIDUAL: THEORETICAL ORIENTATION AND HYPOTHESES

4.1 Introduction

This dissertation investigates the dialogue between expansive sociopolitical powers and local communities in terms of quotidian, or everyday, activities. Specifically, the effects of the transition between the New Kingdom and Napatan State on Nubian populations will be explored via the bioarchaeological examination of activity patterns and stable isotope ratios. These methodologies will inform our understanding of Nubian diet, manual labor, and, ultimately, the everyday lives of multiple Nubian communities. The theoretical perspectives of embodiment, structuration, and social identity will be employed, contextualizing the day-to-day activities of local populations operating under the influence of broader sociopolitical powers. Acknowledging local populations as agents, even within a confining social structure, is crucial to understanding the exchange between those in positions of social, political, and economic authority and those who are not. This chapter presents the theoretical foundations and hypotheses of this research.

4.2 Embodiment

The anthropological concept of embodiment addresses how physical bodies are shaped by social factors and, thus, should be conceptualized as much more complex than mere biological entities. Embodiment refers to how we "literally incorporate, biologically, the material and social world in which we live" (Krieger, 2001:672). The biological manifestations of health, disease, and well-being, from an embodiment-oriented theoretical perspective correspond with the social, political, and economic relations of the self. Thus, embodiment is directly aligned with bioarchaeological objectives that highlight the social nature of skeletal remains and directly applies to the examination of activity and diet in the ancient past.

The 'body,' from an anthropological perspective, has been categorized into three groups: the individual body, the social body, and the body politic (Scheper-Hughes and Lock, 1987). The individual body applies to the lived experiences and the self-conceptualization of the individual. The social body addresses how the body is interpreted within a social system. The body politic concerns social control, both individual and collective, over the body. These components of 'self' have been used throughout cultural and medical anthropology (see Csordas, 1990; Lock and Kaufert, 1998; Van Wolputte, 2004) and to some extent within archaeology (see Joyce, 2005; Lesure, 2005; Meskell, 2000).

The biosocial nature of human skeletal remains facilitates the application of embodiment theory to osteological research and can elucidate the individual, social, and political bodies of the past (Jones, 1997). Bones are the biological remnants of individuals that archive social events (e.g., pathological conditions, physical activities, diet), enabling the examination of broader topics such as health, manual labor, and food choice (Buikstra and Scott, 2009; Knudson and Stojanowski, 2008). Due to skeletal plasticity, human remains can embody social actions and lived experiences similar to archaeological artifacts (e.g., ceramic sherds, lithics, textiles), and therefore, reflect both the natural and cultural surroundings of the individual (Butler 1993, Meskell and Joyce, 2003).

The concept of embodiment has been well studied in cultural anthropology, yet bioarchaeological research has only recently incorporated embodiment into theoretical discourse, despite its applicability (Knudson and Stojanowski, 2008). In *Body as Material culture: A theoretical osteoarchaeology*, Sofaer (2006) addresses embodiment through the examination of human skeletal remains. Sofaer proposes that human bodies are literally created through social practices and, thus, the skeleton can be regarded as a form of material culture akin to an archaeological artifact:

> While archaeologists are familiar with the idea that objects are created by bodies and that ideas and attitudes, rather than occupying a separated domain from the material, may be inscribed in objects, they are perhaps less routinely aware that the body is itself created in relation to a material world that includes objects as well as other people. (Sofaer, 2006:*xv*)

Not only does Sofaer acknowledge a dialogue between the social and the biological, she advances the theoretical conceptualization of skeletal remains as embodied artifacts. Thus, rather than simply providing demographic (e.g., age, sex, population size) or paleopathological information, from this perspective, bioarchaeology has the ability to address both the biological and social past.

Bioarchaeologists employing embodiment theory have tended to focus on the body as an inscriptional surface, an active means of personal expression. Just as clothing, jewelry, and weaponry, have been associated with embodied identity perspectives in the archaeological record (Bayman, 2002; Fisher and DiPaolo Loren, 2003; Gilchrist, 1997; Joyce, 1999; 2002; Wobst, 1977), body ornamentation and modification have similarly been used in the osteological record (Blom, 2005; Robb, 1997; Torres-Rouff, 2002; 2003). When grounded in identity theory, these forms of expression are, by definition, exterior and public; they can serve as material symbols of group identity that are visible and widely interpretable (Joyce, 2005).

However, by establishing an embodied 'exterior' (i.e., visible, public), a dichotomous 'interior' is also implied (Rautman and Talalay, 2000). Joyce furthers this idea by questioning, "Is 'surface' to 'interior' as 'public' is to 'private'?" (Joyce, 2005: 149). This debate certainly applies to the embodiment of osteological indicators of activity (i.e., entheseal remodeling, osteoarthritis). Peterson's (2000) examination of gender relations and household organization in the Early Bronze Age Near East, takes an agent-centered perspective on entheseal remodeling. Females were found to have higher rates of entheseal remodeling, elucidating the transition to a domestic economy in the Near East.

The theoretical perspective of embodiment informs how the social world is imprinted on our physical bodies. Bioarchaeologists have a distinct opportunity to better understand embodiment and how society and culture can impact our biological selves. To address the concept of social structure and agentive individuals I turn to practice theory, Giddens' perspective on structuration, and social identity.

4.3 Practice Theory and Structuration

Practice theory illustrates the significance that everyday actions have in both the maintenance and modification of cultural systems as well as the negotiation of social identities. By bridging the gap between broader social structures and individual agents, this theoretical perspective achieves what other social theories have lacked. For example, traditional structuralist approaches viewed society as an organism that operates mechanistically via interrelated parts (i.e., norms, customs, traditions, institutions; see Lévi-Strauss, 1963). Structuralism has been criticized for not acknowledging individual actors as agents as well as not accounting for social change. At the other end of the spectrum, methodological individualism contends that all cultural phenomena are attributable to individual action (see Elster, 1982). These perspectives lack an adequate dialogue between social structures and the individuals existing within them. This is where practice theory succeeds in developing a theoretical discourse between the influence of social structure and the power and agency of individuals.

Practice theory contends that within any given society, there exist institutions and activities, which are regulated by societal rules and norms. Human actions are carried out within the framework of a pre-existing social structure and, therefore, are somewhat confined. However, individuals existing within this milieu are agentive and can either maintain or contest these norms through their daily practices. These seemingly mundane actions can be multiscalar, contextual, and diverse. Daily practices such as food preparation, bargaining, and gift exchange have been studied within the framework of practice theory (Bourdieu, 1977; Dreyfus, 1991; Taylor 1985). When one considers the individuals existing within these contexts, activities performed become meaningful strategies rather than just monotonous actions.

It can then be said that individuals, as agents, can construct worldviews, social identities and an ordering of daily life. It is through these daily actions that allow for the reproduction of culture to further generations as well as the transmission of culture to new practitioners. Situations of culture contact can create charged encounters in which knowledge of daily practices can be communicated, but also reconstituted, fueling social change (discussed further below). When practice theory is employed, a society can be viewed as a dynamic arena of contact and transformation, rather than a static populace. Ortner succinctly summarizes practice theory, contending that "society is a system, that the system is powerfully constraining, and yet that the system can be made and unmade through human action and interaction" (1984:159).

While many scholars have employed practice theory (e.g., Gillespie, 2001; Greenhalgh, 1995; LiPuma, 1993; Phipps, 2001), Pierre Bourdieu and Anthony Giddens are generally thought to be the architects and pioneers of this theoretical perspective. Bourdieu asserts that it is not cultures that reproduce social practice; instead, individuals produce culture, which leads to social change (Bourdieu, 1977). Focusing on the learned culture of bodily practices, Bourdieu coined the term *habitus* to define the sum of habits, style, and taste (Bourdieu, 1977;

Margolis, 1999). The *habitus* changes with time as individuals interact, cultures come into contact, and the social structure and culture is altered. Furthermore, *hexis* is defined by Bourdieu as a form of communication via body language (e.g., gestures, movements, micro-mimicking) and is considered to lie within *habitus* (Bourdieu, 1977; 1987). *Doxa* is that which is taken for granted in any given society; this includes learned and unconscious beliefs and values that are assumed to be universal by the agentive individual. Through *habitus, hexis, and doxa*, Bourdieu interprets individual agency as tiny movements, which are the underpinnings of alterations to everyday actions that result in social change; "The conditions associated with a particular class of conditions of existence produce *habitus,* systems of durable, transposable dispositions, structured structures predisposed to function as structuring structures" (Bourdieu, 1990:53).

Bourdieu's perspectives of *habitus*, *hexis*, and *doxa* have been critiqued for not incorporating an agency component, implying that societies simply bear culture (Meskell, 2001; Stone, 2003). However, this continues to be debated within archaeological circles (S.T. Smith, in press). Giddens' (1984) theory of structuration accounts for an overarching societal structure but also acknowledges individuals as active producers of culture. This theoretical perspective will provide a frame with which we can interpret the everyday lives of Nubians and understand local identities.

Giddens views agentive action in terms of habitual and routine daily activities. Structuration, as a component of practice theory, describes how human actions are carried out within the framework of a pre-existing social structure, and, therefore, are somewhat confined (Giddens, 1984). However, individual agents can contest these norms by altering their daily practices. These quotidian actions are performed as a means of maintaining existing identities, and cultures, but are altered with interaction and time, leading to new practices, identities and cultures (Giddens, 1984; S.T. Smith, in press). There is a mutual dependence between the two components (i.e., structure and agency), what Giddens (1984) refers to as the duality of structure, in which social structures allow social action, while simultaneously, social action via agency can modify the broader social structure. From this perspective, even the most routine, agent-based, activities can be considered maneuvers that define individuals, informing social practice, negotiation, and identity through time (Barrett, 2001; de Certeau, 1988).

Giddens' concept of structuration is directly applicable to the bioarchaeological record. Quotidian activities of the past, including food consumption and physical movement, can, to some extent, be ascertained through the examination of stable isotope analysis and activity patterns (discussed further in Chapters 5, 6, and 7; Sofaer, 2006). Thus, bioarchaeologists can apply structuration to the ancient past and begin to understand how these influential daily activities, as expressed by agentive individuals, may have altered the social structure. As discussed below, the self-determined identity of an individual is one venue for expression and confrontation of the social structure.

4.4 Social Identity

The term 'identity' often has multiple and conflated definitions and understandings within anthropological literature. Here, I adopt Diaz-Andreu's definition of identity: "individuals' identification with broader groups on the basis of differences socially sanctioned as significant" (Diaz-Andreu, 2005:1). This conceptualization of identity allows for an individual to engage in multiple identities concurrently. Social identities may include, but aren't limited to, ethnicity, religion, gender, status, and age (Meskell, 2001; Shennan, 1994). These cultural markers serve to bring together and unify collectivities with the commonness of an identity. At the same time, these identities can create 'the other,' by distinguishing those that are not a part of ones' associated group.

While scholars in the first half of the twentieth century incorporated identity studies into their research, they viewed the groups and subgroups created from this social process as being unchanging and homogenous (Jones, 1997). Beginning with Barth's (1969) notable discussion of ethnic identity, anthropologists and sociologists began to view identity as a self-defining process (Cohen, 1978). Initially, ritual practices (Beidelman, 1966; Turner, 1969) and the reproduction of consciousness (Geertz, 1973; Ortner, 1978) were theorized to be the modus operandi to maintaining social identities and reproducing culture. More recently, practice theory, with an emphasis on the routine actions of daily life, has been introduced into the discussion of social identity (Hodos, 2010; Jenkins, 1997; Lucy; 2005, McGuire, 1982). From this perspective, activities such as decorating (Gullestad, 1993), cleaning (Linde-Laursen, 1993), bodily gestures (Bourdieu, 1977; Mauss, 1973), and production (Costin et al., 1998) all serve to negotiate social identities as well as create a dialogue between social structures and agentive individuals.

Incorporating the examination of social identity and the quotidian into archaeological research expands our understanding of identities through time. Archaeology strengthens anthropology through the consideration of thousands of years of history in which a broader diachronic image of social processes can be better understood (Robin, 1999). Investigations into day-to-day events have proved to be an enduring goal within archaeological research and comprise a major component of various approaches such as the archaeology of households (see Allison, 1999; Blanton, 1994; Wilk and Rathje, 1982) and communities (see Canuto and Yaeger, 2000; Kolb and Snead, 1997; Rogers and Smith, 1995). The link between everyday actions and social identities has also been explored (Tringham, 1996). Continuing topics in the archaeology of identity include: culture contact (Deagan, 1983; 1990; Hastorf and D'Altroy, 2001; Lightfoot et al., 1998), space, place and architecture (Love, 1999; Robin, 1999; 2002), as well as occupation and crafting (Brumfiel, 1991; 1996; 1998; Costin, 1996; Hendon, 1996; 2002; 2004; Stark, 1991).

Social identities can become well defined and even accentuated during periods of culture contact and interaction. In these situations, the need for individuals to define themselves as a part of a broader group(s), and in doing so determine those who are not in said group (i.e., 'the other'), becomes even more significant (Lightfoot, 1995). One space in which this is particularly applicable is frontiers and borderlands. Once grounded in a core-periphery framework and highly influenced by World-systems theory, these liminal territories were once conceptualized as being static and inherently passive to the political center (Lerner, 1984; Lewis, 1984; Schortman and Urban, 1992; Wallerstein, 1987).

However, this preconceived notion has been readdressed both in anthropological and archaeological literature (Michaelsen and Johnson, 1997; Parker and Rodseth, 2005; Silliman, 2001; Voss, 2005; Wilson and Donnan, 1998). These zones are no longer thought of as cultural borders that constrain interaction, but rather as areas of intense cooperation, communication, and coexistence (Stein, 2002; S.T. Smith, 2003b).

> Frontiers represent ideal places to study interethnic interactions between diverse peoples; the development of new material and cultural innovations; and the construction, negotiation and manipulation of group identities. (Lightfoot and Martinez, 1995:474)

This interpretation of frontier and border zones directly applies to Third Cataract Tombos. This was a peripheral town that, during the New Kingdom, was colonized by Egyptians, but was also home to many indigenous Nubians. In this context both Egyptian and Nubian lifeways converged and social identities were modified to achieve a peaceful coexistence. For New Kingdom Nubians at Tombos, one way this was accomplished was through the selective and voluntary adoption of Egyptian traits (S.T. Smith, 2003b). Later, in the Third Intermediate and Napatan Periods, the material and skeletal record suggests a greater degree of both cultural and biological blending (Buzon et al., 2007; Buzon and Simonetti, 2013; S.T. Smith, 2006; 2007; See section 2.4 for further detail). The inhabitants of the borderland locale of Tombos, therefore, were not passive receptors of culture, becoming increasingly ‘Egyptianized’ as was once thought (see Breasted, 1908; Emery, 1965; Reisner, 1920b). Instead, individuals at Tombos were defining their own identities and blending cultural traditions.

But how do individuals communicate and reinforce their self-defined identities in these culture contact and borderland scenarios? Foodways are an excellent expression of social identity (S.T. Smith, 1995; 2003b); food selection, preparation, and consumption can serve as tools to associate or disassociate oneself or ones group with others, thereby defining and maintaining social identities (Goody, 1982; Wood, 1995). Furthermore, diet is a lived experience that is practiced everyday and in social venues – all of which are defining characteristics of social identity (Caplan, 1997; Counihan and Kaplan, 1998; Scott, 2008).

4.5 The Anthropology of Food

From a biological perspective, dietary consumption is an essential component to life, providing necessary nourishment in the form of carbohydrates, proteins, fats, vitamins, minerals, fiber, phytonutrients, and water (Armelagos, 1987; Larsen, 2000). These nutrients facilitate growth, tissue repair, basal metabolic function, and physical activity. Beyond this, diet and its associated activities (i.e., food selection, preparation, presentation, consumption) play a very important social role (Caplan, 1997; Counihan and VanEsterik, 1997). Anthropological studies of foodways bridge these perspectives and have greatly influenced our understanding of the multifaceted nature of food.

Initial anthropological studies of edibles used ethnographic methods. In 1920, Cushing published an article on Zuni breadstuffs (Cushing, 1920). Soon thereafter, Boas published a book on Kwakiutl salmon recipes, which is highly regarded as an informative ethnographic resource (Boas, 1921). This descriptive, ethnographic perspective soon developed into a functionalist approach as anthropologists began to acknowledge the role of food in social relations. Radcliffe-Brown stressed the social function of food, arguing that cuisine had the power to regulate social systems (Gumerman, 1997:108; Radcliffe-Brown, 1922). Despite the theoretical flaws of functionalism, this was an important step in conceptualizing food as a significant social practice.

Levi-Strauss argued that food could be used to analyze the structure of a society (1963, 1966). From this, he developed a "culinary triangle," which described specific foods on various spectrums such as how cooked the food was (i.e. raw to rotten), various ingredients (i.e. air, oil water) and techniques (i.e. broiling, boiling, roasting and frying). According to Levi-Strauss, he was attempting "to discover for each specific case how the cooking of a society is a language in which it unconsciously translates its structure" (Levi-Strauss, 1966:595).

Other scholars have examined the anthropology of food by analyzing diachronic changes in subsistence as a product of population movement, environments and technologies. Foci of study include human origins (Binford, 1968; Sobolik, 1994), agricultural adaptations (Boserup, 1965; Christensen, 1980; Cohen, 1977; Earle, 1980; Morrison, 1994) and climate change (King, 1993). Another radical transformation in the way anthropologists conceive of food occurred in the early 1980's with Goody's (1982) groundbreaking publication of *Cooking, Cuisine and Class: A Study of Comparative Sociology.* It was this book, in particular, that began to view food as a marker of social identity and considered the agent-based process of food choice in the selection, preparation and consumption of cuisine.

From this perspective, many fields of research have blossomed. The intersections of food and various identities such as gender (Kahn, 1986; Weismantel, 1988; Whitehead, 2000), feasting (Dietler, 1996; Hayden, 2001) and the production of identity through memory (Sutton, 2001) gained in popularity. Furthermore, topics such as dietary change as a result of migration and culture contact (Dennett and Connell, 1988; Goody, 1998; Lockwood and Lockwood, 2000) as well as social action and sociopolitical forces (Chatwin, 1997; Gumerman, 2002; Jing, 2000; Lentz, 1999; Levenstein, 1993; Macbeth, 1997; Mennell, 1985; Wu and Tan, 2001) became widespread

Foodways can also serve a social role within ritual practices and beliefs. In many cultures, certain foods and dietary habits are considered sacred through their association with supernatural beings and processes (Bloch, 1985; Khare, 1992; Singer, 1984; Toomey, 1994). Many have hypothesized the link between food and faith is through the complicated weave of social memory (Feeley-Harnik, 1994; 1995; Sutton, 2001). Weismantel (1991) has suggested that modern indigenous Andean practices of eating and drinking maize-based products (*chica*) during religious feasts is an artifact of ancient Inca traditions. The Inka are known to have held maize in high religious regard; it was believed these offerings would nourish the dead. Brandes (1997) similarly studied the relationship between sugar and Mexican rituals for Dia de los Muertos. Brandes suggests these religious foodways are based in traditional Aztec practices. Eating in ritual contexts such as major religious events and ritual performances is often a public act. Deliberate social statements such as these can reaffirm or transform social relationships (Brown, 1995; Buitelaar, 1993; Murphy, 1986). We must also consider, however, those acts that are not public and therefore, don't serve an immediate role in the communication of identity. Within smaller units, such as the individual, household, and kin group, "ritual and beliefs surrounding food powerfully reinforce religious and ethnic boundaries" (Mintz and du Bois, 2002:107; see also Bahloul, 1989; Fabre-Vassas, 1997).

In certain contexts, variations between diet and gender are detectable. In *Food and Gender: Identity and* Power, Counihan and Kaplan (1998) argue that the association between gender, food and power is multifaceted. The book is centered around two primary arguments, (1) control of production, distribution and consumption can contribute to gender positions and (2) food can symbolically communicate gender and established social status of both men and women. Gender variations in consumption have also been studied in Melanesia (Kahn, 1986), Papua New Guinea (Munn, 1986; Whitehead, 2000), and the Maasai (Talle and Palsson, 1990).

These topics are often difficult, if not impossible, to detect in the archaeological contexts. With the assistance of ethnohistoric evidence, White (2005) has researched gender identity through foodways of the ancient Maya. Hastorf (1996) has also been able to identify gender differences in foodways in the ancient Sausa of the Andes. Many researchers are beginning to look at the effects of sociopolitical processes, such as culture contact, on the above-mentioned social identities (Hastorf, 1996; Voss, 2005). Scott (2008) contends that in scenarios of culture contact, the culturally determined food preferences will reflect the sociopolitically dominant culture.

Investigations into traditional foodways of peripheral territories can not only elucidate the varieties of foods that were consumed, but also address local agency by illustrating the process of food selection and preparation as populations juxtapose indigenous and foreign diets (M.L. Smith, 2006; S.T. Smith, 1997; 2003b). This premise can be applied to the context of the ancient Nile Valley. While Nile Valley diets were in many respects similar, stable isotope analysis allows bioarchaeologists to tease apart Egyptian and Nubian diets. Based on archaeological, botanical and written sources, Egyptians are known to have consumed large quantities of wheat/barley bread and beer as well as fish (Alcock, 2006; Ikram, 2000; Samuel, 1996b; 2000). However, Nubians were more dependent upon sorghum, millet, and cattle (Chaix and Grant, 1992; Edwards, 1996; 2004; see Chapter 7 for further detail).

Thus, by examining daily practices within the context of an Egyptian colonial town in Nubia, I intend to elucidate the relationship between sociopolitical powers and local communities. This involves a reconceptualization of human skeletal remains (embodiment), a dialectic of social structure and individual agency (structuration/practice theory), and an understanding of the mechanism(s) that reinforce this process (social identity). Couched in these theoretical perspectives, this bioarchaeological research interprets quotidian actions (activity patterns, diet) as ways in which social relations are defined and constituted. Additionally, this research will not only contribute to these theoretical debates but will also address important historical questions about Ancient Egypt and Nubia.

4.6 Research Questions and Hypotheses

This dissertation investigates how local quotidian existence is altered in response to and as a consequence of episodes of sociopolitical change. The relationship between everyday activities and sociopolitical power is explored within the context of Ancient Nubia during the New Kingdom/Napatan transition. Specifically, osteological indicators of mechanically strenuous lifestyles (osteoarthritis, entheseal remodeling) and diet (carbon and nitrogen stable isotope analysis) are investigated to inform our understanding of ancient Nubian lifeways during this period.

According to structuration theory, everyday activities can be viewed as agent-based negotiations that, with time, can alter social structures entirely. However, these activities can be highly regulated when under the authority of larger sociopolitical powers, such as empires and states (Hastorf, 1990; Lightfoot et al., 1998; Silliman, 2001). In order to maximize economic gains, local communities are often forced to alter the organization of labor and patterns of production in order to meet institutional requirements (Brumfiel, 1991; D'Altroy and Hastorf, 2001; Sinopoli, 1994). I argue that structuration theory remains applicable to these populations. Even though manual labor can be highly influenced by sociopolitical authorities, local populations maintain the agency to evoke their identities via day-to-day actions.

The degree of sociopolitical control over labor is contextual and highly variable. For example, peripheral territories of the Aztec Empire were placed under the rule of the local nobility who required tribute demands, but didn't actively govern labor (M. Smith, 1986). Conversely, the Incas were known to have practiced forced relocation, where imperial subjects (particularly males) were coercively moved to areas with abundant resources where direct regulation of labor was possible (LaLone and LaLone, 1984; Murra, 1980; Rowe, 1982). The nature of sociopolitical involvement in manual labor is based on several factors including: administrative structure, distance to accumulation points, distribution of centralized institutions, and the economic as well as symbolic significance of the product (Sinopoli, 1994). As discussed above (sections 2.4 and 4.4), Nubians living in colonial New Kingdom Tombos could choose to Egyptianize and, thus, acquire administrative positions. While the Egyptians did not force Nubians to make this cultural transition, it is documented that foreigners (e.g., Nubians) could not advance within the political hierarchy unless they 'became Egyptian' (Trigger, 1976b). This choice would inherently impact what types of physical activities they would be participating in. Those who allied themselves with the Egyptian Empire could be placed in positions such as scribes, artisans, and prosperous servants – all of which required minimal manual labor. However, those who opted to maintain a Nubian identity may have had to engage in the more laborious tasks within the town (i.e., agriculture, mining, construction). Within this context, Nubians at Tombos during the New Kingdom were agentive in electing not only what ethnic identity they would portray, but also the associated occupations (i.e., daily physical actions). However, much less is known about Napatan Tombos; within the Napatan social structure, would individuals have been able to voice their agency through day-to-day action associated with manual labor? Or was the structure too rigid that Napatan Nubians had to find alternative ways to express themselves? More broadly, how can any subjugated populations express agency when manual labor is governed by sociopolitical powers (e.g., Aztec Empire)?

One way in which indiivduals can retain agency and maintain a local identity is within food preparation and consumption. Various subjugated populations, including slaves (Armstrong and Kelly, 2000; McKee, 1995), convicts (Hindmarsh 2002), as well as refugees, and food aid recipients (Eide, 2000; Pottier, 1999; Singer et al., 1987), have been known to exhibit dietary choices. There is evidence to suggest that ancient Nubian's used foodways as means to define as well as advertise their self-defined identities. S.T. Smith (1995; 2003a) has investigated the ceramic assemblage at the archaeological site of Askut (near the Second Cataract of the Nile), during the Middle Kingdom (2,040-1,650 BC) and Second Intermediate Period (1,650-1,550 BC). This study presents a clear dichotomy between Egyptian and Nubian vessels (cooking, serving, and storage vessels), which exemplify social identity enacted via foodways. Nubian serving vessels increase in number during the Second Immediate Period (when Kerma controlled the Second Cataract Region, including Askut), then decrease during the New Kingdom Period when Egypt regained this territory. Interestingly, Nubian cookpots are abundant and increase through time. Smith contends that both gendered and ethnic elements contributed to the distribution of these assemblages. Specifically, he proposes that women (historically known for their role preparing food in both Egypt and Nubia) were more closely associated with the cookpots and the gradual and prolonged increase in these vessels suggests intermarriage between Egyptian men and Nubian women. Men, who were culturally responsible for entertaining (e.g., banquets, feasts), are linked with the serving ware. This interpretation explains the rise in Nubian serving ware during the Second Intermediate Period (when Nubia was in power at Askut) and its gradual decline during the New Kingdom (when Egypt was in power). Furthermore, a residue analysis pilot study indicates that the Egyptian and Nubian vessels held distinctly different foods (discussed further in Chapter 7; S.T. Smith, 2003b). Thus, S.T. Smith's examination of the material record at Askut supports the notion that Egyptians and Nubians associated food with multiple identities (i.e., gender, ethnic).

Human skeletal remains, as embodied artifacts, are direct remnants of both activities performed and of foods consumed during the pivotal New Kingdom/Napatan transition. Analysis of activity patterns will shed light upon the types of activities local Nubians were engaged in as well as the degree with which they were performing said activities. While specific occupations cannot be inferred using this methodology, generalized levels of manual labor (e.g., strenuous versus minimal) can be discerned and can be associated with historically recognized lifeways such as scribes, craftspeople and agriculturalists. When the skeletal remains of New Kingdom Tombos were examined, I found markedly low levels of entheseal remodeling and osteoarthritis (Schrader 2010, 2012). These osteological studies, in addition to the archaeological record and textual evidence, indicate the residents of New Kingdom Tombos were not engaging in strenuous modes of manual labor and the community was likely incorporated into the Egyptian administrative structure (see Chapter 3 for further discussion).

In the aftermath of the Egyptian New Kingdom, did Nubia revert to a tribal or semi-nomadic lifestyle as has been conventionally assumed? What was the economic function of local communities, including Tombos, during this period? In order to sustain and expand the Napatan State was a redistributive economy, complete with increased demands for surplus foodstuffs and trade goods, established? How would these socioeconomic and sociopolitical changes have affected the lifeways of indigenous Nubians? Based on these questions, I propose the following hypotheses and expectations:

I. Did the administrative role of Tombos change with the transition of power from the Egyptian New Kingdom to the Napatan State? Was increased physical labor needed to support the expanding Nubian economy?

Hypothesis 1. *The fall of the Egyptian New Kingdom Empire and development of the Napatan State increased physical demands at Tombos*. With the introduction of Napatan state demands, Nubians were forced to maximize production and alter labor organization. This scenario would be reflected by an increase in activity patterns from what was seen in earlier and would suggest modes of manual labor congruent with agriculturalists, slaves, or miners.

Hypothesis 2. *Tombos continued to play an administrative role during the Napatan period*. Due to increased trade networks and opportunities to advance within the Napatan state hierarchy, local Nubians benefitted from the state structure. Decreased or stabilized levels of activity patterns in comparison with New Kingdom and earlier populations would suggest populations involved with little to no manual labor, perhaps artisans, prosperous servants or local administrators.

II. What do the foodways of local Nubians tell us about their response to sociopolitical changes during the New Kingdom and Napatan periods?

Hypothesis 1. *Local Nubians at Tombos retained a traditional diet during the sociopolitical transitions of the Egyptian New Kingdom and the rise of the Napatan state.* Local diet consists of characteristically Nubian foods (cattle[16], sorghum, millet), suggesting Nubians were maintaining traditional social identities as expressed through foodways. Stable isotope analysis would indicate a nitrogen intake typical of cattle consumption (expected $\delta^{15}N$ ratios: 9 to 11.5‰) and a carbon intake characteristic of sorghum and millet (expected $\delta^{13}C$ ratios for collagen: -9 to -14‰ and carbonate: -0.5 ± 1‰).

Hypothesis 2. *Local Nubians at Tombos adopted an Egyptian diet.* Local Nubians opted for a more Egyptian diet (wheat, barley), suggesting Nubians welcomed an Egyptian-influenced identity. Stable isotope analysis would result in nitrogen intake typical of fish consumption (expected $\delta^{15}N$ ratios: 12 to 15‰) and carbon intake typical of wheat and barley consumption (expected $\delta^{13}C$ ratios for collagen: -20 to -35‰ and carbonate -14.5± 2‰).

[16] Both Egyptians and Nubians are known to have consumed cattle; however, I propose that Nubians would have consumed more cattle because of a pastoral society and religious ties with cattle cults (see Chapter 7 for more detail).

Traditional forms of archaeology that investigate the quotidian (e.g., household archaeology, archaeology of communities) are less feasible in this region due to urban and agricultural expansion as well as past archaeological preference of cemetery excavation. Modern growth often occurs atop ancient habitation sites due to the common desire for river proximity. However, owing to the fact that cemeteries were often located out of the prime agrarian and habitation land, oftentimes in the nearby desert that is epitomized by the dry, hot and arid climate, they are often preserved and the condition of human skeletal remains is excellent (Baker, 1992). As a result, bioarchaeological methods will enable an examination of the everyday where otherwise unavailable.

This examination will inform our understanding of the conditions in which local Nubians were living, in terms of intensity of manual labor, before and during the Napatan state. Stable isotope analysis of carbon and nitrogen will explicate what types of foods ancient Nubians were eating, informing their self-defined social identities. Therefore, the proposed research will address agency through the identification of social identities in local populations, while considering the potential confines of a state structure. These methods can be further extrapolated from analyses of individuals to the community to form collective, local, activity pattern and dietary profiles.

4.7 Summary

The theoretical perspectives of embodiment, structuration, social identity, and the anthropology of food will be used to interpret the everyday lives of Ancient Nubians during the New Kingdom/Napatan transition. This theoretical framework stresses the significance of quotidian action and everyday life. Through the osteological analysis of activity patterns and dietary reconstruction, we can begin to understand how lifeways were altered with the sociopolitical introduction of the Napatan State. As outlined in the above hypotheses, this may result in: 1a) increased activity patterns, 1b) decreased/stabilized activity patterns, 2a) the maintenance of Nubian dietary patterns, 2b) the adoption of Egyptian dietary patterns. In the next chapter I will address these hypotheses using the analysis of entheseal remodeling as a proxy for physical activity.

CHAPTER 5. ENACTING THE EVERYDAY: ENTHESEAL REMODELING DURING THE NEW KINGDOM/NAPATAN TRANSITION

5.1 Introduction

The examination of culture contact and the social, economic, and political implications these events can have for all peoples involved has become a central theme in current archaeological research (see discussion of peripheries, frontiers, and boundaries in section 4.4; Cusick, 1998). Oftentimes, these phenomena are conceptualized as dramatic and abrupt encounters, such as interpersonal violence, forced relocation, and an increase in disease (Hill, 1998; Larsen and Milner, 1994; Saunders, 1998). However, I argue what is equally as important is how peoples' quotidian, or everyday, lives changed during, and as a consequence of, these episodes of contact. It is within these day-to-day experiences that archaeologists can begin to address long-term interaction and coexistence rather than volatile cataclysms.

Ancient Nubia is an excellent venue to examine alterations to everyday life as an artifact of culture contact. Interaction between Nubia and Egypt existed for thousands of years, over which time the political tone ranged from amicable to exploitative and violent, and on multiple occasions resulted in conquest and colonization. The Napatan Period (850-664 BC) is an example of conflict, convergence, and, ultimately, coexistence. As discussed in Chapter 2, the origins, scale, and sociopolitical structure of the Napatan state continue to be topics of heated debate (Kendall, 1999; Morkot, 1994; Török, 1995). In the aftermath of the Egyptian Empire, did Nubia revert to a tribal or semi-nomadic lifestyle as has been conventionally assumed? What was the economic function of local communities, including Tombos, during this period? In order to sustain and expand the Napatan State, was a redistributive economy established? How would these socioeconomic and sociopolitical changes have affected the lifeways of indigenous Nubians?

The bioarchaeological analysis of entheseal remodeling can be used to infer broad levels of physical activity in these Ancient Nubian populations. Entheses, the biological structures that attach muscles and ligaments to bone, adapt with increased usage and strenuous activity. By quantifying entheseal changes, bioarchaeologists can discern changes in activity between different populations. Here, I examine entheseal changes in six distinct Nubian skeletal samples to achieve a better understanding of ancient activity patterns in the Nile Valley. Special attention is paid to the Tombos Napatan data, which address the questions posed above.

Previous bioarchaeological analysis of entheseal remodeling and osteoarthritis in the New Kingdom Tombos sample indicates that this population was not participating in particularly physically stressful activities (Schrader, 2010; 2012). This research, coupled with archaeological evidence, suggest that Tombos was an imperial administrative center during the New Kingdom. In this context, Tombos would have monitored trade and population movement along the Nile River, while imposing an Egyptian presence within Nubia (S.T. Smith, 2003b). Our understanding of the Third Intermediate (1,069-850 BC) and Napatan (850-

644 BC) Periods in Nubia is limited because of a lack of written records after Egyptian withdrawal in addition to sparse archaeological evidence (Edwards, 2004). However, this is a particularly interesting phase in both Nubian and Egyptian history. The reason why the New Kingdom Egyptian Empire began to wane, either due to internal decline (see Adams, 1977) or the emergence of the powerful Napatan State (see Morkot, 2000), is unclear. However, by 1,100 BC Egypt no longer controlled Nubia and by 850 BC Upper Nubia, centered at Napata (near the Fourth Cataract), had emerged as a powerful and centralized state. By 750 BC the Napatans conquered Egypt and ruled both Egypt and Nubia as the 25th Dynasty (Morkot, 2001). Tombos is one of few sites that is known to have been continuously occupied from the New Kingdom to the Napatan period and is, therefore, crucial to the understanding of the New Kingdom/Napatan transition. Thus, the analysis of entheseal remodeling at Tombos will elucidate the lifeways of local Nubians during this important period of culture contact and change.

Therefore, this research builds on previous analyses of activity patterns at Tombos (Schrader, 2010; 2012) by additionally examining the Napatan Period skeletal material. Interpretations of entheseal remodeling in the Napatan sample are couched within this prior bioarchaeological research. Table 5.1. outlines the hypotheses and expectations of this analysis. These data are further contextualized by comparing results of entheseal remodeling at Tombos to skeletal material from the Nubian sites of Kerma, C-Group, Pharaonic, and O16/P37. Additional details regarding these skeletal samples can be found in Chapter 3.

Table 5.1 Hypotheses and Expectations: Activity Reconstruction, Entheseal Remodeling (ER)

Hypotheses	Expectations
Levels of physical activity at Napatan Tombos were higher than at New Kingdom Tombos; this indicates that despite political power during the Napatan period, local Nubians at Tombos were engaged in more intensive manual labor (e.g., agriculture, food production, craftspeople)	Napatan ER > New Kingdom ER
Overall workload at Napatan Tombos was less than or similar to New Kingdom Tombos; Tombos may have continued to serve the Third Cataract region as an administrative center (e.g., minor officials, scribes), while the polity's capital was located farther south, in Napata	Napatan ER ≤ New Kingdom ER

I begin this chapter by describing the physiological structure of an enthesis and the previous bioarchaeological work that has been done in this area of research. I then explain the methods used in this study to quantify entheseal changes on the skeleton. The results of entheseal remodeling analyses on the Napatan Tombos and comparative samples can be found in section 5.3 and discussed further in section 5.4. I then conclude with the implications this examination of entheseal remodeling has for our understanding of ancient Nubian lifeways as well as future bioarchaeological research.

5.1.1 The Physiological Structure of Entheses

Often referred to as tendons and ligaments, or musculoskeletal stress markers in bioarchaeological literature, entheses are complex systems that enable physical motion, while simultaneously dissipating stress (Benjamin et al., 2002). The study of entheses has drawn substantial attention from medical researchers because of the direct application to common sporting injuries. In fact, frequent injuries such as 'tennis elbow' and 'runner's knee' are now known to be entheseal damage. However, despite decades of research, there is still much to be learned about how muscles and ligaments attach to bone and how bone responds to overuse of these tissues.

There are two main categories of entheses: fibrous and fibrocartilaginous (Benjamin and McGonangle, 2001; Benjamin and Ralphs, 1998; Shaw and Benjamin, 2007). Both fibrous and fibrocartilaginous entheses serve to attach and maintain the intersection of muscle and bone. However, these categories differ in how this connection is made. In a fibrous enthesis, the muscle or ligament affixes to a dense connective tissue, which then attaches directly to the bone or periosteum (a dense layer of vascular connective tissue that envelopes the bone's surface). In a fibrocartilaginous enthesis, however, the muscle/bone connection is more complicated and has undergone chondrogenesis. Through this process, four distinct soft/hard tissue zones are created: (1) fibrous connective tissue, (2) uncalcified fibrocartilage, (3) calcified fibrocartilage, and (4) bone (Benjamin et al., 1986; Benjamin et al., 2002). Of the two categories of entheses, fibrocartilaginous attachments have been more thoroughly examined, primarily due to their vulnerability to injury and, therefore, priority within medical research.

Some researchers have pursued the examination of entheses by controlling for body size, diet, sex, and activity via animal experimentation. For example, both hard and soft tissues of rabbits, dogs, mice, and sheep, have been analyzed for entheseal reaction to muscle use (Gao et al., 1996; Thomopoulos et al., 2008; Zumwalt, 2005). However, using animals as proxies for the human body and the complexities of human movement is impractical. The bioarchaeological examination of entheses, particularly in identified skeletal collections (i.e., known sex, age at death, and/or occupation), is one area of research that can shed light on this complicated biological process (Campanacho and Santos, 2013; Cardoso and Henderson, 2013; Lopreno et al., 2013).

5.1.2 Previous Bioarchaeological Studies of Entheseal Remodeling

For decades, bioarchaeologists have been interested in the crests, ridges, and pits that appear on the surface of the bone at the site of muscle and ligament attachment. Since the 1980's the association between entheseal changes reflected on bone and the physical activity of that individual has been a hot topic of research. The reconstruction of activity in the ancient past using methods such as muscle attachment sites, osteoarthritis, and cross sectional bone geometry, has been coined 'the Holy Grail' of bioarchaeology (Jurmain et al., 2012).

Over the past three decades, the analysis and interpretations of entheseal remodeling have undergone dramatic changes within the discipline of bioarchaeology. One of the first publications on entheseal changes to the skeleton was Dutour's (1986) article on Neolithic Saharan populations. Dutour concluded due to increased entheseal changes in the elbow and ankle that Neolithic Saharan populations were engaging in activities such as javelin throwing, wood-cutting, archery, and walking/running. In a similar vein, Lai and Lovell (1992) combined multiple indicators of activity (vertebral osteophytosis, Schmorl's nodes, osteoarthritis, entheseal changes) to examine the Hudson's Bay Company Fur Trade. From these analyses, they suggested this population was participating in carrying, lifting, as well as paddling/rowing. It wasn't until 1995, however, that a systematic method of scoring entheses was published. Hawkey and Merbs (1995) examined Hudson Bay Eskimo samples and clearly defined (both in text and photos) their proposed scoring system, which ranked entheseal robusticity, stress lesions, and ossification. This soon became a standard method of measuring entheseal severity within bioarchaeological studies and, to some extent, is still used today.

Researchers found that entheseal markers have multifactorial causation factors (e.g., sex, age, body size). Perhaps most notably, age has been positively correlated with entheseal changes across multiple populations (Jurmain, 1999; Robb, 1998; Villotte and Knüsel, 2013). Munson Chapman (1997) examined an indigenous Pecos Pueblo (New Mexico) sample and found that Spanish contact had little to no effect on Native activity patterns. However, entheseal markers were found to increase in severity with age. Wilczak (1998) studied skeletal remains from seven samples that included Native Americans as well as American blacks and whites. Entheses were found to increase significantly with age in males, but not females. It is still not clear why entheses increase in frequency and severity with age and many questions remain; are entheseal changes accrued over ones life? Or, as an individual gets older, are their bones more susceptible to entheseal remodeling? How does ‘occupational mobility’ or the ability to change occupations throughout one’s life effect entheseal remodeling (Henderson et al., 2013)? Regardless, it is now generally accepted that they are highly correlated.

In addition to the reconstruction of activity, many scholars have attempted to identify a sexual division of labor in past populations through the examination of entheseal markers. Many studies have found males to have higher rates of entheseal changes than females and have assumed these results are correlated to differences in physical activity (e.g., Munson Chapman, 1997; Nagy, 1999; Peterson, 1998). Conversely, some studies found females to have higher rates of entheseal remodeling than males (al-Oumaoui et al., 2004; Nagy and Hawkey, 1995). Weiss, however, suggests the relationship between entheseal remodeling in males versus females may not be straightforward (Weiss, 2003; 2004; 2007). She points out that males are typically larger and have more muscle mass, which could have a dramatic effect on their respective attachment sites. This issue can be addressed through the analysis of body size. Through statistical analysis (see 5.2.2), body size can be controlled for so that differences in entheseal remodeling between the sexes can be attributed to biological variation or varying workloads.

Age, sex, and body size are contributing factors of entheseal remodeling that can be controlled for. Other conflating factors include acute trauma, pathological conditions (e.g., diffuse idiopathic skeletal hyperostosis, seronegative spondyloarthropathies), genetics, physical activity intensity, socioeconomic status, and environment (Havelková et al., 2013; Jurmain and

Roberts, 2008; Niinimäki and Sotos, 2013). These components of entheses are still being researched and new ways of methodologically and statistically handling them are debated (Jurmain et al., 2012; Robb, 1998).

Recent bioarchaeological research has investigated how the different types of entheses (i.e., fibrous, fibrocartilaginous) differ with regards to skeletal markers. Villotte (2006) has suggested that fibrocartilaginous entheses are easier to detect due to a well-defined margin. Through the use of identified skeletal collections, where age, sex, and occupation are known, Villotte has repeatedly found strong correlations between activity and fibrocartilaginous entheses (Villotte et al., 2010). There have been numerous publications in the last few years that have supported Villotte's findings and further encourage the differentiation of fibrous and fibrocartilaginous entheses in bioarchaeological research (Havelková et al., 2011; Henderson et al., 2010). Results of fibrous attachment sites are not as clear-cut; once fibrous entheses are better understood in both clinical and bioarchaeological research, a separate scoring method will likely be required to associate these entheses with activity.

In association with the fibrous/fibrocartilaginous studies, many researchers have suggested new scoring methods be employed to score entheses (Davis et al., 2013). There are several proposed methods that look beyond Hawkey and Merbs' (1995) basic assumption that entheses linearly progress from bone growths, to bone destruction at the point of overuse (a.k.a., furrow), to ossified exostoses. Villotte and colleagues define an 'entheseopathy,' or pathological enthesis, as (1) irregularity at the attachment margin, and/or (2) irregularity, with a minimum of three foramina, cystic changes, calcification deposit, bony production or osseous defect in the interior enthesis (Villotte et al., 2010). Henderson and colleagues have defined zones of an attachment site to bone (Cardoso and Henderson, 2010; Henderson et al., 2010; Henderson et al., 2012; Henderson et al., 2013). Zone 1 consists of the entheseal margin opposite the acute angle of attachment, whereas zone 2 is the remaining surface and margin. In zone 1 there is a three point scoring system for both bone formation and erosion and in zone 2 there is a two to three point scoring system for bone formation, erosion, fine porosity, and cavitation. Mariotti and colleagues, on the other hand, have argued that entheses vary widely between attachment sites and suggest an independent scale be used for each entheses (Mariotti et al., 2004; 2007). Unfortunately, a consensus on which scoring method is best to use has yet to be reached.

There have also been notable technological advancements in scoring methods. Several objective methods have been employed, including the use of three-dimensional scanners, which offers great potential for future research (Nolte and Wilczak, 2013; Pany et al., 2009; Zumwalt, 2005, 2006). Additional functional changes that are caused by activity are also being used in conjunction with entheseal markers to interpret physical activity (Ibáñez-Gimeno et al., 2013).

Entheseal remodeling is a bioarchaeological method that remains in demand and the reconstruction of activity continues to be of prime interest. Recently, a workshop on musculoskeletal stress markers at the University of Coimbra (2009), an organized session, entitled “Working Nine to Five: The Future of Activity-Related Stress,” at the American Association of Physical Anthropologist’s 81st (2012) annual meeting, as well as an International Journal of

Osteoarchaeology Special Issue (2013), entitled "Entheseal Changes and Occupation: Technical and Theoretical Advances and Their Applications"[17] are three examples of renewed interest in this methodology.

5.2 Materials and Methods

For this study I examined 616 individuals (see Chapter 3). Because some of these burials were comingled or incomplete, the number of elements analyzed can be found in all Chapter 5 tables. A total of 17 attachment sites were examined (Table 5.2). These were chosen because they are major muscles and ligaments within the body and they provide an overview of physical activity. The combined attachment site of multiple entheses (supraspinatus/infraspinatus, common extensors, common flexors, semimembranosus/semitendinosus/biceps femoris) were analyzed as a single unit because in these instances: (1) the single attachment sites were difficult to detect and (2) entheses development within an individual was found to be similar between them (Havelková et al., 2011; Villotte et al., 2010).

[17] International Journal of Osteoarchaeology 23(2):127-251

Table 5.2 Entheses Examined

Humerus	Supraspinatus/ Infraspinatus
	Subscapularis
	Teres minor
	Common extensors
	Common flexors
Ulna	Triceps brachii
	Brachialis
Radius	Biceps brachii
	Brachioradialis
Os Coxae	Semimembranosus/ Semitendinosus/ Biceps femoris
Femur	Gluteus medius
	Gluteus minimus
	Psoas
	Gastrocnemius
	Quadratus femoris
Tibia	Patellar ligament
	Popliteus

5.2.1 Recording of Entheseal Remodeling

Entheseal remodeling was scored on a six-point scale that was inspired by several of the methods discussed above (Table 5.3). Further information on the samples as well as sexing and aging methodologies can be found in Chapter 3.

Table 5.3 Entheseal Remodeling Scoring System

Score	Description
0	absence of marginal bone growth, or pitting; surface is smooth
1	slight marginal bone growth (<1mm), absence of pitting
2	defined marginal bone growth (1-2mm), with minimal pitting/erosion (<25%)
3	defined marginal bone growth (1-2mm), with moderate pitting/erosion (25-50%)
4	moderate marginal bone growth (2-4mm), with minimal to moderate pitting/erosion (<50%)
5	moderate marginal bone growth (2-4mm), with moderate to severe pitting/erosion (>50%)
6	significant marginal bone growth (>4mm), with severe pitting (>50%) and/or cavitation

5.2.2 Statistical Analysis

The scoring method described in section 5.2.1 is based on a ranked system and, therefore, it produces ordinal data (Drennan, 2009). Additionally, when tested for skewness and kurtosis, these data are not normally distributed. Thus, only non-parametric statistical analyses were employed. When a Wilcoxon Signed Ranks Test, which is a non-parametric method for comparing related samples, was performed, entheseal scores between the left and right sides proved to be significantly different ($p \leq 0.05$). Therefore, the left and right sides were analyzed separately. The Mann-Whitney *U* (two variables, i.e., male/female) and the Kruskal-Wallis (three or more variables, i.e., young/middle/old adult) were employed to compare distributions across groups.

Data binning was used as a non-parametric method to control for body size. When employing data binning, data values that fall within a predetermined interval, or a bin, are grouped together into the following categories: small, medium, and large (Barlow, 1989). Thus, similar values are grouped together and can then be compared with one another. For this study, humeri were binned into three groups (i.e., small = maximum humeral length<300cm, medium = max humeral length 301-319cm, large = maximum humeral length>320cm). These cutoff points were determined using the SPSS visual binning tool, which analyzes the distribution of the data and establishes intervals. Femora were also binned into three groups (i.e., small = maximum femoral length<420cm, medium = maximum femoral length 421-440cm, large = maximum femoral length>441cm). Then, these groups were each associated with the biological sex of the individual (i.e., small males, small females, medium males, medium females, large males, large females). With these binned variables, the sexes were then compared within the same body size category. For example, small males were compared to small females. Using this procedure, males and females could be compared while controlling for body size. Similarly, age at death was binned into three groups: young adults (18-29 years old), middle (30-45 years old), and old adults (46+ years old). All statistical analyses were conducted using SPSS (version 19).

5.3 Results

Results from entheseal remodeling analysis are presented here. First, results from the Napatan Tombos sample are compared to other Nile Valley skeletal collections. Then, the discrete burials, those that were not looted and comingled, are then presented as a subsample of the Tombos population.

5.3.1 Entheseal Remodeling: Napatan Tombos in Ancient Nubia

By viewing the variation of entheseal remodeling in Ancient Nubia diachronically, a range of manual labor, from less intensive to more intensive, can be identified. The Tombos Napatan data can then be placed within this broader context of ancient Nile Valley activity patterns. In this section, data from Napatan Tombos, Napatan New Kingdom (see Schrader, 2010 for further details), Kerma, C-Group, Pharaonic, and O16/P37 are presented. Tables 5.4 and 5.5 illustrate the differences between these populations.

Analysis of entheseal remodeling at Tombos suggests there was variation in the amount and type of manual labor being performed between the New Kingdom and Napatan period samples. Entheses from the Napatan sample frequently exhibit higher mean scores than the New Kingdom sample. Several of the mean entheseal scores were found to be significantly different between the two samples. All entheses except the right subscapularis (humerus), left and right teres minor (humerus), right triceps brachii (ulna), right brachialis (ulna), left brachioradialis (radius), right biceps brachii (radius), right semimembranosus/semitendinosus/biceps femoris (os coxa), and the left gluteus minimus (femur) were found to be statistically significantly higher ($p \leq 0.05$) in the Napatan sample than the New Kingdom sample. There were no instances where entheses from the New Kingdom sample were significantly higher than the Napatan sample.

Mean entheseal scores from the Kerma sample were elevated compared to the Napatan Tombos sample; several entheses were found to vary significantly. The Kerma sample had significantly higher scores than the Tombos Napatan sample for all entheses except: left teres minor (humerus), left common extensor (humerus), left triceps (humerus), left and right brachioradialis (radius), left and right semimembranosus/semitendinosus/biceps femoris (os coxa), left gastrocnemius (femur) and the left and right patellar ligament (tibia).

Overall, mean entheseal scores were quite similar between C-Group and Napatan samples; the C-Group sample had higher mean scores in 10 out of the 18 upper body entheses (five on the left, five on the right) and in eight of the 16 lower body entheses (four on the left, four on the right). However, only upper body entheses were found to substantially differ. The right common extensors (humerus), left and right common flexors (humerus), and left and right brachialis (ulna) were the only entheses that were found to be significantly higher in the C-Group sample than the Tombos Napatan sample.

The Pharaonic sample noticeably differs from the Tombos Napatan sample. The majority of entheses resulted in higher mean scores in the Tombos Napatan sample than the Pharaonic sample; 13 of the 18 upper body entheses (seven on the left, six on the right) and 10 of the 16 lower body entheses (five on the left, five on the right) were higher in the Napatan sample. Five entheses were found to be significantly higher in the Napatan sample: left and right supra/infraspinatus (humerus), right brachioradialis (radius), left gastrocnemius (femur), and the right patellar ligament (tibia).

Although O16/P37 and Napatan Tombos often had similar mean entheseal scores, several attachments proved to be significantly different between the two groups. The left and right supra/infraspinatus (humerus), right extensors (humerus), left and right flexors (humerus), left and right brachialis (ulna), and right gluteus minimus (femur) were all found to be significantly higher in the O16/P37 sample than the Napatan Tombos sample. However, the right semimembranosus/semitendinosus/biceps femoris (os coxa) and the right patellar ligament (tibia) were found to be significantly higher in the Tombos Napatan sample than the O16/P37 sample.

Table 5.4 Entheseal Remodeling in the Nile Valley: Napatan Tombos and Comparative Sites (Left)

	Napatan Tombos		**New Kingdom Tombos**[1]		**Kerma**		**C-Group**		**Pharaonic**		**O16/P37**	
	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*
Supraspinatus/ Infraspinatus (H)	1.84	*(32)*	**0.82**	*(33)*	**2.93**	*(112)*	1.77	*(39)*	**0.46**	*(13)*	**2.92**	*(12)*
Subscapularis (H)	1.45	*(31)*	**0.63**	*(32)*	**2.02**	*(89)*	1.00	*(40)*	1.33	*(15)*	1.25	*(12)*
Teres minor (H)	1.13	*(30)*	0.75	*(32)*	2.21	*(95)*	0.97	*(34)*	0.50	*(12)*	1.73	*(11)*
Common extensors (H)	2.65	*(43)*	**1.46**	*(54)*	3.24	*(126)*	2.79	*(48)*	2.18	*(17)*	2.84	*(25)*
Common flexors (H)	1.26	*(43)*	**0.88**	*(60)*	**1.93**	*(128)*	**1.67**	*(49)*	1.11	*(18)*	**2.27**	*(26)*
Triceps brachii (U)	1.70	*(44)*	**1.15**	*(34)*	1.69	*(115)*	1.69	*(16)*	2.00	*(10)*	1.59	*(27)*
Brachialis (U)	1.80	*(45)*	**1.27**	*(33)*	**2.36**	*(119)*	**2.88**	*(16)*	2.20	*(10)*	**2.41**	*(27)*
Biceps brachii (R)	2.07	*(46)*	**1.45**	*(40)*	**2.58**	*(122)*	2.44	*(16)*	1.91	*(11)*	2.35	*(26)*
Brachioradialis (R)	1.75	*(36)*	1.14	*(22)*	1.73	*(92)*	2.07	*(14)*	1.10	*(10)*	2.25	*(12)*
Semimembranosus/ Semitendinosus/ Biceps femoris (OC)	2.92	*(37)*	**1.81**	*(52)*	3.19	*(101)*	3.00	*(3)*	3.10	*(10)*	2.27	*(22)*
Gluteus medius (F)	1.70	*(43)*	**1.15**	*(40)*	**3.22**	*(110)*	1.61	*(23)*	1.17	*(12)*	2.12	*(17)*
Gluteus minimus (F)	1.80	*(44)*	1.29	*(38)*	**3.37**	*(115)*	2.44	*(27)*	1.36	*(14)*	2.25	*(16)*
Psoas (F)	1.81	*(43)*	**1.08**	*(37)*	**2.79**	*(135)*	1.63	*(24)*	1.87	*(15)*	2.10	*(20)*
Gastrocnemius (F)	2.14	*(42)*	**1.12**	*(42)*	2.25	*(126)*	1.81	*(32)*	**1.12**	*(17)*	1.92	*(12)*
Quadratus femoris (F)	1.44	*(48)*	**0.93**	*(45)*	**2.52**	*(147)*	2.03	*(31)*	1.67	*(15)*	1.85	*(20)*
Patellar ligament (T)	2.03	*(30)*	**1.13**	*(40)*	2.21	*(123)*	1.33	*(20)*	1.36	*(14)*	1.13	*(15)*
Popliteus (T)	0.97	*(29)*	**0.38**	*(34)*	**1.64**	*(112)*	1.38	*(21)*	0.71	*(14)*	0.64	*(14)*

Significantly different ($p \leq 0.05$) than the corresponding Napatan Tombos enthesis in **Bold**
[1] = previously published in Schrader 2010; 2012

Table 5.5 Entheseal Remodeling in the Nile Valley: Napatan Tombos and Comparative Sites (Right)

	Napatan Tombos		**New Kingdom Tombos**[1]		**Kerma**		**C-Group**		**Pharaonic**		**O16/P37**	
	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*
Supraspinatus/ Infraspinatus (H)	2.02	*(41)*	**0.84**	*(37)*	**3.09**	*(140)*	1.85	*(60)*	**0.58**	*(12)*	**3.13**	*(15)*
Subscapularis (H)	1.71	*(41)*	1.41	*(32)*	**2.48**	*(127)*	1.50	*(60)*	1.50	*(14)*	2.00	*(17)*
Teres minor (H)	1.23	*(40)*	0.87	*(30)*	**2.30**	*(125)*	1.07	*(56)*	0.43	*(14)*	**1.62**	*(13)*
Common extensors (H)	2.39	*(46)*	**1.74**	*(50)*	**3.30**	*(152)*	**2.88**	*(72)*	2.35	*(17)*	**3.08**	*(25)*
Common flexors (H)	1.30	*(47)*	**0.68**	*(50)*	**2.07**	*(153)*	**1.81**	*(70)*	1.44	*(16)*	2.41	*(27)*
Triceps brachii (U)	1.31	*(52)*	1.32	*(38)*	**1.72**	*(124)*	1.91	*(11)*	1.57	*(14)*	1.43	*(30)*
Brachialis (U)	1.34	*(53)*	1.28	*(40)*	**2.61**	*(137)*	**3.45**	*(11)*	2.07	*(14)*	**2.57**	*(30)*
Biceps brachii (R)	2.18	*(39)*	2.07	*(30)*	**2.67**	*(132)*	2.77	*(13)*	1.69	*(16)*	2.24	*(29)*
Brachioradialis (R)	2.03	*(32)*	**1.06**	*(17)*	1.72	*(96)*	2.15	*(13)*	**1.07**	*(14)*	2.00	*(16)*
Semimembranosus/ Semitendinosus/ Biceps femoris (OC)	3.35	*(37)*	2.65	*(40)*	3.21	*(104)*	2.50	*(6)*	3.17	*(6)*	**2.36**	*(22)*
Gluteus medius (F)	2.14	*(35)*	**1.04**	*(45)*	**3.51**	*(130)*	1.54	*(35)*	1.75	*(12)*	2.35	*(20)*
Gluteus minimus (F)	1.74	*(35)*	**1.11**	*(44)*	**3.44**	*(132)*	1.81	*(37)*	1.77	*(13)*	**2.56**	*(18)*
Psoas (F)	1.84	*(37)*	**0.89**	*(45)*	**2.80**	*(127)*	2.11	*(35)*	2.00	*(12)*	2.22	*(23)*
Gastrocnemius (F)	1.89	*(36)*	**0.80**	*(41)*	2.47	*(123)*	1.81	*(36)*	1.07	*(14)*	2.22	*(18)*
Quadratus femoris (F)	1.61	*(41)*	**0.83**	*(53)*	**2.67**	*(146)*	1.76	*(42)*	1.62	*(13)*	1.85	*(20)*
Patellar ligament (T)	2.03	*(35)*	**1.00**	*(47)*	2.17	*(141)*	2.00	*(22)*	**1.21**	*(14)*	**1.18**	*(17)*
Popliteus (T)	0.94	*(33)*	**0.28**	*(43)*	**1.57**	*(122)*	1.50	*(22)*	0.62	*(13)*	0.38	*(13)*

Significantly different ($p \leq 0.05$) than the corresponding Napatan Tombos enthesis in **Bold**
[1] = previously published in Schrader 2010; 2012

5.3.2 Entheseal Remodeling: Discrete Burials of Napatan Tombos

As section 5.3.1 suggests, entheseal remodeling at Napatan Tombos is dissimilar to New Kingdom Tombos. However, more nuanced features of these two samples can be differentiated when discrete burials are analyzed as a subset of the entire population. Discrete burials are defined as those inhumations that were undisturbed and, when excavated, were associated with a cranium and/or pelvis, which are the most reliable elements for the bioarchaeological estimation of sex and age. Thus, with this additional information, these contributing factors can be controlled for and further interpretations of ancient lifeways at Tombos can be made.

5.3.2.1 Comparison Between Sexes

Here, known males are compared to known females in order to address the possibility of sexual division of labor at Tombos. Only two entheses were found to be significantly different between males and females in the Napatan population: left gastrocnemius (femur) and right popliteus (tibia; Table 5.6). When body size was controlled for the left gastrocnemius continued to be statistically significant ($p \leq 0.05$), whereas right popliteus was no longer statistically different. This suggests that the males were using their left gastrocnemius muscles more than females. The significant difference of the right popliteus between males and females can be attributed to contrasting body sizes between the sexes.

Table 5.6 Entheseal Markers at Tombos: Napatan Males v. Females

	Females				Males			
	Left		Right		Left		Right	
	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*
Supraspinatus/ Infraspinatus (H)	1.77	*(13)*	2.33	*(6)*	2.12	*(17)*	3.60	*(5)*
Subscapularis (H)	1.85	*(13)*	2.00	*(5)*	2.12	*(17)*	2.67	*(6)*
Teres minor (H)	1.23	*(13)*	1.33	*(6)*	1.44	*(16)*	1.50	*(6)*
Common extensors (H)	2.60	*(15)*	3.00	*(7)*	2.94	*(17)*	2.67	*(6)*
Common flexors (H)	1.25	*(16)*	1.71	*(7)*	1.88	*(17)*	1.33	*(6)*
Triceps brachii (U)	1.53	*(17)*	1.00	*(7)*	1.33	*(15)*	2.00	*(6)*
Brachialis (U)	1.88	*(17)*	1.67	*(6)*	1.87	*(15)*	1.50	*(6)*
Biceps brachii (R)	1.75	*(16)*	3.00	*(7)*	1.86	*(14)*	2.67	*(6)*
Brachioradialis (R)	1.93	*(14)*	2.00	*(6)*	2.33	*(15)*	2.00	*(6)*
Semimembranosus/ Semitendinosus/ Biceps femoris (OC)	3.13	*(16)*	4.00	*(8)*	3.06	*(17)*	3.75	*(8)*
Gluteus medius (F)	2.21	*(14)*	2.75	*(8)*	2.38	*(13)*	3.43	*(7)*
Gluteus minimus (F)	2.00	*(14)*	2.63	*(8)*	1.54	*(13)*	2.57	*(7)*
Psoas (F)	1.75	*(16)*	2.63	*(8)*	1.60	*(15)*	2.86	*(7)*
Gastrocnemius (F)	1.73	*(15)*	2.88	*(8)*	**2.00**	*(13)*	2.38	*(8)*
Quadratus femoris (F)	1.75	*(16)*	2.38	*(8)*	1.73	*(15)*	2.63	*(8)*
Patellar ligament (T)	2.17	*(12)*	2.83	*(6)*	1.86	*(14)*	2.57	*(7)*
Popliteus (T)	0.91	*(11)*	1.50	*(6)*	0.71	*(14)*	**2.43**	*(7)*

H=humerus, U=ulna, R=radius, OC=os coxa, F=femur, T=tibia
$p \leq 0.05$. Significantly higher values than the corresponding male/female enthesis in **bold**, (not body size controlled – see text)

5.3.2.2 Comparison Between Age Categories

Many of the entheseal markers were found to increase in severity with age. As noted above, many other researchers have reported similar findings (see 5.1.2). At Tombos, entheseal remodeling scores increased from young, to middle, to old adults. In fact, the majority of entheseal markers examined (left upper body 7/9; right upper body 7/9; left lower body 2/8; right lower body 4/8) were found to be statistically different between the age groups (Table 5.7). A non-parametric Kruskal-Wallis one-way analysis of variance indicates the following entheseal markers vary significantly between age groups: left and right supra/infraspinatus (humerus), left and right subscapularis (humerus), left and right teres minor (humerus), left and right common extensors (humerus), left and right common flexors (humerus), right and left triceps brachii (ulna), left and right brachioradialis (radius), left and right semimembranosus/ semitendinosus/biceps femoris (os coxa), left and right psoas (femur), right quadratus femoris (femur), as well as the right patellar ligament (tibia).

Table 5.7 Entheseal Remodeling at Napatan Tombos: Young, Middle, and Old Adults

	Young Adults				**Middle Adults**				**Old Adults**			
	Left		Right		Left		Right		Left		Right	
	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*	$\bar{x}$	*N*
Supraspinatus/ Infraspinatus (H)	0.75	*(8)*	1.00	*(8)*	1.80	*(5)*	1.88	*(8)*	**3.67**	*(6)*	**4.43**	*(7)*
Subscapularis (H)	0.71	*(7)*	0.78	*(9)*	1.80	*(5)*	2.00	*(8)*	**3.33**	*(6)*	**4.14**	*(7)*
Teres minor (H)	0.13	*(8)*	0.22	*(9)*	1.80	*(5)*	1.75	*(8)*	**2.33**	*(6)*	**2.83**	*(6)*
Common extensors (H)	0.88	*(8)*	1.00	*(9)*	3.57	*(7)*	3.56	*(9)*	**4.00**	*(7)*	**4.33**	*(6)*
Common flexors (H)	0.13	*(8)*	0.33	*(9)*	1.67	*(9)*	2.22	*(9)*	**2.67**	*(6)*	**2.83**	*(6)*
Triceps brachii (U)	0.63	*(8)*	0.86	*(7)*	1.75	*(8)*	1.43	*(7)*	**1.75**	*(8)*	**2.29**	*(7)*
Brachialis (U)	1.50	*(8)*	1.57	*(7)*	1.63	*(8)*	1.63	*(8)*	2.43	*(7)*	2.17	*(6)*
Biceps brachii (R)	1.67	*(9)*	1.71	*(7)*	2.00	*(7)*	2.17	*(6)*	2.86	*(7)*	2.43	*(7)*
Brachioradialis (R)	1.00	*(7)*	1.29	*(7)*	1.83	*(6)*	2.00	*(7)*	**3.00**	*(7)*	**3.43**	*(7)*
Semimembranosus/ Semitendinosus/ Biceps femoris (OC)	1.69	*(13)*	2.23	*(13)*	3.00	*(11)*	3.64	*(14)*	**4.36**	*(11)*	**4.75**	*(8)*
Gluteus medius (F)	1.67	*(9)*	2.25	*(8)*	3.00	*(6)*	2.83	*(6)*	2.86	*(7)*	3.33	*(6)*
Gluteus minimus (F)	1.33	*(9)*	1.25	*(8)*	2.33	*(6)*	1.83	*(6)*	3.29	*(7)*	2.83	*(6)*
Psoas (F)	1.22	*(9)*	0.67	*(9)*	2.29	*(7)*	2.13	*(8)*	**2.75**	*(8)*	**3.50**	*(6)*
Gastrocnemius (F)	1.67	*(9)*	1.40	*(10)*	2.57	*(7)*	2.50	*(6)*	2.29	*(7)*	2.83	*(6)*
Quadratus femoris (F)	1.33	*(9)*	1.10	*(10)*	2.38	*(8)*	2.25	*(8)*	2.29	*(7)*	**3.00**	*(6)*
Patellar ligament (T)	1.40	*(5)*	1.14	*(7)*	2.71	*(7)*	2.38	*(8)*	2.83	*(6)*	**2.83**	*(6)*
Popliteus (T)	1.00	*(6)*	1.43	*(7)*	1.17	*(6)*	1.25	*(8)*	1.20	*(5)*	1.17	*(6)*

H=humerus, U=ulna, R=radius, OC=os coxa, F=femur, T=tibia
$p \leq 0.05$. Significantly higher values than the corresponding young adult and middle adult enthesis in **bold**

5.4 Discussion

Based on the results presented above, certain patterns of activity emerge among these Nile Valley skeletal samples. In this section, I will first address entheseal remodeling in Nubia, discussing Napatan Tombos and the other comparative collections analyzed here. Then, I will present what these interpretations contribute to our understanding of the New Kingdom/Napatan transition. Lastly, I will examine the data from the discrete burials from Napatan Tombos.

5.4.1 Entheseal Remodeling in Nubia

The comparison of entheseal remodeling between the Tombos sample and multiple skeletal collections strengthens our understanding of the social, political, and economic consequences of the New Kingdom/Napatan transition as well as the everyday lives of local Nubians during these periods. While specific physical activities cannot be inferred using this method, a comparison of overall levels of physical stress between samples can be made. Further information on the comparative material and their context can be found in Chapter 3.

Mean entheseal markers at Kerma were regularly the highest out of all comparative material. The majority of entheses are statistically significantly higher at Kerma than the Napatan Tombos sample. Entheseal remodeling analysis of O16/P37 sample resulted in mean scores similar to Kerma. Thus, it is not surprising that the majority of entheses analyzed are significantly higher at O16/P37. Entheseal remodeling in the Tombos New Kingdom sample (see Schrader 2010; 2012) was similar to the Pharaonic sample. These two samples consistently had the lowest entheseal marker scores out of all samples presented here.

The Tombos Napatan sample most closely resembled the C-Group sample. These samples generally fell in between the Kerma and O16/P37 high scores, and the markedly low scores of New Kingdom Tombos and the Pharaonic samples. However, the Napatan sample was found to be significantly higher in five entheses of the upper body when compared to the C-Group. Why are the Kerma and O16/P37 mean entheseal scores so high? Why might the Tombos New Kingdom sample correspond so closely with the Pharaonic sample? Why are entheseal markers similar between Napatan Tombos and the C-Group? A few tentative explanations can be put forward regarding this patterning.

5.4.1.1 <u>Kerma and O16/P37</u>

Kerma and O16/P37 were contemporaneous communities that occupied Upper Nubia during the Kerma Period (2,500-1,500 BC). While Kerma and O16/P37 have not, to my knowledge, previously been analyzed for entheseal changes, these samples have been examined for bioarchaeological indicators of trauma (Judd, 2000; 2002). Judd found that both Kerma and O16/P37 had elevated rates of interpersonal violence and skeletal trauma compared to other Nile Valley skeletal collections (i.e., Sahaba, Naga el-Der, Semna South, Soba, Kulubnarti, Archaeological Survey of Lower Nubia). However, rural O16/P37 was found to have more instances of minor forearm and lower leg injuries, which are typically caused by falls or loss of balance. Judd partially attributes this to accident-related injuries, owing to a more hazardous lifestyle associated with cultivating and herding.

The level of traumatic injury at O16/P37 and Kerma, in addition to the entheseal remodeling data presented here, suggests these two communities were participating in arduous forms of manual labor (Judd, 2006). Ancient Nubia is thought to have maintained an agro-pastoral economy during this period (Morkot, 2001). Activities such as intensive agriculture and animal husbandry are tasks, both extremely physically repetitive and laborious, that would explain the high levels of entheseal changes seen here. Furthermore, Kerma and O16/P37 are located within the Dongola Reach, which has the widest floodplain and is the most agriculturally fertile area in Nubia (north of the Fifth Cataract; Adams, 1977). Thus, Kerma and O16/P37 are examples of pre-imperial Nubian communities that may have engaged in demanding subsistence patterns resulting in higher rates of activity patterns.

5.4.1.2 Pharaonic and New Kingdom Tombos

There has been a long-held notion that Nubians were exploited during New Kingdom Egyptian colonization, being forced into harsh forms of manual labor and slavery; however, this research in addition to recent archaeological work suggests otherwise. Many scholars have begun to suggest that the interaction between Egyptians and Nubians during the New Kingdom was more positive (Morkot, 1987; 2001; O'Connor, 1993; S.T. Smith, 2003b; Török, 1995).

As discussed above and in Chapter 3, New Kingdom Tombos served as an Egyptian administrative center in Nubia and is an example of positive Egyptian/Nubian cooperation (S.T. Smith, 2003b). Inhabitants of New Kingdom Tombos would have been of middle and upper socioeconomic status, likely employed in such occupations as minor officials, professionals, skilled craftspeople, and prosperous servants[18] (Buzon and Richman, 2007). New Kingdom Tombos probably economically benefited from imperial trade networks, and newly constructed temple towns, which served as centers of government and redistribution (Kemp, 1978; S.T. Smith, 1997). In fact, burials at New Kingdom Tombos exemplify a blending of Egyptian and Nubian funerary cultures, suggesting a mutual and amicable process of transculturation (Buzon, 2006a; Buzon et al., 2007; Buzon and Bombak, 2009; S.T. Smith, 2003b).

In a similar manner, the contemporaneous Pharaonic population could have also greatly benefited from an Egyptian imperial presence. Inhabiting the Second Cataract region these burials were deemed 'Pharaonic' by the SJE because of their Egyptian funerary traditions. Much like Tombos, these people were biologically Nubian and Egyptian (Buzon, 2006a). It is no coincidence that both contemporary New Kingdom populations examined here had minimal entheseal changes and, thus, were not participating in physically strenuous forms of manual labor. Individuals from the Pharaonic sample may have been well integrated into the administrative system, like at Tombos, and, thus, were engaging in a limited degree of physical activity. This would also explain the

[18] As stated in Chapter 3, the majority of New Kingdom skeletons from Tombos come from the middle class component of the cemetery owing to better preservation

disparity between the Pharaonic sample and the C-Group sample. Despite spatial overlap, and, to some extent, chronological overlap, there is still varying activity between these two groups. The data from the Pharaonic sample further support the interpretation of New Kingdom Tombos: (1) New Kingdom Egyptian presence in Nubia created positive interaction and coexistence and (2) these communities likely benefited from the broad economic networks maintained by the empire.

5.4.1.3 C-Group and Napatan Tombos

The Napatan Tombos and C-Group samples fall somewhere in between the high Kerma and O16/P37 entheseal scores and the low New Kingdom Tombos and Pharaonic entheseal scores. From this, what can we broadly infer about levels of activity during this time? The Napatan Tombos and C-Group populations were likely engaging in manual labor that was more physically demanding than the imperial New Kingdom Tombos and Pharaonic samples, but also were probably not engaging in immensely strained manual labor as seen in Kerma and O16/P37.

Unfortunately, archaeological evidence of the C-Group peoples continues to be relatively unclear (see Chapters 2 and 3). While many cemeteries have been excavated, few habitation sites have been investigated (Bietak, 1986; S.T. Smith, pers. comm.). It has been suggested that the C-Group was organized into independent chiefdoms that lived alongside, and eventually cohabitated with Egyptian colonists during the Middle Kingdom, Second Intermediate Period, and even into the New Kingdom (Adams, 1977; S.T. Smith, 1995; Vagn Nielsen, 1970). Food production of the C-Group peoples may have been completely self-sufficient, considering their long history of independence. If governed by chiefdoms, foodstuffs may have not been produced on a surplus scale and would be been much less intensive. Unfortunately, a considerable portion of C-Group territory is now flooded due to the construction of the Aswan High Dam. Future archaeological excavations of the few C-Group sites that remain as well as continued bioarchaeological analysis of human skeletal remains will be of great use to further understanding this cultural tradition.

Similarly, the origins of the Napatan state are unclear. Traditional theories suggest Nubia was abandoned during this period (Kendall, 1982; O'Connor, 1983). It has also been suggested that a series of independent chiefdoms were organized in the absence of New Kingdom imperial control (Török, 1995). Others have quested to what degree these smaller polities were complex and unified (i.e., successor state; Morkot, 2000). Regardless, in the comparative context presented here, the people of Napatan Tombos were participating in activities that were similar to that of its C-Group predecessors, which were more intense than Pharaonic/Tombos New Kingdom and less intense than Kerma/O16/P37. Like the C-Group, this may have included forms of manual labor associated with self-sufficient and non-surplus food production. Furthermore, major cities and nome capitals such as Jebel Barkal, Kawa, Napata, el Kurru, and Meroë, are known to have supported non-food producers (e.g., administrators, soldiers, priests, artisans), while other settlements were likely engaging in farming activities (Welsby, 1998:151).

Another possibility, specific to the geological context of Tombos, is granite quarrying. Tombos, located in the rocky Third Cataract region, has abundant natural granite reserves (Edwards, 2004:103; S.T. Smith, 2003b). Granite was a valuable resource to the Ancient Egyptians and Nubians because of the high demand for religious and pharaonic statues as well as monumental construction blocks (S.T. Smith, 1997). Raw granite was likely quarried, cut, and roughly finished on site before being transported to its final destination via the Nile. Furthermore, the granite fields were more heavily exploited during the Napatan Period than the New Kingdom Period (S.T. Smith pers. comm.), which supports the increased physical activity observed here.

There are multiple lines of evidence to suggest that Tombos was a major source of granite for Egypt and Nubia. Several boulders still exhibit quarrying impressions; shims were aligned along the rocks surface and hammered to create a clean and controlled break (Figure 5.1, Figure 5.3). There are also several inscriptions along the Nile in which granite boulders were used as writing surfaces to convey imperial ideologies. For example, here, Thutmosis I boasts his success in battle and his triumph over 'Wretched Kush' (Figure 5.4; S.T. Smith, 2003b). Several statues, now housed at the National Corporation of Antiquities and Museums exhibition in Khartoum, have been shown to originate from Tombos (Harrell, 1999). Perhaps most convincingly, an incomplete statue, in Pharaonic stance and garb, still lies in the granite fields of Tombos (Figure 5.2) This figure, likely the 25th Dynasty (Napatan) Pharaoh Taharqo, was damaged during carving or transportation.

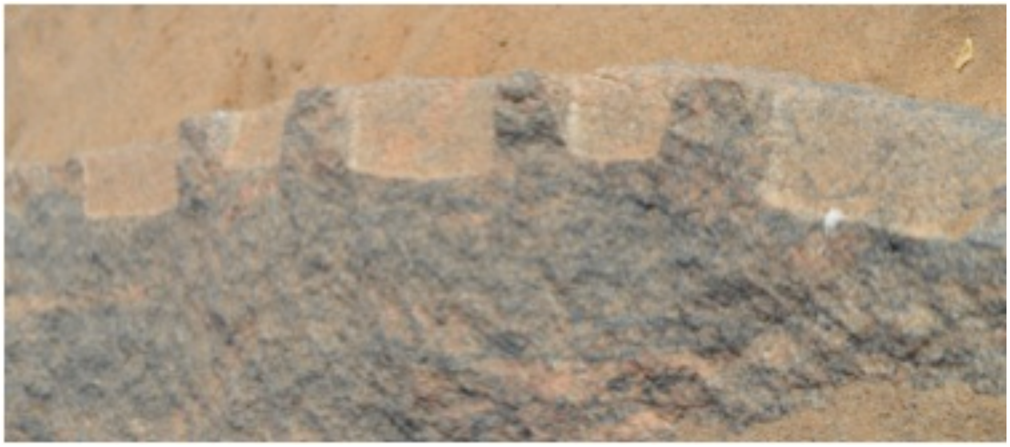

Figure 5.1 Quarry Marks on Granite Boulder at Tombos

(Photo: Schrader)

Figure 5.2 Incomplete Statue at Tombos, Likely Taharqo

(Photo: Schrader)

Figure 5.3 Quarry Marks on Granite Boulder at Tombos

(Photo: Schrader)

Figure 5.4 Stela of Thutmosis I at Tombos

(Photo: Schrader)

Welsby (1998:137) suggests, "The environment of Kush [Napata] was very diverse and must have stimulated the people into practicing a number of different lifestyles." Thus, Napatan Tombos, with the moderately strenuous lifeways presented here, was merely one constituent of the broader Napatan state. Further archaeological excavation will greatly widen the scope of this research and improve our understanding of this crucial time period.

5.4.2 The New Kingdom/Napatan Transition at Tombos

Because Tombos is one of few sites that was continuously occupied from the New Kingdom to the Napatan Period it provides an excellent opportunity to diachronically examine this change in terms of manual labor. While many entheseal scores were higher in the Napatan sample than the New Kingdom sample, 12 were found to significantly differ ($p \leq 0.05$). For the upper body, right supra/infraspinatus (humerus), left common extensors (humerus), and right brachioradialis (radius), were found to significantly differ between the two samples (Figure 5.5). As Table 5.8 indicates, these muscles reflect a wide range of movement in the arms. These data suggest that the Napatan Period sample was performing more arduous tasks with their upper body than the New Kingdom sample.

Table 5.8 Entheseal Anatomical Function:

New Kingdom and Napatan (Upper Body)

Enthesis	Function
Supra/infraspinatus	abduction of the arm; external rotation of the arm
Common extensors	extension at wrist; adduction of fingers
Brachioradialis	flexion at the elbow; supination and pronation of the forearm

(Stone and Stone, 2000)

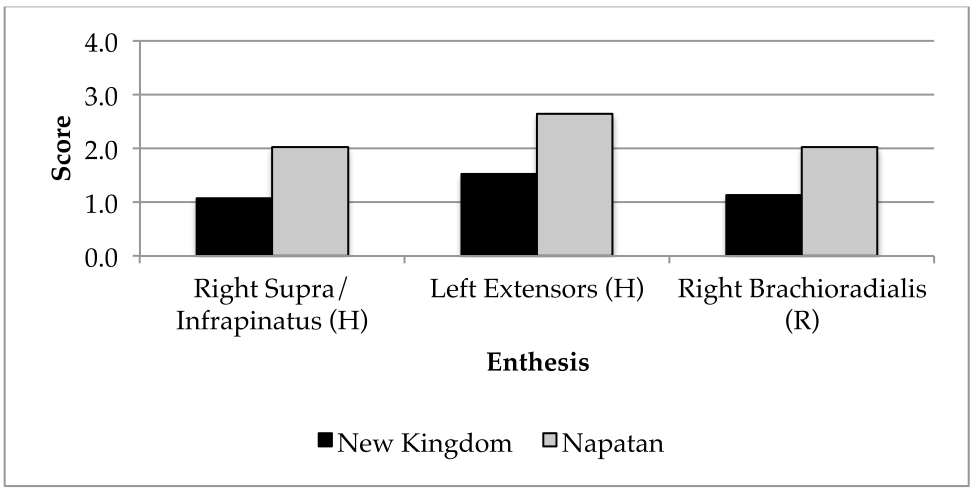

Figure 5.5 Statistically Significant ($p \leq 0.05$) Entheseal Changes at Tombos:

New Kingdom and Napatan (Upper Body)

(H = humerus, R = radius)

A total of nine entheses from the lower body were found to be significantly ($p \leq 0.05$) higher in the Napatan sample than the New Kingdom sample (Figure 5.6). The right semimembranosus/semitendinosus/biceps femoris (os coxa), right gluteus medius (femur), left and right psoas (femur), left and right gastrocnemius (femur), right quadratus femoris (femur), and left and right patellar ligament (tibia), were found to significantly differ between the New Kingdom and Napatan samples. As Table 5.9 indicates, these muscles are responsible for many motions of the leg, including movement of the hip, knee, and ankle. Again, these results indicate that the Napatan sample was using these muscles significantly more than the New Kingdom sample.

Table 5.9 Entheseal Anatomical Function:

New Kingdom and Napatan (Lower Body)

Enthesis	Function
Semimembranosus/ Semitendinosus/ Biceps femoris	extension at hip joint; stabilization of pelvis; flexion and internal rotation in knee joint
Gluteus medius	abducts the hip and stabilizes pelvis; rotation, flexion and extension of hip
Psoas major	flexion at hip joint, external rotation, bends lumbar vertebral column
Gastrocnemius	plantar flexion at talocrural joint; flexion at knee joint
Quadratus femoris	external rotation and adduction at hip joint
Patellar ligament	transmits the draw of quadriceps femoris, using the patella as an angle, that increases leverage

(Stone and Stone, 2000)

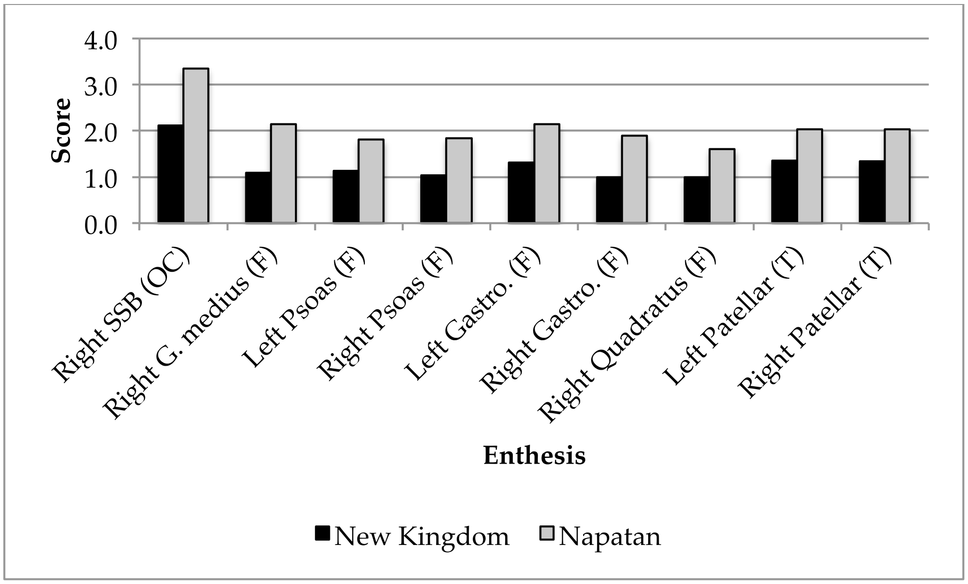

Figure 5.6 Statistically Significant ($p \leq 0.05$) Entheseal Changes at Tombos: New Kingdom and Napatan (Lower Body)

(OC = Os Coxa, F = Femur, T = Tibia)

What is particularly striking about entheseal remodeling analysis of the Tombos samples is the proportion of significantly different entheses in the upper body versus the lower body. Of the 18 upper body attachments (nine on the left, nine on the right), three were found to be significantly higher in the Napatan sample. In contrast, of the 16 lower body attachments (eight on the left, eight on the right), nine were found to be significantly higher in the Napatan sample. These results suggest that, while the Napatan population was performing more strenuous upper body activities than the New Kingdom population, the lower body activities were even more dichotomous and physically straining.

Therefore, entheseal remodeling analysis of the skeletal remains from Tombos suggests the Napatan population was performing more laborious activities, causing more frequent and more severe entheseal remodeling (particularly in the lower body), and were likely engaging in more intense forms of manual labor. Revisiting the presented hypotheses and associated expectations (Table 5.1), these results support the first postulate: that physical activity during the New Kingdom was more limited at Tombos and that despite political power, local Nubians were engaged in more intense manual labor during the Napatan Period.

During the New Kingdom, the Egyptian Empire may have subsidized Tombos because of the unique administrative function it served; lacking this financial backing during the Napatan period, local inhabitants may have had to return to more traditional and physically strenuous lifestyles. Without imperially facilitated trade connections, the people of Tombos may have been planting, growing, harvesting, and processing all of their food. Perhaps, without a strong Egyptian presence, the need for an administrative center and Nile River checkpoint was less critical and the inhabitants of Tombos had to rely on local food and trade resources. The extraction of granite from local sources may have become an esteemed source of income for local residents. These are merely a few possibilities that might explain the increased levels of entheseal markers present in the Napatan sample.

While the inhabitants of Napatan Tombos may have been performing more physically demanding activities, they were by no means impoverished. Ongoing excavations of the Napatan segment of the Tombos cemetery are greatly informing our understanding of this period (S.T. Smith, 2006; 2007). Both Nubian tumulus graves (oblong burial mounds) and Nubian-style pyramids were being used at Tombos during this time. Both of these grave structures have a long tradition within Nubia and were likely a symbol of indigenous identity for the people of Tombos (S.T. Smith and Buzon, in press; S.T. Smith, pers. comm.; Török, 1997). In 2011, we excavated a multi-chamber (one antechamber, five annex chambers) tomb in which a minimum of six individuals from the 25th Dynasty (Napatan Period) were buried. Not only would these grave structures themselves, particularly pyramids, have been quite costly, but the archaeological finds within were also status items. Burial goods found in Napatan burials at Tombos frequently include: jewelry (ivory bracelets, carnelian earplugs, faience udjat belt, scarab rings), religious items (faience amulets), and other prestige goods (bronze bowl, mummiform coffins).

Thus, the bioarchaeological analysis of entheseal remodeling suggests that the inhabitants of Napatan Tombos were performing more arduous physical activities than inhabitants of New Kingdom Tombos. This may be partially due to the unique and specialized function New Kingdom Tombos fulfilled for the Egyptian Empire. Compared to Kerma and O16/P37, the Napatan Tombos sample, exhibiting a lesser degree of entheseal remodeling, were not performing markedly strenuous activities such as agropastoralism. Activity patterns in the Napatan Tombos sample may reflect more traditional modes of labor, similar to that of the C-Group population. If a redistributive economy existed in the Napatan state, the pressures to contribute surplus foodstuffs and crafted trade goods were not exorbitant. However, further excavations of Napatan material at Tombos and elsewhere in Nubia will certainly provide further information on this topic.

5.4.3 Life at Tombos: Discrete Burials from the Napatan Period

When the discrete burial subsample, with known sex and age, was analyzed independently of the comingled material, more nuanced interpretations of activity could be made. Several entheses were also significantly different between the sexes (see section 5.3.2.1; Table 5.6), however, when body size was controlled for the left gastrocnemius (femur) remained statistically significant (see Table 5.9 for anatomical function). Therefore, males were using their knees and ankles markedly more than females.

It is impossible to say with any certainty what specific activities males were engaging in that would explain this differentiation, however, within the historical context described in section 5.4.1, these results are likely due to sociopolitical and socioeconomic environment of the time. For example, if Napatan Tombos had to engage in more intensive agricultural or quarrying practices than before, and if these tasks were culturally considered to be the responsibility of men, this would lead to a specific increase in entheseal remodeling of males. While both males and females were participating in more demanding forms of manual labor during the Napatan period, it is distinctly possible that men bore the brunt of production demands (Hassan, 1998).

Age was also found be highly correlated with many entheses in the discrete burial subsample. This result is not surprising, considering many researchers have reported similar findings (see Jurmain et al., 2012). Unfortunately, the sample size was not large enough to further divide the sample by age and sex. Continued excavations at Tombos will provide more skeletal material and future analyses will be able to more thoroughly address the topic of age and entheses. For now, it can be said that age does appear to play a role in the entheseal development within the Tombos population. The reason why entheses become more frequent and severe with age is currently unclear. This is a topic that certainly needs further attention within bioarchaeological research.

5.5 Summary

This research has examined the quotidian lifeways, via the bioarchaeological analysis of activity patterns, of ancient Nubians, focusing on the crucial New Kingdom/Napatan transition. Entheseal remodeling analysis of multiple Nubian sites, spanning the Kerma, New Kingdom and Napatan periods, were analyzed to develop a broad understanding of activity patterns in the Nile Valley.

The Kerma and O16/P37 comparative samples reflected the highest mean entheseal remodeling scores of the all populations examined here. Previous bioarchaeological analysis indicates an increased amount of trauma in these samples, which may be partially explained by arduous and hazardous forms of manual labor (e.g., agriculture, herding; Judd, 2000; 2002). Contrastingly, the New Kingdom Tombos and Pharaonic populations are characterized by markedly low mean entheseal scores. These findings support previous archaeological (S.T. Smith, 2003b) and bioarchaeological investigations (Schrader 2010; 2012) that suggest Tombos served the specialized imperial function of a Third Cataract administrative center. The similarly low entheseal scores for the concurrent Pharaonic sample indicates that the Egyptian Empire also played a beneficial role to some New Kingdom inhabitants of Lower Nubia. Lastly, entheseal remodeling in the Tombos Napatan sample and the C-Group sample were very similar and fell between the high Kerma/O16/P37 samples and the low New Kingdom Tombos/Pharaonic samples. This suggests a moderate level of strenuous physical labor in these populations. The C-Group population may have been engaged in non-surplus agriculture or hunting/gathering practices. Napatan Tombos was likely participating in agricultural and quarrying activities, which reflect a more traditional and self-sufficient economy.

Through the bioarchaeological analysis of entheseal remodeling, the understanding of the political, economic, and social systems during the Napatan periods has been greatly informed. This research supports the premise that Egyptian/Nubian interaction during the imperial New Kingdom period was, for many, beneficial and amicable[19]. Furthermore, as the Egyptian Empire waned and the Napatan state emerged, local Nubians were engaging in more physically demanding forms of manual labor than before. However, physical activity during the Napatan period was not as strenuous as the preceding Kerma period. Further archaeological excavation, particularly of Napatan sites, will further our understanding of what activities these communities were participating in. Further bioarchaeological analysis of additional comparative collections will also broaden the scope of activity patterns in ancient Nubia.

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[19] One notable exception is the C-Group; latter C-Group burials were concurrent with Pharaonic and New Kingdom Tombos, however, continued to have higher rates of entheseal remodeling

CHAPTER 6.TWO BIOARCHAEOLOGICAL PERSPECTIVES OF ANCIENT ACTIVITY: A METHODOLOGICAL INVESTIGATION OF THE COMPARABILITY OF ENTHESEAL REMODELING AND OSTEOARTHRITIS

6.1 Introduction

Since the development of bioarchaeology as an anthropological subdiscipline, hundreds of publications have examined osteoarthritis and entheseal remodeling as possible venues for activity reconstruction (see Jurmain et al., 2012). As discussed in Chapter 5 (and also below), these two osteological conditions are frequently attributed to a physically strenuous lifestyle. Thus, higher rates of either osteoarthritis or entheseal remodeling would indicate more intense manual labor. However, the intersection of these two conditions has rarely been examined. If osteoarthritis and entheseal remodeling have the common causal factor of workload, a correlation between the frequency and severity of osteoarthritis and entheseal remodeling should be present. If, however, there is no correlation between the two, further bioarchaeological research should reexamine the preconceived notion that both osteoarthritis and entheseal remodeling necessarily reflect physical activity.

In this chapter I will compare the results of entheseal remodeling and osteoarthritis in multiple Nile Valley populations. If a common causation factor exists, the osteoarthritis data presented here will bolster the entheseal remodeling data presented in Chapter 5. If, however, a relationship between the two conditions cannot be established, possible explanations for this differentiation will be explored. Because entheseal remodeling was discussed at length in Chapter 5, I will now present background on osteoarthritis including the degeneration of joint tissues, clinical versus bioarchaeological perspectives, and etiology. A brief overview of osteoarthritis research within bioarchaeology will also be presented.

6.2 The Degeneration of Joint Tissues

Osteoarthritis, the deterioration of joints and associated soft tissue, is the most common post-cranial condition of the skeletal frame (Rogers, 2000). It is estimated that 17 million people living in the United States have osteoarthritis (Praemer et al., 1992). Triggering pain, discomfort, and frequently limiting mobility, osteoarthritis can severely impact everyday life. Despite the frequency of the osteoarthritis, many aspects of this condition (e.g., etiology, treatment) are still debated in both clinical and academic arenas.

Osteoarthritis is generally divided into two categories: primary and secondary. Primary osteoarthritis occurs when there is an absence of an underlying condition; this type of osteoarthritis is (1) the most common, (2) associated with the aging process, and (3) the primary focus of bioarchaeological research (Rogers and Waldron, 1995). Secondary osteoarthritis occurs when there is a preexisting pathological condition (e.g., rheumatoid arthritis, scoliosis) or traumatic event (e.g., bone fracture, joint dislocation) that develops into osteoarthritis.

The initial indicators of osteoarthritis typically materialize in the soft tissue system of a joint. If the fragile cartilage, tendons, ligaments, and various joint structures (e.g., bursa, synovium, joint capsule) are compromised, bone growths on the margin of joint surfaces are formed as a physiological response in an attempt to stabilize the joint and prevent further damage. Often referred to as osteophytes, these bony protrusions are relatively common in skeletal remains can vary from minute growths to marked spicules (Buikstra and Ubelaker, 1994).

Another manifestation of osteoarthritis is joint porosity. Porosity affects the joint surface and is initially characterized by small pits. If the condition progresses, porosity can become more severe and widespread. The small pits can coalesce and cover a larger portion of the joint surface. Further still, joint porosity can also manifest both coalesced and pinpoint pits (Buikstra and Ubelaker, 1994). Recent research has questioned the relevance of porosity in osteoarthritis (Weiss and Jurmain, 2007). Woods (1995) has suggested that joint porosity may actually be a byproduct of increased vascular activity to aid in the maintenance of cartilage tissue. Therefore, it is important to analyze each of these indicators independently of one another before drawing conclusions about the complexities of osteoarthritis.

Perhaps one of the most characteristic and pathognomonic conditions of osteoarthritis is eburnation. Eburnation occurs when little to no cartilage remains on the bones of a joint and, thus, bone on bone contact occurs with movement (Buikstra and Ubelaker, 1994). Skeletally, this results in a polishing of the joint surface and can progress to form striations on the bone surface parallel to the line of motion. Amongst osteoarchaeologists, eburnation is generally considered to be the most diagnostic and quintessential characteristic of osteoarthritis (Ortner, 2003; Rogers and Waldron, 1995).

6.2.1 Clinical Versus Bioarchaeological Perspectives on Osteoarthritis

Bioarchaeologists use skeletal correlates (lipping, pitting, eburnation) to infer osteoarthritis in the ancient past; however, these techniques are much different than those employed by today's clinicians. Obviously, medical doctors have the advantage of conversing with their patients about joint pain and discomfort associated with physical activity. In fact, many patients report osteoarthritis-related pain that is unaccompanied by any observable skeletal or soft tissue changes (Hannan et al., 2000). Furthermore, recent genetic research suggests the presence of specific genes determines whether or not an individual will actually develop osseous changes associated with osteoarthritis (Riancho et al., 2010).

Clinicians also employ the use of radiographs to supplement their diagnoses. The primary indicator of osteoarthritis in a radiograph is a narrowing of joint space, an indirect measure of articular cartilage degeneration (Hayes et al., 2005). However, research has shown that radiographs do not reflect marginal bone growths, porosity, or eburnation that can be examined directly on the bone (Brandt et al., 1991; Spector et al., 1993). Recent technological developments, including magnetic resonance (MR), have shown great improvements and can detect osteological disparities (Hayes et al., 2005). Thus, bioarchaeologists and clinicians are diagnosing osteoarthritis based on very different factors. An examination of both bioarchaeological and clinical criteria would be particularly useful and would promote a common interpretation of this widespread condition.

6.2.2 Etiology of Osteoarthritis

Both the clinical and bioarchaeological sectors continue to grapple with the etiology of osteoarthritis. For decades, physically strenuous labor was thought to be the sole causation factor for osteoarthritis (Jurmain, 1977; Ortner and Putschar, 1985). Many studies examined the frequency of osteoarthritis in certain occupations, including farmers (Croft et al., 1992; Thelin, 1990), textile workers (Hadler et al., 1978; Waldron and Cox, 1989), miners (Anderson et al., 1962; Kellgren and Lawrence, 1958; Lawrence, 1955; Schlomka et al., 1955) and construction workers (Stenlund, 1993). Additionally, multiple sports studies have also been linked with osteoarthritis, including general exercise (Panush and Brown, 1987), baseball pitchers (Hansen, 1982; Woods et al., 1973), football players (Brodelius, 1961; Chantraine, 1985; Moretz et al., 1984; Rall et al., 1964; Solonen, 1966; Vincelette et al., 1972), ballet dancers (Brodelius, 1961), weight-lifters (Aggrawal et al., 1979), and swimmers (Stulberg et al. 1980).

The fact that so many studies found a positive correlation between occupations/sports and osteoarthritis suggests there is a relationship; however, more recently, multiple contributing factors have shown to also be correlated with osteoarthritis. The foremost of which, age has been shown to significantly impact the presence and severity of osteoarthritis (Jurmain et al., 2012; Lieverse et al., 2007; Weiss and Jurmain, 2007). Other contributing factors to osteoarthritis include sex, weight, diet, metabolism, and genetic predispositions (Heliovaara et al., 1993; Sambrook et al., 1999; Waldron, 1994).

With the knowledge that osteoarthritis is multifactorial, several authors have put forward recommendations and considerations for future osteological examinations. Weiss and Jurmain (2007) have suggested that (1) samples should be separated by both age and sex, (2) unique scoring methods should be applied to joint margin changes and surface alterations (e.g., lipping versus pitting), and (3) unconventional studies using new technologies should be applied to the examination of osteoarthritis (e.g., controlled animal experiments). Similarly, Jurmain and colleagues (2012) agree with the above suggestions and also propose further collaborative projects as well as additional genetic research on osteoarthritis. Obviously, there is much work to be done on osteoarthritis; however, this should be viewed as an opportunity for ambitious scholars and clinicians, rather than an obstruction.

6.3 Previous Bioarchaeological Studies of Osteoarthritis

Due to the fact that bones are plastic and adapt to physical activity, bioarchaeologists have a distinct opportunity to interpret ancient lifeways by examining skeletal conditions such as osteoarthritis and entheseal remodeling. These data, coupled with traditional archaeological information, can elucidate subsistence patterns, socioeconomic status, social identity, sexual division of labor, as well as many other matters relating to the ancient past.

The bioarchaeological analysis of osteoarthritis has been used to address numerous anthropological and archaeological questions. While skeletal changes associated with osteoarthritic degeneration had been recognized centuries ago, it was not until Angel's (1966) examination of skeletal remains from the Native American site, Tranquility (California), that osteoarthritis was systematically studied to elucidate past lifeways. He noted marked osteoarthritic changes in the elbow joint and suggested this could be a result of spear throwing (a.k.a., 'atlatl elbow'). Since Angel's examination of the Tranquility sample, bioarchaeologists have continued to interpret ancient lifeways using osteoarthritis as a proxy. Subsistence patterns (Jurmain, 1990; Larsen, 1995; Lieverse et al., 2007; Pickering, 1979), food preparation (Merbs and Euler, 1985; Molleson, 1989), health and socioeconomic status (Watkins, 2012), economic intensification (Klaus et al., 2009), as well as sexual division of labor (Sofaer, 2000; Walker and Holliman, 1989) have all been addressed in past bioarchaeological studies.

As discussed above and in previous chapters, one of the primary causation factors for both of osteoarthritis and entheseal remodeling is physically stressful and repetitive activities (see Chapter 5 for discussion on entheseal remodeling). These topics have both been, independently of one another, thoroughly addressed in bioarchaeological research. However, very few authors have investigated the relationship between the two.

Molnar and colleagues (2011) examined osteoarthritis and entheseal remodeling in two Neolithic populations from Gotland (Baltic Sea), Ajvide (n=46) and Vasterbjers (n=32). Eburnation was used as the criterion for the presence of osteoarthritis and entheseal remodeling was presented in mean scores separated by joint. Both entheseal remodeling and osteoarthritis were highly correlated with age. Females had higher rates of eburnation, while males had higher mean entheseal remodeling scores. Interestingly, higher mean entheseal marker scores were found in those individuals who had eburnation. However, Molnar et al. note that "a direct link, other than age, between eburnation and [entheseal remodeling] was difficult to discern" (Molnar et al., 2011:283). This research suggests that there may be a connection between entheseal remodeling and osteoarthritis; however, other contributing factors also play a role.

I examined Egyptian imperial expansion into Nubia through the analysis of entheseal remodeling and osteoarthritis at New Kingdom Tombos (Schrader, 2010; 2012). I found markedly low levels of both conditions at New Kingdom Tombos, suggesting this population was not participating in particularly stressful manual labor. When compared to other Nile Valley populations, entheseal remodeling and osteoarthritis prevalence at New Kingdom Tombos remained lower than any of the comparative samples. However, I did not examine the commonality of these conditions in populations or individuals. As discussed below, the New Kingdom Tombos population will be examined here and this issue will be addressed (Table 6.1).

Table 6.1 Hypotheses and Expectations:
Activity Reconstruction, Osteoarthritis Compared to Entheseal Remodeling

Hypotheses	Expectations
Osteoarthritis and entheseal remodeling have a common causation factor; thus, these osteoarthritis data can be applied to further elucidate activity patterns during the New Kingdom/Napatan transition at Tombos.	Correlation (OA, ER)
Osteoarthritis and entheseal remodeling have differing causation factors; further examination of these conditions should be undertaken before osteoarthritis is applied to activity reconstruction.	No Correlation (OA, ER)

(OA = Osteoarthritis; ER = Entheseal Remodeling)

There is clearly a need in bioarchaeological research to address the link between osteoarthritis and entheseal remodeling. The etiology and methodology of bioarchaeological examination for both of these conditions have recently become the center of much debate (see Henderson and Cardoso, 2013; Jurmain et al., 2012). Understanding how these two conditions relate to one another, in combination with other current research approaches (e.g., scoring methodology, 3D scanning), could greatly improve our understanding of the human skeletal frame as well as physical activity in ancient populations.

6.4 Materials and Methods

To address the correlation between osteoarthritis and entheseal remodeling, I examined 616 individuals from multiple Nile Valley skeletal collections (see Chapter 3). A total of 11 skeletal elements per individual were examined for osteoarthritis (Table 6.2). The left and right sides were examined separately to account for instances of differential use (i.e., handedness). Osteological indicators of osteoarthritis, namely lipping, porosity, and eburnation, were scored on a ranked scale, independently of one another (Appendix A). Further information regarding sexing and aging methodologies can be found in Chapter 3.

Table 6.2 Joints Examined in the Present Study

Shoulder	Glenoid fossa
	Proximal humerus
Elbow	Distal humerus
	Proximal ulna
	Proximal radius
Wrist	Distal ulna
	Distal radius
Hip	Acetabulum
	Proximal femur
Knee	Distal femur
	Proximal tibia
Ankle	Distal tibia

A total of 17 fibrocartilaginous muscle attachment sites were examined (Table 5.2). Entheseal remodeling was scored on a six-point scale (Table 5.3). To compare osteoarthritis and entheseal remodeling, composite groups were created (shoulder, elbow, wrist, hip, knee) based upon the primary function of the musculoskeletal elements (Table 6.3). For example, entheseal markers of muscles that aid in shoulder movement (i.e., supraspinatus/infraspinatus, subscapularis, teres minor) were compared to the skeletal elements that facilitate shoulder movement (i.e., glenoid fossa, proximal humerus). Therefore, by creating composite groups, the correlation between osteoarthritis and entheseal scores from the same joint system can be examined.

Table 6.3 Composite Osteoarthritis and Entheseal Remodeling Groups

Composite Group	Osteoarthritis Element	Entheseal Attachment
Shoulder	Glenoid fossa Proximal humerus	Supraspinatus/ Infraspinatus (H) Subscapularis (H) Teres minor (H)
Elbow	Distal humerus Proximal radius Proximal ulna	Triceps brachii (U) Brachialis (U) Biceps brachii (R) Brachioradialis (R)
Wrist	Distal radius Distal ulna	Common extensors (H) Common flexors (H)
Hip	Acetabulum Proximal femur	Semimembranosus/ Semitendinosus/ Biceps femoris (OC) Gluteus medius (F) Gluteus minimus (F) Psoas (F) Quadratus femoris (F)
Knee	Distal femur Proximal tibia	Gastrocnemius (F) Patellar ligament (T) Popliteus (T)

6.4.1 Statistical Analysis

Both entheseal remodeling and osteoarthritis were scored on a ranked scale, producing ordinal data. In order to appropriately examine ordinal data, non-parametric statistics are employed here (Drennan, 2009). Spearman's rank correlation was used for bivariate analysis (i.e., entheseal remodeling versus osteoarthritis). Similar to a Pearson's *r* (numerical data), the Spearman's correlation (r_s) examines the strength and significance of a rank order relationship. All statistical analyses were conducted using SPSS (version 19).

6.5 Results

The results of entheseal remodeling/osteoarthritis comparability are presented here. First, the total sample (from Tombos and other sites) is examined in order to test the overall relatedness between the two conditions. Then, entheseal remodeling and osteoarthritis are compared within each site in order to check for inter-site comparability. Lastly, these two conditions are examined controlling for age.

6.5.1 Total Sample

Several statistically significant correlations were found between osteoarthritic lipping and entheseal remodeling (for raw osteoarthritis data refer to Appendix B). Spearman's correlation was calculated for each element/attachment in the composite groups (Appendix C). Table 6.4 summarizes the number of significant correlations for the shoulder, elbow, wrist, hip, and knee.

Table 6.4 Osteoarthritic Lipping and Entheseal Remodeling: Percentage of Statistically Significantly Relationships

	%	n/N	%	n/N
Shoulder	100	*(6/6)*	100	*(6/6)*
Elbow	83	*(10/12)*	83	*(10/12)*
Wrist	100	*(4/4)*	100	*(4/4)*
Hip	100	*(10/10)*	30	*(3/10)*
Knee	100	*(6/6)*	17	*(1/6)*

$p \leq 0.05$; n: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

Many entheseal markers were significantly correlated with osteoarthritic porosity (Table 6.5). However, there were fewer significant relationships with osteoarthritic porosity than with osteoarthritic lipping.

Table 6.5 Osteoarthritic Porosity and Entheseal Remodeling: Percentage of Statistically Significant Relationships

	%	n/N	%	n/N
Shoulder	100	*(6/6)*	100	*(6/6)*
Elbow	33	*(4/12)*	58	*(7/12)*
Wrist	50	*(2/4)*	50	*(2/4)*
Hip	100	*(10/10)*	40	*(4/10)*
Knee	100	*(6/6)*	0	*(0/5)*

$p \leq 0.05$; n= a: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

Eburnation was not correlated with entheseal remodeling (Table 6.6). It should be noted, that the number of possible correlations is often quite low and in some cases zero (i.e., there were no observable cases of eburnation in that joint throughout the entire population; e.g., left elbow, right hip).

Table 6.6 Osteoarthritic Eburnation and Entheseal Remodeling: Percentage of Statistically Significant Relationships

	%[1]	n/N	%[1]	n/N
Shoulder	0	*0/1*	0	*0/2*
Elbow	-	*0/0*	0	*0/4*
Wrist	-	*0/0*	0	*0/2*
Hip	0	*0/5*	-	*0/0*
Knee	0	*0/6*	-	*0/0*

$p \leq 0.05$; - = there were no instances of osteoarthritis/entheseal remodeling and Spearman's could not be calculated; n: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

6.5.2 Separated by Site

In pooling osteological data from multiple Nile Valley sites, as discussed above, nuances of inter-site variation are not observed. Thus, the correlation between entheseal remodeling and osteoarthritis was also examined per site. As expected, there was some degree of variability in significance between sites, particularly with osteoarthritic lipping (Table 6.7, Table 6.8). The Pharaonic sample had the fewest number of significant correlations between osteoarthritic lipping and entheseal remodeling. The Pharaonic sample is juxtaposed by the Kerma sample, which illustrates the greatest number of significant correlations between osteoarthritic lipping and entheseal remodeling.

When osteoarthritic porosity was examined (Table 6.9, Table 6.10), the proportion of correlations between the sites was similar to osteoarthritic lipping. The Pharaonic sample resulted in no correlations between porosity and entheseal remodeling. Conversely, the majority of composite groups in the Kerma sample were significantly similar. Three of the composite groups in the Kerma sample (right shoulder, left knee, right knee) were very strongly correlated.

Eburnation was relatively infrequent in these samples (see Appendix B). Thus, in many instances, Spearman's could not be calculated because they could not be ranked. However, each site has at least one composite group in which eburnation could be compared with entheseal remodeling (Table 6.11, Table 6.12). Eburnation at the Pharaonic, C-Group, Napatan, and O16/P37 sites was not correlated with entheseal remodeling. The right knee of the Tombos New Kingdom sample was significantly correlated with the associated composite group entheses in three out of the six Spearman's tests. Eburnation of the left hip and right knee of the Kerma sample was also correlated with their associated entheses.

Table 6.7 Osteoarthritic Lipping and Entheseal Remodeling Separated by Site: Percentage of Statistically Significant Relationships (Left)

	New Kingdom Tombos		**Napatan Tombos**		**Kerma**		**C-Group**		**Pharaonic**		**O16/P37**	
	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N
Shoulder	17	*1/6*	17	*1/6*	100	*6/6*	0	*0/3*	0	*0/3*	17	*1/6*
Elbow	17	*2/12*	17	*2/12*	67	*8/12*	18	*2/11*	0	*0/11*	33	*4/12*
Wrist	0	*0/4*	0	*0/4*	100	*4/4*	0	*0/4*	0	*0/4*	25	*1/4*
Hip	80	*8/10*	100	*10/10*	100	*10/10*	50	*3/6*	10	*1/10*	60	*6/10*
Knee	0	*0/6*	17	*1/6*	83	*5/6*	0	*0/6*	0	*0/6*	33	*2/6*

$p \leq 0.05$; n: Number of statistically significant correlations; N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

Table 6.8 Osteoarthritic Lipping and Entheseal Remodeling Separated by Site: Percentage of Statistically Significant Relationships (Right)

	New Kingdom Tombos		**Napatan Tombos**		**Kerma**		**C-Group**		**Pharaonic**		**O16/P37**	
	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N
Shoulder	17	*1/6*	100	*6/6*	100	*6/6*	100	*3/3*	0	*0/3*	67	*4/6*
Elbow	17	*2/12*	8	*1/12*	33	*4/12*	30	*3/10*	0	*0/12*	75	*9/12*
Wrist	75	*3/4*	100	*4/4*	50	*2/4*	25	*1/4*	0	*0/4*	50	*2/4*
Hip	70	*7/10*	80	*8/10*	90	*9/10*	10	*1/10*	0	*0/9*	30	*3/10*
Knee	100	*6/6*	50	*3/6*	83	*5/6*	0	*0/6*	33	*2/6*	20	*1/5*

$p \leq 0.05$; n: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

Table 6.9 Osteoarthritic Porosity and Entheseal Remodeling Separated by Site: Percentage of Statistically Significant Relationships (Left)

	New Kingdom Tombos		Napatan Tombos		Kerma		C-Group		Pharaonic		O16/P37	
	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N
Shoulder	0	*0/6*	0	*0/6*	83	*5/6*	0	*0/3*	0	*0/3*	17	*1/6*
Elbow	18	*2/11*	18	*2/11*	11	*1/9*	8	*1/12*	0	*0/11*	0	*0/12*
Wrist	0	*0/4*	0	*0/4*	0	*0/4*	0	*0/4*	0	*0/2*	25	*1/4*
Hip	10	*1/10*	80	*8/10*	80	*8/10*	20	*1/5*	0	*0/10*	20	*2/10*
Knee	17	*1/6*	0	*0/6*	100	*6/6*	0	*0/6*	0	*0/6*	33	*2/6*

$p \leq 0.05$; n: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

Table 6.10 Osteoarthritic Porosity and Entheseal Remodeling Separated by Site: Percentage of Statistically Significant Relationships (Right)

	New Kingdom Tombos		**Napatan Tombos**		**Kerma**		**C-Group**		**Pharaonic**		**O16/P37**	
	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N
Shoulder	0	*0/6*	67	*4/6*	100	*6/6*	100	*3/3*	0	*0/3*	50	*3/6*
Elbow	0	*0/12*	8	*1/12*	33	*4/12*	10	*2/12*	0	*0/0*	58	*7/12*
Wrist	25	*1/4*	0	*0/4*	0	*0/4*	25	*1/4*	0	*0/4*	50	*2/4*
Hip	10	*1/10*	70	*7/10*	50	*5/10*	0	*0/8*	0	*0/10*	40	*4/10*
Knee	33	*2/6*	33	*2/6*	100	*3/3*	0	*0/6*	0	*0/6*	0	*0/5*

$p \leq 0.05$; n: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

Table 6.11 Osteoarthritic Eburnation and Entheseal Remodeling Separated by Site: Percentage of Statistically Significant Relationships (Left)

	New Kingdom Tombos		Napatan Tombos		Kerma		C-Group		Pharaonic		O16/P37	
	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N
Shoulder	-	*0/0*	-	*0/0*	-	*0/0*	-	*0/0*	-	*0/0*	-	*0/0*
Elbow	-	*0/0*	-	*0/0*	-	*0/0*	0	*0/4*	0	*0/7*	-	*0/0*
Wrist	-	*/0*	-	*0/0*	-	*0/0*	-	*0/0*	-	*0/0*	-	*0/0*
Hip	0	*0/1*	-	*0/0*	25	*1/4*	-	*0/0*	-	*0/0*	0	*0/2*
Knee	-	*0/0*	-	*0/0*	0	*0/3*	0	*0/3*	0	*0/6*	-	*0/0*

$p \leq 0.05$; - = there were no instances of osteoarthritis/entheseal remodeling and Spearman's could not be calculated; n: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

Table 6.12 Osteoarthritic Eburnation and Entheseal Remodeling Separated by Site: Percentage of Statistically Significant Relationships (Right)

	New Kingdom Tombos		**Napatan Tombos**		**Kerma**		**C-Group**		**Pharaonic**		**O16/P37**	
	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N
Shoulder	-	*0/0*	-	*0/0*	-	*0/0*	-	*0/0*	0	*0/2*	-	*0/0*
Elbow	-	*0/0*	-	*0/0*	-	*0/0*	0	*0/2*	-	*0/0*	-	*0/0*
Wrist	-	*0/*	-	*0/0*	-	*0/0*	-	*0/0*	0	*0/2*	-	*0/0*
Hip	0	*0/2*	-	*0/0*	-	*0/0*	0	*0/4*	-	*0/0*	-	*0/0*
Knee	50	*3/6*	0	*0/3*	0	*0/3*	0	*0/6*	0	*0/6*	-	*0/0*

p≤0.05; - = there were no instances of osteoarthritis/entheseal remodeling and Spearman's could not be calculated; n: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

6.5.3 Separated by Age Group

Age has also been shown to be a contributing factor in osteoarthritis and entheseal remodeling (Baker and Pearson, 2006; Sokoloff, 1980; Villotte et al., 2010). Therefore, the correlation between entheseal remodeling and osteoarthritis was also compared for separate age cohorts (Young Adult = 18-29; Middle Adult = 30-45; Old Adult = 45+). As shown in Table 6.13, the comparison between entheseal remodeling and osteoarthritic lipping varied between no correlations within composite groups (i.e., young adult left elbow, old adult right wrist), to multiple strong correlations within composite groups (i.e., middle adult left and right shoulder). Overall, old adults had the least number of significant Spearman's correlations out of the three age groups. Middle adults had the greatest number of significant Spearman's correlations.

As with the total sample and the inter-site analysis, the frequency of statistical correlations decreased from lipping, to porosity, to eburnation when the samples were divided into age categories. However, the basic pattern of old adults having the least number of statistical correlations and middle adults having the most is consistent for osteoarthritic porosity as well (Table 6.14).

Eburnation was more common in old adults (see Appendix B), however the correlation between eburnation and entheseal remodeling is not as straightforward. The middle adult age group had the most correlations between the two conditions (Table 6.15). In old adults, only one out of the six Spearman's tests was found to be significant. In young adults there were no correlations despite eburnation being present in some young adults.

Table 6.13 Osteoarthritic Lipping and Entheseal Remodeling Separated by Age Group: Percentage of Statistically Significant Relationships

	Young Adult				**Middle Adult**				**Old Adult**			
	Left		Right		Left		Right		Left		Right	
	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N
Shoulder	17	*1/6*	50	*3/6*	83	*5/6*	83	*5/6*	17	*1/6*	17	*1/6*
Elbow	0	*0/12*	10	*2/12*	25	*3/12*	42	*5/12*	0	*0/12*	0	*0/12*
Wrist	0	*0/4*	25	*1/4*	50	*2/4*	75	*3/4*	0	*0/4*	0	*0/4*
Hip	60	*6/10*	30	*3/10*	50	*5/10*	40	*4/10*	30	*3/10*	30	*3/10*
Knee	83	*5/6*	50	*3/6*	17	*1/6*	83	*5/6*	17	*1/6*	17	*1/6*

$p \leq 0.05$; n: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

Table 6.14 Osteoarthritic Porosity and Entheseal Remodeling Separated by Age Group: Percentage of Statistically Significant Relationships

	Young Adult				Middle Adult				Old Adult			
	Left		Right		Left		Right		Left		Right	
	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N
Shoulder	0	*0/6*	0	*0/6*	33	*2/6*	17	*1/6*	17	*1/6*	17	*1/6*
Elbow	9	*1/11*	50	*3/6*	17	*2/12*	50	*6/12*	9	*1/11*	0	*0/12*
Wrist	0	*0/4*	0	*0/4*	25	*1/4*	25	*1/4*	0	*0/4*	0	*0/4*
Hip	10	*1/10*	10	*1/10*	70	*7/10*	20	*2/10*	10	*1/10*	0	*0/10*
Knee	50	*3/6*	0	*0/6*	0	*0/6*	17	*1/6*	0	*0/6*	0	*0/6*

p≤0.05; n: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

Table 6.15 Osteoarthritic Eburnation and Entheseal Remodeling Separated by Age Group: Percentage of Statistically Significant Relationships

	Young Adult				**Middle Adult**				**Old Adult**			
	Left		Right		Left		Right		Left		Right	
	%[1]	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N
Shoulder	-	*0/0*	-	*0/0*	-	*0/0*	-	*0/0*	-	*0/0*	0	*0/2*
Elbow	0	*0/4*	-	*0/0*	0	*0/2*	0	*0/2*	0	*0/7*	0	*0/4*
Wrist	-	*0/0*	-	*0/0*	-	*0/0*	-	*0/0*	-	*0/0*	0	*0/2*
Hip	-	*0/0*	0	*0/4*	-	*0/0*	-	*0/0*	0	*0/5*	0	*0/4*
Knee	0	*0/2*	0	*0/3*	0	*0/3*	50	*3/6*	17	*1/6*	0	*0/6*

p≤0.05; - = there were no instances of osteoarthritis/entheseal remodeling and Spearman's could not be calculated, n: Number of statistically significant correlations, N: number of possible correlations (if there were no instances of osteoarthritis/entheseal remodeling, then Spearman's could not be calculated and, thus, the number of possible correlations decreased)

6.6 Discussion

By examining osteoarthritis and entheseal remodeling in these Nile Valley populations the relationship between these two conditions has been investigated. The entire sample was initially examined to test the hypothesis that these conditions have activity as a common causal factor. Then, skeletal remains were further separated by archaeological site, to see whether the relationship between entheseal remodeling and osteoarthritis varied between populations. Additionally, because age has been found to be a contributing factor in both entheseal remodeling and osteoarthritis, the sample was divided between age group in order to test the effects of age on these conditions.

The results of this research support the hypothesis that osteoarthritic lipping, porosity, and entheseal remodeling have a common causation factor, which may be activity related. This is not to say that activity is the sole trigger of either condition; in fact, these conditions are likely the result of multiple influences (Jurmain et al., 2012). However, considering so many of the composite groups examined were significantly similar, this study suggests a strong correlation between the two conditions and a promising venue of research for upcoming bioarchaeological studies.

The comparison between osteoarthritic lipping and entheseal remodeling resulted in more correlations than osteoarthritic porosity. Some have suggested that porosity better reflects vascularization of the cartilage tissues rather than degeneration of joint, as is the case with lipping and eburnation (Weiss and Jurmain, 2007; Woods, 1995). This may explain why the correlation between entheseal remodeling and porosity is not very strong.

No significant correlations were found between eburnation and entheseal remodeling in the total sample. This can be explained by the fact that lipping is much more prolific than porosity and eburnation in skeletal remains (see Appendix B for mean scores). These results do not suggest that eburnation is not related to entheseal remodeling or activity; multiple studies have shown strong correlations between eburnation and osteoarthritis, both in bioarchaeological research (Bridges, 1991; Kelley and Angel, 1987; Kilgore, 1984; Larsen, 2002; Roberts and Manchester, 1995) as well as medical research (Cooper et al., 1994; Hoffman, 1993). Rather, the fact that eburnation was not correlated with entheseal remodeling is more likely to be a byproduct of low frequencies. There were several instances where there were no cases of eburnation within a joint system throughout the entire population. As discussed below, it is imperative that sample sizes are large enough to account for infrequent conditions, such as eburnation.

When the sample was further divided by site, additional interpretations regarding the relationship between entheseal remodeling and osteoarthritis could be made. As with the total sample, osteoarthritic lipping was highly correlated with entheseal remodeling (more so than porosity or eburnation). However, in all three forms of osteoarthritis (lipping, porosity, eburnation), a distinct inter-site pattern was apparent. The Pharaonic sample had the least number of correlations and was fairly comparable to the Tombos New Kingdom sample. The Tombos Napatan and C-Group samples were similar to one another and were slightly higher than the Pharaonic/Tombos New Kingdom set. Lastly, Kerma and O16/P37 had a similar number of correlations, the greatest number of correlations of the entire sample. As discussed in Chapter 5, this mirrors the distribution of entheseal remodeling score severity. Furthermore, the frequency of osteoarthritis between these sites is also markedly similar. In other words, in samples where osteoarthritis and entheseal remodeling have higher mean scores, there are more statistical correlations between the two conditions.

6.7 Summary

This chapter has examined the association between osteoarthritis and entheseal remodeling as a product of physically strenuous activity. This topic is significant to the bioarchaeological reconstruction of activity in the ancient past. Many studies have assumed that the etiology of osteoarthritis and entheseal remodeling is repetitive manual labor; however, the intersection between these two conditions was unclear. To address this issue, I examined multiple Nile Valley skeletal collections for both osteoarthritis and entheseal remodeling. Non-parametric bivariate analysis was applied to the comparison of entheseal remodeling versus osteoarthritis using defined physiological composite groups (i.e., shoulder, elbow, wrist, hip, knee).

Results indicate that osteoarthritic lipping is more often correlated to entheseal remodeling than porosity or eburnation. This is not surprising, considering many authors have suggested lipping is one of the initial indicators of osteoarthritis. Correlations between porosity and entheseal remodeling may be limited because porosity is additionally influenced by vascularization of the joint region. Thus, porosity may be more closely associated with angiogenesis rather than physical activity. The relationship between eburnation and entheseal remodeling was also not evident; however, this is likely due to the limited number of cases of eburnation within this sample.

When site samples were analyzed independently from one another, inter-site patterns became apparent. In fact, this patterning roughly replicated the results of the entheseal remodeling data (Chapter 5). The New Kingdom Tombos and Pharaonic samples exhibited the least osteoarthritis, the Napatan Tombos and SJE C-Group samples exhibited moderate levels of osteoarthritis, and the Kerma and O16/P37 samples exhibited the highest levels of osteoarthritis.

Thus, this chapter supports the view that osteoarthritis and entheseal remodeling have a common causal factor. While various contributing factors (e.g., age, genetics, body weight) may have an effect on osteoarthritis, physical activity likely plays an important role in the development of this condition. However, it is crucial to have sufficient sample sizes, particularly with regard to infrequent manifestations such as eburnation; otherwise, interpretation of the data may be skewed. These results support the discussion of activity reconstruction in the Nile Valley, presented in Chapter 5, and encourage future bioarchaeological research of osteoarthritis.

CHAPTER 7. IDENTIFYING FOODWAYS: AN ANTHROPOLOGICAL PERSPECTIVE ON DIETARY RECONSTRUCITON VIA STABLE ISOTOPE ANALYSIS IN THE ANICENT NILE VALLEY

7.1 Introduction

The function of food is both complex and diverse. Most basically, dietary consumption serves as a source of necessary nourishment. However, diet and its associated activities (i.e., food selection, preparation, presentation, consumption) play a very important social role (Counihan and van Esterik, 1997). Several scholars have suggested a direct relationship between food systems and social relations (Bourdieu, 1979; Douglas, 1984; Mead, 1943; Sahlins, 1972). Gumerman puts paramount importance upon the social role of food, contending "social relations are defined and maintained through food" (1997:106).

When examining the social role of food, we must not overlook the roles of individual actors in this process. Goody (1982:29) points out the importance of individual agency in food choice. While this can be extrapolated to societies, anthropologists must be aware that basic food choices are often made at the level of the individual. Food symbolism goes beyond simply reflecting society; rather dietary choice and consumption can be viewed as a method of creating society through the actions of individuals (Hodder, 1986).

The reason foodways play such a significant social role is partially due to their daily practice and repetitive nature. Quotidian actions provide individuals with the opportunity to exhibit their perspectives, even in socially constraining situations. Because these activities are seemingly mundane, they have the ability to illustrate non-public information. This is particularly applicable for individuals and populations within culture contact situations. In these scenarios people might practice varying everyday actions in order to define their social identities. Sometimes, not everyone can publically and demonstrably protest their views owing to social constraints; however, these voices can be heard in a less obvious manner through day-to-day activities (Jenkins, 1997; Love, 1999; Lucy, 2005; McGuire, 1982; Robin, 2002).

Giddens' (1984) theoretical perspective of structuration bridges this gap between individual everyday actions and the authoritative influence of others. Structuration asserts that an overarching social structure is inevitably confining; however, quotidian actions can be used as a means of contesting norms and redefining social systems. Thus, mundane and routine activities, including food consumption, are agentive exercises that can slowly change social structures through time.

This anthropological understanding of food can also be applied to the archaeological record. Using this theoretical orientation, we can address questions of culture contact, coexistence, and identity in the past (Twiss, 2007). The sociopolitical context of Ancient Nubia is an excellent context to examine the social nature of food. As discussed in Chapter 2, the relationship between Egypt and Nubia during the New Kingdom/Napatan Period transition was a phase of intense interaction and the convergence of distinct social systems (Kendall, 1999; Morkot, 1994; Török, 1995). Within this context, did Nubians adopt an Egyptian style diet, suggesting long-term coexistence and cultural blending? Conversely, did Nubians revert to a traditional diet after the withdrawal of the Egyptian Empire?

Using bioarchaeological stable isotope analysis, we can directly assess skeletal material (i.e., bone and tooth enamel), thus, elucidating what types of foods were *consumed*. More specifically, the analysis of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) stable isotopes from human bone has the ability to determine various aspects of an individual's dietary intake (DeNiro, 1987; DeNiro and Epstein, 1981; Schwarcz, 2000; Schwarcz and Schoeninger, 1991; van der Merwe, 1982).

Stable isotope analysis can help bioarchaeologists to tease apart characteristic Egyptian and Nubian diets. Specifically, carbon isotope ratios can differentiate Egyptian grains (barley and emmer wheat) from Nubian grains (millet and sorghum) and nitrogen isotope ratios can discern Egyptian proteins (freshwater fish and riverine fauna) from Nubian proteins (cattle; further discussion in section 7.6).

In collaboration with other quotidian data (i.e., entheseal remodeling, osteoarthritis; Chapters 5, 6) we can begin to understand what daily life was like in Ancient Nubia during this period of change. As proposed in Chapter 4, hypotheses regarding Egyptian and Nubian foodways during the New Kingdom/Napatan transition can be put forward (Table 7.1). Examining day-to-day life via food and activity will inform our understanding of social processes inherent in interaction and coexistence. This chapter will address previous dietary reconstruction research in the Nile Valley and present preliminary carbonate and collagen results from multiple sites in the Nile Valley.

Table 7.1 Hypotheses and Expectations: Dietary Reconstruction

Hypotheses	Expectations
Local Nubians at Tombos retained a traditional diet during the New Kingdom/Napatan sociopolitical transition; local diet at Tombos consists of Nubian foods (cattle, sorghum, millet), suggesting Nubians at Tombos were maintaining traditional social identities as expressed through foodways	• Nitrogen intake typical of cattle consumption (expected bone collagen $\delta^{15}N$ ratios: 9 to 11.5‰) • Carbon intake characteristic of sorghum and millet (expected bone collagen $\delta^{13}C$ ratios: -9 to -14‰ and dental carbonate $\delta^{13}C$ ratios: -0.5±1‰).
Nubians at Tombos adopted a more Egyptian diet (wheat, barley), which would suggest Nubians welcomed an Egyptian-influenced identity	• Nitrogen intake typical of fish consumption (expected bone collagen $\delta^{15}N$ ratios: 12 to 15‰) • Carbon intake typical of wheat and barley consumption (expected bone collagen $\delta^{13}C$ ratios: -20 to -35‰ and dental carbonate $\delta^{13}C$ ratios: -12.5±1.2‰)[20].

7.2 The Bioarchaeology of Food

Bioarchaeology offers a unique perspective on foodways because it is a direct artifact, a product, of foods *consumed*. Furthermore, bioarchaeology incorporates multiple lines of data including skeletal remains and the archaeological record (e.g., material remains, burial practices). Bioarchaeological

[20] All expected bone collagen ratios discussed in Table 7.1 are based on Morgan et al., 1994 and Schwarcz et al., 1985.

methods for understanding ancient foodways include stable isotope analysis, dental indicators (e.g., pathological conditions, wear, antemortem tooth loss), and general indicators of health (e.g., cribra orbitalia, stature).

Within bioarchaeological research, stable isotope analysis has been applied to questions including, but not exclusive to, human migration (e.g., Buzon and Bowen, 2010; Sealy et al., 1995), identity (e.g., Cox and Sealy, 1997; Fornander et al., 2008), socioeconomic status and gender (e.g., Barrett and Richards, 2004) in addition to diet (e.g., Ambrose and DeNiro, 1986; Buikstra and Milner, 1991). More specifically, the analysis of carbon ($^{12}C/^{13}C$) and nitrogen ($^{14}N/^{15}N$) stable isotopes from human bone has the ability to determine various aspects of an individual's dietary intake during their adult life (van der Merwe, 1982; discussed further below). Carbon isotope analysis can differentiate dietary intake of tropical grasses, characterized by C_4 photosynthetic pathways (also known as hatch-Slack), such as sorghum, millet, and sugar cane (-9 to -14‰) versus more common C_3 plants such as wheat, rice, beans, tubers, nuts, as well as most fruits and vegetables (-20 to -35‰, see section 7.3; Deines, 1980; Katzenberg et al., 1995; Schwarcz et al., 1985). Through the analysis of nitrogen isotopes, trophic level can be discerned (Hedges and Reynard, 2007). With these data, bioarchaeologists can identify dietary patterns with specific reference to the degree of meat/fish consumption, ranging the spectrum from an essential lack of meat and animal products in the diet to a complete dependence upon them.

While the various archaeological and bioarchaeological methods mentioned above can elucidate ancient dietary practices, stable isotope analysis is unique in its ability to identify fairly specifically what types of foods people were eating; this is particularly true for contexts in which C_3 and C_4 plants are present, as is the case in the Nile Valley. Conversely, the various other methods described above can only speak to broad trends in dietary change over long periods of time. Thus, stable isotope analysis remains a principal technique in the analysis of ancient diet.

7.3 Principles of Stable Isotope Analysis

At the most basic definition, isotopes are atoms of the same element with an equal number of protons, but differing numbers of neutrons. For example, the element carbon is comprised of 14 isotopes (^{8}C – ^{22}C), all of which have 6 protons, but vary in their number of neutrons (i.e., 2-16, respectively). However, only two of these isotopes are stable (^{12}C and ^{13}C), meaning they are not subject to radioactive decay, or possess half-lives so extensive they are virtually unmeasureable (Dawson et al., 2002). While radioactive isotopes (e.g., ^{14}C) are useful in other contexts, such as dating organic material for archaeological purposes, stable isotopes are conducive to a multitude of analyses because of their enduring and unchanging form. Common stable isotopes studied include oxygen, carbon, nitrogen, hydrogen, and sulfur, although 255 stable isotopes form 80 elements are known to exist (Fry, 2006). Stable isotope analysis is used in numerous scientific disciplines including, but not limited to, biology, ecology, geology, climatology, hydrology, and anthropology.

Stable isotope analysis is complicated by chemical reactions that occur under certain physical conditions, which result in the separation of isotopes. This process is referred to as fractionation. Phenomena such as evaporation and freezing cause the chemical separation of lighter isotopes (i.e., the isotope with the lower atomic mass number; e.g., ^{1}H) from heavier isotopes (i.e., isotope with the higher atomic mass number; e.g., ^{2}H). The effects of fractionation vary depending on the chemical circumstances and the element (Schoeller, 1999). Fractionation of carbon and nitrogen is limited, making these elements ideal for dietary reconstruction.

Isotope analysis is performed on an isotope ratio mass spectrometer (IRMS), a precision instrument designed to determine the isotopic composition of elements within a sample. After ionizing molecules, a powerful magnet is used to direct and quantitatively measure isotopes. Ultimately, the ratios between the stable isotopes of an element are measured (often referred to as a δ value), inferring chemical composition. These results are then compared to standard and accepted measures within biogeochemistry. These standards have known and well-studied isotopic ratios and can therefore be compared between various laboratories, which utilize the same standards. For example, the standard for carbon is Pee Dee Belemnite (VPDB) and nitrogen is atmospheric air. International standards are established through the National Bureau of Standards (NBS) and the International Atomic Energy Agency, Vienna (IAEA; Fry, 2006).

When conducting stable isotope analysis of human remains, samples are usually taken from two primary sources: teeth and bone. Dentition samples offer the particular advantage of preserving better than bone (Lee-Thorp et al., 1989; Sponheimer and Lee-Thorp, 1999); this is due to a thick calcified enamel layer, which covers the tooth and protects it from decay in life. It is important to note that isotope signatures from teeth reflect a unique phase of the human lifecycle – namely, childhood. Most teeth are formed by early adulthood, with third molars typically being the last dental eruption (17-21 years of age; White and Folkens, 2000). Thus, when teeth are sampled for isotope analysis, the childhood diet is being examined. This is contrasted with bone, which is constantly undergoing a process of remodeling. It is estimated that the human skeletal frame completely remodels approximately every 10 years (Rosen, 2003). Thus, dental sampling reflects childhood diet and bone sampling reflects adult diet. Furthermore, human skeletal material is composed of two primary tissue types: an organic composite protein material (collagen, $\delta^{13}C_{CO}$) and a mineral hydroxyapatite material (carbonate, $\delta^{13}C_{AP}$; White and Folkens, 2000). Previous stable isotope analysis research has suggested that collagen and carbonate represent varying components of an individual's dietary intake (Ambrose and Norr, 1993; Kellner and Schoeninger, 2007; Krueger and Sullivan, 1984; Tieszen and Fagre, 1993). Collagen reflects ingested proteins, consisting of both essential and nonessential amino acids. Carbonate, on the other hand, better reflects an individual's overall diet because it is composed of dissolved bicarbonate from the blood, which is influenced by dietary carbohydrates, lipids, and proteins (Katzenberg, 2001; Larsen, 1997). While teeth and bone are the most typical sources of isotopic sampling, other tissues such as muscle, skin, hair, and nails are also utilized (see Nardoto et al., 2006; O'Connell et al., 2001; Thompson et al., 2010; Turner et al., 2013; White and Schwarcz, 1994; White et al., 2009).

Another factor to consider in the bioarchaeological investigation of stable isotopes is diagenesis, or the chemical and physical alterations that occur to skeletal material after their interment. General taphonomic processes, such as plant and fungi decomposition can create contaminants (i.e., humic acid) that bone then absorbs (Schwarcz and Schoeninger, 1991). For collagen, these processes and general skeletal decomposition result in low collagen yields (Schoeninger et al., 1989). Diagenesis testing of collagen is conducted through amino acid analysis and determining the carbon to nitrogen ratio yields (C:N; DeNiro et al., 1985; DeNiro and Schoeninger, 1983; Katzenberg, 1992). Bone carbonate is particularly susceptible to groundwater absorption, but is also affected by recrystallization and general processes of decay. Techniques such as acetic acid pretreatment, x-ray diffraction, and infrared spectroscopy have been used to detect and remove diagenetic contamination (Lee-Thorp and van der Merwe, 1991; Wright and Schwarcz, 1996). In the past, digenesis posed a major complication in the bioarchaeological research of stable isotopes. Now, with the methods described above, digenesis can often be accounted for.

7.3.1 Carbon Isotope Analysis

Carbon isotope analysis is particularly useful in determining plant consumption and is based on plant physiology variation. Three broad categories of plants exist, C_3, C_4, and CAM, which differ based on types of carbon fixation during photosynthesis. In C_3 plants stomata remain open at all times, allowing gas exchange. This results in the transpiration (loss of water vapor) of the lighter isotope (^{12}C), while the heavier isotope (^{13}C) is retained within the plant because it is not subject to transpiration. Therefore, an isotope signature with depleted levels of ^{13}C ($\delta^{13}C$ = -28‰ to -24‰) would reflect C_3 plants (Smith and Epstein, 1971, van der Merwe and Vogel, 1978). C_3 plants are characterized by more temperate species such as rice, beans, tubers, as well as most fruits and vegetables. C_4 plants, on the other hand, are adapted to hot and arid climates by being able to minimize the amount of time that stomata are open, and thereby minimizing water loss. This results in less ^{13}C depleted tissues ($\delta^{13}C$ = -14‰ to -9‰; Deines, 1980; Katzenberg et al., 1995; Schwarcz et al., 1985). C_4 plants are characterized by tropical grasses such as sorghum, millet, and sugar cane. CAM (Crassulacean Acid Metabolism) plants have a unique photosynthetic process, opening their stomata only at night and closing them during the day. CAM plants are typically comprised of succulents; like C_4 plants, this is an adaptation to hot and arid environments. However, isotopically this results in wide ranging effects ($\delta^{13}C$ = -12 to -27‰) depending on the environmental conditions and the plant. Because succulents aren't typically consumed, particularly in the Nile Valley region, CAM plants aren't usually considered to be a confounding dietary resource. Carbon isotope ratios are analyzed and reported as delta values in per mil using the following formula:

$$\delta^{13}C = \left\{ \left(\frac{\left[\frac{^{13}C}{^{12}C}\right]_{sample}}{\left[\frac{^{13}C}{^{12}C}\right]_{standard}} \right) - 1 \right\} \times 1000 \text{ (in per mil, ‰)}$$

7.3.2 Nitrogen Isotope Analysis

Nitrogen isotope analysis has the ability to elucidate protein sources (i.e., terrestrial vs. aquatic, legumes vs. other plants), and trophic level (level in the food chain) of foods consumed (Ambrose and DeNiro, 1986; DeNiro and Epstein, 1981; Hedges and Reynard, 2007; Schoeninger, 1985). With these data, bioarchaeologists can identify dietary patterns with specific reference to the degree of meat consumption, ranging the spectrum from an essential lack of meat and animal products in the diet to a complete dependence upon them.

Legumes have evolved a symbiotic relationship with the bacteria rhizobium, which effectively fixes nitrogen in the plants root system with oxygen and hydrogen, enabling the plant to absorb the necessary nitrogen intake (Brill, 1977). Non-leguminous plants do not possess this adaptation and, therefore, acquire nitrogen from other decomposed organic matter. This process results in legumes reflecting $\delta^{15}N$ values closer to that of atmospheric nitrogen ($N_2 = 0‰$) because of the more direct absorption of nitrogen in the root system. Non-leguminous plants have higher $\delta^{15}N$ values because they are incorporating nitrogen from other plants.

Nitrogen is transferred from food sources to consumers and accrues at each level of the proverbial 'food chain'; this is referred to as trophic level. For example, when a mouse eats a blade of grass, it consumes the nitrogen content of the grass. When a cat eats the mouse, the cat absorbs the nitrogen content of not only the mouse, but the blade of grass as well. This nitrogen enrichment is scaled according to the food chain; therefore, carnivores have the highest $\delta^{15}N$ ratios and plants as well as herbivores have the lowest $\delta^{15}N$ ratios (Schoeninger and DeNiro, 1984).

The consumption of freshwater fish results in increased $\delta^{15}N$ ratios, corresponding to trophic level enrichment, coupled with slightly elevated $\delta^{13}C$ ratios. The majority of carbon intake in aquatic species is from dissolved carbonate ($\delta^{13}C = 0‰$). This can be compared to terrestrial species, including humans, whose carbon originates from atmospheric CO_2 (via the photosynthetic pathways described above), which is composed of less carbon ($\delta^{13}C = -7‰$). As with carbon, nitrogen isotope ratios are expressed according to the following formula:

$$\delta^{15}N = \left\{\left(\frac{\left[\frac{^{15}N}{^{14}N}\right]_{sample}}{\left[\frac{^{15}N}{^{14}N}\right]_{standard}}\right) -1\right\} \text{ x } 1000 \text{ (in per mil, ‰)}$$

7.4 Food in Ancient Egypt and Nubia

While ancient Egyptian and Nubian diets were in many respects similar due to spatial proximity, closer examination enables elements of these two diets to be differentiated. Funerary offerings, artistic depictions, written documents as well as archaeological, archaeozoological, and archaeobotanical remains have suggested foods such as bread, palm date, pomegranate, melon, fig, cucumber, leek, cabbage, onion, beans, lentils, honey, goat, pig, cattle, and fish were available to Nile Valley inhabitants (Darby et al., 1977; James, 1984; Saffirio, 1972; Wilson, 2001).

Egyptians are known to have depended heavily upon bread and beer, particularly those made from emmer wheat and barley (Alcock, 2006; Samuel, 1996a; 1996b; 2000). Bread and beer were often used as a form of income as well as tax, which is evidenced by large-scale bakeries and breweries (in operation by the Old Kingdom 2,600-2,150 BC) and state records (Breasted, 1906; Butzer, 1976; Murray, 2000). There is also evidence to suggest that the tetracycline component of beer may have served an antibiotic purpose (Armelagos et al., 2001; Bassett et al., 1980). In general, the majority of Egyptians did not have access meat, particularly beef (Ikram, 1995; Romer, 1984). Beef in Egypt was considered to be a status food that was only consumed by the most elite and/or royal. Most Egyptians relied upon pig, sheep, goat, and other riverine species (e.g., turtle, crocodile) as a source of protein (Ikram, 2000).

Nubians, on the other hand, may have depended more upon sorghum, millet, and cattle as mainstays of their diet. The domestication of sorghum (*Sorghum bicolor*) in the Nile Valley has been thoroughly debated (de Wet and Huckabay, 1967; Haaland, 1992; 1995; Munson, 1976; Young and Thompson, 1999). Currently, there is no direct evidence of sorghum domestication until *c.* 500 BC (Fuller, 2004). Many have suggested that sorghum was likely domesticated and certainly wild varieties were consumed before this date (see Haaland, 1995; 1999)[21]. Sorghum was often prepared into porridge, similar to many other African cultures, and continued to play an important role in Nubian culture through the Meroitic Period (300 BC – AD 400; Dirar, 1993; Edwards, 1996; 2004). Beer was also popular in Nubia, but was of another variety than Egyptian beers. Bouza, a traditional Nubian beer, is made from millet, rather than wheat or barley (Burckhardt, 1819; Hornsey, 2003). As Haaland describes "Nubia was on the crossroad between the bread-eating cuisine to its north and the porridge/beer-consuming world to the South" (Haaland, 2012: 336).

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[21] Excavations at Um Direiwa, a Neolithic site approximately 100km northeast of modern Khartoum, (*c.* 4,800 BC) have uncovered grindstones with traces of wild sorghum and millet (Haaland, 1987). Additionally, evidence of earlier sorghum domestication has been found outside the Nile Valley. At Mehel Teglinos, in the Kassala region of Sudan (eastern Sudan, bordering with modern Eritrea), recent excavations have found domesticated sorghum dating to *c.* 3,950 BC (Beldados and Constantini, 2011; Haaland, 2012).

Previous examination of carbon and nitrogen stable isotope ratios in Egyptian populations supports the hypothesis that Egyptian diets are characteristically C_3 dominant (Iacumin et al., 1996; Thompson et al., 2005). Similar analysis of Nubian diets has suggested a more mixed C_3/C_4 dietary regimen. Iacumin and colleagues (1998) examined Nubian skeletal remains from Kerma, El Hobagi, Makharag, and Koya and found a mixed C_3/C_4 diet. Thompson and colleagues (2008) examined additional specimens from the Kerma collection and also extrapolated a mixed C_3/C_4 diet.

Archaeological evidence suggests cattle held an important place in Nubian culture since the Predynastic era (*c*. 3,100 BC; Wengrow, 2001). Asserting that African cattle were domesticated during the 10^{th} millennium BC, Marshall and Hildebrand highlight the importance of cattle and pastoralism in arid environments, such as Egypt and Nubia (Marshall and Hildebrand, 2002). Cattle were frequently depicted in works of art, particularly rock art, throughout Nubia (Brandt and Carder, 1987; Davis, 1984). Cattle hides were often included in funerary contexts (Williams, 1991). At Kerma's eastern cemetery, thousands of cattle crania (bucrania) outline the burial tumuli. The largest tumulus is estimated to have had up to 4,000 bucrania (Chaix, 2001; 2004). As Haaland (2012) points out, this would have provided tens of thousands of kilograms of meat for consumption. Chaix's analysis of the zooarchaeological remains of Kerma further support the concept that these cattle were being eaten; cattle were a "significant proportion of the animals consumed" within Nubia (Chaix and Grant, 1992:61). Additionally, many of the bucrania funerary offerings at Kerma exhibited horn deformation, a practice that is likely reinforced with religious significance (Chaix, 1996; Chaix et al., 2012). When these multiple aspects of cattle culture are incorporated and seen throughout Nubian and in various Nubian cultures (e.g., A-Group, C-Group, Kerma), many have suggested this evidence indicates the presence of a cattle cult within Nubia (Brass, 2003; Williams, 1986).

As stated above, there is likely a degree of overlap between Egyptian and Nubian diets. However, it is my aim to differentiate Egyptian and Nubian diets using stable isotope analysis. Thus, the application of stable isotope analysis is an ideal method for this research because of its ability to distinguish C_3 and C_4 diets as well as trophic level variability, which are present in the Nile Valley.

7.5 Materials and Methods

7.5.1 Materials

A total of 156 skeletal samples were tested for dietary reconstruction (134 dental carbonate, 22 bone collagen; Figure 7.1). Dental carbonate samples were taken from the following archaeological sites: Tombos (New Kingdom and Napatan), Saqqara, Kerma, Qurneh, Amara West, Shellal, SJE C-Group, SJE Pharaonic. Bone collagen samples were taken from the following sites: Tombos (New Kingdom), SJE C-Group, SJE Pharaonic. Information on the archaeological context of these sites can be found in Chapter 3.

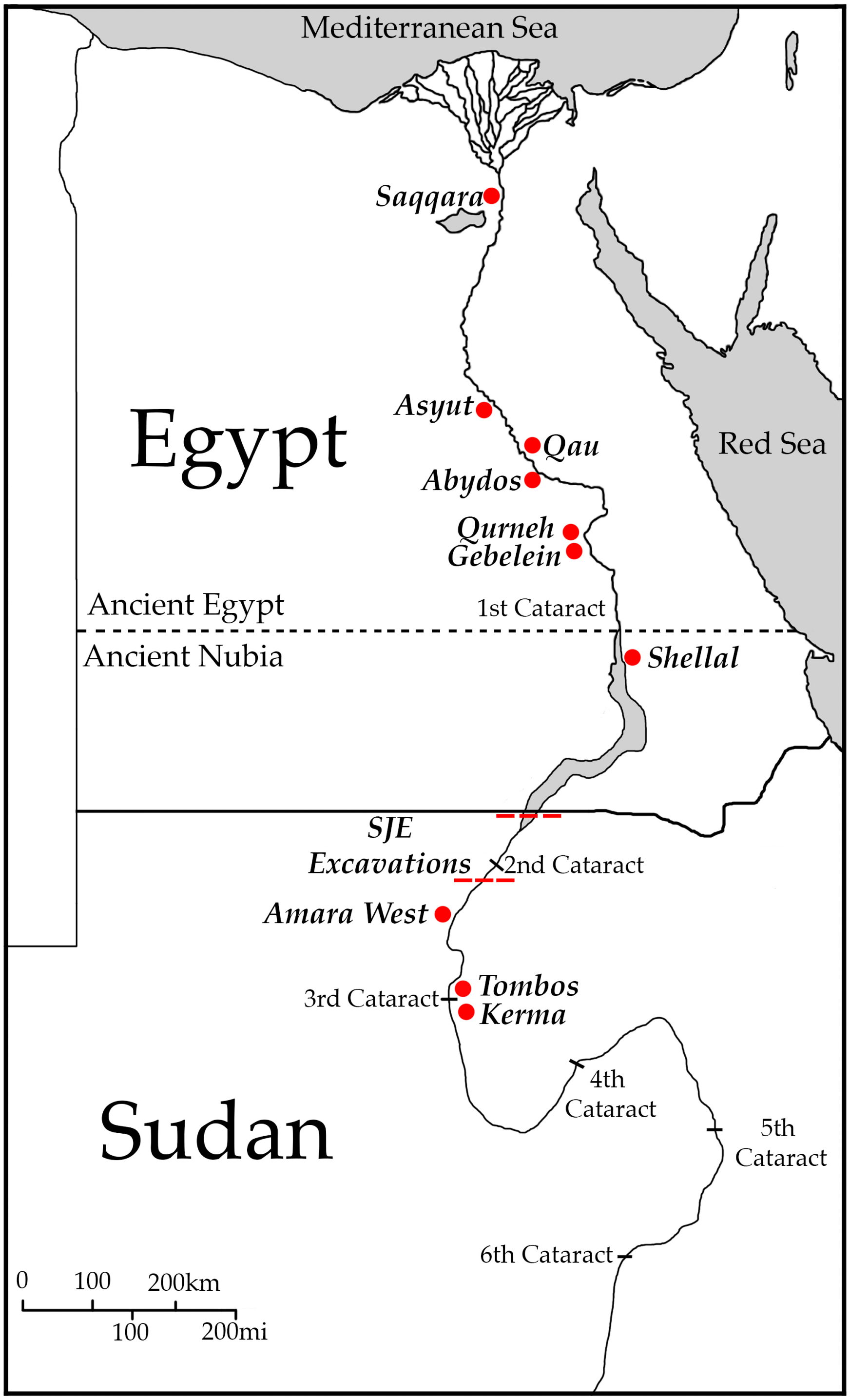

Figure 7.1 Map of Nile Valley Isotope Samples

7.5.2 Methods

7.5.2.1 Dental Carbonate

Approximately 10mg of enamel was taken from the crown of the tooth. These samples were treated with a 5% Sodium hypochlorite (NaOCl) solution, rinsed, and a 0.1 mol acetic acid solution was added. This process was repeated for three days. Samples were rinsed and lyophilized prior to analysis (Koch et al., 1997). Dental carbonate was analyzed using a ThermoFinnigan Delta V Isotope Ratio Mass Spectrometer (IRMS) following reaction at 75°C with orthophosphoric acid and chromatographic isolation of CO_2 on a GasBench automated preparation device (Purdue Stable Isotope Facility, Department of Earth and Atmospheric Sciences, Purdue University).

Uranium concentration in the samples was used to assess contamination (Buzon et al., 2007). Uranium, which can reflect groundwater exposure, is not normally found in skeletal remains (Hedges and Millard, 1995). Thus, the presence of uranium in skeletal tissues should be below the equipment detection limit (i.e., 0.0003ppm – ICP-MS).

7.5.2.2 Bone Collagen Carbon and Nitrogen

Collagen samples were prepared using a modified version of the Longin (1971) method (Chisholm et al., 1983; Garvie-Lok, 2001). Approximately 750mg of cortical bone was removed and thoroughly washed with distilled water. The samples were then cleaned ultrasonically in double-distilled water and air-dried. Samples were placed in 100mL of 1% hydrochloric acid (HCl) solution for 1-2 days (Sealy, 1986). After rinsing, 100mL of 0.125 mol sodium hydroxide (NaOH) solution was added to remove humic and fulvic acid contaminants (Katzenberg and Weber, 1999). The samples soaked in the NaOH solution for 20 hours and then rinsed. Bone collagen was analyzed at the Purdue Stable Isotope Facility, Department of Earth and Atmospheric Sciences using a PDZ/Europa 20 isotope ratio mass spectrometer (IRMS). The degree of collagen preservation was assessed using the atomic ratio of carbon to nitrogen and the total collagen yield (Ambrose, 1990; DeNiro, 1985).

7.6 Results

In this section, results of dental carbonate carbon and bone collagen carbon and nitrogen are presented. These results and following discussion will focus on the dental carbonate data because it proved to be more successful than the bone collagen analysis.

7.6.1 Dental Carbonate Carbon

Uranium was undetectable in all carbonate samples; thus, all samples were included in the following interpretations (Buzon et al., 2007; Appendix D). The Napatan Tombos sample resulted in the lowest mean carbonate carbon value ($\delta^{13}C_{AP}$ = -12.8‰) and, therefore, have more of a C_3 contribution to their diet. The majority of samples (i.e., Qurneh, Amara West, Saqqara, Kerma, SJE Pharaonic, New Kingdom Tombos) resulted in mean $\delta^{13}C_{AP}$ values between -12.4‰ and -11.8‰ (Figure 7.2). SJE C-Group and Shellal had similarly low mean $\delta^{13}C_{AP}$ values (-11.0‰ and -10.7‰, respectively). When statistical testing (t-test = α 0.05) was applied to these data several inter-site comparisons proved to be significantly different. Napatan Tombos was found to significantly differ from the following samples: Qurneh, Saqqara, New Kingdom Tombos, Kerma, SJE C-Group, and Shellal. Previously published carbonate data is too chronologically removed to be applicable for comparison (e.g., X-Group and Christian Period, *c.* AD 350-1300 Schwarcz and White, 2004; Medieval Period, *c.* AD 550-800, Turner et al., 2007).

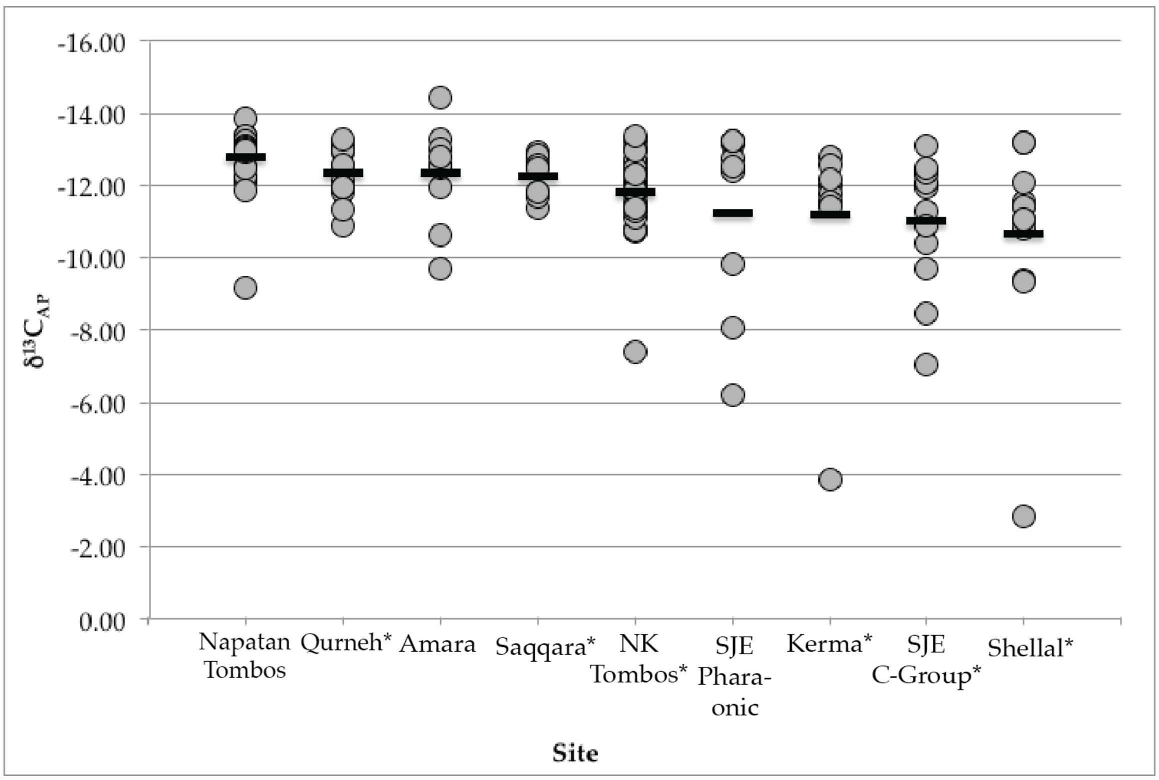

Figure 7.2 Dental Carbonate Results: Tombos and Comparative Sites

[1] Black rectangle = mean $\delta^{13}C_{AP}$ values
* = Significantly different ($p \leq 0.05$) than Napatan Tombos sample
Napatan Tombos (*n*=24); Qurneh (*n*=14); Amara (*n*=10); Saqqara (*n*=12); New Kingdom Tombos (*n*=30); Pharaonic (*n*=8); Kerma (*n*=8); C-Group (*n*=13); Shellal (*n*=12)

7.6.2 Bone Collagen Carbon and Nitrogen

Unfortunately, many of the samples that were analyzed for bone collagen were not viable, owing to low yields and high carbon to nitrogen ratios (Appendix D). As suggested by DeNiro (1985), the ratio between carbon and nitrogen should be 2.9-3.6. Values higher or lower than this could indicate diagenesis, contamination, degradation, or methodological complications. This issue is currently being investigated in hopes that additional data will become available via alternative methods and sampling. Four of the bone collagen samples did have appropriate yields and C:N ratios (Appendix D). These data, coupled with previously published stable isotope data, will be analyzed here. Had all of the bone collagen samples been successful, more complete analysis, including a comparison of $\delta^{13}C_{AP}$ compared to $\delta^{15}N$ as well as $\Delta^{13}C_{CO\text{-}AP}$, could have been conducted (Hedges, 2003; Jim et al., 2004).

All of the successful bone collagen results come from the site of Tombos and date to the New Kingdom Period (1,550-1,069 BC). For these samples, the mean $\delta^{13}C_{CO}$ value is -18.97 ± 0.83‰ and the mean $\delta^{15}N$ value is 12.51 ± 0.34‰ (Figure 7.e). This places the carbon data on the lower brink of C_3 plant dependence (C_3 = -20‰ to -35‰, C_4 = 9‰ to -14‰; Deines, 1980). Furthermore, this nitrogen data suggests a moderate degree of meat consumption.

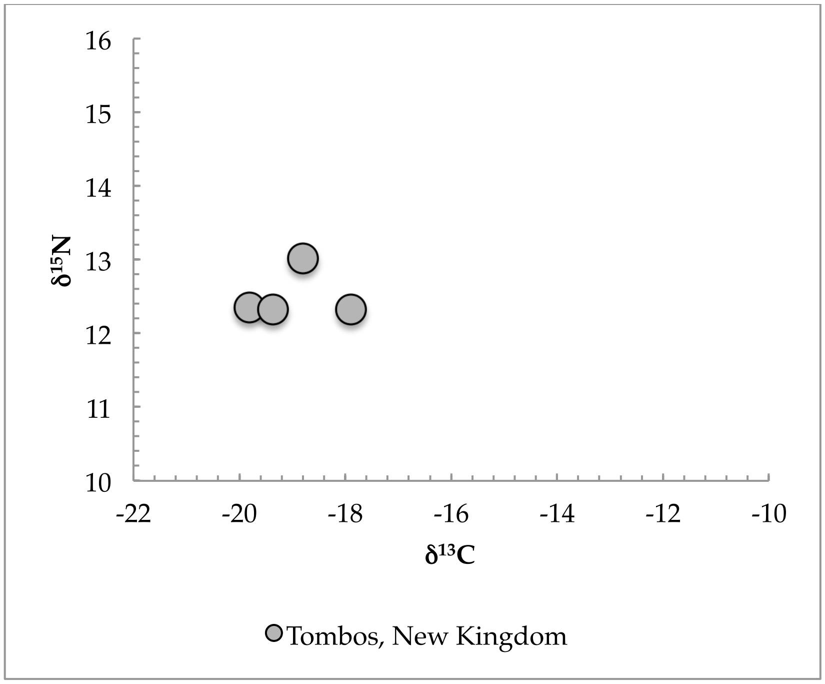

Figure 7.3 Bone Collagen Carbon and Nitrogen Results: Tombos, New Kingdom

(*n*=4)

These results are most interesting when compared to other isotopic data from the region (Figure 7.4). The mean score for the Tombos data ($\delta^{13}C_{CO}$ = -18.97‰, $\delta^{15}N$ = 12.5‰) is very similar to many of the Egyptian samples. Abydos, Gebelein, Asyut, and Tombos have $\delta^{13}C_{CO}$ values clustered around -19.5‰ and $\delta^{15}N$ values clustered around 13‰ (Iacumin et al., 1996; Thompson et al., 2005). Qau and Saqqara values are exactly the same: $\delta^{13}C_{CO}$ = -20.9‰, $\delta^{15}N$ = 12.7‰ (Thompson et al., 2005); this suggests a slightly greater dependence upon C_3 plants than the Abydos, Gebelein, Asyut, Tombos grouping. Qurneh has a similar $\delta^{13}C_{CO}$ value as Qau and Saqqara ($\delta^{13}C_{CO}$ = -21.1‰); however, the Qurneh sample is comparatively $\delta^{15}N$ enriched ($\delta^{15}N$ = 13.8‰; Thompson et al., 2005).

The Kerma sample proved to have a unique isotope signature, with a $\delta^{13}C_{CO}$ mean of -17.8‰ and $\delta^{15}N$ of 13.6‰ (Iacumin et al., 1998; Thompson et al., 2008).

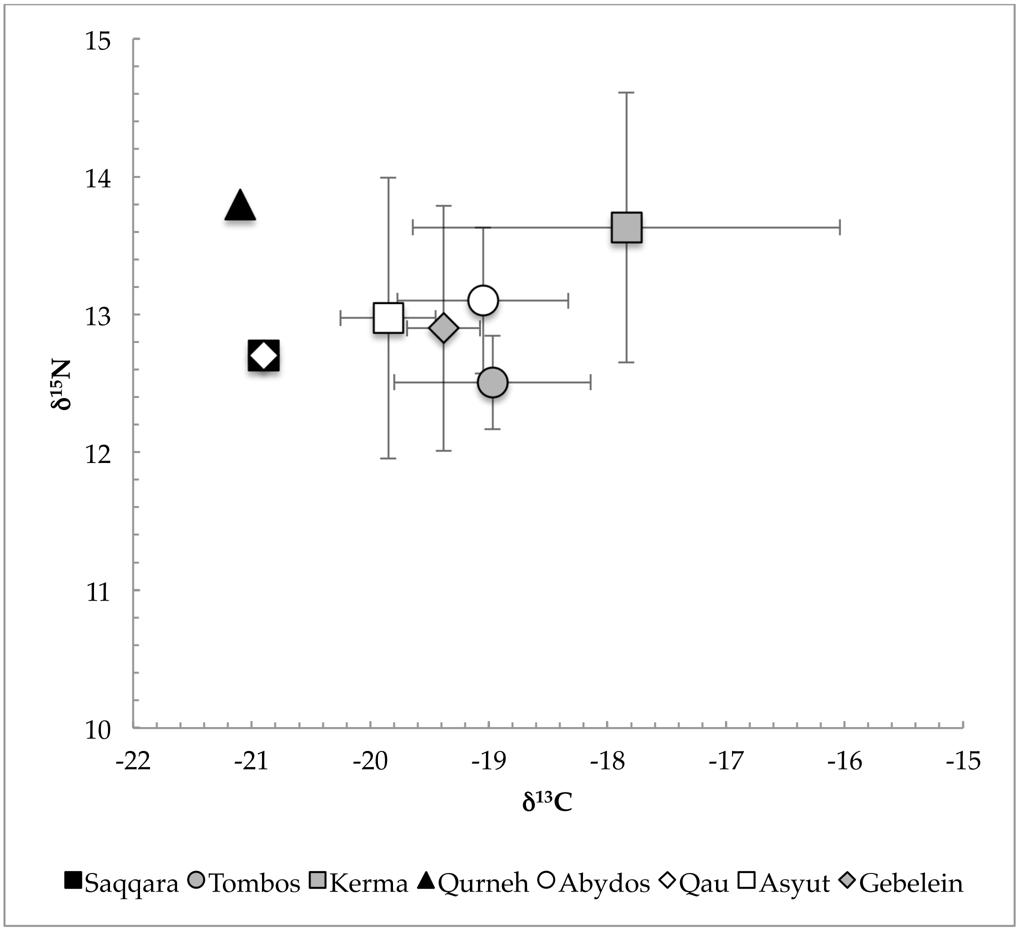

Figure 7.4 Bone Collagen Carbon and Nitrogen Results: Tombos and Comaprative Samples

Saqqara (*n*=1, Thompson et al., 2005); Tombos (*n*=4); Kerma (*n*=62, Iacumin et al., 1998; Thompson et al., 2008); Qurneh (*n*=1, Thompson et al., 2005); Abydos (*n*=4, Thompson et al., 2005); Qau (*n*=1, Thompson et al., 2005); Asyut (*n*=8, Iacumin et al., 1996); Gebelein (*n*=6, Iacumin et al., 1996)

7.7 Discussion

Combined, data from dental carbonate carbon and bone collagen carbon/nitrogen from various Nile Valley sites improve our understanding of what kinds of foods ancient Egyptians and Nubians were consuming. Overall, it appears that the people of Tombos were consuming a mixed C_3/C_4 diet with some protein contribution. More detailed analysis of these data is necessary to define dietary trends and apply anthropological interpretations.

7.7.1 Dental Carbonate

The carbonate results presented here suggest the population of Tombos was consuming a mixed C_3/C_4 diet. In populations with a C_3 dependent diet, bioapatite levels are approximately -14.5 ± 2‰; bioapatite levels of a C_4 diet are approximately -0.5 ± 1‰ (Morgan et al., 1994). Thus, the inhabitants of Napatan and New Kingdom Tombos, with mean carbonate values of -12.8‰ and -11.8‰, respectively, depended heavily on C_3 cereals, fruits, and legumes, but were also incorporating C_4 plants into their diets. This is not altogether surprising considering many of the consumable plants in the Nile Valley are C_3 (see section 7.6; e.g., onions, lentils, dates, figs). However, the only primary C_4 plants in the region are sorghum and millet. This could have been in the form of direct consumption of C_4 plants, or via the consumption of animals that fed on C_4 plants. As discussed above, researchers are uncertain if sorghum/millet was domesticated by the New Kingdom. Regardless, wild sorghum would have been available for consumption and may have been associated with a Nubian social identity.

If C_3/C_4 foods were associated with Nile Valley social identities, we would expect the Egyptian samples (e.g., Saqqara, Qurneh) to have a depleted $\delta^{13}C$ signal (i.e., more C_3 dependent) and the Nubian samples (e.g., Kerma, C-

Group) to have an enriched $\delta^{13}C$ signal (i.e., more C_4 dependent). This postulate is partially upheld by the dental carbonate data. The samples whose mean $\delta^{13}C$ are more depleted than 11.2‰ are more Egyptian/Egyptianized (i.e., Qurneh, Amara, Saqqara, New Kingdom Tombos, SJE Pharaonic). As discussed in Chapter 2, Saqqara and Qurneh are archaeological sites in Egypt and, thus, presumably reflect Ancient Egyptian dietary patterns. Amara, SJE Pharaonic, and New Kingdom Tombos are all sites within Nubia that were colonized by Egyptians and became increasingly culturally Egyptianized during the New Kingdom Period. It is not surprising then that these samples are clustered together. Those samples that are $\delta^{13}C$ enriched beyond -11.2‰ (i.e., Kerma, C-Group) are populations where we might expect a more Nubian diet. Archaeological evidence suggests that both Kerma and C-Group peoples maintained strong Nubian identities (see Williams, 1986; 1991). Thus, these data suggest the Kerma and C-Group peoples were also consuming a mixed C_3/C_4 diet, however, there was a more substantial C_4 component than the other sites examined here. Obviously, there is one explicit exception to this concept – Shellal. However, if we take a closer look at the distribution of data points in the Shellal sample, we see one statistically significant outlier (-2.87‰). If this data point is removed from the pool, the Shellal $\delta^{13}C$ mean becomes -11.31‰, which is within the proposed range of an Egyptian diet. The outlier in the Shellal sample could reflect an individual who was eating a predominantly C_4 diet, or could just be an anomaly. Through this anthropological lens we can begin discern preliminary dietary patterns between Egyptian and Nubian populations.

From this, what can we infer about the Napatan Tombos population? The Napatan Tombos sample was consuming, relatively, the most C_3 foods out of the populations examined here (mean $\delta^{13}C$ -12.8‰). These depleted $\delta^{13}C$ levels are significantly different (*t*-test, α 0.05) than several of the comparative samples – even Egyptian populations. So, why then were the inhabitants of Napatan Tombos eating predominantly C_3 foods? One explanation for the increase in C_3 foods between the New Kingdom and Napatan Periods at Tombos is the unique post-empire transcultural environment of Napatan Nubia. With the rise of the Napatan State, Egyptian cultural elements were not abandoned; rather, they were transformed and selectively blended with Nubian traditions. As discussed in Chapter 2, this process is exemplified in the Napatan burials at Tombos. Napatan burials frequently incorporate both Egyptian qualities (e.g., pyramid superstructure, extended burial position, coffin, religious amulets), as well as Nubian qualities (e.g., tumulus superstructure, flexed burial position, funerary bed; S.T. Smith, 2003b). For example, Unit 27 consists of a tumulus tomb in which at least two females were buried (instances of reuse; burials would have been single inhumations). Additionally, one of these burials was in an extended burial position (the other burial was disturbed/comingled in antiquity). There is also evidence of a coffin that would have been placed on a funerary bed. A cache of figurines, including the Egyptian gods Pataikos, Isis, and Bes, as well as multiple beads, and miscellany amulets were also found in Unit 27. This tumulus illustrates the blending of cultural identities and the continuance of many Egyptian traditions during the Napatan Period at Tombos. Thus, it would not be surprising if food traditions were included with these transcultured mores.

Nubians at Napatan Tombos may have been agentively consuming both Egyptian and Nubian foods as they defined and transformed their social identities. Haaland notes the increase in bread molds at Napatan temple sites, such as Jebel Barkal and Kawa, where offerings of wheat bread would be made to the god Amun (Haaland, 2012). Select Egyptian gods, particularly Amun and Bes, were emphasized in Kush's pantheon (Kendall, 2002). Acknowledging their Egyptian origin, it may have been particularly crucial to make offerings of Egyptians foods, such as wheat bread.

As presented in Chapter 4, foodways, in an anthropological light, can be interpreted as meaningful quotidian actions that can define and maintain social identities. Archaeologists have multiple techniques for interpreting the material record of diet; however, bioarchaeological methods are unique in that they can examine the dietary choices of agentive individuals. The discussion of the data presented here is distinctly grounded in social theory (see Chapter 4). While further archaeological as well as bioarchaeological research is necessary to validate these interpretations, this is a starting point with which we can better understand the social nature of food in the ancient past.

In sum, both the dental carbonate data and archaeological record indicate that Nubians were likely consuming more C_3 foods during the Napatan Period. I propose that this dietary shift is linked with continually adapting social identities through time. Previous studies of Nubian dietary patterns also suggest that food was inextricably linked with identity in the Ancient Nile Valley (see Chapter 4; Haaland, 2012; S.T. Smith, 2003b). However, this is a preliminary hypothesis and just one explanation for the unique $\delta^{13}C_{AP}$ values of Napatan Tombos. Further carbonate and collagen testing of the skeletal material from Tombos as well as other Napatan sites is necessary to bolster this argument. As stated in Chapter 2, there is a distinct need for further archaeological excavation of Napatan Period sites in Nubia; it is only with the successful completion of future excavations that the additional human remains needed to do these analyses will become available.

7.7.2 Environmental Factors

It has been suggested that environmental factors have controlled the C_3/C_4 distribution of flora in the Nile River Valley. Some have used the distribution of modern C_3 and C_4 plants along the Nile River as a proxy for the ancient world (Batanouny et al., 1988; White, 1993). However, this is far from ideal considering (1) the current environment is not identical to the ancient past, and (2) the historical processes that have transpired over the centuries have greatly impacted the flora and fauna of the region. For example, the introduction of the water wheel during the Greco-Roman Period (332 BC-AD 395) allowed Nile Valley inhabitants to move much larger quantities of water, and thus better control irrigation, than with the traditional shaduf (bucket-lift; de Miranda, 2007; Wilkander, 2008). While studying modern vegetation would certainly be convenient, it is not accurate.

C_4 plants are more common in hot and humid climates, owing to the fact they have adapted to this specific climatic niche. Thus, scholars have proposed that because Nubia is more humid than Egypt, in addition to variation in humidity and Nile River levels, that Nubians ate more C_4 plants because they simply were was available (Iacumin et al., 1998). Furthermore, alterations to dietary patterns in the Nile Valley can be solely attributed to environmental change. If this were true, we would expect the diets of Tombos and Kerma to be more similar considering the spatial proximity (~20km apart). More importantly, approaches such as these fail to account for local agency and downplay the importance of food choice in social identity construction. As discussed at the beginning of this chapter, food selection, presentation, and consumption are all significant actions that can define an individual's identity and situate them within the community.

7.7.3 Bone Collagen

As discussed in 7.6.2, only four of the samples tested for bone collagen were successful. This section will focus on what preliminary interpretations can be drawn from these data as well as future methodological directions that will resolve past issues.

7.7.3.1 Carbon

The bone collagen carbon results for Tombos (New Kingdom) are relatively depleted ($\bar{x}$ $\delta^{13}C_{CO}$ = -18.97 ± 0.83‰), however, are very near the accepted range of a C_3 diet (C_3 = -20‰ to -35‰, C_4 = -9‰ to -14‰; Deines, 1980). The fact that the collagen carbon results are slightly less than -20‰ suggests there may have been a C_4 contribution to their diet, which supports the results of dental carbonate analysis (see 7.6.1). Furthermore, there are four common sites that have been tested for both dental carbonate and bone collagen (Qurneh, Saqqara, New Kingdom Tombos, and Kerma)[22]. These sites reflect a similar general ordering within the samples presented here. For example, the bone collagen and dental carbonate data suggest that Qurneh was relatively more C_3 dependent and Kerma less so.

Table 7.2 Bone Collagen and Dental Carbonate Mean Data for Qurneh, Saqqara, New Kingdom Tombos, and Kerma

	Qurneh	Saqqara	New Kingdom Tombos	Kerma
$\delta^{13}C_{AP}$	-12.37‰	-12.27‰	-11.81‰	-11.21‰
$\delta^{13}C_{CO}$	-21.1‰	-20.9‰	-19.0‰	-17.7‰

It should be noted that the comparative data employed here are a select example of studies that performed stable isotope analysis of Ancient Egyptian and Nubian groups. Other notable works include: Dupras, 1999; Macko et al., 1999; Turner et al., 2007; White, 1993; White and Schwarcz 1994; White and Armelagos, 1997; White et al., 1999. However, the samples presented as comparative material here (i.e., Iacumin et al., 1996; Iacumin et al., 1998; Thompson et al., 2005; Thompson et al., 2008) were more spatially and temporally appropriate for comparison to New Kingdom and Napatan Tombos.

[22] These data include previously published results (Qurneh: Thompson et al., 2005; Saqqara: Thompson et al., 2005; Kerma: Iacumin et al., 1998; Thompson et al., 2008); thus, the new data presented here (i.e., Qurneh dental carbonate, Saqqara dental carbonate, Kerma dental carbonate, New Kingdom Tombos dental carbonate, New Kingdom Tombos bone collagen) do not reflect the same individuals. While this is not ideal, this data can be used to better understand, on a community scale, what these populations were eating.

Again, had all collagen samples been successful (i.e., with valid yields and C:N ratios), additional interpretations could be made. Further analyses of both collagen and carbonate samples from these collections are currently underway. For collagen, alternative processing techniques and additional skeletal material from various archaeological sites are being tested to control for diagenesis (discussed in further detail in Chapter 8). Hopefully, these results will provide the data needed to address these questions.

7.7.3.2 Nitrogen

The nitrogen levels at New Kingdom Tombos presented here (mean $\delta^{15}N$ = 12.5‰) are quite similar to many of the comparative samples. As discussed above, the enrichment of ^{15}N in the diet reflects the consumption of terrestrial animals, fish, or legumes. Iacumin and colleagues (1998), with specific reference to this region, estimated that a caprine, cattle, and freshwater fish dominated diet would result in $\delta^{15}N$ values around 9‰, 11.5‰, and 12‰, respectively. When Iacumin and colleagues (1998) applied these estimates to the Kerma sample (Figure 7.4), they concluded the Kerman diet likely included caprine, cattle, and fish causing a relatively enriched $\delta^{15}N$. Had legumes been a substantial part of the diet, Iacumin notes, the nitrogen levels would have been substantially lower (Iacumin et al., 1998).

Thus, using this comparative material, we can presume that the New Kingdom Tombos diet, with a mean $\delta^{15}N$ value of 12.5‰, likely included caprine, cattle, and freshwater fish components. As Katzenberg (2001) reports, freshwater fish consumption can lead not only to increased $\delta^{15}N$ ratios, but also slightly increased $\delta^{13}C$. If this is the case, the mean $\delta^{13}C_{CO}$ of Tombos (-18.97‰), which is right on the brink of a C_3/C_4 mixed diet, would actually indicate a more C_4 dependent diet. However, further testing will be necessary to confirm this.

Another possibility for elevated $\delta^{15}N$ levels is nitrogen enrichment as a product of the arid environment and its impacts on local fauna. Several ecological factors contribute to this phenomenon. Ammonia, which is isotopically light, evaporates preferentially from soil in particularly hot climates. Thus, the soil can become ^{15}N enriched, which is transmitted to the plants and animals of the region (Schwarcz et al., 1999). Also, nitrogen-fixing bacteria are often hindered in arid climates, such as Nubia (Ambrose, 1991). Additionally, many animals in arid zones have evolved nitrogen-depleted urea that enables the internal conservation of water. This causes nitrogen-enriched bodily tissues, which is accumulated with each trophic level increase (Ambrose and DeNiro, 1986). However, if cultural and social identity factors are considered within these contexts, other explanations beyond the biological and environmental can be proposed.

7.8 Summary

Grounded in anthropological theory, foodways become meaningful quotidian acts that can be used to examine social interaction and identity. Bioarchaeological methods have the unique vantage of discerning foods consumed on the level of an individual. Of these methods, stable isotope analysis was employed here in an attempt to distinguish Egyptian and Nubian dietary practices.

The $\delta^{13}C_{AP}$ results for the comparative material tentatively indicate variation in Nile Valley dietary practices. This initial stable isotope testing does suggest that Nubian populations (Kerma, SJE C-Group) were consuming a larger portion of C_4 foods than their Egyptian/Egyptianized counterparts (Qurneh, Saqqara, Amara, New Kingdom Tombos, SJE Pharaonic). It appears that the Tombos population was consuming a mixed C_3/C_4 diet in addition to some cattle, caprine, and freshwater fish. Through the lens of anthropological studies of food, I suggest the depleted $\delta^{13}C_{AP}$ ratios exhibited in the Napatan Tombos sample may be attributed to a post-imperial, transcultured social sphere. Unfortunately, the $\delta^{13}C_{CO}$ analysis was not as successful as the dental carbonate. The four bone collagen samples that were viable did tentatively support the $\delta^{13}C_{AP}$ interpretations. However, these results are preliminary and substantial further testing is required to definitively substantiate a cultural link between Nile Valley populations and foodways. Future directions for this research are discussed further in Chapter 8.

CHAPTER 8. SYNTHESIZING THE QUOTIDIAN: DISCUSSION AND CONCLUSIONS OF ACTIVITY AND DIETARY RECONSTRUCTION

8.1 Introduction

In this dissertation I have used bioarchaeological data to address the quotidian in light of sociopolitical change. Specifically, this research has focused on physical activity and diet during the New Kingdom/Napatan transition in Ancient Nubia. Couched in the theoretical perspectives of embodiment, structuration, and social identity, these day-to-day activities become highly meaningful and greatly inform this period of Nubian history.

A total of 616 skeletons from nine archaeological sites were examined to elucidate Ancient Nubian daily life. The focal site of this research, Tombos, is one of few excavated sites that were continuously occupied from the New Kingdom to the Napatan Period. In this chapter, I summarize the main results of this research and discuss the interconnectedness of entheseal remodeling, osteoarthritis, and dietary reconstruction. I conclude with a statement on the applicability of a bioarchaeology of the everyday and discuss venues for future research.

8.2 Revisiting Hypotheses: Activity and Diet

8.2.1 Activity Reconstruction

8.2.1.1 Entheseal Remodeling

A total of 17 fibrocartilaginous muscle attachment sites were examined to gauge variation in physically strenuous activity. The Tombos Napatan sample was contrasted with previously published Tombos New Kingdom material (Schrader, 2010; Schrader, 2012). These samples were then put in a Nile Valley context by further examining other comparative material. Comparative samples included: Kerma, SJE Pharoanic, SJE C-Group, and O16/P37.

Higher rates of entheseal remodeling were identified at Napatan Tombos than at New Kingdom Tombos. Within Napatan Tombos, males had higher entheseal remodeling means; only one of these comparisons was statistically significant when body size was controlled for (Gastrocnemius of the femur). There was also a relatively consistent correlation between entheseal markers and age. Between sites, Kerma was found to have comparable rates of entheseal remodeling to O16/P37. Entheseal remodeling at Napatan Tombos was similar to the SJE C-Group sample. Lastly, entheseal remodeling means at New Kingdom Tombos closely corresponded to SJE Pharaonic mean scores. Based on these results, the first hypothesis is supported (Table 8. 1).

Table 8.1 Supported Hypothesis: Activity Reconstruction, Entheseal Remodeling (ER)

Hypotheses	Expectations
Levels of physical activity at Napatan Tombos were higher than at New Kingdom Tombos; this indicates that despite political power during the Napatan period, local Nubians at Tombos were engaged in more intensive manual labor (e.g., agriculture, food production, craftspeople).	Napatan ER > New Kingdom ER
~~Overall workload at Napatan Tombos was less than or similar to New Kingdom Tombos; Tombos may have continued to serve the Third Cataract region as an administrative center (e.g., minor officials, scribes), while the polity's capital was located farther south, in Napata.~~	~~Napatan ER ≤ New Kingdom ER~~

8.2.1.2 <u>Osteoarthritis</u>

The correlation between osteoarthritis and entheseal remodeling was examined in order to (1) test the hypothesis that a common causation factor exists between the two conditions and (2) further elucidate the New Kingdom/Napatan transition. Osteoarthritis in the form of lipping, porosity, and eburnation from five joints (shoulder, elbow, wrist, hip, knee) was compared to entheseal remodeling scores reported in Chapter 5.

The total sample was initially studied to test for statistical correlations between osteoarthritis and entheseal remodeling. Results suggest a common correlation between osteoarthritis lipping and entheseal remodeling;

osteoarthritic porosity and eburnation were less frequently correlated with entheseal remodeling. This indicates that there is a common contributing factor between the two conditions, which is likely related to physically strenuous activity. The fact that porosity and eburnation are less frequently correlated can be explained by their infrequent presence in the sample. Several bioarchaeological studies have firmly established eburnation, in particular, to reflect of osteoarthritis (see Rogers and Waldron, 1995; Weiss and Jurmain, 2007).

When the samples were separated by site, activity pattern profiles emerge. The Kerma and O16/P37 samples had comparable rates of osteoarthritis, which were the highest out of the comparative samples examined here. Levels of osteoarthritis in the Napatan Tombos and SJE C-Group samples were similar and were less than the Kerma/O16/P37 grouping. Lastly, Tombos New Kingdom and SJE Pharaonic samples were alike and collectively exhibited the least osteoarthritis. This osteoarthritis patterning reflects the entheseal remodeling data and, thus, reinforces the entheseal remodeling interpretations (Chapter 5) and supports the first hypothesis (Table 8.2).

There is also a positive correlation between age and osteoarthritis; as individuals get older they are more likely to develop the condition. This is not surprising, considering many studies have found similar results (see Molnar et al., 2009; Weiss and Jurmain, 2007). However, the sample size was not large enough to control for this contributing factor. Future analysis will incorporate these controls and take age into consideration.

Table 8.2 Supported Hypothesis: Activity Reconstruction, Osteoarthritis

Hypotheses	Expectations
Osteoarthritis and entheseal remodeling have a common causation factor; thus, these osteoarthritis data can be applied to further elucidate activity patterns during the New Kingdom/Napatan transition at Tombos.	Correlation (OA, ER)
~~Osteoarthritis and entheseal remodeling have differing causation factors; further examination of these conditions should be undertaken before osteoarthritis is applied to activity reconstruction..~~	~~No Correlation (OA, ER)~~

OA = Osteoarthritis; ER = entheseal remodeling

8.2.2 Dietary Reconstruction

Carbon and nitrogen stable isotope analysis was presented for both collagen (*n*=4) and carbonate (*n*=133) samples. Results obtained from carbonate stable isotope analysis suggest the people of Tombos were eating a mixed C_3/C_4 diet. There does appear to be some preliminary patterning regarding Egyptian/Egyptianized samples (Qurneh, Saqqara, Amara, New Kingdom Tombos, SJE Pharaonic) versus Nubian samples (SJE C-Group, Kerma). However, these interpretations are tentative and further stable isotope testing must be conducted to support this hypothesis. The bone collagen analysis was only partially successful; again, further experimentation is required to acquire additional data. Based on these results, there is not enough evidence to confirm or deny the proposed hypotheses (Table 8.3). While mean $\delta^{13}C_{AP}$ and $\delta^{13}C_{CO}$ ratios at Tombos roughly conform to the second hypothesis, variation within the sample spans the carbon and nitrogen values in both hypotheses.

Table 8.3 Supported Hypothesis: Dietary Reconstruction

Hypotheses	Expectations
Local Nubians at Tombos retained a traditional diet during the New Kingdom/Napatan sociopolitical transition; local diet at Tombos consists of Nubian foods (cattle, sorghum, millet), suggesting Nubians at Tombos were maintaining traditional social identities as expressed through foodways	• Nitrogen intake typical of cattle consumption (expected $\delta^{15}N$ ratios: 9 to 11.5‰) • Carbon intake characteristic of sorghum and millet (expected $\delta^{13}C$ ratios: -9 to -14‰ and dental carbonate $\delta^{13}C$ ratios: -0.5±1‰).
Nubians at Tombos adopted a more Egyptian diet (wheat, barley), which would suggest they welcomed an Egyptian-influenced identity	• Nitrogen intake typical of fish consumption (expected $\delta^{15}N$ ratios: 12 to 15‰) • Carbon intake typical of wheat and barley consumption (expected $\delta^{13}C$ ratios: -20 to -35‰ and dental carbonate $\delta^{13}C$ ratios: -12.5±1.2‰).

8.3 Integrating Activity and Diet into a Quotidian Approach

By incorporating the activity and dietary reconstructions discussed above, we can improve bioarchaeological methods, elucidate the alleged Nubian 'Dark Age,' and address the polarity of structure and agency in social systems.

8.3.1 Contribution to Bioarchaeological Methodology

Recent bioarchaeological studies of ancient activity have tended to analyze either entheseal changes or osteoarthritis, but have not incorporated both (entheseal remodeling: see Davis et al., 2013; Henderson et al., 2013; Nolte and Wilczak, 2013; Villotte and Knüsel, 2013; osteoarthritis: see Klaus et al., 2009; Rando and Waldron, 2012; Weiss and Jurmain, 2007). By comparing entheseal remodeling and osteoarthritis data, this research supports the hypothesis that a common, likely activity-related, causation factor exists between the two conditions. In light of the findings presented here, it is recommended that osteoarthritis be used as another method bioarchaeologists can analyze everyday activities in the past. Furthermore, osteoarthritis and entheseal data can be combined to can strengthen anthropological interpretations.

While the relationship between the two conditions seems to be complex (i.e., lipping is more frequently correlated with entheseal remodeling that porosity or eburnation), further research will certainly elucidate this connection. Focal topics of upcoming studies should include: (1) the relationship between lipping, porosity, and eburnation, (2) the re-examination of traditional scoring methods (e.g., Buikstra and Ubelaker, 1994), and (3) utilization of recorded skeletal collections (e.g., collections with known: age at death, occupation, sex). Furthermore, researchers should employ all available resources including both medical and bioarchaeological knowledge to better-understand these highly complex conditions.

This dissertation is an example of how bioarchaeological methods (e.g., osteoarthritis and entheseal remodeling) can be used to address anthropological questions. Here, not only are the methodological advancements discussed above made, regional cultural history is informed (see 8.3.2) and theoretical advancements comparing structure to agency are framed (8.3.3). This research is an example of human skeletal remains, as embodied artifacts, can be used as medium that can communicate social information.

8.3.2 Illuminating the Nubian 'Dark Age'

This research provides a better understanding of the New Kingdom/Napatan transition in Nubia, particularly at the site of Tombos. Due to Egyptocentric research interests of the past and a lack of a Nubian writing system, this period of sociopolitical transformation remains shrouded in uncertainty. Until recently, few archaeologists had pursued the excavation and interpretation of non-elite cemeteries, habitation sites, and the everyday lives of Nubians during the Napatan Period. Tombos, which was occupied from the New Kingdom to the Napatan Period, is one of few archaeological sites spanning this critical time period that has been excavated. As previously stated, this makes the analysis of archaeological and bioarchaeological material from Tombos critical to our understanding of the Nubian past.

From the entheseal remodeling and osteoarthritis data we can infer that the Napatan population of Tombos was likely performing more physically strenuous activities than their New Kingdom predecessors. Using these methodologies, it is impossible to specify what kinds of activities these people were engaging in. However, if we turn to our comparative samples, we can develop a broad understanding of manual labor during this time.

The Kerma and O16/P37 samples had the highest rates of both entheseal remodeling and osteoarthritis. Others have suggested that, based on archaeological and bioarchaeological evidence, these groups were participating in an active and intense agro-pastoral lifestyle (Judd, 2000; 2002; Welsby, 1998). Conversely, New Kingdom Tombos, likely served as a regional administrative colonial center, whose occupants were participating in non-labor intensive occupations such as scribes and artisans (Schrader, 2010; Schrader, 2012). It is conceivable that the concurrent SJE Pharaonic sites benefitted from Egyptian imperial connections much the same way New Kingdom Tombos did, thus, explaining the limited and comparable levels of entheseal remodeling and osteoarthritis. Drawing from these comparative contexts we can conclude that the Napatan Tombos and SJE C-Group were engaging in more physically strenuous activities than New Kingdom Tombos/SJE Pharaonic, but less than Kerma/O16/P37. Within this historical framework, I propose that Napatan Tombos could have been actively engaging in a more traditional way of life. This may have included activities such as non-intensive farming, herding, and quarrying.

The people of Napatan Tombos were not participating in markedly strenuous lifeways, like the Kerma and O16/P37 samples. There could be several explanations for these findings; without imperial support, the people of Tombos may have been engaging in food production. Rather than serving the empire in relatively physically inactive administrative roles, the people of Napatan Tombos were planting, growing, harvesting, and preparing their own food. Welsby (1998) has indicated that farming would have played a large role during the Napatan Period. Napatan Tombos could also have been a primary source for quarried granite, requiring more intensive manual labor. Another possibility is that the community at Napatan Tombos could have been engaging in other forms of craft production (e.g., textile production, ceramic production) that are, as of yet, unidentifiable in the funerary record.

Archaeological evidence from funerary contexts indicates the population of Napatan Tombos was fairly affluent (S.T. Smith, 2003b; 2007; Smith and Buzon, in review). Napatan burials at Tombos possess complex substructures (e.g., multi-chamber tombs), costly funerary goods (e.g., bronze bowl, carnelian hair-rings, faience amulets), and elite burial treatments (e.g., painted coffins). These are burial features that only the relatively wealthy would have been able to afford. Within the historical context discussed in Chapter 2, these findings support the hypothesis that the Napatan state was already undergoing formation and expansion (Morkot, 2001). First and foremost, this research provides direct evidence that this region was not depopulated after Egyptian imperial withdrawal. Since the depopulation concept was first proposed, several researchers have also found fault with this theory (see S.T. Smith, 1998; Morkot, 2001).

If we take into consideration the mindset of an inhabitant of Napatan Tombos, the concept of depopulation seems farfetched. By the end of the New Kingdom Period (*c*. 1,069 BC), Egyptians and Nubians would have been living side by side for approximately 500 years. Bioarchaeological evidence indicates these populations were intermarrying, reproducing, and exchanging genetic material (Buzon, 2006a). Archaeological evidence suggests that transculturation was occurring and the cultural traditions of Egypt and Nubia were being blended (S.T. Smith, 2003a). With families, homes, and settled lives at Tombos, why would Egyptian expatriates abandon the status quo to return to a politically weakened and economically failing Egypt? Furthermore, if the Napatan state was being formed and growing in power during this time, this may have presented an opportunity for individuals to acquire elite administrative posts within the new government and gain socioeconomic status.

Second, these data suggest that in lieu of the Egyptian Empire, Napatan Nubia did not revert to tribal or semi-nomadic lifeways. If Napatan Tombos had semi-nomadic or tribal lifeways we might expect higher levels of activity patterns (i.e., C-Group), however, the refined funerary tradition, complete with prestige goods, would not be present. Napatan burials in the Tombos cemetery suggest extensive trade connections as well as thriving economy.

This economy may have been redistributive, as suggested by Welsby (1998). If so, Tombos could have served the burgeoning Napatan state as a redistribution center. Some individuals may have engaged in more administrative roles, while others performed the food-production and quarrying activities discussed above. The unique geopolitical context of Tombos, located on the banks of the rocky Third Cataract, would have made it an ideal location for controlling trade and being a point of contact for northern Upper Nubia. Furthermore, the historical context of Tombos as a New Kingdom administrative center may have contributed to its function and economic standing within the

Napatan State. The people of Tombos would have been adept at monitoring and facilitating trade; these operations would have been in place since the early New Kingdom (*c.* 1,550 BC). It seems reasonable to assume that if the Napatan State was sufficiently developed, the administrative services of Tombos could have continued with minimal disruption. However, further archaeological excavations, both at Tombos and elsewhere, are needed to fully interpret the Napatan economy.

This dissertation has shed light on what was once thought to be the Nubian Dark Age. This, in fact, wasn't a time of depopulation, de-evolution, and barbarism. While the people of Napatan Tombos were engaging in more physically strenuous forms of manual labor, the archaeological record suggests there was an active economy. This research has shown that this area was not depopulated during the New Kingdom/Napatan transition and that Nubians did not revert to a tribal/semi-nomadic lifestyle. Furthermore, it is likely that Napatan State formation was occurring during or soon after the end of the Egyptian New Kingdom. It is possible that Tombos served the Napatan State as a redistribution center, owing to its geopolitical location and previous position within the Egyptian Empire. Continued excavations will greatly inform our understanding of Tombos as a component of the Napatan State.

8.3.3 Interpreting Structure Versus Agency

In addition to contributing to a better understanding of the New Kingdom/Napatan transition, this dissertation has also made theoretical advancements with regards to food choice, social identity, and the relationship between structure and agency. As discussed in Chapters 2 and 4, indigenous Nubians within the imperial context of New Kingdom Tombos were agentive in their decision to ethnically and culturally integrate. As S.T. Smith has suggested, this population could (1) assimilate, (2) selectively adopt certain practices, or (3) maintain a traditional ethnicity (S.T. Smith, 2003b). This agentive choice would have had implications for workload and quotidian action in this frontier community (see 2.4, 4.4, 4.6).

Unfortunately, many of the stable isotope samples that were tested for this research were not viable (see 7.6.2). Despite this setback, tentative hypotheses regarding the social nature of foodways can be discussed. Within the sociopolitical context of the New Kingdom/Napatan transition, dental carbonate results indicate that diet did change between the New Kingdom and Napatan Periods. These data suggest the people of Napatan Tombos were eating more C_3 plants than the people of New Kingdom Tombos. While both samples were consuming a mixed C_3/C_4 diet, the proportion of C_3 plants in the diet increases with time. When put in the context of the comparative samples, the residents of Napatan Tombos were consuming the highest volume of C_3 than the other Egyptian and Nubian sites examined here. I suggest this could be one indicator of the complex transculturation process that occurs in Nubia during this time. Furthermore, previous studies, including Smith's examination of gendered and ethnic ceramic assemblages at Askut (S.T. Smith, 2003b) as well as Haaland's cultural examination of Egyptian versus Nubian foodways (Haaland, 2012), suggest that Egyptian and Nubian diets varied and were entwined within a complex notion of multiple social identities. This explication is highly influenced by social theory and anthropological interpretations of foodways (Chapter 4). It is through cultural elucidations, such as these, that anthropologists can move beyond the biological and consider the social nature of food.

If supported by further data, these findings would suggest that Nubians at Tombos were agentive and were meaningfully choosing to consume more C_3 foods during the Napatan Period. However, we must keep in mind that food choice may have been only one of various quotidian activities that Nubians were using as a way to define their identities. It is my hope that future bioarchaeological research at Tombos, and elsewhere, will identify multiple skeletal correlates of everyday activities. Framed by structuration, these quotidian movements can be highly revealing and can greatly inform our understanding of the ancient world.

8.4 Implications and Future Research

8.4.1 Implications

This research highlights the importance of the quotidian in maintaining ones collective and individual identities. Moreover, periods of sociopolitical transformation can fuel changes to the social system and elicit alterations to these daily activities. Using bioarchaeological methods, the examination of everyday action in the past can contribute to an understanding of how day-to-day movements are used within social contexts. Furthermore, bioarchaeology, like archeology, contributes the element of diachronic examination to the discipline of anthropology. By examining the quotidian in the ancient past, the temporal scope of this anthropological question is greatly expanded.

This dissertation suggests that bioarchaeologists should move beyond analyzing dramatic and abrupt events, such as violence, and begin examining the materiality of the everyday. Bioarchaeology has the distinct opportunity to investigate the daily activities of individuals and how these activities changed through time. Just as household and community archaeology advanced the scope of archaeological research in the 1980's, so too should bioarchaeological studies reexamine the breadth and focus of the subdiscipline.

Drawing from theoretical perspectives typically aligned with cultural anthropology and sociology (social identity, structuration, embodiment), the vitality of the quotidian is highlighted. This dissertation has shown how social identity can be maintained through everyday activities and also how, in times of social, political, and economic change, pressures can be placed on these movements, which further intensifies the dialogue between structure and agency (i.e., structuration). The effects of materiality of these changes can be intensified in borderland zones; these frontiers are the contexts in which these structure/agency dialogues occur. Furthermore, this research is an example of how human skeletal remains can be reconceptualized as material artifacts of an individual who was once active, social, and agentive (i.e., embodiment).

The interpretation of everyday activities in the past is invaluable to our understanding of the inner-workings of ancient populations. This unconventional perspective provides insight into the most basic existence of people and provides a truly anthropological approach to bioarchaeology.

8.4.2 Future Research

Several venues of future research will greatly contribute to a bioarchaeology of the everyday. First and foremost, carbon and nitrogen stable isotope analysis will be revisited. As discussed in Chapter 7, the erroneous bone collagen samples, with elevated carbon to nitrogen ratios, may be the product of flawed preparation/protocol methods, contamination, or degradation. Multiple preparation/protocol methods exist for isotope analysis of bone; several methods will be tested to determine if this causing the unsuitable carbon to nitrogen ratios. Furthermore, additional steps, including careful handling, and delicate cleaning, can be taken to prevent contamination both during the preparation and analytical processes. If degradation is responsible for the unsuccessful samples, testing of recently excavated bone could be pursued in the future. Another point of potential interference is laboratory specialization. Alternative labs that focus on carbon and nitrogen analyses of solid materials, with experience in bone collagen, will be utilized in future studies.

Emerging isotope techniques (lipid, amino acid) analyze specific elements within the diet, rather than evaluating bulk carbon and nitrogen components. These are new and promising methods, which have the ability to refine the interpretations presented above; foods being consumed during the New Kingdom/Napatan transition could be examined at a lipid or amino acid level. From this, a more specific understanding of diet and, thus, social identity during this pivotal time period could be inferred.

Further excavations, both at Tombos and other Nubian archaeological sites, would also greatly contribute to our understanding of the origins of the

Napatan State. Future excavations in the Tombos cemetery will certainly provide additional skeletal remains, which will bolster the sample size and resolve questions about the role of Tombos within the Napatan State. The excavation of other sites will also provide skeletal material that can be used as points of comparison with the Tombos skeletal collections. Additionally, material remains from multiple contemporary Nubian sites will elucidate the New Kingdom/Napatan transition and the origins of power of the Napatan State.

With regards to the bioarchaeological examination of activity patterns, age has been shown to be a contributing factor to both osteoarthritis and entheseal remodeling. In fact, this dissertation found significant correlations between age and entheseal remodeling in Chapter 5 and osteoarthritis in Chapter 6. The sample size was not large enough to control for age here. Future excavations at Tombos will provide more skeletal remains, which will add the sample size and allow for age controls. Additionally, the application of other bioarchaeological aging techniques including the analysis of coronal pulp cavity indices (Burns and Maples, 1976), transition analysis (Milner and Boldsen, 2012), as well as sternal rib end morphology (Iscan et al., 1984), might be able to further refine the age distribution.

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Appendix A Standard Osteoarthritis Scoring Method

Table A 1 Standardized Scoring Method for Osteoarthritic Lipping

Score	Description
1	Barely discernable
2	Sharp ridge
3	Extensive spicule formation
4	Ankylosis

Table A 2 Standardized Scoring method for Osteoarthritic Porosity

Score	Description
1	Pinpoint
2	Coalesced
3	Pinpoint and coalesced

Table A 3 Standardized Scoring Method for Osteoarthritic Eburnation

Score	Description
1	Barely discernable
2	Polish only
3	Polish with groove(s)

*Buikstra and Ubelaker, 1994

Appendix B Osteoarthritis Data

Table B 1 Osteoarthritis at Tombos: New Kingdom v. Napatan (Left)

	New Kingdom							Napatan					
	Lipping		Porosity		Eburnation			Lipping		Porosity		Eburnation	
	n	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$		*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$
Glenoid fossa	*(19)*	0.58	*(19)*	0.21	*(19)*	0.00		*(42)*	0.69	*(42)*	0.45	*(42)*	0.00
Proximal humerus	*(35)*	0.40	*(35)*	0.14	*(35)*	0.00		*(35)*	0.37	*(34)*	0.12	*(34)*	0.00
Distal humerus	*(59)*	0.31	*(59)*	0.12	*(59)*	0.00		*(46)*	0.28	*(46)*	0.09	*(46)*	0.02
Proximal ulna	*(35)*	0.74	*(35)*	0.14	*(35)*	0.00		*(45)*	0.64	*(45)*	0.20	*(45)*	0.00
Distal ulna	*(19)*	0.74	*(19)*	0.21	*(19)*	0.00		*(27)*	0.44	*(27)*	0.15	*(27)*	0.00
Proximal radius	*(30)*	0.23	*(30)*	0.03	*(30)*	0.00		*(47)*	0.09	*(47)*	0.00	*(47)*	0.00
Distal radius	*(28)*	0.50	*(28)*	0.04	*(28)*	0.00		*(42)*	0.52	*(42)*	0.07	*(42)*	0.00
Acetabulum	*(57)*	0.72	*(57)*	0.23	*(57)*	0.02		*(39)*	0.77	*(39)*	0.23	*(39)*	0.00
Proximal femur	*(51)*	0.47	*(50)*	0.10	*(50)*	0.00		*(48)*	0.43	*(38)*	0.13	*(48)*	0.00
Distal femur	*(48)*	0.54	*(48)*	0.19	*(48)*	0.00		*(43)*	0.42	*(43)*	0.23	*(43)*	0.00
Proximal tibia	*(39)*	0.36	*(39)*	0.28	*(39)*	0.00		*(31)*	0.58	*(31)*	0.19	*(31)*	0.00
Distal tibia	*(48)*	0.19	*(48)*	0.00	*(48)*	0.00		*(40)*	0.28	*(40)*	0.10	*(40)*	0.00

Table B 2 Osteoarthritis at Tombos: New Kingdom v. Napatan (Right)

	New Kingdom						**Napatan**					
	Lipping		Porosity		Eburnation		Lipping		Porosity		Eburnation	
	n	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$
Glenoid fossa	*(29)*	0.48	*(29)*	0.14	*(29)*	0.00	*(50)*	0.52	*(50)*	0.20	*(50)*	0.00
Proximal humerus	*(41)*	0.41	*(41)*	0.10	*(41)*	0.00	*(45)*	0.51	*(45)*	**0.36**	*(45)*	0.00
Distal humerus	*(50)*	0.32	*(50)*	0.08	*(50)*	0.00	*(43)*	0.33	*(43)*	0.05	*(43)*	0.00
Proximal ulna	*(38)*	0.84	*(38)*	0.18	*(38)*	0.00	*(52)*	0.63	*(52)*	0.12	*(52)*	0.00
Distal ulna	*(22)*	0.73	*(22)*	0.09	*(22)*	0.00	*(29)*	0.66	*(29)*	0.14	*(29)*	0.00
Proximal radius	*(27)*	0.33	*(27)*	0.07	*(27)*	0.00	*(39)*	0.21	*(39)*	0.05	*(39)*	0.00
Distal radius	*(26)*	0.42	*(26)*	0.15	*(26)*	0.00	*(34)*	0.53	*(34)*	0.09	*(34)*	0.00
Acetabulum	*(49)*	0.84	*(49)*	0.45	*(49)*	0.00	*(40)*	0.73	*(40)*	0.28	*(40)*	0.00
Proximal femur	*(49)*	0.47	*(49)*	0.16	*(49)*	0.02	*(41)*	0.51	*(41)*	0.20	*(41)*	0.00
Distal femur	*(46)*	0.63	*(46)*	0.37	*(46)*	0.02	*(40)*	0.45	*(40)*	0.35	*(40)*	0.03
Proximal tibia	*(50)*	0.28	*(50)*	0.18	*(50)*	0.04	*(37)*	0.41	*(37)*	0.19	*(37)*	0.00
Distal tibia	*(48)*	0.19	*(48)*	0.02	*(48)*	0.00	*(37)*	0.19	*(37)*	0.03	*(37)*	0.00

p*≤0.05. Significantly higher Napatan values than the corresponding New Kingdom element in **bold

Table B 3 Osteoarthritis in the Nile Valley: Tombos and Comparative Sites (Left – Lipping)

	New Kingdom		**Napatan**		**Kerma**		**C-Group**		**Pharaonic**		**O16/P37**	
	n	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$
Glenoid fossa	*(19)*	0.58	*(42)*	0.69	*(103)*	0.62	**-**	-	-	-	*(22)*	0.50
Proximal Humerus	*(35)*	0.40	*(35)*	0.37	*(131)*	0.45	*(47)*	$\mathbf{0.83^{ab}}$	*(15)*	0.40	*(16)*	0.38
Distal Humerus	*(59)*	0.31	*(46)*	0.28	*(139)*	$\mathbf{0.12_{ab}}$	*(49)*	$\mathbf{0.55^{a}}$	*(18)*	0.50	*(28)*	0.29
Proximal Ulna	*(35)*	0.74	*(45)*	0.64	*(126)*	0.61	*(16)*	$\mathbf{1.56^{ab}}$	*(10)*	0.70	*(26)*	0.88
Distal Ulna	*(19)*	0.74	*(27)*	0.44	*(91)*	$\mathbf{0.34_{a}}$	*(13)*	0.62	*(8)*	0.25	*(14)*	0.50
Proximal Radius	*(30)*	0.23	*(47)*	0.09	*(113)*	0.11	*(17)*	$\mathbf{0.41^{b}}$	*(10)*	0.10	*(23)*	$\mathbf{0.35^{b}}$
Distal Radius	*(28)*	0.50	*(42)*	0.52	*(115)*	0.35	*(17)*	0.59	*(12)*	0.33	*(20)*	0.35
Acetabulum	*(57)*	0.72	*(39)*	0.77	*(131)*	0.69	*(6)*	1.00	*(12)*	0.67	*(28)*	0.64
Proximal Femur	*(51)*	0.47	*(47)*	0.43	*(153)*	0.48	*(32)*	0.63	*(18)*	0.28	*(21)*	0.48
Distal Femur	*(48)*	0.54	*(43)*	0.42	*(140)*	0.46	*(32)*	0.69	*(16)*	0.38	*(21)*	0.43
Proximal Tibia	*(39)*	0.36	*(31)*	0.58	*(137)*	$\mathbf{0.33_{b}}$	*(22)*	0.45	*(15)*	0.40	*(19)*	0.26
Distal Tibia	*(48)*	0.19	*(40)*	0.28	*(123)*	$\mathbf{0.06_{ab}}$	*(21)*	0.14	*(12)*	0.08	*(18)*	0.06

$p \leq 0.05$. Significantly different values in **bold**;
^{a} =significantly higher than corresponding New Kingdom value,
^{b} = significantly higher than corresponding Napatan value,
$_{a}$ = significantly lower than corresponding New Kingdom value,
$_{b}$ = significantly lower than corresponding Napatan value

Table B 4 Osteoarthritis in the Nile Valley: Tombos and Comparative Sites (Right - Lipping)

	New Kingdom		Napatan		Kerma		C-Group		Pharaonic		O16/P37	
	n	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$
Glenoid fossa	*(29)*	0.48	*(50)*	0.52	*(107)*	**0.81**^{b}					*(21)*	0.71
Proximal Humerus	*(41)*	0.41	*(45)*	0.51	*(151)*	0.48	*(69)*	**1.04**^{ab}	*(18)*	0.72	*(22)*	0.50
Distal Humerus	*(50)*	0.32	*(43)*	0.33	*(157)*	0.22	*(71)*	**0.51**^{b}	*(18)*	0.39	*(31)*	0.32
Proximal Ulna	*(38)*	0.84	*(52)*	0.63	*(138)*	0.76	*(12)*	**1.17**^{b}	*(15)*	0.80	*(29)*	0.76
Distal Ulna	*(22)*	0.73	*(29)*	0.66	*(104)*	0.44	*(9)*	0.56	*(12)*	0.67	*(19)*	0.53
Proximal Radius	*(27)*	0.33	*(39)*	0.21	*(129)*	**0.09**$_{a}$	*(13)*	0.38	*(16)*	0.19	*(22)*	0.23
Distal Radius	*(26)*	0.42	*(34)*	0.53	*(124)*	0.38	*(14)*	0.43	*(17)*	0.53	*(24)*	0.42
Acetabulum	*(49)*	0.84	*(40)*	0.73	*(126)*	0.70	*(8)*	0.88	*(11)*	0.82	*(27)*	0.63
Proximal Femur	*(49)*	0.47	*(41)*	0.51	*(149)*	0.46	*(37)*	**0.76**^{a}	*(14)*	**0.14**$_{b}$	*(25)*	0.44
Distal Femur	*(46)*	0.63	*(40)*	0.45	*(146)*	0.48	*(41)*	0.73	*(14)*	0.71	*(26)*	0.38
Proximal Tibia	*(50)*	0.28	*(37)*	0.41	*(152)*	**0.28**$_{b}$	*(24)*	**0.67**^{a}	*(13)*	0.31	*(23)*	0.35
Distal Tibia	*(48)*	0.19	*(37)*	0.19	*(127)*	**0.03**$_{a}$	*(24)*	0.21	*(11)*	0.27	*(21)*	0.10

$p \leq 0.05$. Significantly different values in **bold**;
^{a} = significantly higher than corresponding New Kingdom value,
^{b} = significantly higher than corresponding Napatan value,
$_{a}$ = significantly lower than corresponding New Kingdom value,
$_{b}$ = significantly lower than corresponding Napatan value

Table B 5 Osteoarthritis in the Nile Valley: Tombos and Comparative Sites (Left - Porosity)

	New Kingdom		**Napatan**		**Kerma**		**C-Group**		**Pharaonic**		**O16/P37**	
	n	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$
Glenoid fossa	*(19)*	0.21	*(42)*	0.45	*(103)*	**0.20**$_{b}$	**-**	-	-	-	*(22)*	0.41
Proximal Humerus	*(35)*	0.14	*(35)*	0.12	*(131)*	**0.35**^{b}	*(47)*	**1.15**^{ab}	*(15)*	0.33	*(16)*	0.31
Distal Humerus	*(59)*	0.12	*(46)*	0.09	*(139)*	**0.04**$_{a}$	*(49)*	**0.43**^{ab}	*(18)*	0.39	*(28)*	0.14
Proximal Ulna	*(35)*	0.14	*(45)*	0.20	*(126)*	0.13	*(16)*	**1.38**^{ab}	*(10)*	0.20	*(26)*	**0.42**^{a}
Distal Ulna	*(19)*	0.21	*(27)*	0.15	*(91)*	**0.05**$_{a}$	*(13)*	**0.62**^{b}	*(8)*	0.13	*(14)*	0.50
Proximal Radius	*(30)*	0.03	*(47)*	0.00	*(113)*	0.04	*(17)*	**0.35**^{ab}	*(10)*	0.10	*(23)*	0.13^{b}
Distal Radius	*(28)*	0.04	*(42)*	0.07	*(115)*	0.07	*(17)*	**0.59**^{ab}	*(12)*	0.00	*(20)*	0.20
Acetabulum	*(57)*	0.23	*(39)*	0.23	*(131)*	0.33	*(6)*	0.83	*(12)*	0.25	*(28)*	0.50
Proximal Femur	*(51)*	0.10	*(47)*	0.13	*(153)*	0.22	*(32)*	**0.50**^{ab}	*(18)*	0.22	*(21)*	**0.29**^{a}
Distal Femur	*(48)*	0.19	*(43)*	0.23	*(140)*	0.19	*(32)*	**0.53**^{ab}	*(16)*	0.69	*(21)*	0.29
Proximal Tibia	*(39)*	0.28	*(31)*	0.19	*(137)*	0.19	*(22)*	**0.64**^{b}	*(15)*	0.47	*(19)*	0.21
Distal Tibia	*(48)*	0.00	*(40)*	0.10	*(123)*	**0.00**$_{b}$	*(21)*	**0.24**^{a}	*(12)*	0.00	*(18)*	0.00

$p \leq 0.05$. Significantly different values in **bold**;
^{a} = significantly higher than corresponding New Kingdom value,
^{b} = significantly higher than corresponding Napatan value,
$_{a}$ = significantly lower than corresponding New Kingdom value,
$_{b}$ = significantly lower than corresponding Napatan value

Table B 6 Osteoarthritis in the Nile Valley: Tombos and Comparative Sites (Right - Porosity)

	New Kingdom		Napatan		Kerma		C-Group		Pharaonic		O16/P37	
	n	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$
Glenoid fossa	*(19)*	0.14	*(42)*	0.20	*(103)*	0.38	-	-	-	-	*(22)*	**0.76**^{ab}
Proximal Humerus	*(35)*	0.10	*(35)*	0.36	*(131)*	**0.32**^{a}	*(47)*	**1.19**^{ab}	*(15)*	**0.68**^{a}	*(16)*	**0.50**^{a}
Distal Humerus	*(59)*	0.08	*(46)*	0.05	*(139)*	0.06	*(49)*	**0.39**^{ab}	*(18)*	0.17	*(28)*	0.13
Proximal Ulna	*(35)*	0.18	*(45)*	0.12	*(126)*	0.18	*(16)*	**1.00**^{ab}	*(10)*	0.00	*(26)*	**0.34**^{b}
Distal Ulna	*(19)*	0.09	*(27)*	0.14	*(91)*	0.07	*(13)*	**0.67**^{ab}	*(8)*	0.09	*(14)*	0.37
Proximal Radius	*(30)*	0.07	*(47)*	0.05	*(113)*	0.02	*(17)*	0.23	*(10)*	0.00	*(23)*	0.14
Distal Radius	*(28)*	0.15	*(42)*	0.09	*(115)*	0.06	*(17)*	0.21	*(12)*	0.35	*(20)*	**0.33**^{b}
Acetabulum	*(57)*	0.45	*(39)*	0.28	*(131)*	0.36	*(6)*	**0.75**^{ab}	*(12)*	0.27	*(28)*	0.56
Proximal Femur	*(51)*	0.16	*(47)*	0.20	*(153)*	0.16	*(32)*	**0.95**^{ab}	*(18)*	0.21	*(21)*	0.24
Distal Femur	*(48)*	0.37	*(43)*	0.35	*(140)*	**0.17**$_{ab}$	*(32)*	0.63	*(16)*	0.86	*(21)*	0.23
Proximal Tibia	*(39)*	0.18	*(31)*	0.19	*(137)*	0.11	*(22)*	**0.67**^{ab}	*(15)*	0.15	*(19)*	0.17
Distal Tibia	*(48)*	0.02	*(40)*	0.03	*(123)*	0.01	*(21)*	**0.17**^{a}	*(12)*	0.18	*(18)*	0.00

$p \leq 0.05$. Significantly different values in **bold**;
^{a} = significantly higher than corresponding New Kingdom value,
^{b} = significantly higher than corresponding Napatan value,
$_{a}$ = significantly lower than corresponding New Kingdom value,
$_{b}$ = significantly lower than corresponding Napatan value

Table B 7 Osteoarthritis in the Nile Valley: Tombos and Comparative Sites (Left - Eburnation)

	New Kingdom		Napatan		Kerma		C-Group		Pharaonic		O16/P37	
	n	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$
Glenoid fossa	*(19)*	0.00	*(42)*	0.00	*(103)*	0.00	-	-	-	-	*(22)*	0.00
Proximal Humerus	*(35)*	0.00	*(35)*	0.00	*(131)*	0.00	*(47)*	0.02	*(15)*	0.00	*(16)*	0.00
Distal Humerus	*(59)*	0.00	*(46)*	0.02	*(139)*	0.00	*(49)*	0.02	*(18)*	**0.11**[a]	*(28)*	0.00
Proximal Ulna	*(35)*	0.00	*(45)*	0.00	*(126)*	0.00	*(16)*	0.06	*(10)*	0.00	*(26)*	0.00
Distal Ulna	*(19)*	0.00	*(27)*	0.00	*(91)*	0.00	*(13)*	0.00	*(8)*	0.00	*(14)*	0.00
Proximal Radius	*(30)*	0.00	*(47)*	0.00	*(113)*	0.00	*(17)*	0.06	*(10)*	**0.10**[b]	*(23)*	0.00
Distal Radius	*(28)*	0.00	*(42)*	0.00	*(115)*	0.00	*(17)*	0.00	*(12)*	0.00	*(20)*	0.00
Acetabulum	*(57)*	0.02	*(39)*	0.00	*(131)*	0.00	*(6)*	0.00	*(12)*	0.00	*(28)*	0.00
Proximal Femur	*(51)*	0.00	*(47)*	0.00	*(153)*	0.01	*(32)*	0.03	*(18)*	0.00	*(21)*	0.05
Distal Femur	*(48)*	0.00	*(43)*	0.00	*(140)*	0.01	*(32)*	0.06	*(16)*	**0.31**[ab]	*(21)*	0.00
Proximal Tibia	*(39)*	0.00	*(31)*	0.00	*(137)*	0.00	*(22)*	0.05	*(15)*	**0.13**[ab]	*(19)*	0.00
Distal Tibia	*(48)*	0.00	*(40)*	0.00	*(123)*	0.00	*(21)*	0.00	*(12)*	0.00	*(18)*	0.00

$p \leq 0.05$. Significantly different values in **bold**;
[a] = significantly higher than corresponding New Kingdom value,
[b] = significantly higher than corresponding Napatan value,
$_a$ = significantly lower than corresponding New Kingdom value,
$_b$ = significantly lower than corresponding Napatan value

Table B 8 Osteoarthritis in the Nile Valley: Tombos and Comparative Sites (Right - Eburnation)

	New Kingdom		**Napatan**		**Kerma**		**C-Group**		**Pharaonic**		**O16/P37**	
	n	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$	*n*	$\bar{x}$
Glenoid fossa	*(19)*	0.00	*(42)*	0.00	*(103)*	0.00	-	-	-	-	*(22)*	0.00
Proximal Humerus	*(35)*	0.00	*(35)*	0.00	*(131)*	0.00	*(47)*	0.00	*(15)*	0.11	*(16)*	0.00
Distal Humerus	*(59)*	0.00	*(46)*	0.00	*(139)*	0.01	*(49)*	0.01	*(18)*	0.06	*(28)*	0.00
Proximal Ulna	*(35)*	0.00	*(45)*	0.00	*(126)*	0.00	*(16)*	0.00	*(10)*	0.00	*(26)*	0.00
Distal Ulna	*(19)*	0.00	*(27)*	0.00	*(91)*	0.00	*(13)*	0.00	*(8)*	0.00	*(14)*	0.00
Proximal Radius	*(30)*	0.00	*(47)*	0.00	*(113)*	0.00	*(17)*	0.00	*(10)*	0.00	*(23)*	0.00
Distal Radius	*(28)*	0.00	*(42)*	0.00	*(115)*	0.00	*(17)*	0.00	*(12)*	0.06	*(20)*	0.00
Acetabulum	*(57)*	0.00	*(39)*	0.00	*(131)*	0.00	*(6)*	0.00	*(12)*	0.00	*(28)*	0.00
Proximal Femur	*(51)*	0.02	*(47)*	0.00	*(153)*	0.00	*(32)*	**0.11**[b]	*(18)*	0.00	*(21)*	0.00
Distal Femur	*(48)*	0.02	*(43)*	0.03	*(140)*	0.01	*(32)*	0.13	*(16)*	**0.29**[ab]	*(21)*	0.00
Proximal Tibia	*(39)*	0.04	*(31)*	0.00	*(137)*	0.01	*(22)*	0.13	*(15)*	0.08	*(19)*	0.00
Distal Tibia	*(48)*	0.00	*(40)*	0.00	*(123)*	0.00	*(21)*	0.00	*(12)*	**0.09**[a]	*(18)*	0.00

$p \leq 0.05$. Significantly different values in **bold**;
[a] = significantly higher than corresponding New Kingdom value,
[b] = significantly higher than corresponding Napatan value,
$_{a}$ = significantly lower than corresponding New Kingdom value,
$_{b}$ = significantly lower than corresponding Napatan value

Appendix C Entheseal Remodeling Data

Table C 1 Entheseal Markers at Tombos: Young, Middle, and Old Adults (Left)

	Young Adult					Middle Adult					Old Adult			
		Lip.	Por.	Ebu.			Lip.	Por.	Ebu.			Lip.	Por.	Ebu.
	n	$\bar{x}$	$\bar{x}$	$\bar{x}$		*n*	$\bar{x}$	$\bar{x}$	$\bar{x}$		*n*	$\bar{x}$	$\bar{x}$	$\bar{x}$
Glenoid fossa	*(8)*	0.00	0.00	0.00		*(14)*	0.93	0.50	0.00		*(12)*	**1.00**	0.33	0.00
Proximal Humerus	*(11)*	0.00	0.00	0.00		*(12)*	0.33	0.17	0.00		*(15)*	**0.73**	0.58	0.00
Distal Humerus	*(11)*	0.09	0.00	0.09		*(19)*	0.32	0.11	0.00		*(15)*	**0.60**	0.20	0.00
Proximal Ulna	*(11)*	0.18	0.00	0.00		*(16)*	0.56	0.31	0.00		*(15)*	**0.93**	0.13	0.00
Distal Ulna	*(9)*	0.11	0.00	0.00		*(14)*	0.50	0.21	0.00		*(13)*	**1.08**	0.31	0.00
Proximal Radius	*(12)*	0.08	0.00	0.00		*(17)*	0.06	0.00	0.00		*(15)*	0.27	0.00	0.00
Distal Radius	*(12)*	0.25	0.00	0.00		*(17)*	0.29	0.06	0.00		*(14)*	**1.07**	0.21	0.00
Acetabulum	*(23)*	0.17	0.00	0.00		*(38)*	0.66	0.18	0.00		*(27)*	**1.30**	**0.48**	0.04
Proximal Femur	*(13)*	0.23	0.08	0.00		*(16)*	0.31	0.19	0.00		*(19)*	**0.89**	0.26	0.00
Distal Femur	*(13)*	0.31	0.15	0.00		*(16)*	0.19	0.00	0.00		*(17)*	**0.65**	0.29	0.00
Proximal Tibia	*(10)*	0.30	0.10	0.00		*(13)*	0.38	0.15	0.00		*(11)*	0.73	0.36	0.00
Distal Tibia	*(10)*	0.30	0.30	0.00		*(14)*	0.07	0.07	0.00		*(15)*	0.40	0.00	0.00

Lip.= Lipping, Por.= Porosity, Ebu.= Eburnation
$p \leq 0.05$. Significantly higher values than the corresponding male/female enthesis in **bold**, (not body size controlled)

Table C 2 Entheseal Markers at Tombos: Young, Middle, and Old Adults (Right)

	Young Adult				**Middle Adult**				**Old Adult**			
		Lip.	Por.	Ebu.		Lip.	Por.	Ebu.		Lip.	Por.	Ebu.
	n	$\bar{x}$	$\bar{x}$	$\bar{x}$	*n*	$\bar{x}$	$\bar{x}$	$\bar{x}$	*n*	$\bar{x}$	$\bar{x}$	$\bar{x}$
Glenoid fossa	*(8)*	0.00	0.00	0.00	*(16)*	0.75	0.50	0.00	*(13)*	**1.15**	0.31	0.00
Proximal Humerus	*(12)*	0.00	0.00	0.00	*(18)*	0.56	0.39	0.00	*(12)*	**0.83**	**0.33**	0.00
Distal Humerus	*(12)*	0.17	0.00	0.00	*(18)*	0.28	0.06	0.00	*(13)*	0.54	0.15	0.00
Proximal Ulna	*(10)*	0.40	0.10	0.00	*(15)*	0.67	0.13	0.00	*(17)*	**1.06**	0.24	0.00
Distal Ulna	*(9)*	0.22	0.00	0.00	*(14)*	0.50	0.07	0.00	*(15)*	**1.27**	0.33	0.00
Proximal Radius	*(10)*	0.20	0.00	0.00	*(16)*	0.13	0.06	0.00	*(16)*	0.44	0.19	0.00
Distal Radius	*(10)*	0.20	0.00	0.00	*(15)*	0.33	0.00	0.00	*(16)*	**0.94**	0.44	0.00
Acetabulum	*(25)*	0.12	0.44	0.00	*(33)*	0.64	0.15	0.00	*(23)*	**1.83**	**0.65**	0.00
Proximal Femur	*(14)*	0.21	0.14	0.00	*(18)*	0.56	0.17	0.00	*(19)*	**0.74**	0.16	0.00
Distal Femur	*(14)*	0.43	0.36	0.07	*(16)*	0.38	0.31	0.00	*18*	0.78	0.44	0.06
Proximal Tibia	*(11)*	0.45	0.09	0.00	*(15)*	0.20	0.20	0.07	*16*	**0.81**	0.44	0.06
Distal Tibia	*(11)*	0.18	0.09	0.00	*(14)*	0.07	0.00	0.00	*16*	0.44	0.00	0.00

Lip.= Lipping, Por.= Porosity, Ebu.= Eburnation
$p \leq 0.05$. Significantly higher values than the corresponding male/female enthesis in **bold**,
(not body size controlled)

Appendix D Osteoarthritis and Entheseal Remodeling Comparisons

Table D 1 Total Sample: Composite Shoulder

				Lipping		Porosity		Eburnation	
				Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus
		$\bar{x}$		0.58	0.49	0.25	0.41	-	0.00
			n	*216*	*299*	*216*	*298*	*216*	*298*
Left	Supra/Infra	2.20	*256*	0.00	0.00	0.00	0.00		
Left	Subscap	1.48	*233*	0.00	0.00	0.00	0.01		
Left	T. minor	1.51	*228*	0.00	0.00	0.01	0.01		-
		$\bar{x}$		0.66	0.60	0.32	0.49	-	0.01
			n	*238*	*374*	*238*	*375*	*237*	*375*
Right	Supra/Infra	2.35	*329*	0.00	0.00	0.00	0.00		
Right	Subscap	1.97	*315*	0.00	0.00	0.00	0.00		-
Right	T. minor	1.65	*300*	0.00	0.00	0.00	0.00		-

Supra/Infra = Supraspinatus/Infraspinatus (humerus); Subscap = Subscapularis (humerus); T. minor = Teres minor (humerus)
Blank = not observable; - = not significant

Table D 2 Total Sample: Composite Elbow

Side	Muscle	$\bar{x}$	n	Lipping: Distal Humerus	Lipping: Proximal Ulna	Lipping: Proximal Radius	Porosity: Distal Humerus	Porosity: Proximal Ulna	Porosity: Proximal Radius	Eburnation: Distal Humerus	Eburnation: Proximal Ulna	Eburnation: Proximal Radius
Left	$\bar{x}$			0.28	0.72	0.17	0.14	0.25	0.07	0.01	0.00	0.01
Left	n			*367*	*296*	*265*	*367*	*296*	*265*	*367*	*296*	*265*
Left	Triceps	1.68	*284*	0.01	0.00	0.00	-	0.01	0.05	-	-	-
Left	Brachialis	2.20	*286*	-	0.00	0.04	-	-	-	-		-
Left	Biceps	2.24	*293*	-	0.00	0.00	-	-	0.01	-		-
Left	Brachiorad.	1.76	*203*	0.03	0.00	0.04	-	-	0.03	-		-
Right	$\bar{x}$			0.32	0.76	0.19	0.13	0.21	0.06	0.01	-	-
Right	n			*402*	*326*	*277*	*402*	*326*	*277*	*400*	*326*	*277*
Right	Triceps	1.62	*311*	0.01	0.00	-	-	0.00	-	-		
Right	Brachialis	2.25	*326*	0.04	0.00	-	0.00	0.00	-	-		
Right	Biceps	2.42	*296*	0.47	0.00	0.01	-	0.00	0.02	-		
Right	Brachiorad.	1.78	*210*	0.00	0.00	0.00	-	0.01	0.01	-		

Triceps = Triceps brachii (Ulna), Brachialis = Brachialis (Ulna), Biceps = Biceps brachii (Radius); Brachiorad. = Brachioradialis (Radius)
Blank = not observable; - = not significant

Table D 3 Total Sample: Composite Wrist

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.43	0.41	0.16	0.12	-	-
			n	*195*	*261*	*195*	*261*	*195*	*261*
Left	Extensors	2.72	*342*	0.00	0.00	-	0.00		
Left	Flexors	1.62	*352*	0.02	0.00	-	0.01		
		$\bar{x}$		0.53	0.43	0.14	0.13	-	0.00
			n	*222*	*271*	*221*	*271*	*220*	*268*
Right	Extensors	2.87	*395*	0.00	0.00	-	0.01		-
Right	Flexors	1.77	*394*	0.01	0.00	-	0.00		-

Table D 4 Total Sample: Composite Hip

		$\bar{x}$	n	Lipping: Acetabulum	Lipping: Proximal Femur	Porosity: Acetabulum	Porosity: Proximal Femur	Eburnation: Acetabulum	Eburnation: Proximal Femur
Left	$\bar{x}$			0.68	0.48	0.30	0.22	0.00	0.01
			n	*309*	*355*	*309*	*355*	*309*	*355*
Left	OCSSB	2.71	*255*	0.00	0.00	0.00	0.00	-	
Left	G.Med	2.26	*274*	0.00	0.00	0.00	0.00		-
Left	G.Min	2.50	*281*	0.00	0.00	0.00	0.00		-
Left	Psoas	2.20	*307*	0.00	0.00	0.00	0.00		-
Left	QuadFem	1.98	*340*	0.00	0.00	0.00	0.00		-
Right	$\bar{x}$			0.70	0.48	0.37	0.26	-	0.01
			n	*302*	*355*	*302*	*355*	*302*	*355*
Right	OCSSB	2.98	*251*	0.00	-	0.04	-		
Right	G.Med	2.51	*305*	-	-	-	-		
Right	G.Min	2.50	*307*	-	-	-	0.00		
Right	Psoas	2.22	*318*	-	0.02	-	0.01		

SSB = Semimembranosus, Semitendinosus, Biceps femoris (Os Coxa); G. Med = Gluteus medius; G. Min = Gluteus minimus; QuadFem = Quadratus femoris
Blank = not observable; - = not significant

Table D 5 Total Sample: Composite Knee

		$\bar{x}$	*n*	Lipping: Distal Femur	Lipping: Proximal Tibia	Porosity: Distal Femur	Porosity: Proximal Tibia	Eburnation: Distal Femur	Eburnation: Proximal Tibia
		$\bar{x}$		0.49	0.38	0.27	0.24	0.03	0.01
			n	*335*	*293*	*335*	*293*	*334*	*293*
Left	Gastro	1.97	*297*	0.01	0.00	0.01	0.00	-	-
Left	Pat	1.86	*276*	0.00	0.00	0.00	0.00	-	-
Left	Pop	1.25	*249*	0.00	0.00	0.00	0.00	-	-
		$\bar{x}$		0.54	0.35	0.31	0.19	0.04	0.02
			n	*350*	*330*	*350*	*330*	*347*	*330*
Right	Gastro	2.02	*295*	-	-	-	-		
Right	Pat	1.87	*309*	0.05	-	-	-		
Right	Pop	1.20	*276*	-	-		-		

Gastro = Gastrocnemius, Pat = Patellar ligament, Pop = Popliteus
Blank = not observable; - = not significant

Table D 6 New Kingdom Tombos: Composite Shoulder

				Lipping		Porosity		Eburnation	
				Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus
		$\bar{x}$		0.58	0.40	0.21	0.14	-	-
			n	*19*	*35*	*19*	*35*	*19*	*35*
Left	Supra/Infra	0.82	*33*	-	0.00	-	-		
Left	Subscap	0.63	*32*	-	-	-	-		
Left	T. minor	0.75	*32*	-	-	-	-		
		$\bar{x}$		0.48	0.41	0.14	0.10	-	-
			n	*29*	*41*	*29*	*41*	*29*	*41*
Right	Supra/Infra	0.84	*37*	-	-	-	-		
Right	Subscap	1.41	*32*	-	0.01	-	-		
Right	T. minor	0.87	*30*	-	-	-	-		

Table D 7 New Kingdom Tombos: Composite Elbow

				Lipping			**Porosity**			**Eburnation**		
				Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius
		$\bar{x}$		0.31	0.74	0.23	0.12	0.14	0.03	-	-	-
			n	*59*	*35*	*30*	*59*	*35*	*30*	*59*	*35*	*30*
Left	Triceps	1.15	*34*	-	-	-	-	-	-			
	Brachialis	1.27	*33*	-	0.00	-	-	0.01	-			
	Biceps	1.45	*40*	-	0.00	-	-	0.05	-			
	Brachiorad.	1.14	*22*	-	-	-	-	-				
		$\bar{x}$		0.32	0.84	0.33	0.08	0.18	0.07	-	-	-
			n	*50*	*38*	*27*	*50*	*38*	*27*	*50*	*38*	*27*
Right	Triceps	1.32	*38*	-	-	-	-	-	-			
	Brachialis	1.28	*40*	-	0.03	-	-	-	-			
	Biceps	2.07	*30*	-	-	-	-	-	-			
	Brachiorad.	1.06	*17*	-	-	0.05	-	-	-			

Table D 8 New Kingdom Tombos: Composite Wrist

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.74	0.50	0.21	0.04	-	-
			n	*19*	*28*	*19*	*28*	*19*	*28*
Left	Extensors	1.46	*54*	-	-	-	-		
	Flexors	0.88	*60*	-	-	-	-		
		$\bar{x}$		0.73	0.42	0.09	0.15	-	-
			n	*22*	*26*	*22*	*26*	*22*	*26*
Right	Extensors	1.74	*50*	0.05	0.02	-	-		
	Flexors	0.68	*50*	0.01	-	0.04	-		

Table D 9 New Kingdom Tombos: Composite Hip

Side	Muscle	$\bar{x}$	n	Lipping Acetabulum	Lipping Proximal Femur	Porosity Acetabulum	Porosity Proximal Femur	Eburnation Acetabulum	Eburnation Proximal Femur
		$\bar{x}$		0.72	0.47	0.23	0.10	0.02	-
			n	*57*	*51*	*57*	*50*	*57*	*50*
Left	OCSSB	1.81	*52*	0.00	0.01	0.01	-	-	
Left	G.Med	1.15	*40*	-	0.01	-	-		
Left	G.Min	1.29	*38*	-	0.05	-	-		
Left	Psoas	1.08	*37*	0.01	0.00	-	-		
Left	QuadFem	0.93	*45*	0.03	0.00	-	-		
		$\bar{x}$		0.84	0.47	0.45	0.16	-	0.02
			n	*49*	*49*	*49*	*49*	*49*	*49*
Right	OCSSB	2.65	40	0.00	0.01	0.01	-		
Right	G.Med	1.04	45	0.05	-	-	-		
Right	G.Min	1.11	44	-	-	-	-		
Right	Psoas	0.89	45	0.00	0.00	-	-		-
Right	QuadFem	0.83	53	0.01	0.00	-	-		-

Table D 10 New Kingdom Tombos: Composite Knee

				Lipping		Porosity		Eburnation	
				Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia
		$\bar{x}$		0.54	0.36	0.19	0.28	-	-
			n	*48*	*39*	*48*	*39*	*48*	*39*
Left	Gastro	1.12	*42*	-	-	-	-		
Left	Pat	1.13	*40*	-	-	-	0.05		
Left	Pop	0.38	*34*	-	-	-	-		
		$\bar{x}$		0.63	0.28	0.37	0.18	0.02	0.04
			n	*46*	*50*	*46*	*50*	*46*	*50*
Right	Gastro	0.80	*41*	0.01	0.03	-	0.04	0.05	0.00
Right	Pat	1.00	*47*	0.02	0.00	-	-	-	-
Right	Pop	0.28	*43*	0.00	0.00	-	0.00	-	0.00

Table D 11 Napatan Tombos: Composite Shoulder

				Lipping		**Porosity**		**Eburnation**	
				Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus
		$\bar{x}$		0.69	0.37	0.45	0.12	-	-
			n	*42*	*35*	*42*	*34*	*42*	*34*
Left	Supra/Infra	1.84	*32*	-	0.00	-	-		
	Subscap	1.45	*31*	-	-	-	-		
	T. minor	1.13	*30*	-	-	-	-		
		$\bar{x}$		0.52	0.51	0.20	0.36	-	-
			n	*50*	*45*	*50*	*45*	*50*	*45*
Right	Supra/Infra	2.02	*41*	0.02	0.00	-	0.00		
	Subscap	1.71	*41*	0.00	0.00	0.00	0.00		
	T. minor	1.23	*40*	0.00	0.00	-	0.00		

Table D 12 Napatan Tombos: Composite Elbow

				Lipping			Porosity			Eburnation		
				Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius
		$\bar{x}$		0.28	0.64	0.09	0.09	0.20	-	0.02	-	-
			n	*46*	*45*	*47*	*46*	*45*	*47*	*46*	*45*	*47*
Left	Triceps	1.70	*44*	-	-	-	-	-	-			
Left	Brachialis	1.80	*45*	-	0.00	-	-	0.01	-			
Left	Biceps	2.07	*46*	-	0.00	-	-	0.05	-			
Left	Brachiorad	1.75	*36*	-	-	-	-	-				
		$\bar{x}$		0.33	0.63	0.21	0.05	0.12	0.05	-	-	-
			n	*43*	*52*	*39*	*43*	*52*	*39*	*43*	*52*	*39*
Right	Triceps	1.31	52	-	-	-	-	0.01	-			
Right	Brachialis	1.34	53	-	-	-	-	-	-			
Right	Biceps	2.18	39	-	-	-	-	-	-			
Right	Brachiorad	2.03	32	0.04	-	-	-	-	-			

Table D 13 Napatan Tombos: Composite Wrist

				Lipping		**Porosity**		**Eburnation**	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.44	0.52	0.15	0.07	-	-
			n	*27*	*42*	*27*	*42*	*27*	*42*
Left	Extensors	2.65	*43*	-	-	-	-		
Left	Flexors	1.26	*43*	-	-	-	-		
		$\bar{x}$		0.66	0.53	0.14	0.09	-	-
			n	*29*	*34*	*29*	*34*	*29*	*34*
Right	Extensors	2.39	*46*	0.00	0.01	-	-		
Right	Flexors	1.30	*46*	0.01	0.00	-	-		

Table D 14 Napatan Tombos: Composite Hip

				Lipping		Porosity		Eburnation	
				Acetab-ulum	Proximal Femur	Acetab-ulum	Proximal Femur	Acetab-ulum	Proximal Femur
		$\bar{x}$		0.77	0.43	0.23	0.13	-	-
			n	*39*	*47*	*39*	*48*	*39*	*48*
Left	OCSSB	2.92	*37*	0.00	0.00	0.00	0.01		
Left	G.Med	1.70	*43*	0.01	0.04	-	0.01		
Left	G.Min	1.80	*44*	0.00	0.00	0.04	0.04		
Left	Psoas	1.81	*43*	0.00	0.00	0.01	0.00		
Left	QuadFem	1.44	*48*	0.00	0.01	-	0.01		
		$\bar{x}$		0.73	0.51	0.28	0.20	-	-
			n	*40*	*41*	*40*	*41*	*40*	*41*
Right	OCSSB	3.35	*37*	0.00	0.00	0.00	0.03		
Right	G.Med	2.14	*35*	-	-	-	-		
Right	G.Min	1.74	*35*	0.01	0.03	0.04	-		
Right	Psoas	1.84	*37*	0.00	0.00	0.04	0.04		
Right	QuadFem	1.61	*41*	0.00	0.00	0.04	0.00		

Table D 15 Napatan Tombos: Composite Knee

		$\bar{x}$	n	Lipping: Distal Femur	Lipping: Proximal Tibia	Porosity: Distal Femur	Porosity: Proximal Tibia	Eburnation: Distal Femur	Eburnation: Proximal Tibia
		$\bar{x}$		0.42	0.58	0.23	0.19	-	-
			n	*43*	*31*	*43*	*31*	*43*	*31*
Left	Gastro	2.14	*42*	-	-	-	-		
Left	Pat	2.03	*30*	-	-	-	-		
Left	Pop	0.97	*29*	-	0.01	-	-		
		$\bar{x}$		0.45	0.41	0.35	0.19	0.03	
			n	*40*	*37*	*40*	*37*	*40*	*37*
Right	Gastro	1.89	*36*	0.01	-	0.00	-	-	
Right	Pat	2.03	*35*	-	0.05	-	0.02	-	
Right	Pop	0.94	*33*	-	0.00	-	-	-	

Table D 16 Kerma: Composite Shoulder

				Lipping		Porosity		Eburnation	
				Glendoid Fossa	Proximal Humerus	Glendoid Fossa	Proximal Humerus	Glendoid Fossa	Proximal Humerus
		$\bar{x}$		0.62	0.45	0.20	0.35	-	-
			n	*103*	*131*	*103*	*131*	*103*	*131*
Left	Supra/Infra	2.93	*112*	0.00	0.00	0.04	0.00		
	Subscap	2.02	*89*	0.00	0.00	0.05	0.00		
	T. minor	2.21	*95*	0.00	0.00	-	0.00		

				Lipping		Porosity		Eburnation	
		$\bar{x}$		0.81	0.48	0.38	0.32	-	-
			n	*107*	*151*	*107*	*151*	*106*	*151*
Right	Supra/Infra	3.09	*140*	0	0	0.00	0.00		
	Subscap	2.48	*127*	0	0.00	0.00	0.00		
	T. minor	2.30	*125*	0	0	0.02	0.01		

Table D 17 Kerma: Composite Elbow

				Lipping			Porosity			Eburnation		
				Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius
		$\bar{x}$		0.12	0.61	0.11	0.04	0.13	0.04	-	-	-
			n	*139*	*126*	*113*	*139*	*126*	*113*	*139*	*126*	*113*
Left	Triceps	1.69	*115*	-	0.00	0.05	-	-				
Left	Brachialis	2.36	*119*	-	0.00	-	-	0.04				
Left	Biceps	2.58	*122*	-	0.00	0.03	-	-	-			
Left	Brachiorad	1.73	*92*	0.03	0.00	0.04	-	-				
		$\bar{x}$		0.22	0.76	0.09	0.06	0.18	0.02	0.01	-	-
			n	*157*	*138*	*129*	*157*	*138*	*129*	*155*	*138*	*129*
Right	Triceps	1.72	*124*	-	0.00	-	-	0.00	-	-		
Right	Brachialis	2.61	*137*	-	0.00	-	0.03	0.02	-	-		
Right	Biceps	2.67	*132*	-	0.00	-	-	0.00	-	-		
Right	Brachiorad	1.72	*96*	-	0.01	-	-	-	-	-		

Table D 18 Kerma: Composite Wrist

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.34	0.35	0.05	0.07	-	-
			n	*91*	*115*	*91*	*115*	*91*	*115*
Left	Extensors	3.24	*126*	0.02	0.03	-	-		
Left	Flexors	1.93	*128*	0.05	0.01	-	-		
		$\bar{x}$		0.44	0.38	0.07	0.06	-	-
			n	*104*	*124*	*104*	*124*	*103*	*121*
Right	Extensors	3.30	*152*	-	0.00	-	-		
Right	Flexors	2.07	*153*	-	0.00	-	-		

Table D 19 Kerma: Composite Hip

				Lipping		Porosity		Eburnation	
				Acetabulum	Proximal Femur	Acetabulum	Proximal Femur	Acetabulum	Proximal Femur
		$\bar{x}$		0.69	0.48	0.33	0.22	-	0.01
			n	*131*	*153*	*131*	*153*	*131*	*153*
Left	OCSSB	3.19	*101*	0.00	0.00	0.00	0.01		
Left	G.Med	3.22	*110*	0.01	0.03	0.02	0.02		-
Left	G.Min	3.37	*115*	0.05	0.05	0.05	0.00		-
Left	Psoas	2.79	*135*	0.00	0.00	0.00	0.00		-
Left	QuadFem	2.52	*147*	0.01	0.03	-	-		0.00

				Lipping		Porosity		Eburnation	
				Acetabulum	Proximal Femur	Acetabulum	Proximal Femur	Acetabulum	Proximal Femur
		$\bar{x}$		0.70	0.46	0.36	0.16	-	0.00
			n	126	149	126	149	126	149
Right	OCSSB	3.21	104	0.00	-	0.00	0.02		
Right	G.Med	3.51	130	0.00	0.01	0.00	-		
Right	G.Min	3.44	132	0.01	0.00	0.01	0.04		
Right	Psoas	2.80	127	0.00	0.00	-	-		
Right	QuadFem	2.67	146	0.05	0.04	-	-		

Table D 20 Kerma: Composite Knee

		$\bar{x}$	n	Lipping: Distal Femur	Lipping: Proximal Tibia	Porosity: Distal Femur	Porosity: Proximal Tibia	Eburnation: Distal Femur	Eburnation: Proximal Tibia
Left	$\bar{x}$			0.46	0.33	0.19	0.19	0.01	0.00
Left	n			*140*	*137*	*140*	*137*	139	137
Left	Gastro	2.25	*126*	0.00	0.01	0.00	0.01	-	
Left	Pat	2.21	*123*	-	0.02	0.04	0.02	-	
Left	Pop	1.64	*112*	0.00	0.00	0.01	0.01	-	
Right	$\bar{x}$			0.48	0.28	0.17	0.11	0.01	0.01
Right	n			146	152	146	152	145	152
Right	Gastro	2.47	123	0.00	0.00	0.01	0.00	0.03	-
Right	Pat	2.17	141	0.02	-	-	-	-	-
Right	Pop	1.57	122	0.00	0.00	-	0.02	-	-

Table D 21 C-Group: Composite Shoulder

				Lipping		**Porosity**		**Eburnation**	
				Glendoid Fossa	Proximal Humerus	Glendoid Fossa	Proximal Humerus	Glendoid Fossa	Proximal Humerus
		$\bar{x}$			0.83		1.15		0.02
			n		*47*		*47*		*47*
Left	Supra/Infra	1.77	*39*		-		-		
	Subscap	1.00	*40*		-		-		
	T. minor	0.97	*34*		-		-		
		$\bar{x}$			1.04		1.19		0.00
			n		*69*		*69*		*69*
Right	Supra/Infra	1.85	*60*		0.00		0.00		
	Subscap	1.50	*60*		0.00		0.02		
	T. minor	1.07	*56*		0.00		0.00		

Table D 22 C-Group: Composite Elbow

				Lipping			Porosity			Eburnation		
				Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius
		$\bar{x}$		0.55	1.56	0.41	0.43	1.38	0.35	0.02	0.06	0.06
			n	*49*	*16*	*17*	*49*	*16*	*17*	*49*	*16*	*17*
Left	Triceps	1.69	*16*	-	0.00		-	0.03	-		-	
Left	Brachialis	2.88	*16*	-	0.00	-	-	-	-		-	
Left	Biceps	2.44	*16*	-	-	-	-	-	-			-
Left	Brachiorad.	2.07	*14*	-	-	-	-	-	-			-
		$\bar{x}$		0.51	1.17	0.38	0.39	1.00	0.23	0.01	-	-
			n	*71*	*12*	*13*	*71*	*12*	*13*	*71*	*12*	*13*
Right	Triceps	1.91	*11*	-	-	-	-	-	-			
Right	Brachialis	3.45	*11*	-	-	-	-	-	-			
Right	Biceps	2.77	*13*	0.03		0.03	-	-	0.04	-		
Right	Brachiorad.	2.15	*13*	-		-	0.02	-	-	-		

Table D 23 C-Group: Composite Wrist

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.62	0.59	0.62	0.59		
			n	*13*	*17*	*13*	*17*	*13*	*17*
Left	Extensors	2.79	*48*	-	-	-	-		
	Flexors	1.67	*49*	-	-	-	-		
		$\bar{x}$		0.56	0.43	0.67	0.21		
			n	*9*	*14*	*9*	*14*	*9*	*14*
Right	Extensors	2.88	*72*	-	0.01	-	-		
	Flexors	1.81	*70*	-	-	-	0.03		

Table D 24 C-Group: Composite Hip

				Lipping		Porosity		Eburnation	
				Acetabulum	Proximal Femur	Acetabulum	Proximal Femur	Acetabulum	Proximal Femur
		$\bar{x}$		1.00	0.63	0.83	0.50		0.03
			n	*6*	*32*	*6*	*32*	*6*	*32*
Left	OCSSB	3.00	*3*	-		-			
Left	G.Med	1.61	*23*		-		-		
Left	G.Min	2.44	*27*		0.01		-		
Left	Psoas	1.63	*24*		0.04		-		
Left	QuadFem	2.03	*31*	-	0.01		0.03		

				Lipping		Porosity		Eburnation	
				Acetabulum	Proximal Femur	Acetabulum	Proximal Femur	Acetabulum	Proximal Femur
		$\bar{x}$		0.88	0.76	0.75	0.95		0.11
			n	*8*	*37*	*8*	*37*	*8*	*37*
Right	OCSSB	2.50	*6*	-		-			
Right	G.Med	1.54	*35*	-	-		-		-
Right	G.Min	1.81	*37*	-	0.04	-	-		-
Right	Psoas	2.11	*35*	-	-	-	-		-
Right	QuadFem	1.76	*42*	-	-	-	-		-

Table D 25 C-Group: Composite Knee

				Lipping		Porosity		Eburnation	
				Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia
		$\bar{x}$		0.69	0.45	0.53	0.64	0.06	0.05
			n	*32*	*22*	*32*	*22*	*32*	*22*
Left	Gastro	1.81	*32*	-	-	-	-	-	
Left	Pat	1.33	*20*	-	-	-	-		-
Left	Pop	1.38	*21*	-	-	-	-		-
		$\bar{x}$		0.73	0.70	0.63	0.70	0.13	0.13
			n	*41*	*23*	*41*	*23*	*40*	*23*
Right	Gastro	1.81	*36*	-	-	-	-	-	-
Right	Pat	2.00	*21*	-	-	-	-	-	-
Right	Pop	1.48	*21*	-	-	-	-	-	-

Table D 26 Pharaonic: Composite Shoulder

				Lipping		Porosity		Eburnation	
				Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus
		x̄		0.00	0.40	0.00	0.33	0.00	0.00
			n	*2*	*15*	*2*	*15*	*2*	*15*
Left	Supra/Infra	0.46	*13*		-		-		
Left	Subscap	1.33	*15*		-		-		
Left	T. minor	0.50	*12*		-		-		
		x̄		0.00	0.72	0.00	0.68	0.00	0.11
			n	*1*	*18*	*1*	*19*	*1*	*19*
Right	Supra/Infra	0.58	*12*		-		-		
Right	Subscap	1.50	*14*		-		-		-
Right	T. minor	0.43	*14*		-		-		-

Table D 27 Pharaonic: Composite Elbow

				Lipping			Porosity			Eburnation		
				Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius
		$\bar{x}$		0.50	0.70	0.10	0.39	0.20	0.10	0.11		0.10
			n	*18*	*10*	*10*	*18*	*10*	*10*	*18*	*10*	*10*
Left	Triceps	2.00	*10*	-	-	-	-	-	-	-		-
Left	Brachialis	2.20	*10*	-	-	-	-	-	-	-		-
Left	Biceps	1.91	*11*	-	-	-	-	-	-	-		-
Left	Brachiorad.	1.10	*10*	-	-		-	-		-		
		$\bar{x}$		0.39	0.80	0.19	0.17			0.06		
			n	*18*	*15*	*16*	*18*	*15*	*16*	*18*	*15*	*16*
Right	Triceps	1.57	*14*	-	-	-						
Right	Brachialis	2.07	*14*	-	-	-						
Right	Biceps	1.69	*16*	-	-	-						
Right	Brachiorad.	1.07	*14*	-	-	-						

Table D 28 Pharaonic: Composite Wrist

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		x̄		0.25	0.33	0.13			
			n	*8*	*12*	*8*	*12*	*8*	*12*
Left	Extensors	2.18	*17*	-	-	-			
	Flexors	1.11	*18*	-	-	-			

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		x̄		0.67	0.53	0.09	0.35		0.06
			n	*12*	*17*	*11*	*17*	*11*	*17*
Right	Extensors	2.35	*17*	-	-	-	-		-
	Flexors	1.44	*16*	-	-	-	-		-

Table D 29 Pharaonic: Composite Hip

		$\bar{x}$	n	Lipping: Acetabulum	Lipping: Proximal Femur	Porosity: Acetabulum	Porosity: Proximal Femur	Eburnation: Acetabulum	Eburnation: Proximal Femur
	$\bar{x}$			0.67	0.28	0.25	0.22		
			n	*12*	*18*	*12*	*18*	*12*	*18*
Left	OCSSB	3.10	*10*	-	-	-	-		
Left	G.Med	1.17	*12*	-	-	-	-		
Left	G.Min	1.36	*14*	-	-	-	-		
Left	Psoas	1.87	*15*	0.01	-	-	-		
Left	QuadFem	1.67	*15*	-	-	-	-		
	$\bar{x}$			0.82	0.14	0.27	0.21		
			n	*11*	*14*	*11*	*14*	*11*	*14*
Right	OCSSB	3.17	*6*		-	-	-		
Right	G.Med	1.75	*12*	-	-	-	-		
Right	G.Min	1.77	*13*	-	-	-	-		
Right	Psoas	2.00	*12*	-	-	-	-		
Right	QuadFem	1.62	*13*	-	-	-	-		

Table D 30 Pharaonic: Composite Knee

				Lipping		Porosity		Eburnation	
				Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia
		$\bar{x}$		0.38	0.40	0.69	0.47	0.31	0.13
			n	*16*	*15*	*16*	*15*	*16*	*15*
Left	Gastro	1.12	*17*	-	-	-	-	-	-
	Pat	1.36	*14*	-	-	-	-	-	-
	Pop	0.71	*14*	-	-	-	-	-	-
		$\bar{x}$		0.71	0.31	0.86	0.15	0.29	0.08
			n	*14*	*13*	*14*	*13*	*14*	*13*
Right	Gastro	1.07	*14*	0.04	0.05	-	-	-	-
	Pat	1.21	*14*	-	-	-	-	-	-
	Pop	0.62	*13*	-	-	-	-	-	-

Table D 31 O16/P37: Composite Shoulder

				Lipping		Porosity		Eburnation	
				Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus
		$\bar{x}$		0.50	0.38	0.41	0.31		
			n	*22*	*16*	*22*	*16*	*22*	*16*
Left	Supra/Infra	2.92	*12*	-	-	-	-		
Left	Subscap	1.25	*12*	-	0.02	-	0.02		
Left	T. minor	1.73	*11*	-	-	-	-		
		$\bar{x}$		0.71	0.50	0.76	0.50		
			n	*21*	*22*	*21*	*22*	*21*	*22*
Right	Supra/Infra	3.19	*16*	0.01	0.01	0.01	0.00		
Right	Subscap	2.11	*18*	-	0.00	-	0.01		
Right	T. minor	1.64	*14*	-	0.02	-	-		

Table D 32 O16/P37: Composite Elbow

				Lipping			Porosity			Eburnation		
				Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius
		$\bar{x}$		0.29	0.88	0.35	0.14	0.42	0.13			
			n	*28*	*26*	*23*	*28*	*26*	*23*	*28*	*26*	*23*
Left	Triceps	1.59	*27*	0.00	0.02	-	-	-	-			
Left	Brachialis	2.41	*27*	-	-	-	-	-	-			
Left	Biceps	2.35	*26*	0.04	-	0.02	-	-	-			
Left	Brachiorad.	2.25	*12*	-	-	-	-	-	-			
		$\bar{x}$		0.32	0.76	0.23	0.13	0.34	0.14			
			n	*31*	*29*	*22*	*31*	*29*	*22*	*31*	*29*	*22*
Right	Triceps	1.43	*30*	0.05	0.01	0.01	0.01	0.00	-			
Right	Brachialis	2.57	*30*	-	0.03	-	-	0.05	-			
Right	Biceps	2.24	*29*	0.01	0.01	0.00	0.02	0.01	0.02			
Right	Brachiorad.	2.00	*16*	-	0.00	0.04	-	0.01	-			

Table D 33 O16/P37: Composite Wrist

				Lipping		**Porosity**		**Eburnation**	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.50	0.35	0.50	0.20	-	-
			n	*14*	*20*	*14*	*20*	*14*	*20*
Left	Extensors	2.84	*25*	0.03	-	0.04	-		
Left	Flexors	2.27	*26*	-	-	-	-		

				Lipping		**Porosity**		**Eburnation**	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.53	0.42	0.37	0.33	-	-
			n	*19*	*24*	*19*	*24*	*19*	*24*
Right	Extensors	3.12	*26*	0.02	-	0.04	0.05		
Right	Flexors	2.43	*28*	0.00	-	-	-		

Table D 34 O16/P37: Composite Hip

				Lipping		Porosity		Eburnation	
				Acetab-ulum	Proximal Femur	Acetab-ulum	Proximal Femur	Acetab-ulum	Proximal Femur
		$\bar{x}$		0.64	0.48	0.50	0.29		0.05
			n	*28*	*21*	*28*	*21*	*28*	*21*
Left	OCSSB	2.27	*22*	0.00	0.04	-	-		
	G.Med	2.12	*17*	-	-	-	-		-
	G.Min	2.25	*16*	-	-	-	-		-
	Psoas	2.10	*20*	0.01	0.00	-	0.01		
	QuadFem	1.85	*20*	0.02	0.02	-	0.03		
		$\bar{x}$		0.63	0.44	0.56	0.24		
			n	*27*	*25*	*27*	*25*	*27*	*25*
Right	OCSSB	2.48	*23*	0.00	-	0.04	-		
	G.Med	2.38	*21*	-	-	-	-		
	G.Min	2.68	*19*	-	-	-	0.00		
	Psoas	2.25	*24*	-	0.02	-	0.01		
	QuadFem	1.90	*21*	-	0.02	-	0.01		

Table D 35 O16/P37: Composite Knee

				Lipping		**Porosity**		**Eburnation**	
				Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia
		$\bar{x}$		0.43	0.26	0.29	0.21		
			n	*21*	*19*	*21*	*19*	*21*	*19*
Left	Gastro	1.92	*13*	-	-	-	-		
	Pat	1.31	*16*	0.00	-	0.01	-		
	Pop	0.64	*14*	-	0.02	-	0.04		
		$\bar{x}$		0.38	0.35	0.23	0.17		
			n	*26*	*23*	*26*	*23*	*26*	*23*
Right	Gastro	2.21	*19*	-	-	-	-		
	Pat	1.28	*18*	0.05	-	-	-		
	Pop	0.38	*13*		-		-		

Table D 36 Young Adult: Composite Shoulder

		$\bar{x}$	n	Lipping: Glenoid Fossa	Lipping: Proximal Humerus	Porosity: Glenoid Fossa	Porosity: Proximal Humerus	Eburnation: Glenoid Fossa	Eburnation: Proximal Humerus
	$\bar{x}$			0.12	0.20	0.05	0.28	-	-
			n	*42*	*54*	*42*	*54*	*42*	*54*
Left	Supra/Infra	1.43	*46*	0.04	-	-	-		
Left	Subscap	0.80	*45*	-	-	-	-		
Left	T. minor	0.87	*46*	-	-	-	-		

		$\bar{x}$	n	Lipping: Glenoid Fossa	Lipping: Proximal Humerus	Porosity: Glenoid Fossa	Porosity: Proximal Humerus	Eburnation: Glenoid Fossa	Eburnation: Proximal Humerus
	$\bar{x}$			0.13	0.18	0.13	0.15	-	-
			n	*40*	*62*	*40*	*62*	*40*	*62*
Right	Supra/Infra	1.39	*56*	-	0.01	-	-		
Right	Subscap	0.89	*54*	-	0.00	-	-		
Right	T. minor	0.91	*58*	-	0.00	-	-		

Table D 37 Young Adult: Composite Elbow

				Lipping			Porosity			Eburnation		
				Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius
		$\bar{x}$		0.05	0.31	0.04	0.05	0.12	0.02	0.02	-	-
			n	*60*	*52*	*50*	*60*	*52*	*50*	*60*	*52*	*50*
Left	Triceps	0.86	*50*	-	-	-	-	-	-	-		
Left	Brachialis	1.82	*51*	-	-	-	-	0.01	-	-		
Left	Biceps	1.67	*49*	-	-	-	-	-	-	-		
Left	Brachiorad	1.40	*42*	-	-	-		-	-	-		

				Lipping			Porosity			Eburnation		
				Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius
		$\bar{x}$		0.08	0.39	0.10	0.03	0.20	0.00	-	-	-
			n	*65*	*51*	*51*	*65*	*51*	*51*	*64*	*51*	*51*
Right	Triceps	1.20	*44*	-	0.02	-	-	0.00				
Right	Brachialis	1.86	*50*	-	-	-	-	0.00				
Right	Biceps	1.98	*51*	0.04	-	-	-	0.00				
Right	Brachiorad	1.19	*37*	-	-	-						

Table D 38 Young Adult: Composite Wrist

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.08	0.10	0.03	0.02	-	-
			n	*38*	*48*	*38*	*48*	*38*	*48*
Left	Extensors	2.14	*58*	-	-	-	-		
	Flexors	1.17	*58*	-	-	-	-		

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.18	0.13	0.03	0.04	-	-
			n	*40*	*46*	*40*	*46*	*39*	*45*
Right	Extensors	2.00	*61*	-	0.01	-	-		
	Flexors	1.17	*63*	-	-	-	-		

Table D 39 Young Adult: Composite Hip

				Lipping		Porosity		Eburnation	
				Acetabulum	Proximal Femur	Acetabulum	Proximal Femur	Acetabulum	Proximal Femur
		$\bar{x}$		0.14	0.18	0.03	0.13	-	-
			n	*64*	*60*	*64*	*60*	*64*	*60*
Left	OCSSB	1.30	*56*	0.00	0.00	0.04	-		
Left	G.Med	1.81	*53*	0.02	-	-	-		
Left	G.Min	2.04	*55*	-	-	-	-		
Left	Psoas	1.60	*55*	0.01	0.00	-	-		
Left	QuadFem	1.51	*59*	-	0.01	-	-		
		$\bar{x}$		0.13	0.21	0.19	0.13	-	0.02
			n	*62*	*62*	*62*	*62*	*62*	*62*
Right	OCSSB	1.60	*53*	0.00	-	0.01	-		
Right	G.Med	1.92	*51*	-	-	-	-		-
Right	G.Min	1.84	*50*	-	-	-	-		-
Right	Psoas	1.52	*54*	-	-	-	-		-
Right	QuadFem	1.35	*62*	0.01	0.04	-	-		-

Table D 40 Young Adult: Composite Knee

				Lipping		Porosity		Eburnation	
				Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia
		$\bar{x}$		0.21	0.18	0.11	0.16	-	0.02
			n	*61*	*57*	*61*	*57*	*61*	*57*
Left	Gastro	1.65	*60*	-	0.00	-	0.01		
Left	Pat	1.29	*51*	0.02	0.01	-	-		-
Left	Pop	0.98	*49*	0.02	0.00	0.05	0.02		-
		$\bar{x}$		0.26	0.19	0.18	0.10	0.02	-
			n	*61*	*63*	*61*	*63*	*59*	*63*
Right	Gastro	1.60	*55*	-	0.03	-	-	-	
Right	Pat	1.12	*52*	-	0.00	-	-	-	
Right	Pop	0.83	*58*	-	0.00	-	-	-	

Table D 41 Middle Adult: Composite Shoulder

				Lipping		Porosity		Eburnation	
				Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus
		$\bar{x}$		0.66	0.45	0.27	0.40	-	-
			n	*86*	*118*	*86*	*118*	*86*	*118*
Left	Supra/Infra	2.44	*96*	0.00	0.03	-	0.02		
	Subscap	1.73	*89*	0.00	0.00	-	0.00		
	T. minor	1.75	*85*	0.01	-	-	-		
		$\bar{x}$		0.79	0.62	0.36	0.56	-	-
			n	*94*	*152*	*94*	*152*	*94*	*152*
Right	Supra/Infra	2.68	*136*	0.00	0.01	-	-		
	Subscap	2.25	*131*	0.00	0.00	0.00	-		
	T. minor	1.93	*125*	0.01	-	-	-		

Table D 42 Middle Adult: Composite Elbow

		$\bar{x}$	n	Lipping			Porosity			Eburnation		
				Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius
	$\bar{x}$			0.24	0.77	0.12	0.11	0.31	0.05	0.00	0.00	0.01
	n			*139*	*117*	*103*	*139*	*117*	*103*	*139*	*117*	*103*
Left	Triceps	1.86	*113*	-	0.00	-	-	0.03	-			
Left	Brachialis	2.36	*115*	-	0.00	-	-	0.01	-			
Left	Biceps	2.40	*115*	-	0.01	-	-	-	-			-
Left	Brachiorad	1.65	*80*	-	-	-	-	-	-			-
	$\bar{x}$			0.32	0.86	0.14	0.11	0.19	0.06	0.01	0.00	0.00
	n			*161*	*128*	*118*	*161*	*128*	*118*	*160*	*128*	*118*
Right	Triceps	1.72	*121*	0.03	0.00	-	-	0.00	-			
Right	Brachialis	2.55	*127*	-	0.00	-	0.04	0.00	-			
Right	Biceps	2.44	*118*	-	0.01	-	-	0.00	0.00	-		
Right	Brachiorad	1.73	*88*	-	0.01	-	-	0.04	-	-		

Table D 43 Middle Adult: Composite Wrist

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.42	0.36	0.18	0.12	-	-
			n	*83*	*103*	*83*	*103*	*83*	*103*
Left	Extensors	3.01	*129*	-	0.02	-	-		
Left	Flexors	1.79	*135*	-	0.01	-	0.02		
		$\bar{x}$		0.55	0.45	0.12	0.11	-	-
			n	*93*	*114*	*93*	*114*	*93*	*112*
Right	Extensors	3.18	*159*	-	0.00	-	0.04		
Right	Flexors	2.05	*154*	0.05	0.00	-	-		

Table D 44 Middle Adult: Composite Hip

				Lipping		Porosity		Eburnation	
				Acetabulum	Proximal Femur	Acetabulum	Proximal Femur	Acetabulum	Proximal Femur
		$\bar{x}$		0.63	0.44	0.32	0.17		0.01
			n	*139*	*132*	*139*	*132*	*139*	*132*
Left	OCSSB	2.83	*117*	0.00	0.01	0.00	0.02		
Left	G.Med	2.89	*102*	-	-	0.03	-		
Left	G.Min	2.94	*101*	-	-	-	0.01		
Left	Psoas	2.43	*115*	0.00	0.00	0.05	0.01		
Left	QuadFem	2.44	*124*	0.01	-	-	0.01		
		$\bar{x}$		0.65	0.46	0.34	0.22		
			n	*133*	*144*	*133*	*144*	*133*	*144*
Right	OCSSB	3.13	*115*	0.00	-	0.01	0.00		
Right	G.Med	3.01	*122*	0.01	-	-	-		
Right	G.Min	2.94	*126*	-	-	-	-		
Right	Psoas	2.39	*122*	0.02	0.05	-	-		
Right	QuadFem	2.39	*137*	-	-	-	-		

Table D 45 Middle Adult: Composite Knee

				Lipping		Porosity		Eburnation	
				Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia	Distal Femur	Proximal Tibia
		$\bar{x}$		0.47	0.35	0.21	0.21	0.03	0.00
			n	*121*	*113*	*121*	*113*	*121*	*113*
Left	Gastro	2.23	*105*	-	-	-	-	-	
Left	Pat	1.99	*102*	-	-	-	-	-	
Left	Pop	1.41	*91*	-	0.05	-	-	-	
		$\bar{x}$		0.55	0.34	0.29	0.19	0.04	0.03
			n	*140*	*124*	*140*	*124*	*139*	*124*
Right	Gastro	2.33	*116*	0.00	0.00	-	0.00	0.00	-
Right	Pat	2.02	*122*	0.04	-	-	-	0.03	-
Right	Pop	1.40	*104*	0.01	0.00	-	-	0.02	-

Table D 46 Old Adult: Composite Shoulder

				Lipping		**Porosity**		**Eburnation**	
				Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus	Glenoid Fossa	Proximal Humerus
		$\bar{x}$		0.94	0.72	0.39	0.52		
			n	*36*	*58*	*36*	*58*	*36*	*58*
Left	Supra/Infra	2.64	*55*	-	0.00	-	-		
Left	Subscap	2.17	*41*	-	-	0.00	-		
Left	T. minor	2.09	*45*	-	-	-	-		
		$\bar{x}$		1.24	0.85	0.64	0.71		0.03
			n	*42*	*68*	*42*	*69*	*41*	*69*
Right	Supra/Infra	3.15	*59*	-	-	-	-		
Right	Subscap	2.60	*58*	-	-	-	-		-
Right	T. minor	2.31	*52*	0.02	-	0.04	-		-

Table D 47 Old Adult: Composite Elbow

				Lipping			**Porosity**			**Eburnation**		
				Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius	Distal Humerus	Proximal Ulna	Proximal Radius
		$\bar{x}$		0.55	0.98	0.32	0.30	0.25	0.12	0.03	0.00	0.02
			n	*64*	*51*	*50*	*64*	*51*	*50*	*64*	*51*	*50*
Left	Triceps	1.92	*51*	-	-	-	-	-	-	-		-
	Brachialis	2.51	*51*	-	-	-	-	-	-	-		-
	Biceps	3.00	*52*	-	-	-	-	0.02	-	-		-
	Brachiorad	2.46	*41*	-	-	-	-	-	-	-		
		$\bar{x}$		0.48	0.97	0.36	0.18	0.25	0.16	0.03	0.00	0.00
			n	*71*	*59*	*56*	*71*	*59*	*56*	*71*	*59*	*56*
Right	Triceps	1.95	*60*	-	-	-	-	-	-	-		
	Brachialis	2.50	*60*	-	-	-	-	-	-	-		
	Biceps	2.76	*63*	-	-	-	-	-	-	-		
	Brachiorad	2.39	*46*	-	-	-	-	-	-	-		

Table D 48 Old Adult: Composite Wrist

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.84	0.68	0.29	0.19	0.00	0.00
			n	*38*	*53*	*38*	*53*	*38*	*53*
Left	Extensors	3.22	*58*	-	-	-	-		
	Flexors	1.98	*59*	-	-	-	-		

				Lipping		Porosity		Eburnation	
				Distal Ulna	Distal Radius	Distal Ulna	Distal Radius	Distal Ulna	Distal Radius
		$\bar{x}$		0.89	0.71	0.26	0.29	0.00	0.02
			n	*47*	*58*	*46*	*58*	*46*	*58*
Right	Extensors	3.54	*72*	-	-	-	-		-
	Flexors	2.29	*72*	-	-	-	-		-

Table D 49 Old Adult: Composite Hip

				Lipping		Porosity		Eburnation	
				Acetab-ulum	Proximal Femur	Acetab-ulum	Proximal Femur	Acetab-ulum	Proximal Femur
		$\bar{x}$		1.29	0.89	0.54	0.47	0.01	0.03
			n	*69*	*64*	*69*	*64*	*69*	*64*
Left	OCSSB	3.90	*58*	-	-	-	0.05	-	
Left	G.Med	2.76	*45*	-	-	-	-		-
Left	G.Min	2.92	*50*	0.04	-	-	-		-
Left	Psoas	2.98	*53*	0.01	-	-	-		-
Left	QuadFem	2.27	*64*	-	0.03	-	-		-
		$\bar{x}$		1.41	0.72	0.67	0.34	-	0.03
			n	*64*	*67*	*64*	*67*	*64*	*67*
Right	OCSSB	4.08	*51*	-	-	-	-		
Right	G.Med	2.87	*60*	-	-	-	-		-
Right	G.Min	2.69	*59*	-	0.01	-	-		-
Right	Psoas	2.75	*64*	-	0.04	-	-		-
Right	QuadFem	2.40	*68*	-	0.01	-	-		-

Table D 50 Old Adult: Composite Knee

		$\bar{x}$	*n*	Lipping: Distal Femur	Lipping: Proximal Tibia	Porosity: Distal Femur	Porosity: Proximal Tibia	Eburnation: Distal Femur	Eburnation: Proximal Tibia
		$\bar{x}$		0.74	0.71	0.53	0.40	0.05	0.04
			n	*58*	*52*	*58*	*52*	*57*	*52*
Left	Gastro	2.12	*52*	-	-	-	-	0.05	-
Left	Pat	2.42	*53*	0.03	-	-	-	-	-
Left	Pop	1.64	*47*	-	-	-	-	-	-
		$\bar{x}$		0.76	0.64	0.46	0.34	0.09	0.05
			n	*68*	*59*	*68*	*59*	*68*	*59*
Right	Gastro	2.28	*58*	-	-	-	-	-	-
Right	Pat	2.39	*57*	-	-	-	-	-	-
Right	Pop	1.67	*45*	0.03	-	-	-	-	-

Appendix E Carbon and Nitrogen Stable Isotope Data

Table E 1 Samples with Inconsistant C:N Ratios

Site	Period	Unit, Locus, Burial[1]	ID	$\delta^{13}C$	SD $\delta^{13}C$	$\delta^{15}N$	SD $\delta^{15}N$	C:N Ratio
Tombos	New Kingdom	U.5 Pit B (a)	11	-18.41	0.18	14.18	0.02	18.13
		U.5 Pit B (b)	11	-21.68	0.13	13.75	0.61	15.23
		U.6 L.4 B.1 (a)	18	-22.64	0.13	18.50	0.48	11.55
		U.6 L.4 B.1 (b)	18	-18.85	0.09	16.99	0.30	19.70
		U.6 L.G B.10	16	-23.35	0.31	15.16	0.14	14.81
		U.6 L.47 B.2	13	-23.19	0.05	15.78	0.84	13.16
		U.7 B.3	5	-19.37	0.29	22.64	0.34	8.51
		U.7 B.10 (a)	3	-18.51	0.18	23.16	0.14	13.48
		U.7 B.10 (b)	3	-20.85	0.43	23.06	0.16	10.35
		U.7 B.10 (c)	3	-20.10	0.06	22.40	0.44	10.36
	Napatan	U.10 B.1	114	-21.23	0.51	18.96	0.73	9.55
		U.10 B.1	114	-15.41	0.06	15.65	0.45	11.31
		U.20 S.1	117	-22.95	0.03	17.01	1.16	11.30
		U.20 S.1	117	-20.86	0.02	20.27	0.24	6.58
SJE	New Kingdom	SJE 28:253	133	-20.88	0.57	13.40	1.00	5.88
		SJE 400:17a	134	-19.01	-	14.85	-	33.01

[1]U = Unit, L = Locus, B = Burial

Table E 2 Collagen Results: Tombos, New Kingdom

Site	Period	Unit, Locus, Burial[1]	ID	δ^{13}C	δ^{15}N	%C	%N	C:N
Tombos	New Kingdom	U.5 Pit B	11	-19.8	12.4	42.1	13.5	3.1
		U.5 Pit D	20	-19.4	12.3	39.5	13.9	2.8
		U.3 B.1	28	-18.8	13.0	36.9	12.8	2.9
		U.6 Pit A	30	-22.2	11.3	9.5	3.3	2.9
		U.6 L.47 B.2	13	-22.4	15.9	3.8	1.2	3.2
		U.6 L.47 B.1	18	-17.9	12.3	37.2	13.0	2.9

[1]U = Unit, L = Locus, B = Burial

Table E 3 Collagen Results: Comparative Material

Site	Period	ID	δ13C	δ15N	%C	%N	C:N	Source
Gebelein	1st Intermediate Period	61	-19.6	13.2				Iacumin et al., 1996
		62	-19.7	11.5				
		70	-19.5	13				
		71	-18.9	13.8				
		91	-19.5	13.7				
		92	-19.1	12.2				
Asyut		94	-20.1	14.4				
		134	-19.8	13.5				
		228	-20.3	13.3				
		231	-19.2	12.7				
		270	-20	11.8				
		281	-19.9	13.9				
		282	-20.2	12.8				
		312	-19.3	11.4				
Qau	Old Kingdom	E27	-20.9	12.7	71.6	21.5	3.9	Thompson et al., 2005
Abydos	Middle Kingdom	E4	-18.5	13.6	41.7	14.5	3.4	
		E36	-18.4	12.4	28.9	10.1	3.4	
		E29	-19.9	13	16.4	4.4	4.4	
		E35	-19.4	13.4	34.3	10.7	3.7	
Saqqara	New Kingdom	E13	-20.9	12.7	40.1	8.1	5.8	
Qurneh	3rd IP	E7	-21.1	13.8	49.7	8.5	6.8	
Kerma	Kerma Ancien	44	-14.2	12.6	41.2	14.3	3.4	Iacumin et al., 1998
		45	-16.1	11.8	42.9	13.8	3.6	
		50	-17.6	12.2	40.4	13.6	3.5	
		193a	-16.8	13.3	21.7	7.1	3.6	
		193b	-17.2	11.2	36.2	12.5	3.4	
	Kerma Moyen	189	-20.6	12.1	35.6	12.1	3.4	
		171.1	-20.4	12.4	39.8	13.5	3.4	
		188a	-18.6	13.4	39.9	13.2	3.5	
		190	-19.2	14.4	32.8	10.8	3.5	
	Kerma Classique	185	-23.0	10.5	33.8	11.2	3.5	
		186	-17.6	13.6	40.7	14.7	3.2	
		K309A	-19.3	14.2	41.4	13.9	3.5	Thompson et al., 2008
		III313	-15.4	15.4	43.1	14.8	3.4	
		332B	-15.3	13.7	43	14.6	3.4	
		339B	-18.6	12.9	38.2	13.4	3.3	
		K420i	-14.3	13.5	38.1	13.2	3.5	
		IT420i	-19.3	13.9	40.5	13.8	3.4	
		K420A	-17.7	14.1	38.8	13.1	3.5	
		K421	-19.1	14.7	43	15	3.4	
		K423	-17.6	14	44	14.5	3.6	
		K425B	-18.3	14.3	45.5	15	3.6	
		437C	-12.3	16.1	40.2	13.8	3.4	
		IVBFA	-16.5	13.8	42.5	14.7	3.4	
		IVBDA	-18.7	13.4	37.9	13.1	3.4	
		IVBSA	-18.7	13.9	39.5	13.3	3.5	
		IV414E	-18.3	13.6	43.8	15.1	3.4	

Table E 3 Continued.

		1024	-19.2	12.6	44.3	15.4	3.4	
		1024(2)	-18.7	14	44.8	15.8	3.3	
		1029	-18.4	14.8	41.7	14.6	3.4	
		1029.2	-16.3	15	41.6	14.2	3.5	
		IA1029	-18.1	14.7	40.5	14	3.4	
		1029AII	-11.9	14.3	45.6	15.8	3.4	
		1030B	-18.7	13.1	41.8	14.6	3.4	
		1030X	-18.1	14.1	39	13.2	3.5	
		1041D	-16.3	13.9	40	13.8	3.4	
		1042	-19.6	13.3	40.4	13.9	3.4	
		1044	-18.6	14.7	39.5	13	3.6	
		1044X	-17.9	12.9	41	14.1	3.4	
		1045II	-17.7	14.3	35.5	11.8	3.5	
		1045III	-17.3	13.5	41.4	14.2	3.4	
		1045B	-17.5	13.5	44.5	15.2	3.4	
		1048.2	-18.3	13.6	41.3	14.1	3.5	
		1048.1	-17.5	14	36.2	12.1	3.6	
		1050A	-18.1	13.8	34.4	11.7	3.5	
		1058IIB	-17.6	13.7	41.1	14.4	3.3	
		1058D	-17	14.2	40.3	14.1	3.3	
		1065II	-18.4	14.2	42	15	3.3	
		1065G	-17.4	12.5	39.8	13.8	3.4	
		1084	-19.9	12.8	43.9	14.4	3.6	
		1088A	-18.4	12.4	43.4	14.8	3.4	
		XBZC	-19.6	13.8	42.5	14.2	3.5	
		XBZIT	-17.2	14.6	41.6	13.9	3.5	
		XBTIT	-17.7	14.1	34.7	11.9	3.4	
		XBMB	-18.1	13.1	37.4	12.6	3.5	
		XBOCA	-18.9	13.9	35.2	12	3.4	
		1625D	-19	13.4	23.9	8.4	3.3	
		IIGI803	-18.6	13.5	35.5	11.4	3.6	
		D1803	-17.2	14.6	42.3	14.6	3.4	
		1805	-18.7	14.4	39.2	13.6	3.4	

IP = Intermediate Period
For Chronology of Ancient Egypt and Nubia, please see Table 2.2.1

Table E 4 Carbonate Results: Tombos and Other Nile Valley Sites

Site	Period	Unit, Locus, Burial[1]	ID	$\delta^{13}C$	SD
Tombos	New Kingdom	U.6 L.47 B.3	1	-11.83	0.21
		U.7 B.6	6	-11.39	
		U.7 B.8	7	-12.35	0.08
		U.7 B.2	8	-13.03	
		U.7 B.9	10	-13.24	
		U.5 Pit B	11	-11.96	0.12
		U.5 Pit A	12	-11.81	0.12
		U.6 L.47 B.2	13	-11.92	0.54
		U.5 Pit E	17	-12.70	0.83
		U.7 B.5	19	-12.67	
		U.6 B.8	21	-12.31	
		U.6 B.1	22	-10.75	0.10
		U. 6 B.7	23	-11.88	
		U.1, South Alley	24	-7.42	
		U.3 B.1	28	-11.12	0.07
		U.6 B.3	29	-12.96	0.17
		U.6 B.12	31	-12.10	
		U.7 B.4	33	-11.52	0.14
		U.6, Cranium 20	34	-11.77	0.21
		U.6, Cranium 17	37	-10.70	
		U.6, Cranium 12	38	-11.90	
		U.6, Cranium 5	39	-11.29	
		U.6, Cranium 23	41	-11.86	
		U.6, Cranium 24	43	-11.46	0.31
		U.6, Cranium 11	45	-13.35	
		U.6, Cranium 1	46	-10.79	
		U.6, Cranium 27	50	-12.49	
		U.6 B.14	52	-12.03	
		U.6, Cranium 3	54	-12.31	
		U.6, Cranium 25	58	-11.39	
	Napatan	U.15 L.6, Cranium 3	100	-12.94	0.05
		U.15 L.6, Cranium 7	101	-13.03	0.07
		U.15 L.6, Cranium 6	102	-13.23	0.05
		U.15 L.5, Cranium 1	103	-12.52	0.06
		U.15 L.9, Cranium 11	104	-12.97	0.05
		U.15 L.6, Cranium 14	105	-13.09	0.04
		U.15 L.9, Cranium 10	106	-12.97	0.04
		U.15 L.5, Cranium 4	107	-13.18	0.05
		U.15 L.9, Cranium 12	108	-12.08	0.04
		U.22 B.2	109	-13.24	0.08
		U.25 B.1	110	-13.35	0.10
		U.14 B.1	111	-9.16	0.07
		U.15 B.2	112	-13.01	0.11
		U.16 B.2	113	-13.85	0.05
		U.10 B.1	114	-13.03	0.05
		U.15 B.1	115	-13.32	0.06
		U.20, Shaft 7, B.1	116	-13.08	0.08

Table E 4 Continued.

		U.20, Shaft 1, B.1	117	-12.25	0.06
		U.20, Shaft 4, B.1	118	-13.35	0.10
		U.17 B.1	119	-12.47	0.06
		U.9 L.28	120	-12.16	0.05
		U.21 L.2	121	-11.89	0.03
		U.9 L.33	122	-13.38	0.05
		U.9 L.33	123	-13.24	0.07
Amara West	New Kingdom		AMR-1	-12.56	0.08
			AMR-2	-11.94	0.06
			AMR-3	-12.49	0.04
			AMR-4	-12.55	0.03
			AMR-5	-13.30	0.06
			AMR-6	-13.00	0.08
			AMR-7	-12.79	0.05
			AMR-8	-9.69	0.10
			AMR-9	-10.64	0.09
			AMR-10	-14.45	0.05
Scandinavian Joint Expedition: C-Group	Middle Kingdom-New Kingdom		CGR-1	-12.37	0.04
			CGR-2	-10.91	0.07
			CGR-3	-12.11	0.06
			CGR-4	-8.45	0.05
			CGR-5	-9.69	0.05
			CGR-6	-7.05	0.08
			CGR-8	-12.34	0.08
			CGR-9	-12.47	0.03
			CGR-10	-10.40	0.07
			CGR-11	-10.97	0.05
			CGR-12	-11.97	0.03
			CGR-13	-13.12	0.04
			CGR-14	-11.31	0.07
Kerma	Middle Kingdom-2nd Intermediate Period		KER-7	-11.45	0.09
			KER-8	-12.56	0.08
			KER-9	-12.17	0.07
			KER-10	-12.76	0.05
			KER-11	-11.99	0.06
			KER-12	-11.76	0.03
			KER-13	-3.85	0.05
			KER-14	-11.58	0.06
			KER-15	-12.78	0.06
Memphis	New Kingdom		MEM-1	-12.85	0.03
			MEM-3	-12.84	0.11
			MEM-4	-11.73	0.05
			MEM-6	-11.68	0.10
			MEM-7	-12.58	0.08
			MEM-8	-11.81	0.09
			MEM-9	-12.47	0.10
			MEM-10	-12.54	0.07
			MEM-11	-12.93	0.04
			MEM-12	-11.82	0.08
			MEM-14	-12.63	0.06
			MEM-15	-11.38	0.06

Table E 4 Continued.

			PHR-1	-8.05	0.09
			PHR-4	-12.41	0.06
			PHR-6	-6.22	0.03
			PHR-7	-9.83	0.04
			PHR-8	-12.55	0.06
			PHR-9	-13.23	0.05
			PHR-12	-13.14	0.07
			PHR-14	-12.75	0.07
			PHR-15	-13.23	0.05
Qurneh	New Kingdom		QUR-1	-13.15	0.08
			QUR-2	-12.96	0.03
			QUR-3	-11.80	0.04
			QUR-4	-13.29	0.02
			QUR-6	-11.32	0.04
			QUR-7	-11.95	0.06
			QUR-8	-12.59	0.06
			QUR-9	-11.96	0.06
			QUR-10	-10.89	0.04
			QUR-11	-12.13	0.04
			QUR-12	-12.93	0.13
			QUR-13	-12.54	0.06
			QUR-14	-12.54	0.03
			QUR-15	-13.13	0.05
Shellal	New Kingdom		SHL-1	-11.04	0.05
			SHL-2	-11.07	0.05
			SHL-3	-13.19	0.04
			SHL-4	-11.44	0.04
			SHL-6	-2.87	0.05
			SHL-7	-11.09	0.07
			SHL-8	-9.37	0.05
			SHL-9	-12.08	0.08
			SHL-10	-13.18	0.04
			SHL-11	-10.82	0.04
			SHL-12	-11.43	0.03
			SHL-13	-11.56	0.06
			SHL-15	-9.39	0.08

VITA

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EDUCATION

Ph.D. **Purdue University**, Anthropology
Thesis: "Bioarchaeology of the Everyday: Analysis of Diet and Activity Patterns in the Nile Valley"
Advisor: Dr. Michele Buzon
Committee: Dr. Stuart Tyson Smith
Dr. Ian Lindsay
Dr. Bryce Carlson

M.S. **Purdue University,** Anthropology, Distinguished (2010)
Thesis: "A Bioarchaeological Investigation of Activity Patterns in New Kingdom Nubia"
Advisor: Dr. Michele Buzon

B.A. **University of California, Santa Barbara**, Physical Anthropology, Honors (2006)
Thesis: "Comparative Analysis of Stature in California Native Americans"
Advisor: Dr. Phillip L. Walker

B.A. **University of California, Santa Barbara**, History, Honors (2006)

RESEARCH & TEACHING INTERESTS

Bioarchaeology, Biocultural Anthropology, Social Theory, Osteological indicators of activity patterns, Isotope analysis, Culture contact, Nubia, Egypt

TEACHING

Course Instructor

Anthropology 312, Archaeology of Ancient Egypt and The Near East
Purdue University (Summer 2012)

Anthropology 212, Culture, Food, and Health
Purdue University (Summer 2013)

Teaching and Research Assistant Positions

Teaching Assistant and Lab Coordinator – Anthropology 201
Purdue University (Fall 2012, Spring 2013)

Research Assistant – Dr. Sharon R. Williams
Purdue University (Summer 2011, Fall 2011)

Research Assistant – Dr. Michele R. Buzon
Purdue University (Summer 2010)

Research Assistant and Lab Director – Dr. Michele R. Buzon
Tombos, Sudan and Purdue University (Spring 2010)

Teaching Assistant – Anthropology 204, Introduction to Human Evolution
Purdue University (Fall 2009)

Teaching Assistant – Anthropology 100, Introduction to Anthropology
Purdue University (Fall 2008, Spring 2009)

PUBLICATIONS

2012

Sarah A. Schrader, "Activity Patterns in New Kingdom Nubia: An Examination of Entheseal Remodeling and Osteoarthritis at Tombos." *American Journal of Physical Anthropology* (149:60-70).

RESEARCH FUNDING

National Science Foundation Dissertation Improvement Grant, "Bioarchaeological Analysis of Diet and Activity Patterns in the Nile Valley,"

Global Research Synergy Grant, "Identifying Migration: Egyptian Diet and Social Identity in Ancient Nubia," Purdue University

Walter Hirsch Award, Dissertation Research Award, Purdue University

Purdue Research Foundation Grant, "Archaeology of the Everyday: A Bioarchaeological Approach to Activity Patterns and Diet of Ancient Nubians," Purdue University

ARCHAEOLOGICAL FIELDWORK AND MUSEUM EXPERIENCE

Tombos Expedition
(December 2012-February 2013)

The British Museum, London, UK
(Spring 2012)

Duckworth Collection, Department of Biological Anthropology, University of Cambridge, UK
(Spring 2012)

Panum Institute, Biological Anthropology Laboratory, University of Copenhagen, Denmark
(Winter 2012)

Tombos Expedition
(December 2010-March 2011)

Tombos Expedition
(January-March 2010)

Port Anta Archaeology Research and Instruction
Instituto Geológico e Mineiro de Portugal, Lisbon (May-August 2008)

Port Anta Archaeology Internship
Instituto Geológico e Mineiro de Portugal, Lisbon (June-August 2007)

AWARDS

Committee for the Education of Teaching Assistants Teaching Award
Purdue University (Spring 2013)

Graduate Teaching Certificate
Purdue University (Fall 2011)

Distinguished Masters Thesis Award
Purdue University (2010)

PROFESSIONAL CONFERENCE PRESENTATIONS AND INVITED LECTURES

Schrader, Sarah A. "Investigating Activity at the Third Cataract (Nubia): Entheseal Remodeling at Kerma and Tombos," abstract submitted to the *American Association of Physical Anthropologists* annual meeting, Knoxville, Tennessee (April 2013)

Buzon, Michele and Sarah A. Schrader "Isotopic Variation of Geographic Origin and Diet in Upper and Lower Nubia During the Bronze Age: An Examination of the Sociopolitical Effects on Population Composition and Lifeways," abstract submitted to the *American Association of Physical Anthropologists* annual meeting, Knoxville, Tennessee (April 2013)

Schrader, Sarah A. "Continuity of Entheseal Changes from the C-Group to the New Kingdom in Ancient Nubia," paper presented at the *Paleopathology in Egypt and Nubia: A Century in Review* symposium, London, United Kingdom (August 2012)

Schrader, Sarah A. "Activity Patterns in New Kingdom Third Intermediate, and Napatan Period Nubia: A Diachronic Study of Osteoarthritis and Entheseal Remodeling at Tombos," poster presented at the *American Association of Physical Anthropologists* annual meeting, Portland, Oregon (April 2012)

Schrader, Sarah A. "The Horse Discovered at Tombos, Sudan." Invited Archaeological Institute of America presentation given at The University of Chicago (October 2011)

Hubbell, Zachariah and Sarah A. Schrader "The Next Wave: An Introduction to Three-Dimensional Laser Scanning." Workshop presented at the *Midwest Bioarchaeology and Forensic Anthropology Association*, West Lafayette, IN (October 2010)

Schrader, Sarah A. and Michele R. Buzon "Investigating Activity Patterns: Osteoarthritis, Vertebral Degeneration and Musculoskeletal Stress Markers in Colonized Ancient Nubia." Poster presented at the 75th Annual Meeting of *Society for American Archaeology*, St. Louis, MI (April 2010)

Schrader, Sarah A. "Social Identity in Skeletal Remains: Osteoarthritis and Musculoskeletal Stress Markers in Nubia." Paper presented at the 42nd Annual Meeting of the *Chacmool Archaeological Association*, Calgary, Canada (November 2009)

Professional Activities and Service

Departmental Service

Vice President – Anthropology Graduate Student Organization (2009-2010)
Secretary – Anthropology Graduate Student Organization (2011)
Faculty Liaison – Anthropology Graduate Student Organization (2009)
Guest Speaker – Purdue Anthropology SocieTy (PAST) (2009)

Professional Societies

Current Anthropology, reviewer
International Journal of Osteoarchaeology, reviewer
American Association of Physical Anthropologists, 2007-present; volunteer
Society for American Archaeology, 2008-present; volunteer
Sudan Archaeological Research Society, 2012-present
Sudan Studies Association, 2010; organizer, volunteer
Midwest Bioarchaeology and Forensic Archaeology Association, 2009-present; session chair, volunteer