OHIO HOPEWELL LEADERSHIP AND BIOLOGICAL STATUS: INTERREGIONAL AND INTRAREGIONAL VARIATION

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Anthropology

2012

ABSTRACT

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This research examined the relationship between social positions of both leadership and prestige and the biological status of two Ohio Hopewell skeletal collections from the Middle Woodland period (ca. 100 BC to 400 AD). Biological status was assessed through an analysis of skeletal markers of nonspecific systemic physiological stress, dietary nutritional stress, nonspecific infection and/or disease, or trauma to the skeletal system. The two skeletal samples used in this research are represented by 46 adults from the Turner Mound Group in the southwest region, and 91 adults from the Hopewell Mound Group, Seip Mounds, Raymond Ater Mound, Edwin Harness Mound, and Rockhold Mound in the south-central region.

This study tested the validity of a proposed archaeological model derived from mortuary analysis for leadership and prestige in Ohio Hopewell society from a skeletal biology perspective. There were two main goals of this research: 1) To evaluate intraregional and interregional differences in the relationship between biological status and social status of male and female adults, and 2) To determine whether differences in biological status were related to differences in social status at prestigious burial mounds within the south-central region.

The results of the intraregional analysis did not reveal statistically significant differences in biological status between males and females in each region. In contrast, the results of the

interregional analysis revealed variation between the biological status of adults from the southwest region and the south-central region. This variation in biological status is consistent with differences detected between the two regions for material culture artifacts, the ideology of political economy, and the access of males and females to positions of leadership and prestige. However, there is little evidence that social status based on sex strongly influenced biological status within or between the two regions. Furthermore, there is no skeletal stress evidence to support the premise that differential access to food resources and nutrients was based on sex differences within or between the two regions. The results of analyses from within the south-central region revealed no statistically significant differences in the biological status of leaders buried in the most prestigious mound (i.e. Hopewell Mound 25) as compared to adults buried in the less prestigious south-central mounds.

This study also contributes to our understanding of the relationship between differing levels of social status and skeletal stress in a complex egalitarian society. Differences in Ohio Hopewell social status, as indicated by mortuary analyses, were most likely based on achievement; however, based on the results of the current study, these differences were not dramatic enough during life, particularly in childhood, to have a measurable effect on an individual's biological status. The lack of statistically significant differences in biological status related to social status supports a model of Ohio Hopewell leadership and prestige primarily based on the achievement of social status.

To Dana and my parents, Gerard and Sheila

ACKNOWLEDGMENTS

I would like to thank Martha Otto, Linda Pansing, William Pickard, and Dr. Bradley Lepper at the Ohio Historical Society for granting me access to the OHS Hopewell skeletal collections. They graciously answered all my questions and helped me locate skeletal material for analysis. Perhaps more importantly, they made me feel at home during my many trips to Columbus. Thank you to Dr. Michele Morgan and Olivia Herschensohn from the Peabody Museum of Archaeology and Ethnology at Harvard University for making my trip to Boston productive and memorable. As a boy who grew up in Massachusetts, I always knew I would study at Harvard one day. Finally, I need to thank Dr. Jonathan Haas and Dr. Robert Martin for granting me access to the Hopewell Mound Group skeletal collections at The Field Museum, and Jamie Kelly for efficiently handling all of the logistics involved with studying these collections.

I received travel funding from several sources in order to study the Hopewell skeletal collections in Boston, Chicago, and Columbus. Thank you to the Forensic Anthropology Lab, Department of Anthropology, the College of Social Science, and the Graduate School at Michigan State University for all contributing to the Kenneth E. Corey Research Enhancement Award that I received. I also am very grateful to the late Dr. Susan Krouse who awarded me financial support for travel on several occasions through the American Indian Studies Program. I am also fortunate to have been a student in a course taught by Dr. Krouse that shaped the focus of my graduate work on prehistoric Native Americans.

The completion of this dissertation was made possible by the help of my advisor, Dr. Norman Sauer. Norm, I am thankful for all that I have learned from you about osteology in the classroom and lab, as well as about life over a beer (or two). Each of my other committee members, Dr. Todd Fenton, Dr. Jodie O'Gorman, and Dr. William Lovis, played an important role in the planning of this study and the writing of this dissertation. The feedback and support I received from Dr. Gillian Bice was excellent. She is without a doubt the best outside reader at MSU. I am also appreciative for the support and advice of my fellow graduate students Wendy Lackey-Cornelison, Jered Cornelison, and Ryan Tubbs. I am particularly grateful for the timely and beneficial feedback on several of my chapters that I received from Dr. Lindsey Jenny. Thank you to Nancy Smith, graduate secretary, for helping me to navigate the bureaucracy of graduate school.

I must also thank several individuals in the Department of Radiology, Division of Human Anatomy for gainful employment over the past years. Thank you to Dr. E. James Potchen, Mr. Thomas Cooper, Dr. James Rechtien, and Dr. Anthony Paganini for the opportunity to teach at MSU, allowing me time to pursue my "human capital", and supporting the completion of this dissertation.

On a personal note, I cannot express in words how thankful I am for the love and support of Dana, my beautiful wife. The sacrifices that Dana has made during the entire dissertation process are innumerable. I am also appreciative of the unconditional love that my smart and handsome boys have provided me, despite the many nights that I said goodnight over the phone. Colin and Gerrit, Daddy is done "his book". My parents are truly exceptional, and have been wonderful supporters of my pursuit of a PhD. They may not have always been sure when the time was right to ask me how my research was progressing, but they never stopped loving and encouraging me. Mom and Dad, thank you! Thank you to Christian, my younger brother, who helped motivate me to finish my dissertation by completing his own PhD before me. Finally, thank you to all the wonderful members of my wife's family who have indoctrinated me into Spartan Nation, and demonstrated to me all that is special about Michigan State University.

GO GREEN!

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Chapter 1: Introduction

Although contemporary biomedical research reveals that socioeconomic status has an impact on a person's health status, this association is not as clear for pre-contact Native American societies. This study contributes to filling this void through an examination of the relationship between social status and biological stress from a skeletal biology perspective.

Contemporary North American researchers in health care fields, such as public health and epidemiology, who examine the complex relationship between individuals and the overall quality of their health, have concluded that along with age and gender, socioeconomic status is a powerful factor in the determination of an individual's health status (e.g. Adler et al., 1994; Fiscella, 2004; McDade, 2009; Wilkinson, 1999). Studies have focused on the association of socioeconomic status and specific diseases, in which people of lower socioeconomic status have an increased prevalence of adult diabetes (Jotkowitz et al., 2006). Sapolsky (2004) reviews the evidence that stress in both animals and humans can have an impact on health, in particularly on the cardiovascular and immune systems. "Do poor humans suffer a disproportionate share of poor health? The answer must be a robust, Yes - regardless of gender, age, or race…" (Sapolsky, 2004:412).

A number of previous researchers have used a bioarchaeological approach to examine the relationship between social status and skeletal health in North America (e.g. Buikstra, 1976; Cook, 1981; Goodman et al., 1988; Powell, 1991). Traditionally, however, the vast majority of these studies have focused their research on ranked societies, such as Mississippian period skeletal populations (e.g. Goodman et al., 1988; Powell, 1991). In a comprehensive review article on skeletal health and social organization, Danforth writes: "Bioarchaeological studies of egalitarian societies are not as numerous as might be predicted considering that this level of political organization characterized the majority of prehistoric societies, especially in the New World" (Danforth, 1999:6).

This dissertation research examines the biological status of a pre-contact Native American society that does not display substantial social stratification. In this study, biological status is generally defined as the quality of skeletal health as evaluated by markers of skeletal stress and trauma. Social status is based on archaeological and sociological theories and evidence involving the social and political organization of prehistoric societies.

The region of study and skeletal sample used for this research is the Ohio Hopewell of the Middle Woodland cultural period, ca. 100 BC to 400 AD (Greber and Ruhl, 1989). Hopewell regional traditions were located in most of the eastern half of North America, especially focused along the valleys of the Mississippi and Ohio Rivers. Hopewell societies are known for the creation of large earthworks and burial mounds and the widespread trade of exotic materials used for the production of artwork that was incorporated into elaborate mortuary rituals. Recent edited archaeological volumes by Carr and Case (eds., 2005) and Case and Carr (eds., 2008), utilize a "thick prehistory" approach in an attempt to personalize and describe the Ohio Hopewell people. Using a regional, multi-site, mortuary archaeological, and bioarchaeological perspective, the authors and their colleagues argue against the notion that there was a pan-Hopewellian interaction sphere, which produced similar cultural features across the geographic spread of the Hopewell in North America.

Archaeologists have examined and documented archaeological evidence of different North American Hopewell regional traditions since the 1960s, such as the Illinois Havana Hopewell and the Ohio Hopewell (e.g. Prufer, 1964; Struever, 1964; Caldwell, 1964; Brose and

Greber, eds., 1979). More recently, archaeologists have detected local variation between Ohio Hopewell regions regarding the architecture of mortuary ceremonial centers, ceramics, and stone tools (Carskadden and Morton, 1996; Seeman, 1996; Hawkins, 1996; Nolan et al., 2007). Regional variation in the ritual, social, and symbolic significance of artifacts, such as panpipes and copper earspools has also been reported (Turff and Carr, 2005; Ruhl and Seeman, 1998). Additionally, research has indicated evidence for regional differences between gender and the access of social positions of leadership and prestige in the Ohio Hopewell (Field et al., 2005; Rodrigues, 2005), and the orientation of political economy (Coon, 2009). Most of this regional variation in Ohio corresponds with different river drainage systems.

In this study, the theoretical framework for Ohio Hopewell social status is based on the premise that an individual's social role and resulting degree of prestige and leadership is reflected in their burial by the inclusion of artifacts that mark different, identifiable social roles in their community (Carr and Case, 2005). Field et al. (2005) utilize mortuary analysis at the local level in Ohio to demonstrate different regional patterns of female access to prestige and leadership positions. Field and her colleagues detect that in the south-central region males filled the majority of prestigious leadership positions, while in the southwest region women had increased access to these social positions of prestige and leadership. Field and her colleagues hypothesize that their analysis of male and female local differences in access to positions of leadership may also indicate regional differences in Ohio regarding matrilineal and patrilineal descent systems.

This study utilizes skeletal markers of biological status to examine regional differences between Ohio Hopewell adult males and females from the south-central and southwest regions. The southwest (SW) region skeletal sample in this research is represented by 46 adults from the

Turner Mound Group located on the Little Miami River. The south-central (SC) region sample is comprised of 91 adults from the Hopewell Mound Group, Seip Mounds, Raymond Ater Mound, Edwin Harness Mound, and Rockhold Mound located on the Scioto River or one its tributaries, Paint Creek.

Biological status in this study is assessed by the analysis of skeletal markers of nonspecific systemic physiological stress, dietary nutritional stress, nonspecific infection and/or disease, or trauma to the skeletal system. Linear enamel hypoplasias (LEH) are an interruption in the growth and development of an individual's teeth. LEH lesions are caused by nonspecific systemic stress related to nutritional deficiency and/or childhood illness. Porotic hyperostosis affects the spongy bone of the bone of cranial vault and is also the result of nonspecific systemic stress from dietary nutritional deficiency and/or infection. Adult stature is an indicator of nutritional stress and to a lesser extent, nonspecific infection. Periosteal reactions indicate nonspecific disease and/or infection, or trauma. Skeletal trauma is the final marker of biological status used for analysis, and is the result of accidents or violence. The objectives of this study are addressed by using the above skeletal markers to evaluate biological status from the two different Ohio Hopewell regions and to compare the results by sex, within and between regions.

Research Goals

There are three goals of this research study.

1) To document the markers of biological status that indicate skeletal stress and trauma for Ohio Hopewell people from the SC and SW regions of Ohio.

2) To evaluate intraregional and interregional differences in the relationship between biological status and social status of male and female adults.

3) To determine whether differences in biological status were related to differences in social status at prestigious burial mounds within the SC region.

This research addresses the following fundamental question: Does the biological status of Ohio Hopewell skeletal populations reflect variation in social status? More specifically, the first set of research questions was developed to answer the question: Do local differences in selected markers of biological status exist for adult males and females within and between different Ohio Hopewell regions? In the process of examining the potential local differences of markers of biological status, the archaeological model constructed by Field et al. (2005) regarding differences in the nature of male and female leadership and prestige in two different geographical regions of Ohio is tested from a skeletal biology perspective. The following question is used to test Field and her colleague's model: Is there an association between indicators of biological status and proposed greater access to leadership and prestige for each sex within and between the SC and SW regions?

The second set of research questions examines differences in markers of biological status within and between prestigious SC burial mounds. The SC region contains the most elaborate Ohio Hopewell ceremonial centers that are marked by large burial populations, a high percentage of prestigious community leaders, the deposition of exotic artifacts, and elaborate mortuary rituals. Is the biological status of the adults buried at the most prestigious mounds different than those adults buried at the other less prestigious mounds? In essence, this research study assesses whether the model of leadership and prestige proposed by Carr and Case (2005) for the Ohio Hopewell has any impact on skeletal biology.

The anthropological approach used in this dissertation research is bioarchaeological; it integrates archaeological perspectives on the social roles of Ohio Hopewell people with an analysis of their skeletal biology. Bioarchaeology incorporates the analysis of human skeletal remains into the archaeological investigation of a group of people's lifeways. There is a diverse array of previous bioarchaeological research involving human skeletal remains, which includes: dietary reconstruction; determination of health and nutrition status of groups and individuals; biological distance between populations; activity levels as evidenced from cross-sectional geometry; paleodemography; and analysis of interpersonal violence and trauma (e.g. Larsen, 1997). The theoretical framework for this research is rooted in contemporary mortuary analysis. Mortuary analysis is the attempt through the archaeological excavation and analysis of mortuary sites to reconstruct the social organization of past societies. The theoretical goal of this study is to integrate existing mortuary theory on the social status of Ohio Hopewell people with an analysis of their biological status in a bioarchaeological framework.

Organization of Dissertation

In Chapter 2, the question of "Who Are the Ohio Hopewell?" is addressed as the literature is reviewed regarding their lifeways. This chapter also examines previous studies of Hopewell mortuary analysis and Ohio Hopewell mortuary analysis conducted by Carr and Case (2005). The latter is important background knowledge for understanding the theoretical approach to mortuary analysis used by Carr and Case, and how this is applied to their analysis of the leadership and prestige of Hopewell social leaders. This chapter also examines Ohio Hopewell social status and proposed regional differences of male and female access to social positions of leadership and prestige (Field et al., 2005), as well as archaeological evidence of variation in social status between different prestigious SC burial mounds. This study's research questions are introduced at the end of Chapter 2.

Chapter 3 discusses the concept of stress in skeletal biology and its effect on the skeletal system. It reviews the literature pertaining to the markers of skeletal stress and trauma utilized in this study to evaluate biological status and what each marker may reveal about an individual's biological status. It also reviews previous studies that have examined the relationship between biological and social status in the Eastern Woodlands. Chapter 4 discusses the skeletal collections used for the SW and SC regions of Ohio and summarizes important background information about the sites from where the skeletal collections were excavated. This chapter also describes the methods used for data collection and analysis. The end of Chapter 4 details the specific research hypotheses that were tested in the analysis phase of this study.

Chapter 5 contains the results of the statistical analysis of this study in three parts. First, the demography of the skeletal collections is presented. This is followed by overview statistics that detail the frequency of the different skeletal markers of biological status in the two skeletal collections from different regions. The second part of this chapter reveals the results of the testing of each of the three specific research hypotheses that examine local differences in markers of biological status within and between each region based on sex. The third part contains the results of the statistical testing of the last four research hypotheses that examine whether there is a difference in markers of biological status based on prestigious burial mound location in the SC region. The results of this study and the integration of whether Ohio Hopewell biological status is in accord with the expectations of archaeological hypotheses for Ohio Hopewell social status are discussed in Chapter 6. Chapter 7 summarizes the contributions and limitations of this study, and identifies future lines of research.

Chapter 2: Who Are the Ohio Hopewell?

This chapter answers the question "Who are the Ohio Hopewell?" as it reviews the literature concerning their subsistence and settlement lifeways, and mortuary practices. This chapter explores Ohio Hopewell social status and organization. It examines interregional differences of male and female access to social positions of leadership and prestige between the south-central (SC) and southwest (SW) regions of Ohio. This chapter also highlights the local variation amongst different prestigious burial mounds within the SC region. At the end of this chapter, the research questions and expectations of this study are introduced.

Historical Overview

The term Hopewell describes people who lived in the Middle Woodland cultural period in North America. Over time, the term Hopewell has been used to represent a culture type, a culture phase, temporal horizon, and even a cult (Pennefather-O'Brien, 2006). The name Hopewell comes from the family that owned the farmland in Ross County, Ohio, which contains the Hopewell Mound Group, the type site, comprised of large earthworks and associated mounds first excavated by William K. Moorehead in 1891. The Ohio Hopewell regional tradition has been dated to ca. 100 BC to 400 AD (Greber and Ruhl, 1989), and ca. 1 to 400 AD (Seeman 1995).

Hopewell societies are known for their geographical spread from the Eastern Woodlands to the Rocky Mountains and from Wisconsin to Florida. Hopewell regional traditions are found in most of the eastern half of North America especially centered along river valleys associated with the Ohio and Mississippi Rivers. Hopewell populations are known for the creation of large geometric earthworks that enclosed from 10 to 100 acres of land, and associated mounds that were used as public ceremonial and mortuary centers. Additionally, the Hopewell may have built the "Great Hopewell Road" composed of meter high earthen walls for the length of 17 km, and perhaps as many as 90 km, in central Ohio (Lepper, 2006).

The Hopewell are also known for trading nonlocal raw materials, such as copper from Michigan's Upper Peninsula, alligator and shark teeth and conch shells from the Florida coast, and mica from the southern Appalachians (Griffin, 1967). These materials were then used for the creation of exotic stone, shell and copper artifacts that are found in mortuary contexts. In turn, copper artifacts were distributed to southeast states such as Florida and Georgia and to northern states from New York to Iowa, while platform pipes made of Ohio pipestone were distributed from New York to Wisconsin (Griffin, 1967). Seeman (2004) suggests the Hopewell symbolic system focused on animal and ancestral symbolism was, at its time, one of the most complex present in North America. The Ohio Hopewell are also well known for their art that depicts many realistic animals including the following: platform pipes with effigies of various animals, clay figurines of humans and animals, drawings of animals on sheets of mica and copper, and engravings of animals on both nonhuman and human long bones (Griffin, 1967).

The concept of Hopewell has changed over time, as it has evolved from the belief that it was a "single unified society" to an idea of Middle Woodland societies who created alliances with one another Abrams (2009). Abrams writes, "Hopewell connotates those Middle Woodland societies participating in some expansive form of riverine-specific *regional integration* materially reflected through large-scale earthworks and/or earthwork centers and exotic artifacts principally deposited in funerary contexts" (Abrams, 2009:172). Several different regional Hopewell traditions have been identified, such as the Ohio Hopewell, the Goodall tradition in northern Indiana and southern Michigan, the Crab Orchard tradition in southern Indiana and Illinois, the Havana tradition in Illinois, and the Kansas City Hopewell along the Missouri River (Griffin, 1967). Mortuary sites along the Scioto River Valley in SC Ohio are considered to represent the most elaborate displays of Hopewell deposits of exotic artifacts and mortuary rituals (Abrams, 2009).

In the early part of the twentieth century, archaeological excavations were focused on the large earthwork sites of the Hopewell and were conducted throughout Ohio, and several of these expeditions were led in an attempt to obtain artifacts for the Pre-Columbian display at the Chicago World's Fair (Dancey, 2005). A review of the Ohio Hopewell and the development of archaeological theory over time for interpreting their societies has been provided by Abrams (2009). In the mid 1960s, archaeologists started to excavate sites other than only earthworks and mounds. Caldwell (1964) and Struever (1964) developed the theory that began to examine the identify of Hopewell culture at the regional level in the volume *Hopewellian Studies* edited by Caldwell and Hall (1964). In this volume, the Ohio Hopewell culture is examined and documented (Prufer, 1964), as well as the Havana Hopewell tradition from west-central Illinois and the Orchard Tradition from southern Illinois (Struever, 1964). The identification of regional differences in Hopewell traditions, led Caldwell (1964) and Struever (1964) to develop the "Hopewell Interaction Sphere" model in which different regional Hopewell traditions share exotic materials and similar mortuary rituals. Caldwell writes, "that various and separate societies were interacting within and beyond the boundaries of their respective regional traditions is perhaps the one thing about the Hopewellian situation we can be sure of" (Caldwell, 1964:138). In the Hopewell Interaction Sphere model, different regional Hopewell traditions exchanged materials and ideas related to mortuary artifacts and behavior, while also adapting at the regional level to their specific environment.

Research published in *Hopewell Archaeology: The Chillicothe Conference* (Brose and Greber, eds., 1979) also addressed differences in different geographical regions for Hopewell communities. Regional studies in this volume are divided into four geographical areas: central, western, northern, and southeastern. Abrams (2009:173) astutely notes that this also marks the point in Hopewell archaeology when cultural ecology was considered as part of research hypotheses. The issue of how Hopewell groups in different ecological niches adapted to their environment has guided the focus of Hopewell regional studies (e.g. Asch et al., 1979). Ford (1979) discusses the implications of Hopewell subsistence for social organization. In addition, Brown (1979) analyzes Hopewell charnel houses and mortuary crypts, Seeman (1979) examines charnel house ritual and its role in redistribution, and Greber (1979a) compares the mortuary rituals at several SC Ohio sites. This volume also contains the examination of non-mortuary components of a SC Ohio site by Baby and Langlois (1979) which represents a paradigm shift away from previous Ohio Hopewell archaeological research chiefly focused on burial mounds (Abrams, 2009).

Where Did the Ohio Hopewell People Come From?

The Scioto Hopewell tradition found in the SC region of Ohio at sites located along the Scioto River and Paint Creek, which are tributaries of the Ohio River, was defined by Prufer (1964). The Scioto Hopewell region is considered by archaeologists to be the epicenter of the development of Ohio Hopewell communities (e.g. Abrams, 2009; Seeman and Branch, 2006).

There are at least nine major mounds and earthworks sites and numerous smaller mounds within 30 km of the Scioto River and Paint Creek confluence (Ruby et al., 2005). Archaeologists have proposed that the people from the Havana Tradition of Illinois migrated east to start the Scioto Tradition (e.g. Prufer, 1964). However, Dancey (2005) does not agree that large-scale migrations from Illinois to Ohio explain the development of the Hopewell in Ohio, because these migrations were more likely at a smaller scale. Several Ohio archaeologists have established that the Adena culture of the Early Woodland period occurs in the central region of Ohio before the Hopewell period (e.g. Otto, 1979; Greber, 2005). Seeman and Branch (2006) effectively demonstrate that the Adena people were also prolific mound builders, but a key difference between the Adena and Hopewell peoples was the location of Hopewell mounds. Hopewell earthworks and mounds are focused on river valley terraces along the Scioto-Paint Creek confluence, and also more clustered around two main sites: Hopewell Mound Group and Mound City.

The question of where the Ohio Hopewell people originated from has also been asked by physical anthropologists. Reichs (1975, 1984) analyzes biological distance utilizing cranial measurements and discrete cranial nonmetric traits in order to test the hypothesis that Hopewell peoples migrated from Illinois to Ohio. Her results do not support this hypothesis. Reichs concludes that the Hopewell had two separate biological lineages, one in Illinois and one in Ohio. Her Ohio sample is composed of individuals from SC sites: Hopewell, Seip, and Raymond Ater Mound; and the Illinois sample is from the Gibson and Pete Klunk mound groups.

In another biodistance study, Sciulli and Mahaney (1986) find that Ohio Valley populations from the Late Archaic through Middle Woodland are derived from the same ancestors. The sample that represents the Middle Woodland is composed of individuals from the Hopewell Mound Group and they employ cranial measurements and discrete nonmetric traits. In their study, Sciulli and Mahaney (1986:189) conclude there is “strong phenotypic similarity among the terminal Late Archaic samples and the Hopewell sample”. They do not rule out small-scale migration from Illinois to Ohio by Hopewell people, but their data does not support massive migrations from Illinois as the source of Ohio Hopewell populations. They propose that their results indicate that Ohio Valley groups “form an ancestor-descendant chain of populations or an evolutionary lineage” (Sciulli and Oberly, 2002: 444). Furthermore, the authors note that this lineage extends through 1,800 years of prehistory from the Late Archaic through the Late Woodland periods.

Most recently, research by Pennefather-O’Brien (2006) examines biological distance in Hopewell skeletal populations from eleven different archaeological sites and four different Hopewell regional traditions. Populations from Crab Orchard, Scioto, Havana, and Marksville (Louisiana) traditions are analyzed based on cranial nonmetric (epigentic) traits. In general, her results support the hypothesis that there is overall interregional similarity for biodistance across her research sample. She postulates that this biological relatedness, i.e. shared kinship, may be one component of the Hopewell Interaction Sphere.

Pennefather-O’Brien’s results demonstrate that the Klunk Mounds and Utica Mounds sites, which are both from the Illinois Havana tradition, have individuals that are statistically similar to one another. Furthermore, the Klunk and Utica populations are not different than individuals from the Turner Mound Group in SW Ohio. Interestingly, of the five Havana tradition sites involved in this study, only individuals from Klunk and Utica Mounds are biologically related. This is not the case for individuals from the Crab Orchard (southern

Illinois) and Scioto (Ohio) traditions, as individuals in these traditions display strong intraregional biological relationships. Individuals from Hopewell Mound Group are different than all other sites except for Turner; this means individuals from the Turner and Hopewell sites are statistically similar to each other. Pennefather-O'Brien also discovers more interregional similarity between regional Hopewell groups than previous biodistance studies (e.g. Reichs, 1975, 1984; Sciulli and Mahaney, 1986). She attributes this may be due to the fact that her research design utilizes many more epigenetic traits than other studies, has a very large sample size (n = 573 individuals), and that no previous biodistance analysis included Klunk, Utica and Turner Mounds in the same study (Pennefather-O'Brien, 2006).

Physical anthropologists have also studied Hopewell biological relationships through the analysis of mitochondrial DNA (mtDNA). In a study of biological relatedness based on mtDNA, Mills (2003) supports Sciulli and Mahaney's (1986) hypothesis that there is biological continuity in the Ohio River valley over time, as the preceding Adena population and Ohio Hopewell cluster together for biological relatedness. Through the analysis of mtDNA, Bolnick and Smith (2007) also find evidence for gene flow between Illinois and Ohio Hopewell populations. However, the direction of flow is from Ohio to Illinois which counters the hypotheses of archaeologists, such as Prufer (1964), who argue for migration from Illinois to Ohio.

A recent study using isotopic analysis refutes Bolnick and Smith's (2007) mtDNA hypothesis that migration was from Ohio to Illinois. Strontium isotopic analysis finds a larger number of individuals with non-local isotopic signatures buried at the Hopewell Mound Group than at Hopewell sites in Illinois (Beehr, 2011). Five of the 36 adults buried at Hopewell Mound Group are possible immigrants to the region (Beehr, 2011). This is interpreted by Beehr as evidence that the Hopewell Mound Group was the center of population movement, although the potential immigrants at Hopewell did not come from the Illinois sites in her study.

Lifeways: Settlement and Subsistence

Settlement

This section reviews the literature regarding the settlement and subsistence patterns of Ohio Hopewell people. Based on the vacant ceremonial center model (Prufer, 1964) and dispersed agricultural hamlet model (Prufer, 1965) for Ohio Hopewell settlement, Dancey and Pacheco (1997) propose the dispersed sedentary community model for Ohio Hopewell settlement and subsistence. This is one of the dominant contemporary models for the interpretation of Ohio Hopewell settlement, and has also been termed the dispersed sedentary household model (Dancey, 2005; Pacheco and Dancey, 2006). This model hypothesizes that single or multiple family units lived in hamlets (or homesteads) dispersed across the landscape. These homesteads were within walking distance to a shared, centrally located ceremonial earthwork which was a corporate "sacred place". The homesteads contained several generations of the family, and were composed of bent pole houses that were located 200 to 300 meters apart from one another (Dancey, 2005). Carr (2008b) suggests residential communities were composed of five to twenty-five people.

In this dispersed sedentary community model, the homestead can be viewed as an economic and reproductive unit which allowed the people to utilize the ecological niche near their home base for most of the year. The other type of habitation sites incorporated in this model are used as specialized camps for obtaining resources, such as hunting or fishing camps

(Pacheco and Dancey, 2006). Hopewell people may have moved around the landscape to other camps for logistical reasons, but Pacheco and Dancey argue that after these brief periods of habitation somewhere else that they then returned to their homestead (Pacheco, 2010). Pacheco notes that the use of the term permanent does not mean the Hopewell were always living in the same place for the entire year. "It does imply, however, that members of a settlement who leave on trips do eventually return to their residential base" (Pacheco, 2010:36).

Carr supports the vacant ceremonial center-dispersed hamlet model, but with two main modifications. Carr (2005a; 2005c; 2008b) and Bernadini (2004) hypothesize that multiple earthworks and mound centers were used by each different community in the SC region, and some earthworks were shared by multiple communities which fostered community interaction and cooperation for these dispersed communities. Bernadini (2004) hypothesizes that a dispersed Hopewell population in the SC region was responsible for the shared construction of five different tripartite ceremonial centers which would require several hundred laborers working over a period of 10 years to complete, based on a conservative estimate.

On the other side of the settlement discussion are the archaeologists who counter that the Ohio Hopewell represent seasonally mobile foragers. Yerkes and Cowan analyze most of the same archaeological sites as Pacheco and Dancey, but reach different conclusions regarding Ohio Hopewell settlement and subsistence. Yerkes (2005, 2006) does not challenge the idea that Hopewell people gathered at the earthworks for scheduled rituals, but he argues that when they dispersed they did not return to sedentary homesteads, rather they moved across the landscape in search of seasonal resources. Cowan (2006) postulates the Ohio Hopewell were more residentially mobile than depicted by Pacheco and Dancey's model. Cowan counters that the habitation sites that Pacheco and Dancey refer to as homesteads are instead small hamlets that were used by visitors when they attended ceremonies at the nearby earthworks, since many of these sites are located within a one hour walk of the earthworks. A key criticism of the dispersed sedentary model raised by both Yerkes and Cowan is whether there is enough archaeological evidence for long term habitation at the sites that Pacheco and Dancey categorize as homesteads.

Other researchers argue that the Ohio Hopewell settlement model was most likely not one of the extremes of the spectrum (i.e. sedentary or mobile). The discussion of Ohio Hopewell settlement is hindered by researchers using data from many different river drainages to support their hypotheses (Carr, 2008b). In the central Scioto-Paint Creek area, the diverse and abundant food resources supports the model of residential stability with some logistical mobility for certain resources, whereas in river drainages in Ohio with less productive ecological niches, there is a different pattern. In the northern and southern part of the Scioto Valley these river valleys are less productive, thus the archaeological evidence supports a pattern involving more residential mobility than in the central Scioto Valley (Carr, 2008b). Abrams (2009) also agrees that the pattern of Ohio Hopewell settlement depended on the environment in which each specific population was located. If the community was located in a diverse and rich ecological niche there is a greater chance for more long term settlement. Smith (2006) postulates that the Hopewell utilized a settlement model that was dependant on hamlets during the growing seasons and then during the cold season they moved to upland hunting camps. Griffin asks the question: Where did the Ohio Hopewell hibernate during the winter (as cited in Smith, 2006)?

Burks and Pederson (2006) report that their analysis of the nonmound debris at the Hopewell Mound Groups reveals that sites near this earthwork were not permanent habitation sites. Rather, the artifacts which are present (fire-cracked rock, small quantities of stone tool debitage, and few fragments of pottery) indicates that these sites were used for short term occupation and for limited, nondomestic activities. Burks and Pederson (2006) hypothesize that these sites at Hopewell Mound Group indicate the location of where people camped when they visited the earthworks for social and ceremonial events. A somewhat similar conclusion is suggested for the nondomestic use of sites near the Seip Earthworks by Baby and Langlois (1979) who interpret these sites as representing the location of specialized workshops used by artisans to prepare artifacts for mortuary ceremonies.

Subsistence

The consensus of contemporary archaeologists is that Hopewell people did not depend on maize as their primary food source. This stance has been argued based on isotope studies, dental wear and pathology research, and the lack of archaeological evidence for widespread agriculture. Bender et al. (1981) determine that carbon isotope values for Hopewell sites from Wisconsin, Illinois, and Ohio are similar in all three regions and consistent with the carbon isotope values of populations without a maize-based diet. Other carbon isotope research by Sciulli (1997:515) demonstrates that maize was not part of the diet of Ohio populations from the Late Archaic through Late Woodland, but maize contributes to nearly 50% of the diet in the Late Prehistoric period. Beehr (2011) finds the diet of individuals from Hopewell Mound Group and two Illinois sites was composed of mainly C3 plants (not maize) based on strontium isotopic analysis. Sciulli's (1997) dental analysis of 40 different skeletal population from the upper Ohio River Valley from the Late Archaic to Late Prehistoric time period reveals that it is not until the Late Prehistoric period (ca. 1,000 years BP – 350 years BP) that there is dental evidence for a maize-based diet in Ohio populations. Sciulli and Oberly (2002) conclude the Ohio Hopewell are characterized by low rates of dental wear, and low frequencies of caries, abscesses, and antemortem tooth loss. These are not results consistent for a population with a high-carbohydrate diet based on maize agriculture.

Based on paleoethnobotanical evidence, Wymer (1996, 1997) hypothesizes there is evidence in central Ohio that the Hopewell were farmers, not of maize, but of domesticated plants. These plants belong to the Eastern Agricultural Complex and can be categorized as oily (i.e. sumpweed), or starchy (i.e. maygrass, erect knotweed, and goosefoot). There is also evidence in the Hopewell diet of squash seeds and rinds, fruit and berry seeds, and nuts from many types of trees (Wymer, 1996). Wymer proposes that the Hopewell used slash and burn techniques to modify the forest in order to make room for these domesticated plants in what she terms "garden plots". She argues that cultigens form these gardens were a major component of the Hopewell diet (Wymer, 1996). Furthermore, based on the small sizes of these discovered sites, this most likely indicates a small population who maintained these garden plots (Wymer, 1997). Wymer also asserts that planting, maintenance, and harvesting of these plants implies a certain level of sedentism based on the amount of energy expended for these activities.

Dancey (2005) categorizes the Hopewell as having a subsistence based on the intensive harvesting of both wild and domesticated foods. Pacheco and Dancey (2006) agree that Hopewell groups were not farmers, contrary to Wymer (1997), but they represent a "domesticatory society" that was tied to the natural reproduction cycle of plants and animals. The Hopewell utilized domesticated starchy and oily plants, and cultivated the seeds in small gardens, but were not solely dependent on these resources, as they also hunted deer, gathered nuts, and fished in the different ecological niches near their homesteads. Because such a subsistence strategy is best utilized by small dispersed groups with a home base, Pacheco and Dancey weave together settlement and subsistence for their dispersed sedentary household model of Hopewell societies. Pacheco and Dancey (2006) propose that the dispersed model of Hopewell communities also plays a part in explaining why mounds and earthworks were created. They think these structures were used for ceremonies which brought isolated people from homesteads together for large scale social interactions at these sacred spaces.

Yerkes (2006) strongly disputes that the Hopewell were farmers based on several lines of evidence. The lack of prehistoric agricultural tools in the Hopewell toolkit, the lack of evidence that wild plants were dependant on humans for reproduction, and the lack of archaeological evidence for long-term occupation at habitation sites (Yerkes, 2006:57-59). Yerkes argues that the Hopewell represent complex, mobile and dispersed tribes whose mobility was caused by the seasonality of available resources. He proposes that the Ohio Hopewell occupied lowland sites in warmer months and upland sites in the colder months, and contends the use of cultivated plants supplemented a diet based on meat from hunting, especially white-tail deer, and the gathering of wild foods and nuts. Yerkes (2006) concludes the Hopewell were not agricultural chiefdoms that possessed food surpluses that in turn led to the creation of earthworks directed by chiefs. Rather, feasts and rituals at these ceremonial centers were important for the social integration of these isolated, but mobile groups.

Smith (2006) suggests a middle-ground view of Ohio Hopewell subsistence, noting they were neither solely hunter-gatherers nor agriculturists, but low-level food producers. Smith (2001) makes the case for the Hopewell as low-level food producers who utilized domesticated plants in addition to hunting and gathering wild plant foods and nuts. Smith defines domestication as having some control of the reproduction cycle of plants that then leads to morphological changes in these plants (e.g. larger seeds). Activities that lead to the domestication of wild plants include planting seeds in selected locations, weeding, harvesting, and storing. Smith (2001) states there is evidence to support the hypothesis that the Hopewell cultivated at least seven different indigenous seed crops and that four of these crops were domesticated. Carr (2008a:79) agrees with the notion that wild foods (meat, fish, nuts, and berries) were a main component of the Scioto Hopewell diet that was supplemented by cultivated plants. Carr also supports Wymer's (1997) hypothesis that cultivated plants were grown in land cleared of trees, i.e. swidden farming.

In summary, although there is continued debate regarding Ohio Hopewell settlement and how long a community needs to live in one habitation area during the year to be considered sedentary, there is consensus that these populations were dependant on a broad based subsistence pattern that involved the gathering of wild and domesticated plants and nuts, hunting deer and other mammals, and fishing. Based on both archaeological and biological data, it also appears that maize was not part of the subsistence pattern of Ohio Hopewell populations. The greatest elaboration of Hopewell culture in Ohio, as evidenced by mound and earthworks construction and exotic materials for artifacts, was the Scioto River Valley which also happens to be an ecological niche with the potential for the production of high energy foods (Abrams, 2009:176).

Review of Ohio Hopewell Mortuary Analysis

Note Regarding Social Status Terminology

Throughout this chapter, a literature review of previous mortuary analyses of Ohio Hopewell archaeological sites is presented. The term "social status" can be problematic in archaeological and bioarchaeological studies, because different researchers employ different operational definitions and utilize different archaeological attributes to assess social status. When reviewing literature in this dissertation, the specific social status terminology that each author uses in his/her publication is utilized. For the most part, the use of the term social status in this dissertation infers that social, i.e. hierarchical, ranking existed in the society in question. Several of the bioarchaeological studies reviewed in other chapters of this dissertation in which the term "social status" is utilized are stratified societies with well-documented archaeological evidence for hierarchical social ranking (e.g., Cook, 1981; Powell, 1991). Fried provides a useful description of a ranked society: "A rank society is one in which positions of valued status are somehow limited so that not all those of sufficient talent to occupy such statuses actually achieve them" (Fried, 1967:109). In essence, this creates a pyramid in which as rank level, or hierarchy, increases, the number of people that can fill these ranks decreases. Possible terminology used by other researchers in this dissertation includes: social status, social ranking, ranking, ascribed ranking, achieved ranking, social prestige, leadership, wealth, and rank.

Greber's Mortuary Analysis

N'omi Greber was the first archaeologist to systematically approach the topic of assessing the level of social organization of the Ohio Hopewell through mortuary analysis. Greber (1979a) examines three "Classic Ohio Hopewell sites": Seip Earthworks (SC Ohio), Raymond Ater Mound (SC Ohio), and the Turner Burial Place at the Turner Mound Group (SW Ohio). Greber uses the following variables as the source of data for rank sum statistical analysis: artifacts, burial type, spatial organization, age, and sex of buried individuals. Before discussing her results, it is important to note that Greber utilizes Fried's (1967) definitions of status (ascribed and achieved), prestige, and value. "Essentially, status is used in the sense of social standing, with prestige being the ideological aspect of status" (Greber, 1979a:37). She also works from the premise that each cemetery represents one distinct Ohio Hopewell community. Greber (1979a) detects a range of differing social structure and complexity at these three sites. Her spatial and artifact analysis reveals three main ranked social divisions, with membership within these divisions ascribed, at Seip-Pricer (Seip 1), and two ranked social divisions (and possibly a third) at Seip-Conjoined (Seip 2), which has half as many burials as Seip-Pricer.

Greber (1979a) finds less social complexity at Ater Mound in the SC region. She identifies one major social component, but ranking exists within this group. There is a 2:1 male to female ratio of buried individuals and a complete lack of infants and children at the site that Greber interprets as hierarchy within the group based on age and distinct sex differentiation. It should be noted, however, that this site was not fully excavated and all burials were not recovered.

At Turner in the SW region, Greber (1979a) finds two major social groups based on grave orientation, but the two social divisions appear more equal in terms of ranking to one another, unlike Seip-Conjoined (Seip 2). The Turner site also has sampling issues, as the entire site was not completely excavated. There is a high percentage of subadult burials (38%) at Turner compared to the other sites, and known males and females have similar ranking to one another.

Greber (1979b) identifies three major social divisions that correspond to the tripartitae (mounds with three lobes) pattern of earthworks at Seip-Pricer (Seip 1), Seip-Conjoined (Seip 2), and the Edwin Harness Mound. Within each of these three major social divisions, Greber proposes membership was ascribed and there were kin-related subgroups. At these sites "group affiliation appears to have been a major social force with individuals achieving social status in a manner suitable to their ascribed divisional association. Obviously in many societies an individual who begins life in a kin-group having a relatively high social prestige may more easily acquire achieved statuses than a person who begins in a less prestigious kin-group" (Greber, 1979b:38). Thus, Greber proposes that individuals increased their social status on the basis of achievement within the ranked group they had been ascribed to at birth.

Conversely, Greber and Ruhl (1989) do not discover evidence of social ranking at the Central Mound of Hopewell Mound 25. The Central Mound is associated with two of the most elaborate deposits of any Ohio Hopewell site, other than the thousands of flint discs found at Hopewell Mound 2 (Greber and Ruhl, 1989:80). Some of the large number of artifacts deposited in the two clay basins (called altars by previous researchers) include over 500 copper and other metal earspools, 19,000 pearls, over 1,000 shell beads, and roughly 300 bear claws. According to Greber and Ruhl (1989:292), there "appears to be little or no differences in social ranking" among the major groups (they speculate two to five) in different burial areas of the mound, but there is possible "internal social ranking" within these major groups. All of the major groups have the presence of large amounts of grave goods and associated social status. Although burials at Seip-Pricer were not associated with as many elaborate grave goods as at Hopewell 25, Greber finds the presence of three major ranked social statuses among the three burial groups at Seip-Pricer, and also internal ranking within each major group (Greber and Ruhl, 1989:292).

Carr's Mortuary Analysis

In the volume *Gathering Hopewell: Society, Ritual, and Ritual Interaction*, editors Christopher Carr and D. Troy Case (2005) and fellow collaborators provide "thick prehistory" accounts of the Ohio Hopewell. The first set of chapters deal with the social and political organization of northern Hopewellian peoples, primarily from Ohio, with some discussion of the Hopewell in Illinois. The second part examines these groups' extensive and elaborate ritual gatherings, while the final section discusses ritual connections across North America and interregional differences in Ohio Hopewell communities concerning symbolic and ritual items.

In the examination of the social and political organization of Ohio and Illinois Hopewell societies, Carr is critical of past middle-range theory in North American mortuary studies that have focused on identifying whether social ranking was present in certain cultures groups. He maintains there have been two main problems with all previous analyses of social ranking based on archaeological date from mortuary sites (Carr, 2005a). First, he contends there are four distinct vertical dimensions of social differentiation that are routinely confused in these studies. The dimensions in question include achieved social prestige, wealth, rank, and leadership. In Carr's opinion, the specific archaeological correlates of each of these distinct variables have not been accurately addressed in past mortuary studies. Second, he notes too many previous studies utilizing mortuary theory have been based on the assumption that a single cemetery should be the main unit of analysis because each cemetery represented the burial site of only one distinct community. Research by Goldstein was instrumental in demonstrating that all mortuary studies should involve spatial analysis (as cited in Carr, 2005a). Carr employs the phrase "regional-scale multi-cemetery perspective" to refer to the mortuary analysis approach used throughout the *Gathering Hopewell* volume.

Carr's first critique must be addressed further, because it is critical to understanding the theory of social ranking employed by Carr and his colleagues throughout their edited volume. Carr (2005a) notes that his definition of social ranking is based on the work of Fried. Rather than simply summarizing Carr's definition, it is important to read it in its entirety (Carr, 2005a:109).

> Social ranking is defined as the differential allocation of prestige to individuals on the basis of criteria other than age, sex, or personal attributes, which results in a limited number of social categories that vary in distinction. Ranks can be assigned to individuals, families, lineages, or clans, on the basis of descent or without reference to descent. Ranks may be defined finely, approaching a continuum, coarsely, finely at the top and more coarsely for lower ranks, or amalgamated into two or three broad "conceptual classes".

In summary, Carr's definition allows for rank to be determined by either ascription or achievement, and he makes a clear difference between social rank in a society and leadership in that same society. "Leadership in a rank society, in contrast to rank, may be achieved, ascribed by rank, or ascribed by other criteria" (Carr, 2005a:109). Ranking is expressed in the archaeological record through material culture artifacts that are "symbols of rank". These artifact classes or mortuary traits "indicate a degree of prestige through their labor investment, workmanship, exotic material source, relative infrequency, context of deposition, or symbolic flamboyance" (Carr, 2005a:109). In a burial, these exotic, nonutilitarian artifacts might be found with adults of both sexes and all ages. Furthermore, Carr thinks symbols of rank should not be found only with people capable of gaining prestige because of certain physical attributes, such as healthy, young adult males. Therefore, if certain artifact classes are only present in the burials of the latter, Carr (2005b:245) would argue that these are symbols of leadership, rather than symbols of rank. Carr insists that symbols of rank cross-cut age, sex, and physical categories. Therefore, in the case of a society with coarse ranking, in which many people fill each rank level, Carr expects that the demographic profile of this rank group would be similar to the demographic profile of the entire population. Carr provides a summary of the methods required to assess whether an artifact or artifact class was a symbol of rank, symbol of achieved prestige, symbol of achieved leadership, a symbol of leadership ascribed by rank, or a symbol of wealth (see Table 6.1 in Carr, 2005b).

Carr's definition of social ranking is restrictive, and this author is not entirely sure that Carr's definition is actually based on Fried's definition of social ranking as Carr (2005a:109) claims. Fried's definition (1967:109) was described previously: "A rank society is one in which positions of valued status are somehow limited so that not all those of sufficient talent to occupy such statuses actually achieve them." This author prefers the broad definition of ranking utilized by Wason (1994), who notes that his definition follows the work of Berreman and involves more than age, sex, personal characteristics, and family roles. Wason writes that his interpretation of ranking denotes "institutionalized status inequality, any hierarchy of statuses which are a part of social structure" (Wason, 1994:19). Carr's emphasis on symbols of rank cross-cutting age and sex categories is problematic, as several archeologists have noted that rank indicators do not always cross-cut these categories. For example, O'Shea (1981) demonstrates that only males in Omaha society exhibit rank, while the Arikara and Pawnee restrict rank, even further, to adult males. Buikstra (1976) also finds that the most restricted rank level at an Illinois Havana Hopewell mortuary site was solely for adult males.

Furthermore, there is some confusion in Carr's theoretical support of his opinion on the theory involved in social ranking. For example, Carr describes how social ranking should result in a pyramidal distribution of people among rank groups, fewer people in the higher social ranks and more people at the bottom, but he writes the lack of this pyramidal distribution does not necessarily rule out ranking (Carr, 2005b:245). Small societies with coarse ranking "may have moieties, dual divisions, clans, sodalities, or communities that differ in prestige institutionally, but that do not differ much in their numbers of individuals" (Carr, 2005b:245). In fact, coarse ranking is his expectation for the level of complexity represented by "mixed hunter-gatherer-horticulturalists", such as the Hopewell. However, this is not always his result, as he finds evidence for social ranking for the Illinois Hopewell (Carr, 2005b), but not for the Ohio Hopewell (Carr, 2005c) which is discussed later in this chapter.

Carr is also critical of mortuary analysis based on a single cemetery which follows work by Goldstein (1980, 1981). Goldstein examines Saxe's hypotheses, particularly number eight, in an attempt to develop an analytic framework for the spatial study of prehistoric social organization. In the analysis of the Schild and Moss cemeteries, Goldstein discovers that corporate group identity is identifiable by the spatial organization and relationships of burials. Goldstein also demonstrates the need for archaeologists to examine the spatial relationships at burial sites, not just artifacts such as grave goods, or traits such as grave area. Based on the mortuary analysis of the Effigy Mound Tradition in Wisconsin, Goldstein (1995) also presents a strong argument that mortuary analysis must be regional in its scope to accurately address the relationship between the landscape, population settlements, and mortuary practices. Likewise, Buikstra and Charles (1999) address the concept of sacred places, cemeteries and mounds, in the formation of the landscape in the west-central area of Illinois. Carr believes the lack of “regional-scale multi-cemetery perspective” is a specific problem with all previous mortuary studies on Illinois Havana Hopewell and Ohio Hopewell societies, with the exception of the landmark study by Buikstra (1976) in Illinois which utilizes a regional perspective.

In the *Gathering Hopewell* volume, Carr and Case (2005) lay the theoretical groundwork for many of the subsequent chapters for examining the nature of Ohio Hopewellian leadership. In order to understand their view of leadership it is first necessary to examine what they mean by the term leadership. Carr and Case (2005:180) write that they view leadership broadly and diversely.

> By a leader in society we mean a person of importance who influences joint social action. A leader may be a person in an institutionalized, socially recognized position of power and authority, be that position social, political, and/or religious in its basis. War chiefs peace chiefs, priests and classic shamans are examples. Leaders may also be prestigious, influential persons who hold no socially formalized or institutionalized position and have no authority in the strict sense, but have sway because they command social, political, religious, and/or economic resources through their character, personal capabilities, family of birth, residence of birth, or other ascribed or achieved qualities. Self-recruited Big Men, self-made war heroes, and spiritually called visionaries, diviners, and other spiritual specialists are examples.

Carr and Case propose that they can identify different social roles of leadership and prestige in Ohio Hopewell communities based on the mortuary analysis of artifact classes of 767 burials from 15 Ohio Hopewell ceremonial centers which includes 60 mounds. They write “the goal was to find kinds of artifact role markers that repeatedly occurred together in burials, indicating a given role or bundle of roles, and those artifact role markers that seldom or never occurred together, indicating role segregation" (Carr and Case, 2005:214). Based on the statistical analysis of these artifact classes, they identify 21 different social roles that represent distinct bundles of artifacts (see Table 5.5, Carr and Case, 2005). Thirteen of these roles mark important community leadership or prestige positions, while eight of the roles are represented by an artifact class that is independent of the other thirteen. Some of these roles are represented by a unique artifact class, while others are "role bundles" and are represented by a combination of artifact classes. Five of the 21 different roles are bundled together, such as non-shaman-like and shaman-like public ceremonial leadership, or war or hunt diviners and non-shaman-like public ceremonial leadership, while others are distinct roles, such as shaman-like public ceremony leaders, body processors, healers, high achievers in warfare, or high achievers in sodalities (Carr and Case, 2005). Each role is represented by an artifact class. For example, Role 8 is postulated to be that of a body processor and is represented in burials by the presence of an awl and a small pipe, while role 10 is a healer and is marked by a panpipe, tortoise shell, plummet, and fancy points.

Specific artifacts that are associated with prestige are copper headplates, breastplates, celts, and earspools (Carr, 2005:279). Of the 767 individuals used in this analysis, 272 have one of the 13 artifact classes marking leadership and prestige. According to Carr and Case, leadership is diversified because 64% of these individuals had only one role marked, while 91% had one or two roles indicated and there was no individual in their analysis that had the presence of more than four different leadership roles. They also conclude that leadership in Ohio Hopewell societies was primarily based on religion (both classic shaman and shaman-like), decentralized, and institutionalized to a moderate degree, as there was some evidence for ascribed leadership (Carr and Case, 2005:231). They conclude that the amount of hierarchy present among leadership roles still needs to be studied. Carr's theoretical argument for the basis of leadership being religious and/or spiritual in the Ohio Hopewell is based on cross-cultural anthropological and ethnological research on the role of magicoreligious practitioners in prehistoric societies, and is a concept other researchers have also explored (e.g. Brown, 2006; Seeman, 2004). Brown (2006) presents a model for shamans as Hopewell leaders who are privileged ritual specialists.

Several other archaeologists have also suggested there were various types of Hopewell artifacts that represent different levels of social status. Greber and Ruhl (1989:70) write that artifacts of elevated social status include copper headplates, plaques (also called breastplates), celts, or beads. Seeman (2004:59) notes that leadership roles were marked by the presence of precious objects which ranged from marine shell and pearl beads to higher signs of wealth such as metal earspools, pipes, and bear canines. Seeman (1995:134) states that more copper was traded in the Middle Woodland period in the Eastern Woodlands than at any other time in prehistory, and suggests that Hopewell copper celts represent a prestigious good.

To better understand Carr's theoretical approach to Ohio Hopewell mortuary analysis it is helpful to first discuss his reviews of previous research. Carr (2005c:268-277) critically reviews Greber's (1979a, 1979b) research and notes several problems with her theoretical approach to social ranking. Carr believes Greber rejects attempts at social typology, but also neglects to provide archaeological correlates to support her views of social ranking. Carr writes that Greber "offered no anthropological definition of ranking, no models of the possible variant organizations of rank societies, and no formal expectations of their archaeological manifestations against which to interpret data" (Carr, 2005c:270). Carr (2005c:274) also argues that Greber

(1976:17-18) made an error in her methodology because she began her analysis with the assumption that different burial clusters within sites represent social divisions within that society. Greber then proceeded to look for differences in artifact classes and mortuary treatment between these burial clusters, and when she found differences she concluded these were evidence of social rank. Carr (2005c:275) is also critical of the mortuary characteristics that Greber used as her "symbols of rank" (in Carr's terminology), which Carr criticizes as utilitarian artifacts. Also according to Carr, the distributions of prestigious artifacts selected by Greber do not cross-cut age and sex categories.

A final criticism of Greber's research by Carr (2005c) is that her work was site-specific and did not use a regional mortuary perspective. The lack of regional analysis and the assumptions that each mound only represented the cemetery of one group of people are valid criticisms of Greber's work by Carr. However, in fairness to Greber, her 1976 dissertation was the basis for her 1979 publications, so she did not have the benefit of some of the emerging theoretical work on identifying social ranking at archaeological sites as advocated by scholars such as Buikstra (1976) and Brown (1981). Brown's (1981) study attempts to bridge the gap between sociocultural theory and archaeological theory of mortuary analysis as he examines how social rank is displayed in the archaeological record. In general, societies with minimal ranking of individuals tend to bury their dead based on sex, age, and personal achievement, while ranked societies typically differentiate beyond these former categories. Brown concludes that archaeologists need to separate social rank, power, and authority because these principles appear to operate independently.

Based on the previously discussed critiques of Greber's research and his own analysis, Carr (2005c:277-313) argues that the existence of social ranking at the Ohio Hopewell sites Seip-

Pricer (Seip 1), Seip-Conjoined (Seip 2), Edwin Harness Mound, Hopewell Mound Group, and Ater Mound is doubtful, but there is evidence at these sites for mortuary differences based on prestige and leadership. Furthermore, Carr (2005c:311-317) postulates that a ceremonial alliance existed between several Hopewell communities in the Scioto region who shared these cemeteries with each other. This alliance is represented by the grouping of tripartitae earthworks found at Seip Earthworks, Hopewell Mound Group, and Liberty Earthworks, which contains the Edwin Harness Mound.

Carr agrees with Greber and Ruhl (1989) that there is no evidence for social ranking at Hopewell Mound 25 among the three major burial clusters. However, Carr presents evidence that the Hopewell mounds were the burial place of people with high levels of prestige. Carr (2005c:278-280) cites several lines of reasoning to support this viewpoint: high percentage of exotic grave goods at Hopewell mounds (present in nearly a third of the burials at Hopewell Mound 25), disproportionate number of adult males buried at Hopewell compared to females (particularly at Mound 23 and 25), very few subadult burials (less than 3% of individuals of known age are buried at Mound 23 and 25, whereas 29% of individuals of known age are subadults at Sep-Pricer), and a high percentage of extended inhumations, rather than cremations. Carr uses the term “inhumation” to refer to primary burials and it serves as an antonym to cremations. He also sometimes refers to them as “extended inhumations”, but not on a consistent basis. There is evidence for some Ohio Hopewell bundle burials (secondary burials), but this is not the most common form of burial (Carr, 2005:471). Specifically, 76% of the burials at Hopewell Mound 25 and 94% of Hopewell Mound 23 burials are inhumations, while 12 of the remaining 20 smaller mounds have at least 50% of their burials as inhumations (Carr, 2005c:279). This is a much different pattern than at Seip, Edwin Harness Mound, or Ater

Mound, where cremations are the most common type of burial, and no more than 13% are inhumations at any of these sites. Furthermore, inhumations are more commonly associated with relatively rare artifacts that are deemed prestigious by Carr's mortuary analysis, such as copper headplates, breastplates, celts, or earspools than cremations at each site. This leads Carr (2005c:279) to speculate that body treatment may be related to prestige; individuals who are cremated have less prestige than individuals who are inhumed. Additionally, Carr (2005c:280) notes that Greber's (1979a:44) rank sum statistics are higher for artifacts associated with extended inhumations than cremated burials at Seip-Pricer (Seip 1).

Based on these lines of evidence, Carr suggests that the Hopewell Mound Group "was a burial place for persons of import: those who had lived to be old enough to accumulate prestige or to demonstrate the prestige they might have inherited" (Carr, 2005c:278). Carr continues that this is in contrast to individuals buried at Seip-Pricer Mound, Edwin Harness, and Ater mounds who "appear to represent a much broader spectrum of social actors in terms of age, balance of the sexes, and prestige" (Carr, 2005c:278). However, Carr adds that individuals buried at Seip, Edwin Harness, and Ater do not represent a cross-section of society, as there are still high percentages of people buried with prestigious artifacts. Carr (2005c:280) hypothesizes that Ohio Hopewell communities buried their most prestigious community members at Hopewell Mound Group and less prestigious members of their communities at Seip, Edwin Harness, and Ater mounds which "served to contain a broader but still incomplete society".

Carr (2008e:659) also notes that Hopewell Mounds 23 and 25 are quite different from the other mounds at the Hopewell Mound Group. These two mounds share a similar loaf shape, are the two largest mounds by volume, and also have the largest number of burials which are predominantly extended primary burials, as discussed above. Additionally, Mound 25 covered charnel houses, and it is possible that Mound 23 did as well based on posts discovered by Moorehead (Carr, 2008e:659). Carr (2008e:659) suggests an avenue of exploration is the examination of the possibility for social ranking to exist between Mounds 23 and 25 compared to the other smaller fifteen Hopewell mounds with burials.

An alternate explanation for the elaborate burials in SC Ohio is that social ranking does exist in this region (Carr, 2005c:337, endnote #43). In this alternate hypothesis, Hopewell Mound 25 represents a burial place for ranked individuals who either achieved, or were ascribed leadership positions, while Seip-Pricer was the burial place for individuals from the same rank group. However, Seip-Pricer represents those who did not achieve or inherit roles as prestigious as those buried at Hopewell Mound 25. Both of these sites, however, contained elaborate deposits of artifacts and time-intensive tomb construction (Carr, 2005c:337). The next rank group would be represented by Hopewell Mound 23 where there is less elaborate deposition of artifacts and tomb preparation than Hopewell 25, but still involves burial in a mound within an earthwork. Carr suggests there may be a third rank group which would be represented by burial in mounds not associated with earthworks and also lack the elaborate artifacts and tomb construction of the first rank group, but he does not give an example of a specific mound for this possible third group. However, Carr (2005c:337) does not believe the current data supports the alternative hypothesis that Hopewell Mound 25 is a burial place for ranked individuals, but rather "Mound 25 was apparently the burial place for primarily key social figures of a restricted (high) range of social importance" (Carr, 2005c:322).

Social and Political Organization

What is an egalitarian society? Egalitarian societies are described by Fried (1967) as societies in which differences among individuals based on wealth and power are minor. Fried (1967:33) writes "an egalitarian society is one in which there are as many positions of prestige in any given age-sex grade as there are persons capable of filling them". Binford (1971) notes that mortuary analysis can be used to detect variation in egalitarian societies based on age and sex differences. Service (1971) details the social organization of bands, tribes, and chiefdoms; and he also discusses band level societies as egalitarian.

This discussion is further complicated by the work of other anthropologists. Flanagan (1989) notes that Sahlins questions whether a truly egalitarian society has ever even existed in human history: "Theoretically, an egalitarian society would be one in which every individual is of equal status, a society in which no one outranks anyone. But even the most primitive societies could not be described as egalitarian in this sense" (Sahlins 1958, as quoted in Flanagan 1989:246). Flanagan notes that the characteristics used by Sahlins at the simplest level to separate people in a society are age, sex, and personal characteristics, and that any society that uses traits other than these is a "stratified" society, according to Sahlins. Flanagan contends that egalitarian societies are based primarily on an "egalitarian economy" in which reciprocity and the sharing of power are equally important, and that in these societies "that control of productive, as well as reproductive, resources enhances female power (1989:249-250)".

The classification of Ohio Hopewell societies in the literature has varied over time. In 1936, Shetrone referred to the individual buried at Hopewell Mound 25 with elaborate artifacts and a copper elk antler effigy headdress as a "king" (as cited in Carr and Case, 2005:187).

Struever (1965) agues that Ohio Hopewell leaders should be called chiefs. Seeman (1979) hypothesizes the Ohio Hopewell represent a low level chiefdom organization that was centered on a mortuary program that allowed for ritual regulation and the redistribution of deer meat during mortuary feasting. Seeman (2004:59-60) does not seem to support his previous hypothesis of Ohio Hopewell chiefdoms, but he asserts that it difficult to identify specific types of leaders in Ohio because there is a lack of institutionalized hierarchies through which leadership can be inherited. Recall from previous discussions of Greber's (1979a, 1979b) research in this chapter that she detects social ranking at Seip, Ater, Harness, and Turner. Brown (1979) argues that Ohio Hopewell mortuary architecture that utilizes charnel houses and ritual procedures reveals greater social complexity than sites associated with the Havana Illinois Hopewell that are more frequently associated with burial crypts. Brown (1981) finds evidence of social ranking for the Havana Hopewell, but Brown (1979) is not clear as to whether he thinks that Ohio Hopewell social groups were ranked.

This research study works from the perspective that Ohio Hopewell societies represent complex egalitarian societies. Based on his own model of Hopewell subsistence of hunting, gathering, and using both wild and domesticated plants, Ford (1979) argues the Hopewell represent an egalitarian society which is also a view supported by Griffin (1979). Ford hypothesizes that the Hopewell would not have had a surplus of food on a regular basis. Therefore, he does not think that a society based on hereditary (i.e. ascribed) ranking fits this subsistence model, because food surpluses can be controlled by a select group of individuals in more complex societies. Contrary to Greber, Carr (2005c) states the evidence for social ranking at Ohio Hopewell sites is doubtful. Pacheco and Dancey (2006:21) postulate that the Ohio Hopewell represent an egalitarian society because status and wealth are related to individual achievement, and there was not any institutionalized social stratification that led to ascribed ranked leadership in Ohio Hopewell populations. Yerkes (2006) also argues that Ohio Hopewell societies were clearly not chiefdoms, because there is not solid archaeological evidence for surplus plant-based food production. Yerkes contends these groups represent mobile foragers whose social complexity is based on Sahlins' and Service's tribal models.

Ohio Hopewell Interregional Differences

As previously discussed in this chapter, archaeologists have examined and documented archaeological evidence of different North American Hopewell regional traditions since the 1960s (e.g., Prufer, 1964; Struever, 1964; Caldwell, 1964; Brose and Greber, eds., 1979). More recently, the *Gathering Hopewell* volume contains research which detects and compares interregional variation between Hopewell traditions regarding the ritual, social, and symbolic significance of artifacts. Examples include Keller and Carr (2005) who examine the role of ceramic figurines in Ohio, Mann, and Havana traditions, and Bernadini and Carr (2005) who analyze copper celts from the Ohio, Havana, Crab Orchard, and Point Peninsula traditions. The geographical source of silver for the preparation of silver artifacts in Eastern Woodlands Hopewell sites (Spence and Fryer, 2005) is also studied. The analysis of panpipes (Turff and Carr, 2005) and copper earspools (Ruhl, 2005) from Hopewell locations in the Eastern Woodlands also reveals differences between Hopewell traditions.

In the volume *A View From the Core: A Synthesis of Ohio Hopewell Archaeology*, edited by Paul Pacheco (1996) a new research theme develops. This is the examination of Ohio Hopewell archaeology at the regional, or local, level: documenting and analyzing the differences between different river drainage systems. In this volume, the "core" refers to the major river drainage of southern Ohio – along the Scioto River and tributaries. Pacheco's (1996) contribution to this volume examines the settlement pattern and land use of population from the central Muskingum-Licking region. Hawkins (1996) identifies differences in ceramics from the Great Miami River valley compared to the core Scioto area. Carskadden and Morton (1996) focus on the settlements and mortuary customs of sites along the Muskingum River in central Ohio and the transition from Hopewell to Late Woodland and compare their results to the classic Hopewell sites from the Scioto region. Seeman (1996) makes the argument that ceremonial sites from northern and northeastern Ohio are quite different than classic Hopewell mortuary sites from SC and SW Ohio. The regional pattern in eastern and northeastern Ohio is for small mound sites with large stone slabs covering burials located in the floor of these mounds. At one of these sites, Yant Mound, Seeman notes that the recovered ceramics are poor local copies of classic Hopewell ware, but the bladelets do resemble classic Ohio styles. The study by Seeman builds on the work of Magrath (1945) who describes a similar small mound and stone slab mortuary pattern at another northeastern Ohio site. Ruhl and Seeman (1998) analyze Ohio Hopewellian copper earspools and find variation in design between different regions in Ohio (Little Miami drainage and Scioto drainage). Nolan et al. (2007) examine the production of bladelets at the Turner Earthworks along the Little Miami River in SW Ohio. They compare their results from Turner to bladelets from Liberty Earthworks along the Scioto River in the SC region and discover differences in the size of the bladelets and blade-cores.

This type of archaeological analysis at the regional level is also presented in the volume *Gathering Hopewell*. Turf and Carr (2005) identify distinct interregional differences between the Scioto Valley region (includes Turner) and the northern and northeast Ohio region through the analysis of the style of panpipes and the panpiper's social role in a community. Spence and Fryer (2005) detect a similar dichotomy between Scioto and Miami River drainage sites when compared to sites from northern and northeastern Ohio in their research on the geographical source of silver in Hopewell silver artifacts. The classic Hopewell artifacts found at sites from SC and SW Ohio are made from silver obtained from the Keweenaw Peninsula in northern Michigan, while communities from northern and northeast Ohio procured their silver from the Cobalt region of northern Ontario.

Coon (2009) discovers interregional differences in political economy between SW and SC Ohio Hopewell communities based on the archeological data at different ceremonial centers. Southwest Ohio represented by the Turner and Fort Ancient sites displays a more corporate political economy, whereas the SC Ohio sites of Hopewell and Seip Earthworks display a more exclusionary political economy. Corporate political strategies are focused on group solidarity and discourage individual competition for wealth and prestige in an attempt to minimize status differences (Coon, 2009:50). In a mortuary context this would create an emphasis on the community rather than the individual. On the other hand, exclusionary strategies allow select individuals to gain prestige and control power (Coon, 2009:50). This type of strategy leads to more elaborate mortuary rituals and the focus is on prestige for the individual.

Male and Female Access to Social Positions of Leadership and Prestige

In the *Gathering Hopewell* volume, there are several studies that examine the leadership and prestige of Hopewellian women. Differences in female clay figurines between Mann, Scioto, and Havana Hopewell traditions indicate that Havana females may have greater access to positions of leadership and prestige than females from Mann and Scioto (Keller and Carr, 2005). This conclusion is based on the differences in stylistic characteristics between the regions that the female figurines display, such as prestigious earspools and unique hair styles involving a topknot or shaved side of the head which would allow for earspools to be more visible (Keller and Carr, 2005). In the analysis of copper and silver jacketed panpipes from many different Hopewell traditions across eastern North America, Turff and Carr (2005) find evidence of panpipes in the burials of males and females of all ages, including children. This is contrary to Griffin et al. (1970) who only find panpipes in the burials of adult males. Turff and Carr hypothesize that panpipes may have been involved in rites of passage involving age and/or gender.

The analysis of Ohio Hopewell male and female social roles and their access to positions of leadership and prestige has been examined by Field et al. (2005) and Rodrigues (2005). Both of these studies find increased female access to leadership positions in SW Ohio when compared to other Ohio local regions. Carr (2005a:116) argues this contemporary research which focuses on Ohio Hopewell females is an important theoretical development, because this view of "Hopewellian women of multiple regional traditions counterbalances the generally accepted view of Hopewellian women as subordinate". Carr suggests this subordinate viewpoint of Hopewell women is based primarily on Buikstra's analysis of the Havana Hopewell in Illinois. Buikstra (1976) detects social ranking within the burial rituals involved in the mortuary program, and the individuals at the top of this hierarchical ranking were all adult males. Only males were buried individually in the central tombs which were the most energy-expensive burials, and all males were buried with more diverse grave goods than females. If females were buried in the central tombs they were always buried with males.

Field and colleagues (2005) utilize mortuary analysis of Ohio Hopewell burials from SW, SC, and northeastern Ohio to assess the degree of male and female access to leadership and prestige in each of these three geographic regions at the local level. Their study is driven by research from those in the fields of gender studies and gender archaeology who have proposed that women in matrilineal societies benefit from an increase in prestigious positions within a society (Brettel and Sargent, 1997). It has been hypothesized that women in matrilineal societies obtain a higher status than women from a society where status is dependent on a marriage bond (Sacks, 1979, as cited in Nelson, 2004:92). Field and her colleagues review the cross-cultural factors that influence the status of females, and note that it has been postulated that gender is a prestige structure, similar to age and sex, and the status of females can be assessed by what prestigious roles they obtain in society. "In general, matrilineal and matrilocal societies afford women a greater degree of power and autonomy than patrilineal and patrilocal arrangements" (Field et al. 2005:389). Women stay together with their lineages after marriage in matrilineal societies, whereas in patrilineal societies they leave their home to become part of their husband's family. Field and co-workers note these are, of course, general observations and there are specific cultural occurrences, such as cousin marriage practiced by patrilineal societies that would not follow the above generalizations.

Based in part on this theoretical framework, Field and her colleagues use Carr's mortuary data regarding the identification of leadership and prestige social roles previously discussed in this chapter by Carr and Case (2005) and Carr (2005c) to analyze adult burials from ten Ohio Hopewell sites in which age, sex, and social role were all identifiable. They use the frequencies of female vs. male burials for certain leadership and prestige roles in order to assess the statistical significance of the extent of male or female leadership in each region. Artifact classes are divided into four main categories: shamanic leadership (e.g. quartz artifacts, bone awl, animal headplate, copper nostrils, conch shell, flute, panpipe, and tortoise shell ornament), nonshamanic leadership/high prestige (e.g. copper breastplate, copper earspool, copper/iron celt, nonanimal headplate, and trophy skull or jaw), clan (e.g. animal effigy or power part), and personal prestige (e.g. small pipe, copper necklace, and copper/sliver bracelet). Within each of these categories, further subdivisions exist (see Table 9.1, Field et al., 2005). Their analysis detects distinct regional differences. The SC region was characterized by both male and female access to leadership roles and prestige, but with a male bias, while the SW region was the epicenter of female leadership and prestige for Ohio Hopewell communities. The northeast region is marked by male dominance for leadership and prestige social roles.

The analysis of 95 adult burials from six SC sites along Scioto River drainages, including Hopewell Mound Group, Seip, Edwin Harness, and Ater reveals that males are more frequently buried with artifacts indicating nonshamanic leadership/high prestige positions, shamanic leadership positions, and clan positions (Field et al., 2005). Furthermore, only males had access to the most powerful positions marked by metal headplates, and “predominantly males possessed items of achieved leadership/high prestige, including breastplates and earspools” (Field et al, 205:394). Although women did have access to certain other achieved leadership/high prestige roles, marked by metal breastplates and metal earspools, they filled these roles less frequently than males. Women had equal access to a community-wide leadership position indicated by copper celts that the researchers speculate was potentially inherited through ascription because of the presence of this artifact in children’s burials (Field et al., 2005:394). Both males and females were represented in shamanic leadership positions, with males slightly more common, but there seems to be certain specific shamanic roles associated with each sex. Clan artifacts are more frequently found with male burials, while personal prestige items are roughly equal in both males and females. Field and her colleagues hypothesize that the SC region is typical of a community with a patrilineal descent system.

The SW region is represented by 20 adult burials from the Turner Mound Group along the Little Miami River. The archaeological evidence from the SW region reveals females had access to positions of leadership and were associated more frequently with clan items. Females at this site were buried with artifact classes (metal breastplates and earspools) that mark non-shamanic leadership/high prestige and shamanic leadership roles more frequently than males. Females were associated with the majority of clan items, such as animal effigy parts (also see Thomas et al., 2005), and women were most frequently associated with shamanic artifacts which the authors believe supports the "conclusions that women in matrifocal societies have access to prestigious religious positions" (Field et al., 2005:402). Field and her colleagues also note evidence for the existence of multiple genders which leads credence to Nanda's (2000) hypothesis that gender variance in North America is associated with spiritual power, especially when males and females are somewhat equal in terms of power. Based on the above mortuary information regarding enhanced female access to leadership, higher frequency of females with clan items, and gender theory literature that women in matrilineal descent systems benefit from this type of power and autonomy, Field and colleagues hypothesize that this society may have followed a system of matrilineal descent. However, the authors are cautious to note that their analysis in this region was based on only one site with a small burial sample (*n* = 20) (Field et al, 2005).

The third region that Field and co-workers (2005) analyze is the northeast region of Ohio which they define geographically as an area involving Lake Erie and Muskingum River drainages which includes three sites: Esch, Martin, and North Benton. The adult sample size for this region is even lower than from the SW region (*n* = 15), but none of the females (*n* = 5) were associated with any markers of nonshamanic leadership/high prestige or shamanic leadership positions, and three of the female burials have no grave goods at all (Field et al., 2005:395). Males were associated with all clan items which combined with the fact that only males, children, and infants were buried with artifacts associated with leadership leads Field and colleagues (2005:395) to postulate that women in the northeastern region had little to no power or prestige, and hypothesize that this region followed a patrilineal kinship system.

In conclusion, Field and colleagues remark that their research reinforces the viewpoint that the analysis of the status of women is best done at the regional or local level, rather than to assume that it was similar in all Hopewell communities across North America. "Our gendered analysis does not add women into the current definition of an 'interregional' Hopewell. Instead it contributes to theory about variation underneath the umbrella of Hopewell ritual and belief" (Field et al., 2005). They also note that the focus of their study is on the SC region because of its large sample size (*n* = 95) and has more reliable data compared to the smaller samples sizes in the SW (*n* = 20) and northeastern (*n* = 15) regions. Historically, patrilineal descent systems were employed by Algonkian tribes of the Eastern Woodlands which would fit with Ohio Hopewell pattern detected in the SC and northeastern regions (Field et al., 2005:402). Additionally, they speculate that the SW region with a possible matrilineal descent system could align this region with southeastern Woodland tribes who utilized matrilineal descent.

Rodrigues (2005) also provides an analysis of gender and social differences in an Ohio Hopewell population, but based on skeletal remains. She examines the concept of division of labor based on sex differences at the Turner site, from the SW region of Ohio, using musculoskeletal markers of stress (MSM) from 19 adults. The results based on MSM data demonstrate that males and females had similar workloads, but each sex performed different types of activities (Rodrigues, 2005). Additionally, lower limb injuries which may have resulted from running and regular travel were more common than upper limb injures for all individuals.

Rodrigues adapts Carr's social roles based on artifact classes (Carr and Case, 2005) to create five broad social categories, three of which she terms "high-status": shamanic practitioner (e.g. awls, conch shells, mica]), unspecified leader or important social role (e.g. copper breastplates, celts, and earspools), and prestigious personal items (e.g. metallic tools). She labels two "low-status": nonprestigious clan symbols indicated by non-metal artifacts and nonprestigious personal items (e.g. pearl beads, projectile points) (see Table 10.5, Rodrigues, 2005). The use of the term "status" by Rodrigues is interesting, because this is the only chapter in the *Gathering Hopewell* volume found by this author that uses the term status when associated with Carr's social roles involving leadership and prestige.

Rodrigues' mortuary results reveal that both females and males filled high-status leadership and prestige positions. However, only females occupied the shamanic high-status roles. Females were also more frequently associated with the high-status role of unspecified leadership and importance, and two low-status roles: nonprestigious clan membership and nonprestigious personal prestige. Males were more represented in the high-status roles which involve personal prestige, which Rodrigues speculates may have been based on achievement. Notably, the comparison of high-status males and females with MSM workload data shows that high-status males were sheltered from an increased workload, but this was not the case for females. The relationship between social status and cribra orbitalia and porotic hyperostosis (which she associates with iron-deficiency anemia) indicates that high-status individuals were not afforded better health, as these lesions were more prevalent in this group than low-status individuals, or those with no graves goods at all (Rodrigues, 2005:426). Although the sample size for this research is small (*n* = 19), Rodrigues' assessment of SW Ohio Hopewell leadership with an emphasis on females is similar to the results of Field et al. (2005). Likewise, Rodrigues (2005:423) also speculates that female shamanic and leadership roles may have been inherited through the female line. However, this is not too surprising since both studies were based on the same theoretical principles and data set which was generated by Carr and Case for analysis of Ohio Hopewell social roles (Carr and Case, 2005; Carr, 2005c).

Matrilineal and Patrilineal Societies

In Field et al.'s (2005) discussion of female social status, it should be noted that they fail to cite contemporary ethnographic and ethnohistorical research that documents the difference between complementary gender roles and gender hierarchy. If women had increased access to positions of leadership and prestige in the hypothesized matrilineal society of SW Ohio, it does not necessarily indicate that men will have less access to these positions and that one sex will be subordinate to the other (Bilharz, 1995). Previous studies have proposed that that in several Native American matrilineal societies, gender roles were complementary and not hierarchical (e.g. Ackerman, 1995; Bilharz, 1995; Knack, 1995; Maltz and Archambault, 1995; Sattler, 1995; Tooker, 1984).

The Iroquois, a matrilineal society of the Eastern Woodlands, provide an excellent example of complementary gender roles (Bilharz, 1995; Tooker, 1984; Perrelli, 2009). In the division of labor associated with subsistence, women did all the horticultural work except men cleared the fields, and men did all of the hunting and fishing. Women's activities were focused on the village domain, while men's activities occurred in the forest domain (Perrelli, 2009). Bilharz (1995:107) emphasizes that "Iroquois society in the precontact period was most likely characterized by complementary gender roles with matrilineal descent and matrilocal residence suitable for a horticultural society where males were often absent hunting or on the warpath." Furthermore, men and women had different roles in society, but neither was dominant (Bilharz, 1995). Male and female Iroquois relationships were not dependant on political power or the control of economic resources, but instead on reciprocal obligations (Tooker, 1984).

The complementary gender roles of Plateau Indians, hunter-gatherers from northwest North America has also been examined (Ackerman, 1995). Ackerman finds that in economic, domestic, political, and religious spheres that this group displays complementary gender roles, despite differential access of men and women to certain public roles (chiefs were always males). These complementary gender roles did not lead to male superiority. Ackerman proposes that this ethnographic study supports the theory that complementary gender roles do not necessarily imply gender stratification. This contradicts Lamphere (1977) who argues that complementary gender roles automatically lead to gender stratification, and that no society can be complementary but equal (Ackerman, 1995).

It should also be noted that determining whether a group utilized matrilineal or patrilineal descent based on archaeological data can be problematic. The analysis of the mortuary variability of three nineteenth century Plains Indian societies reveals that although archaeology could determine mortuary variability based on vertical differentiation, such as status and wealth, it could not do as well on horizontal differentiation, such as moieties, clans, or sodalities (O'Shea, 1981). For example, there was no archaeological evidence as to whether any of these tribes were matrilineal or patrilineal, although this is has been determined by ethnographers of the time period. However, there will most likely always be rituals associated with mortuary ceremonies that are not recorded symbolically or at least in a fashion that will be preserved in the archaeological record. Because O'Shea did not discover evidence for patrilineal or matrilineal descent systems does not necessarily mean that in another culture this is impossible.

Biological evidence from Hopewell populations does not support the use of a matrilineal descent system. Mills (2003) does not find evidence for the segregation of individuals buried at Hopewell Mounds 2 and 25 in SC Ohio based on their mtDNA lineage. The multiple burials at Mound 25 also do not show mtDNA evidence for matrilineal descent, but this conclusion is based on the visual examination of different haplotypes in the burials because of small sample sizes (only three multiple burials). Mills concludes that at the Hopewell Mound Group, mortuary treatment and spatial patterning is not based on matrilineal decent. Mills (2003:115) importantly notes that researchers need to remember that "cultural kinship is not always rooted in biological fact". Kinship is a cultural concept, so sometimes a society's kinship is not determined biologically, thus ethnographic analogies for a prehistoric population are important (Mills, 2003:115).

Mitochondrial DNA analysis of Illinois Havana Hopewell sites has also not detected evidence for matrilineal descent. The results of one study demonstrate that the mortuary pattern at the Pete Klunk Mound Group is not based on matrilineal kinship, and there is no evidence of maternally inherited or ascribed status (Bolnick and Smith, 2007). The data does, however, suggest a matrilocal system of post-marital residence in which the married couple lives near the wife's family (Bolnick and Smith, 2007). Raff (2008) also finds no evidence for a burial program based on matrilineal descent at the Klunk cemetery using mtDNA.

Introduction to Research Questions

As previously discussed in this chapter, Hopewell archaeologists have examined regional differences regarding the role of leadership and prestige in males and females between different Ohio Hopewell populations based on mortuary analysis (Field et al., 2005; Rodrigues, 2005). The study by Rodrigues (2005) employs bioarchaeology to investigate social status variation, but the main focus of analysis is on musculoskeletal markers of stress and differences between males and females in only one region of Ohio. An analysis and comparison of local Ohio Hopewell populations utilizing skeletal biology to examine markers of biological status has not yet been conducted.

This study examines the biological status of Ohio Hopewell populations at the regional level. The first set of research questions evaluates intraregional and interregional differences in the relationship between biological status and social status of male and female adults from the SC and SW regions. The second set of research questions determines whether differences in biological status were related to differences in social status at prestigious burial mounds within the SC region. Biological status was assessed through an analysis of skeletal markers of nonspecific systemic physiological stress, dietary nutritional stress, nonspecific infection and/or disease, or trauma to the skeletal system.

Skeletal markers of the biological status of adult males and females from these two regions are used in the first three research questions to test the hypotheses of whether increased social status marked by leadership and prestigious social positions is associated with differences in biological status. The model of Ohio Hopewell leadership proposed by Carr and Case has previously been discussed in this chapter. In summary, they propose that leadership was diversified, primarily based on religion, decentralized, and moderately institutionalized (Carr and Case, 2005). The archaeological model proposed by Field and her colleagues argues that male and female access to leadership and prestige in Ohio Hopewell societies differs by region (Field et al., 2005). Females had increased access to social positions of leadership and prestige in the SW, whereas males predominantly filled these roles in the SC region. In the SW region, Greber (1979a) found similar ranking of males and females at the Turner site which appears to agree with the hypotheses of Field and her colleagues.

Skeletal markers of the biological status of adult males and females buried at different mounds in the SC region are used in the final four research questions to test the hypotheses of whether increased social status marked by burial in prestigious SC mounds is associated with differences in biological status. Carr (2005c:280) hypothesizes that Ohio Hopewell communities buried their most prestigious community members, "special persons", at Hopewell Mound Group and less prestigious members of their communities at other SC sites: Seip, Edwin Harness, and Ater Mounds which "served to contain a broader but still incomplete society". Hopewell Mound 25 and Mound 23 share several similar architecture and elaborate tomb construction when compared to the other 15 smaller mounds with burials at the Hopewell Mound Group. Carr (2008e:659) questions whether there is evidence for social ranking between these two groups. Conversely, there are several contrasting differences between Hopewell Mounds 23 and 25 that prompts Carr (2005c:337) to speculate whether individuals buried at Mound 25 have a higher social ranking than individuals buried at Mound 23. Additionally, Hopewell Mound 25 is unique when compared to the other mounds of the Hopewell Mound Group, even when compared to

Mound 23, because of its rich deposits of exotic artifacts and the most elaborate tomb construction.

This research uses the working null hypotheses that there should not be statistically significant differences among the skeletal markers of biological status compared in each research question. This study only focuses on the biological status of adult males and adult females from the SW and SC regions of Ohio. All references to regions of Ohio with increased male or female access to social positions of leadership or prestige are based on Field et al.'s (2005) hypotheses generated from mortuary data.

Based on the archaeological hypotheses presented above, it is expected that intraregional and interregional differences in the markers of biological status exist, and are associated with the differences of male and female social status within and between the SW and SC regions. Likewise, it is expected that differences in biological status will be associated with differences in social status marked by burial in prestigious SC mounds. This is based on archaeological hypotheses that prestigious SC mounds were reserved for special persons. In the following section of research expectations, the use of the term "better" biological status means there is a lower prevalence of binary scored (absence or presence) indicators of skeletal stress or trauma, or larger mean measurements for the long bone measurements that were used for the assessment of adult stature. Alternatively, the use of the term "poor" biological status means there is a greater prevalence of these binary scored skeletal indicators, or smaller mean long bone measurements.

Research Questions and Expectations

Intraregional Variation of Biological Status

Question 1) Is there an association between indicators of biological status and greater access to leadership and prestige for each sex in a specific region?

In order to address this question for each of the two different regions, this question is separated into two parts.

Question 1A) In the SW region, it has been proposed that females have increased access to leadership and prestige. As a result, does biological status differ between males and females in the SW region?

Expectation: In the SW region, it is expected that the biological status of females be similar to that of males. Indicators of poor biological status should be equally distributed in males and females, because in several Native American Indian matrilineal societies, gender roles are complementary, not hierarchical (e.g. Ackerman, 1995; Bilharz, 1995; Knack, 1995; Maltz and Archambault, 1995; Sattler, 1995; Tooker, 1984). Complementary gender roles do not have to lead to one sex being subordinate to the other (Bilharz, 1995).

Question 1B) In the SC region, it has been proposed that males have increased access to leadership and prestige. As a result, does biological status differ between males and females in the SC region?

Expectation: In the SC region, it is expected that the biological status of males be better than that of females. Indicators of poor biological status should be more prevalent in females than in males. Decreased access to positions of leadership and prestige for females could lead to differential access to food resources and critical nutrients during growth and development.

Interregional Variation of Biological Status

Question 2) Do interregional differences between the biological statuses of females associate with the hypothesized differences of female access to leadership and prestige?

In the SW region, it has been proposed that females have increased access to leadership and prestige. As a result, does the biological status of SW and SC females differ?

Expectation: If the results of research question 1A reveal a positive association between biological status and increased access to female leadership and prestige, then it is expected that the biological status of females from the SW region be better than the biological status of females from the SC region. SC females had decreased access to leadership, and therefore may have also had decreased access to food resources and nutrients during growth and development.

Question 3) Do interregional differences between the biological statuses of males associate with the hypothesized differences of male access to leadership and prestige?

In the SC region, it has been proposed that males have increased access to leadership and prestige. As a result, does the biological status of SC and SW males differ?

Expectation: If the results of research question 1B reveal a positive association between biological status and increased access to male leadership and prestige, then it is expected that the biological status of males from the SC region be better than the biological status of males from the SW region. SC males had increased access to leadership, and therefore may have also benefited from increased access to food resources and nutrients during growth and development. However, if gender roles are complementary in the SW region for males and females and the results from question 1A do not reveal a difference in biological status between males and females in the SW region there could be an alternate expectation. The alternate expectation is that indicators of biological status will not be different between SW males and SC males, because there was not differential access to food resources and nutrients for SW males during growth and development.

Biological Status Between and Within Prestigious SC Mounds

Hopewell Mounds vs. Other SC Mounds

Question 4) There are several key architectural and mortuary features which makes the Hopewell Mound Group unique when compared to other nearby SC sites. Is the biological status of adults buried at the Hopewell Mounds different than the biological status of adults buried at Seip, Harness, Ater, and Rockhold Mounds?

Expectation: It is expected that the biological status of the adults buried at the Hopewell Mounds should be better than the biological status of those buried at Seip, Harness, Ater, and Rockhold. Indicators of poor biological status should be less prevalent in adults from the Hopewell Mounds who have increased social status as marked by burial in prestigious SC mounds. If this is indeed the result, it could provide skeletal evidence to support Carr's (2005c) hypothesis that those buried at Hopewell Mound were prestigious community leaders, or "special persons".

Intrasite Analysis at the Hopewell Mound Group

Question 5) Within the Hopewell Mound Group, Mounds 23 and 25 stand out from the other mounds with burials because of their similar size and shape, large burial populations, and shared mortuary features. Is the biological status of adults buried at Hopewell Mounds 23 and 25 different than the biological status of adults buried with provenience at the other Hopewell Mounds?

Expectation: It is expected that the biological status of the adults buried at Hopewell Mounds 23 and 25 should be better than the biological status of those from the other Hopewell Mounds. Indicators of poor biological status should be less prevalent in adults from Hopewell Mounds 23 and 25 who are prestigious community leaders. If this is the case, it could provide skeletal evidence to support Carr's hypothesis that burial at Mound 25 was restricted to important adults, and Mound 23 was for the burial of their spouses or relatives who were restricted from burial in Mound 25 (Carr, 2008e).

Question 6) Hopewell Mound 25 burials have more prestigious and numerous grave goods and evidence of more elaborate mortuary rituals than burials at Mound 23. Is the biological status of adults buried at Hopewell Mound 25 different than the biological status of adults buried at Hopewell Mound 23?

Expectation: If the results of question 5 reveal that biological status is better for prestigious community leaders, then it is expected that the biological status of those from Hopewell Mound 25 should be better than those from Hopewell Mound 23. Indicators of poor biological status should be less prevalent in adults from Hopewell Mound 25 who are prestigious community leaders. If the biological status of adults buried at Mound 25 is better than those from Mound 23 it could provide skeletal evidence to support Carr's (2005c:337) alternate hypothesis that those buried at Hopewell Mound 25 are members of the highest social rank group, or his hypothesis that burial at Mound 25 was restricted to important individuals (Carr, 2008e).

Question 7) Hopewell Mound 25 is unique when compared to the other mounds of the Hopewell Mound Group because of its large size, rich deposits of exotic artifacts, and the most elaborate mortuary rituals. Is the biological status of adults buried at Hopewell Mound 25 different than the biological status of adults buried with provenience at the other Hopewell Mounds?

Expectation: If the results of question 5 or 6 reveal that biological status is better for prestigious community leaders, it is expected that the biological status of those buried at Hopewell Mound 25 should also be better than those buried with provenience at all other Hopewell Mounds. Indicators of poor biological status should be less prevalent in adults from Hopewell Mound 25 who are prestigious community leaders. This could also provide skeletal evidence to support Carr's (2005c:337) alternate hypothesis, that social ranking exists in Ohio Hopewell societies and those buried at Hopewell Mound 25 are members of the highest rank group. Furthermore, if any of the last four research questions reveal that the biological status of prestigious community leaders is better than that of another group these results may indicate that the model of Ohio Hopewell leadership and prestige proposed by Carr and Case (2005) has a measurable effect on skeletal biology, particularly markers of skeletal stress and trauma.

Chapter Summary

Ohio Hopewell settlement and subsistence models indicate small residential communities scattered across the landscape. The people in these communities utilized broad-based hunting and gathering subsistence strategies that involved fishing, the hunting of white-tailed deer and other mammals, gathering wild foods such as nuts and berries, and gathering domesticated plants (Carr, 2008a; Smith, 2001; Wymer, 1996; Pacheco and Dancey, 2006). There is no biological or archaeological evidence to support the hypothesis that Ohio Hopewell populations were dependant on maize as a primary staple for subsistence (Bender et al., 1981; Beehr, 2011, Sciulli, 1997; Wymer, 1997). There is also no evidence that large agricultural food surpluses existed that could be controlled by a few select community leaders (Ford, 1979; Yerkes, 2006).

This study is based on the perspective that Ohio Hopewell communities represent complex egalitarian societies. Ohio Hopewell ceremonial centers contained the burials of prestigious community leaders associated with elaborate mortuary architecture and exotic artifacts. Archaeologists agree that Ohio Hopewell communities had the presence of many different types of leaders who filled specific types of social roles and that differences in social status were marked at death (e.g. Carr and Case, 2005; Greber, 1979a, 1979b; Seeman, 2004; Pacheco and Dancey, 2006). Variation has been detected between the SW and SC regions of Ohio for stone tools, ceramics, copper earspools, and for differences in the social status of males and females (Hawkins, 1996; Nolen et al., 2007; Ruhl and Seaman, 1998; Filed et al., 2005).

This study examines the relationship between social status and biological status in Ohio Hopewell skeletal collections from the SW and SC regions in an attempt to determine whether differences in social status contributed to differential access to food resources and critical nutrients, and/or buffered high status individuals from stress. The following chapter explains the biocultural model of stress and its effect on the skeletal system, and describes the markers of skeletal stress and trauma used in this study for the evaluation of biological status.

Chapter 3: The Relationship Between Biological Status and Social Status

This chapter discusses the concept of stress and its effect on the skeletal system, and defines the term biological status. It reviews the literature pertaining to the markers of biological status that were utilized in this study to analyze the skeletal remains of Ohio Hopewell adults. What the presence of each biological status marker may reveal about an individual's biological status, and when this marker affected the individual is also discussed. The second part of this chapter reviews previous research studies that have examined the relationship between biological status and social status in the Eastern Woodlands, and are pertinent to this study's examination of Ohio Hopewell biological and social status.

The Concept of Stress

The concept of stress as a physiological disturbance and its effect on human biology was first discussed by Hans Selye. Selye (1936) observed that chronic activation of the stress response system in mice led to functional disorders of the thymus gland and adrenal cortex which are both components of the immune system. The Selyean stress model involves a nonspecific hormonal response of mice to noxious stimuli which causes tissue damage. These stimuli represent environmental stressors in this stress model, and may have mechanical, chemical, or thermal origins (Selye, 1936).

Stress and its effect on the human skeletal system has been addressed by Goodman and his colleagues (Goodman et al., 1988; Goodman and Armelagos, 1989). The hormones and anatomical pathways by which Selyean stress travels through the body was discovered by different researchers in the 1970s (Goodman et al., 1988). Kagan refers to the activation of these pathways as the "Selyean stress response" (as cited in Goodman et al., 1988). The Selyean stress response involves the release of endocrine system hormones, most notably cortisol by the cortex of the adrenal gland and catecholamines (epinephrine and norepinephrine) by the medulla of the adrenal gland. This response is initiated by fight or flight stimuli that activate the sympathetic nervous system along the pituitary-adrenal cortical and sympathetic-adrenal medullary pathways. Cortisol suppresses the immune system and reduces swelling and pain at the location of tissue inflammation, while catecholamines prepare body systems for fight or flight-related activities.

Research by Mason was critical in developing the current theoretical view of stress as a model for adaptation, and demonstrates that Selye was not quite accurate in his conclusion that stress was a nonspecific response (as cited in Goodman et al., 1988). Mason's work reveals that stresses, such as hypothermia and hypercaloric situations, do *not* result in the hormonal response to stress by the sympathetic nervous system (as cited in Goodman et al., 1988). By not responding to certain types of stimuli, the body does not waste energy, therefore this is an adaption for the conversation of energy. According to Mason, the Selyean stress response is specific to stressors that are perceived as threatening, which is contrary to Selye's original hypothesis (as cited in Goodman et al., 1988). Secondly, Mason's research supports the notion that *perceived* stressors consistently stimulate the release of stress-related hormones in the same manner as actual environmental stressors that Selye observed. Goodman and his colleagues propose that the missing component to the Selyean stress model, which in its original design primarily focuses on environmental stressors, is the inclusion of psychosocial stress and particularly *perceived* stress. The latter can include sociopolitical processes that individuals perceive that they have very little control over and feel that they cannot influence. These stimuli of psychosocial stress become risk factors for illness following the Selyean stress model.

In the model of stress proposed by Goodman and his co-workers, the environment is both the cause of, and solution to stress (see Figure 1 in Goodman and Armelagos, 1989). Stress is represented by environmental stressors as well as psychosocial stress. Environmental stressors, such as limited food resources, or culturally induced stressors, such as marriage practices, have the potential to affect adaptation. Some of these stressors can be buffered by cultural systems, such as subsistence or habitation strategies. If the individual does not have the ability to shield him/herself from stress (environmental or psychosocial), this stressor can lead to a physiological disruption (stress) that may be represented by the disruption of growth in the teeth and bones of the skeletal system.

The next component of Goodman and his co-workers' model of stress is the impact of stress on the entire population. Keeping in mind that not all segments of a population may be affected equally by stress because of possible cultural buffers, stress can negatively affect the health, work capacity, and reproductive capacity of a population (Goodman et al., 1988; Goodman and Armelagos, 1989). Additionally, it may cause sociocultural disruption which creates additional psychosocial stress and in turn feeds back into the model as stress on the individual. If a population is not able to adapt to the stresses placed upon it which cause physiological disruption, this population may not survive. Certainly not all types of stress placed on an individual will manifest themselves in the skeletal system, but if the type of stress that affects bone and teeth is severe, or of long enough duration it will have an impact on the skeleton (Goodman et al., 1988:177). Other factors that influence how stress will impact an individual's skeleton are genetics, age, sex, nutrition status, and immunity. Goodman and colleagues caution that because the skeletal system has limited processes for how it can respond to stress, many indicators of stress on the skeletal system are nonspecific. The researchers note that in skeletal biology the stress concept is very general. "This perspective, in which many types of stressors lead to a common stress response, is similar to that of the Selyean stress model. However, the skeletal study of stress differs markedly from Selyean stress in that there is little room for consideration of perceived stress response" (Goodman et al., 1988:195). Unfortunately, unlike in research conducted on contemporary living populations, there is not the ability to assess an individual's level of *perceived* psychosocial stress in the study of prehistoric skeletal remains.

Contemporary research has supported the hypothesis that even perceived psychosocial stress can lead to elevated levels of corticosteroids and catecholamines that in turn results in the suppression of the immune system (e.g. Biondi and Zannino, 1997; Booth, 1998; Herbert and Cohen, 1993; Kemeny and Schedlowski, 2007; Segerstrom and Miller, 2004). Psychosocial stress has been shown to make humans more susceptible to infectious diseases and can affect the onset and severity of these diseases (Biondi and Zannino and Zannino, 1997). For example, in a study of medical students there was an association between exam stress, frequency of illness, and suppression of the immune system (Booth, 1998). The response to stress leads to decreased immunity responses along both the neuroendocrine and autonomic pathways to the immune system. However, it also must be noted that in response to stress that growth hormone and prolactin hormone released by the anterior pituitary gland actually enhance the immune response and act to balance the suppressive effects of corticosteroids and catecholamines (Booth, 1998). Booth notes "that a critical parameter is the *perception* of stress clearly has important implications and illustrates how much the way we respond psychologically to our environment can affect the way we respond physiologically" (Booth, 1998:2222).

According to Booth (1998), the relationship between the nervous and immune systems and the psychosocial domain is complex and that different types of stress will result in differing responses of the immune system. Booth writes "the immune, neural and psychosocial domains are coordinated as coherent self-generative processes within an individual's life such that it is the context, interpretation, and meaning of stress for the individual that determines its immune effects" (Booth, 1998:2227). The context of when a psychosocial stress event occurs is perhaps more important than the actual event which caused stress (Booth, 1998). In the meta-analysis of over 300 studies on stress and humans from the last 30 years, Segerstrom and Miller (2004) summarize that the more chronic a stressor is found to be, the more components of the immune system it affects in a detrimental manner. They also found that in some clinical studies older individuals and those already affected by disease suffered from increased susceptibly to immune system suppression during stress events. One of the needs of future research is to analyze the effects of stress-induced changes to the immune system on healthy individuals (Segerstrom and Miller, 2004). Do stress-related changes to the immune system result in stress-related disease in healthy people?

The relationship between skeletal stress and the immune system is poorly understood. Furthermore, the cultural ecology of human immunity is a complex relationship. The function of the immune system is dependent on the interrelationship of nutritional ecology, ecology of infectious disease, reproductive ecology, and social ecology (McDade, 2005). McDade (2005) warns that many studies in the burgeoning field of psychoneuroimmunology involving psychosocial stress and the immune system utilize test subjects that are relatively homogenous and include many of the following characteristics: affluent, male, a descendant of a Western population, and a college student. Caution must be used when creating hypotheses about the relationship between a population's level of psychosocial stress and immunity, particularly when working with prehistoric populations.

Summary: The Concept of Stress

It has been demonstrated by Mason that the Selyean stress response is a specific hormonal response to any environmental stressors that the body perceives as threatening (as cited in Goodman et al., 1988). This has been incorporated into a model of stress for the human skeletal system in which adaptation is driven by both environmental and perceived psychosocial stress (Goodman et al., 1988; Goodman and Armelagos, 1989). The skeletal system has limited processes in which it may respond to stress (environmental or psychosocial), thus many of the indicators of skeletal stress are nonspecific (Goodman et al, 1988). Clinical research has revealed strong associations between increased perceived stress and decreased immunity (e.g. Biondi and Zannino, 1997; Booth, 1998; Herbert and Cohen, 1993; Kemeny and Schedlowski, 2007; Segerstrom and Miller, 2004). However, these studies have not primarily focused on diseases which affect the skeletal system. Furthermore, the ability to assess an individual's perceived level of psychosocial stress is not possible in the analysis of prehistoric skeletal remains.

Biological Status

It should be noted that the goal of this dissertation research is not to assess the health of the Ohio Hopewell population. Health is formed by two components: length of life and quality of life (Steckel et al., 2002b). This study does not analyze the life expectancy of Ohio Hopewell groups, but rather focuses on the quality of skeletal health as represented by skeletal indicators of biological status. In this study, biological status refers to the analysis of skeletal markers of nonspecific systemic physiological stress, dietary nutritional stress, nonspecific infection and/or disease, or trauma to the skeletal system. This follows the concept of "biological status" utilized by Robb et al. (2001). The skeletal markers of biological status used in this study are discussed below.

Markers of Skeletal Stress

Linear Enamel Hypoplasias

Dental enamel hypoplasias are a type of developmental defects of enamel that cause a decrease in enamel thickness. All enamel defects are caused by an error during amelogenesis, when ameloblasts are prevented from secreting and depositing enamel at the tooth's surface (Goodman and Rose, 1990). Enamel hypoplasias can take many forms. They may manifest themselves as small vertically or horizontally arranged pits, or as more pronounced vertically or horizontally arranged furrows. Horizontal furrow defects are termed linear enamel hypoplasias (LEH) in anthropological literature, and mark a horizontal area of decreased enamel thickness.

According to Goodman and Rose (1990), enamel hypoplasias are caused by three factors: hereditary genetic anomalies, localized trauma, or systemic metabolic stress. Enamel defects in teeth that are the result of genetic defects can be differentiated from the other two causes because all of the teeth are typically affected by enamel defects. The frequency of genetic enamel defects are less than 1% in modern populations. On the other hand, enamel defects that are the result of trauma will be represented by a single episodic defect on only one tooth or a few teeth in one area. Whereas, "defects resulting from systemic metabolic stress are likely to be found on most or all teeth developing at the time of the stress, and the locations of the defects reflect the relative completeness of enamel crowns at the time of the disruption" (Goodman and Rose, 1990:64). Goodman and Rose (1990) conclude that since the frequency of genetic enamel defects and defects from trauma are both quite low, the enamel defects studied in archaeological populations are LEH that are the result of systemic metabolic stress. Linear enamel hypoplasias are the focus of dental data collection and analysis in this study.

Hilson (2008) provides a concise summary of enamel development. Enamel is deposited by ameloblasts during appositional growth along an enamel rod (prism) from the direction of the dentin-enamel junction to the crown's surface. This enamel grows in an incremental manner, as a period of active enamel matrix secretion is then followed by a period of reduced enamel secretion. Originating from the dentin-enamel junction, brown striae of Retzius reach the tooth's surface and create a wave-like pattern at the tooth's surface as these grooves run around the crown's circumference like rings on a tree when viewed in a transverse section. Striae of Retzius appear to represent the disturbance of enamel secretion by ameloblasts at a regular period of about seven days (circaseptan) and mark the point in which enamel secretion slowed down (Aiello and Dean, 1990). The grouping of shallow grooves formed by the striae of Retzius when they reach surface of the crown is known as perikymata.

LEH parallel perikymata on the crown's surface and can range in size from the disruption of only one band of perikymata, which only can be observed microscopically, to LEH that have disrupted as many as 20 adjacent perikymata and can be observed with the naked eye (Hilson, 2008). Goodman and Rose (1990) thoroughly review the relationship between LEH observed without magnification at the crown's surface and histological disturbances of normal enamel development. They note the histological study of linear enamel hypoplasias reveals that the enamel within a LEH is well mineralized. This means that ameloblasts do not die after the period of stress, but slow down their rate of secretion and lose their functional abilities that results in less enamel being present at the tooth's surface. Research involving hypoplasias in sheep teeth also indicates that hypoplastic lesions occur during the secretory phase of amelogenesis and that it does not matter if the lesion is caused by local trauma or systemic stress, it still results in an area of reduced enamel thickness (Suckling, 1989).

Linear enamel hypoplasias are a marker of nonspecific systemic physiological or metabolic stress that result in a linear enamel defect of decreased enamel thickness on immature and mature tooth crowns. The presence of LEH in permanent teeth are a marker of a period during enamel growth and development that was interrupted as the individual suffered from systemic physiological stress that could have been caused by nutritional stress and/or childhood illness. Epidemiologists studying dental defects have identified almost 100 factors related to the development of enamel defects which include nutritional deficiencies, drug toxicities, childhood fevers, or any disease which stresses metabolism or normal physiological processes (Cutress and Suckling, 1982). Interference with normal growth and development of enamel can be the result of many different causes, including nutritional deficiencies, vitamin D deficiency, hypoparathyroidism, and a childhood illness such as rheumatic fever (Schwartz, 1995). Linear enamel hypoplasias document periods of growth disruption in the enamel of adult teeth during the formation of permanent crowns which ranges in time from birth to seven years of age (Goodman and Martin, 2002).

In an important review article on the relationship between LEH and childhood weaning, Katzenberg et al. (1996) conclude that the many researchers who have stated that LEH in prehistoric populations are typically caused by childhood weaning are erroneous in singling out weaning as the primary factor for the presence of LEH. Katzenberg and her colleagues caution that the relationship between morbidity, mortality, and weaning is complex. Because skeletal evidence for LEH occurs during the time range that weaning also occurs (two to four years), researchers should not solely focus on weaning as the cause of LEH in prehistoric populations (Katzenberg et al., 1996). Larsen agrees with this viewpoint and concludes that although weaning may indeed be a cause of systemic stress, "the link between enamel defects and weaning is coincidental rather than real in many circumstances" (Larsen, 1997:49).

Porotic Hyperostosis and Cribra Orbitalia

Porotic hyperostosis (PH) is the expansion of the spongy bone of the skull (diploë) located between the inner and outer tables of the bones of the cranial vault. It is typically symmetric and affects the frontal and parietals more frequently than the occipital (Aufderheide and Rodriguez-Martin, 1998). In fully developed active cases of PH the spongy bone can be observed from the outside surface of the vault as the outer table of cortical bone has been resorbed and the affected bones are thicker as a result of the expansion of spongy bone and thinning of the compact bone of the outer table (Aufderheide and Rodriguez-Martin, 1998:348). This is rarely observed in most skeletal populations. PH is more typically represented by areas of small perforations (pitting) and porosity of the outer table of the cranial vault.

Several different researchers hypothesize that PH is a condition that affects the skulls of juveniles, and when its presence is detected in adults these lesions are almost always healed and represent the origin of this condition in childhood. The majority of active, unhealed lesions of PH are young juveniles under the age of five, while most PH cases in adults are healed, remodeled lesions indicating they occurred earlier in life (Larsen, 1997:32). In the edited volume *The Backbone of History: Health and Nutrition in the Western Hemisphere* (Steckel and Rose, eds., 2002), which compiles skeletal health data from North and South America, there is a dramatic reduction in the number of individuals with evidence of PH after the age of fifteen in their database of prehistoric populations (see Figure 3 in Walker et al., 2009 with data by Steckel et al., 2002a). PH is more typically found in the skeletons of children because in childhood the hemopoietic centers for red blood cell (RBC) production are the diploë of the cranial vault bones and the marrow cavity of long bones (Stuart-Macadam, 1985). Whereas in adults, the marrow space in adult cranial bones is wider than in juveniles, therefore marrow hypertrophy does not occur in the same manner that it does in children when RBC production increases (Walker et al., 2009). Additionally, adult hemopoietic centers are located in the spongy bone of the vertebrae and ribs.

The etiology of porotic hyperostosis has traditionally been explained by paleopathologists as an indicator of genetic anemia, such as thalassemia or sickle cell anemia, or the result of iron-deficiency anemia (e.g. Aufderheide and Rodriguez-Martin, 1998; Ortner and Putschar, 1981; Steinbock, 1976). Lesions similar to PH can be difficult to distinguish from lesions associated with infectious diseases and scurvy (Ortner, 2003:375). However, the distribution of PH in archaeological populations across the world is so widespread that it is unlikely that the genetic anemias are the principle cause of PH in prehistoric skeletal populations (Walker et al., 2009).

Historically, biological anthropologists have hypothesized that iron-deficiency anemia caused porotic hyperostosis because of the dietary hypothesis, or “maize dependency” hypothesis (El-Najjar, 1976). A poor diet, one lacking in iron, and problems with iron absorption form the basis of the dietary hypothesis to explain iron-deficiency anemia and its manifestation on the skeleton as porotic hyperostosis. Supporters of the dietary hypothesis point to evidence of a transition to maize agriculture and an increased prevalence of PH as the result of a diet low in iron, or inhibited by the phytates in maize that prevents the absorption of iron. Foods high in iron include red meat, poultry, lentils, beans and leafy vegetables. Other hypotheses for the presence of iron-deficiency anemia are based on increased disease and/or pathogen load, poor sanitation, parasitic activity, and increased population density (Stuart-Macadam, 1992).

An alternative model for the existence of porotic hyperostosis is that iron-deficiency is not detrimental, but advantageous for children in resisting pathogens (Stuart-Macadam, 1992). Stuart-Macadam's hypothesis is that an increased pathogen load results in the increased prevalence of PH in a population independent of poor diet. Increased pathogen loads can result from increased parasitic activity in warmer environments, or in communities with increased sedentism and population density and resulting poor sanitary conditions. Because iron-deficiency anemia results in the body producing fewer red blood cells, the onset of infectious disease in the body is countered with the body lowering its iron level to make it a less likely target for bacteria to reproduce, as iron is an essential component for bacterial growth. In essence, Stuart-Macadam proposes that iron-deficiency anemia is an adaptive advantage for surviving invasion from pathogens. Furthermore, she disputes the notion that PH is an indicator of nutritional stress. Interestingly, Stuart-Macadam (1992:44) cautions there is not a lot of clinical research to support a link between the severity of iron-deficiency anemia and its manifestation on the skull in living individuals.

The analysis of porotic hyperostosis in prehistoric Ecuador also counters the dietary and nutrition hypothesis. In Ecuador, PH and chronic anemia result from invading parasites and infectious diseases which are plentiful in lowland sites and absent in highland sites (Ubelaker, 1992). Ubelaker proposes that PH is associated with increased population density, sedentism, and poor sanitation over a temporal scale. The consensus of contemporary bioarcheologists is that PH is the result of iron-deficiency anemia that is acquired during childhood from multiple stressors including: crowded living conditions, infection rates, parasite load, and poor diet (Larsen, 1997). In each location where PH is discovered, Larsen cautions, the causes of this condition must be considered differently as different cultural practices, such as access to nutrients or poor sanitation conditions, can play a role in the prevalence of PH in particular setting.

Cribra orbitalia (CO) is indicated by lesions similar to PH which affect the outer table and cause porosity and pitting, but CO occurs on the roofs of the bony eye orbits. These lesions occur bilaterally 90% of the time and are typically located in the anterior-lateral aspect of the orbital roof (Aufderheide and Rodriguez-Martin, 1998). Several researchers note that CO is a lesion that primarily affects infants and children (e.g. Aufderheide and Rodriguez-Martin, 1998; Stuart-Macadam, 1992; Walker et al. 2009). According to Walker et al. (2009), many paleopathologists have historically considered CO to be caused by the same physiological processes as PH; a notion which Walker and colleagues argue is erroneous.

Walker and his colleagues present a convincing case that the correlation between PH and CO is quite low across worldwide skeletal populations (Walker et al., 2009). Based on data from 217 different North American and South American collections involving 4,419 individuals, there are 1,506 individuals who have PH or CO, or both conditions. Only 27% (n = 405) of these individuals have both PH and CO (Walker et al., 2009). Additionally, CO (19.4%) is more frequently detected in the above archaeological skeletal populations than PH (14.6 %).

Furthermore, the study by Walker et al. (2009) incorporates research by physiologists and chemists to effectively propose that PH is most likely caused by either megaloblastic anemia or hemolytic anemia. Walker and his colleagues argue that iron-deficiency anemia cannot produce the type of spongy bone expansion (marrow hypertrophy) associated with PH and some forms of CO, because the human response to iron-deficiency anemia is to restrict RBC production. There are approximately two hundred different types of hemolytic anemias which cause the premature destruction of red blood cells. Some are genetically inherited, while others are acquired during life. Megaloblastic anemia is a type of anemia which results from problems with DNA synthesis during RBC production and causes the production of RBCs that do not contain enough amounts of hemoglobin for transporting oxygen. Both of these types of anemia result in the need for increased RBC production, and place stress on the hemopoietic centers of the body to create these needed RBCs (Walker et al., 2009).

Megaloblastic anemias are caused by a deficiency of vitamin B12, a deficiency in folic acid, or a combined deficiency of both B12 and folic acid. Vitamin B12 deficiency can be caused by malabsorption of this vitamin, or by a diet that is low in B12, or by gastrointestinal infections caused by a parasite. Vitamin B12 is only found in foods that come from animals, such as fish, shellfish, meat, poultry, eggs, or dairy products. Another cause of megaloblastic anemia is a deficiency in folic acid (vitamin B9) which is also linked to the malabsorption of folate, a deficiency in dietary intake of folate, or a condition that exists during pregnancy. Folate is found in leafy vegetables and legumes and is an important nutrient which prevents anemia in pregnant women. Walker et al. (2009) emphasize that in clinical studies it is megaloblastic and hemolytic anemias, not iron-deficiency anemia, that cause marrow hypertrophy in an attempt to increase RBC production.

There is also very little clinical evidence that reveals a link between CO and iron-deficiency anemia. In fact, Walker and colleagues (2009) note that in the medical literature only paleopathologists make this connection. Walker contends that CO is most likely the result of a subperiosteal hematoma occurring in the orbits that can be linked to chronic cases of scurvy, caused by a deficiency of vitamin C. Walker et al. (2009) propose that PH and some forms of CO result from megaloblastic anemia that infants acquire from their breastfeeding mothers who are vitamin B12 deficient. In studies of living populations, breastfeeding mothers with low B12 levels do not typically show signs of megaloblastic anemia, but their nursing infants are more likely to develop this condition. This relationship also fits with the skeletal data for PH in which CO and PH active lesions are more prevalent in children than in adults. In Walker and co-worker's (2009) model, the complex relationship between B12 deficiency and PH involves depleted B12 levels in the mothers, poor sanitation related to nutrient loss in the infants who may have gastrointestinal tract infections, and resulting diarrhea around the time of weaning.

In a brief response to Walker's hypothesis, Oxenham and Cavill (2010) make the point that Walker and his colleagues misinterpret the clinical research, and that in their opinion iron-deficiency anemia is still a possible candidate for causing the marrow hypertrophy associated with PH. Oxenham and Cavill note that both iron-deficiency anemia and B12 deficiencies cause the excessive growth of immature red blood cells, and thus can cause marrow hypertrophy. Regardless of the specific etiology of porotic hyperostosis and cribra orbitalia, the lesions caused by these conditions have a deleterious effect on the biological status of individuals with these lesions. It is accepted by biological anthropologists that some form of anemia has affected these individuals and placed these individuals under physiological stress. Symptoms of iron-deficiency anemia range from weakness and loss of appetite to extreme fatigue. Symptoms of vitamin B12 deficiency include fatigue, weight loss, diarrhea, and even mental confusion.

Due to the low rate of preservation of bony orbits in the skeletal samples observed during data collection and the strong evidence presented above that lesions associated with CO are not caused by the same etiology as PH (see Walker et al., 2009), CO is not analyzed in this study.

Long Bone Measurements

Anthropometry, the study of human body measurements, has been utilized by biological anthropologists and human biologists to study the effect of genetics and the environment on living and past human populations for over a hundred years. There are two periods of rapid growth velocity in stature; the first occurs during the first few years of life, and the second occurs during adolescence. The start of peak growth velocity in modern populations of North American and European children ranges from 10 – 13 years of age in females, and 12 – 15 years of age in males (Malina and Bouchard, 1991). Males obtain taller stature than females as adults because males grow for approximately two more years than females during puberty (Steckel et al., 2002b). Stature has environmental, nutritional, and genetic components. Individuals with adequate nutrition have the capability to reach their genetic potential for stature (Larsen, 1997). The study of anthropometry in living humans has also established associations between bone measurements, illness, nutrition, and work capacity and that this field allows for an assessment of a population's general quality of life (Goodman and Martin, 2002).

Steckel and colleagues (2002b:144) write that an individual's height at a certain age represents an individual's "history of net nutrition" which is equal to their diet minus energy needed for activity and energy claimed by disease. Children with poor nutrition levels do not have the needed energy for growth. Likewise, children who suffer from higher rates of infection do not have the needed energy for growth as certain infectious diseases can affect an individual's diet. Additionally, activity levels have a role in growth. Therefore, if children in a society are being counted on as a major component of the group's work force, they may lack the energy needed for growth because they are expending so much energy for work at the expense of growth.

A study by Malcolm and another by Martorell and Habicht on growth involving genetic and environmental variables have demonstrated that most differences in average height are due to environmental factors (as cited in Steckel et al., 2002b:144). Therefore, Goodman and Martin (2002) propose that growth is best thought of as a nonspecific indicator of stress in subadults because several different environmental factors (limited access to nutrients, or widespread infection) will have the same end result on stature as genetic differences, and they emphasize that contextual information is required about the population being studied. Saul and Saul succinctly note that "stature is important, because it is a polygenic and multifactorial trait that may be affected by nutrition and disease within both an ontogenic (life cycle) and phylogenic (generation to generation) context" (Saul and Saul, 1997:48).

Based on the environmental and genetic components to stature, several researchers have hypothesized that adult stature of elite individuals in a society should be greater than those of non-elites (e.g. Buikstra, 1976; Powell, 1991; Robb et al. 2001; Shimada et al., 2004). However, there is no difference in stature between elite females and non-elite females reported for any archaeological site from the New World (Larsen, 1997). Larsen speculates whether this may mean that the burden of stress is placed on males in ranked societies.

Periosteal Reactions

The presence of periosteal reactions, or periostitis, on bones may be due to different factors. According to Ortner (2003:208), periostitis is a component of several different disease syndromes (e.g. syphilis or tuberculosis), while it is also a specific disease itself. Ortner terms the former "secondary periostitis" and the latter "primary periostitis", but notes distinguishing the two in skeletal populations can be challenging. Since the periosteum contains osteoblasts throughout life, disturbance of the periosteum causes a periosteal reaction when bone is deposited at the periosteal surface (Ortner, 2003). According to Richardson, any mechanism which "tears, stretches, or even touches the periosteum" will cause the stimulation for bone production (as cited in Weston, 2008:49).

Historically, periostitis was considered a nonspecific inflammatory response to either bone infection or trauma (e.g. Ortner and Putschar, 1981; Steinbock, 1976). However, Weston (2008) provides a list of eight different pathological categories that involve periosteal reactions which includes the following: trauma, circulatory disorders, joint disease, hematological disease, skeletal dysplasias, infectious diseases, metabolic diseases, and neoplastic diseases. Specific pathological conditions that result in periosteal reactions include, but are not limited to: burns, shin splints, hypertrophic osteoarthropathy, rheumatoid arthritis, scurvy, syphilis, leprosy, osteomyelitis, tropic ulcer, tuberculosis, and yaws (Table 1 in Weston, 2008). Periostitis in archaeological populations is most frequently caused by trauma or infections, but the percentage of cases of periosteal reactions linked to infection and not to other causes is unknown (Ortner, 2003). In addition to infection and trauma, periosteal reactions may also be the result of the damage of adjacent soft tissue structures, such as skin ulcers or hemorrhage (Aufderheide and Rodriguez-Martin, 1998; Ortner, 2003). Botel and Ortner (2011) provide diagnostic characteristics for identifying chronic skin ulcers of the tibia and resulting periosteal reactions that indicate a problem with blood circulation.

Evidence of periosteal reactions appear as areas of reactive woven bone on the periosteal surface of the cortex if they are caused by active lesions, or marked by smooth remodeled lesions if they are representative of healed lesions (Larsen, 1997). Mensforth and colleagues describe periosteal reactions as “usually manifested grossly as a smooth, irregular, or spiculated new layers of bone which appear to ‘scab’ over the normal cortex. More severe involvements exhibit serial layers of new bone that can envelope the entire bone and distort its normal contours” (Mensforth et al., 1978:9). Periosteal reactions may also affect the normal shape of bones as the diaphysis thickens in a circumferential direction (Ortner 2003). Periostitis can be classified as acute if it only affects specific localized areas of a single bone, or chronic if it affects several different bones of the same individual (Larsen, 1997; White and Folkens, 2005). Periosteal reactions which affect several bones in the same individual are typically associated with systemic (as opposed to local) infection in a study by Goodman and Martin (2002). Unlike LEH and PH, periosteal reactions may occur at any time during an individual’s lifetime.

In previous bioarchaeological studies, the tibiae are the most commonly affected bone by periosteal reactions, most likely due to the fact that they are located close to the skin and have no overlying muscle to act as protection along their anterior crest (e.g. Goodman at al., 1988; Powell, 1991; Robb et al., 2004). Mensforth et al. (1978) found the tibia, humerus, and femur to be the long bones most frequently affected by periosteal reactions, and that periosteal reactions typically occur bilaterally, unless they are the result of trauma. However, Ortner (2003:211) disputes the notion that periostitis from infection is always bilateral, and notes a case in which severity of periostitis is not bilaterally symmetrical. Trauma to the anterior tibia has the potential for subcutaneous and subperiosteal bruises to allow pathogens to enter an individual's circulatory system which may then result in periostitis (Larsen, 1997). Lesions from syphilis, which is a specific infection associated with periostitis, are also more frequent on the bones closer to the skin's surface, such as the tibia (Ortner, 2003). One of the processes by which infectious diseases that cause periosteal reactions may enter the body is through wounds in the skin of the individual. There is clinical research which concludes there is "strong support" for a link between chronic psychosocial stress and wound healing in which higher levels of stress result in slower wound healing rates (Kemeny and Schedloski, 2007:1016).

An important contribution to the study of periosteal reactions by bioarcheologists is provided by Weston (2008). Weston notes that most literature in bioarchaeology equates periostitis with the phrase "nonspecific infection". She writes, "This is patently untrue, and may be derived from confusion between the terms 'inflammation' and 'infection'" (Weston, 2008:57). Weston reinforces the fact that many different types of etiology result in periosteal reactions, as anything that causes inflammation of the periosteum will result in a periosteal reactions. Infections are a common cause of periosteal inflammation, but they are by no means the only mechanisms which cause inflammation, as trauma, neoplasm, or circulatory disorders can all result in periosteal reactions. The danger of only considering periosteal reactions as nonspecific indicators of infection is that it misses the potential to identify specific diseases in a population, while also potentially overestimating the amount of infectious disease in a population (Weston, 2008:57).

An example of bioarcheologists who may possibly overstate the importance of studying the level of non-specific infections as evidenced by periosteal reactions in bone is provided by Goodman and Martin (2002). They note that “low-level, lingering, but nonlethal bouts of infection can reveal something about lifestyle and group living that the more virulent and epidemic infection do not” (Goodman and Martin, 2002:32). When groups of individuals survive periods of time with non-specific infections this evidence provides information about the community’s nutritional level, hygiene, and sanitary conditions. Other researchers report an increase in infectious disease has been linked to more sedentary lifestyles as they examine the transition from foraging based subsistence to agriculture based subsistence (e.g. Lallo and Rose, 1979; Perzigian et al., 1984; Sciulli and Oberly, 2002). Care must be taken by bioarcheologists to avoid only associating the presence of periosteal reactions with infectious diseases.

A skeletal population’s frequency of periosteal reactions may provide some information about the level of psychosocial stress a population experienced. Current research from the field of psychoneuroimmunology demonstrates that increased levels of psychosocial stress may lead to increased rates of infectious diseases (e.g. Adler and Matthews, 1994; Biondi and Zannino, 1997; Kemeny and Schedlowski, 2007). On the other hand, perhaps a group’s overall decreased rate of infection is not the result of less psychosocial stress, but rather higher levels of social support within the group. Research demonstrates that groups with higher levels of social support are healthier, and have the ability to counteract the negative affect of psychosocial stress on the immune system (e.g. Adler and Matthews, 1994; Booth, 1998; Cohen, 1998; Uchino, 2006). Caution, however, must be used with the reserch showing links between psychosocial stress and infectious disease, as most of these studies are based on specific viral infectious diseases such as HIV, Epstein-Barr virus, and influenza.

In archaeological populations, the examination of periosteal reactions has the potential to be an important indicator of biological status, but it must be used as an indicator of nonspecific disease or acute trauma, and cannot only be considered a marker of nonspecific infection. Periosteal reactions can be used to analyze whether differences in social status (due to age, sex, kinship, or some other factor) prevent different groups from having higher rates of periosteal reactions. These lesions may be caused by accidental trauma or microtrauma (shin splints) inflicted as a result of different subsistence activities, or trauma obtained during warfare (bone bruises). Additionally, periosteal reactions have the potential to provide evidence whether a group was buffered from diseases (infectious or not) that caused periosteal reactions due to the complex relationship between nutrition, immunity, infection and psychosocial stress.

Trauma

Trauma is considered by biological anthropologists to be the second most common pathology which affects the skeleton after degenerative changes such as osteoarthritis (White and Folkens, 2005). Evidence of healed (antemortem) skeletal trauma in an individual is marked by remodeled bone calluses, and such trauma is the result of an accident, or an indication of interpersonal violence. Wrist and ankle fractures are possible examples of accidental fractures, whereas parry fractures of the ulna can be indicative of fractures sustained during defensive movements. Depressed fractures occur in flat cranial bones and may be the result of either accidental falls, or violence. A fracture in one bone may have an affect on neighboring bones, such as the spread of infection, the development of osteoarthritis, or even tissue death (White and Folkens, 2005). Previous studies in North America have focused on skeletal trauma as war-related (e.g. Milner, 1995; Smith, 1997), or violence inflicted on women (e.g. Martin, 1997; Wilkinson, 1997), while others report that most trauma is accidental (e.g. Lovejoy and Heiple, 1981). Lovejoy and Heiple (1981) report that fracture risk is elevated in 10-25 year olds and individuals older than 45 years of age. This coincides with a period of high activity levels (10-25), and the latter is the result of decreasing bone density in older individuals.

The analysis of trauma in a population reveals information about biological stress and the quality of life in this group. However, unlike LEH, PH, or periosteal reactions, this is not stress associated with a nonspecific systemic disease or infection, or related to dietary or nutritional deficiencies. Rather, fracture repair involves specific organ systems. The healing of fractured bones places increased stress on both the immune and cardiovascular systems as cells from these organ systems initiate a localized inflammatory response after a bone fractures (Probst and Siegel, 1997). Cells of the cardiovascular and skeletal systems are also then involved in the repair of blood vessels and in the formation of soft tissue and skeletal calluses during the stages of fracture repair. Regardless of the cause of specific fractures, it cannot be disputed that a bone fracture also affects the quality of an individual's health, as they are accompanied by pain, and the following possible complications: infection, tissue necrosis and loss of innervation, bone deformity, traumatic arthritis, or joint fusion (Ortner, 2003:128). A fracture can also possibly lead to (temporary or permanent) decreased mobility and the need for community involvement in the care for such individuals (Steckel et al., 2002a). Lovejoy and Heiple (1981) note that the "excellent state of healing" at the prehistoric Libben site indicates that there was extensive care for patients who suffered from fractured bones, but this is not the case in all prehistoric populations (see Larsen, 1997:152-153). All of these conditions related to bone fractures have a negative affect on an individual's quality of life, or in terms of this study, biological status.

Unlike other biological status indicators which primarily affect children, trauma may affect the skeleton at any point during an individual's lifetime.

Another interesting aspect of fractured bones to consider is the relationship between psychosocial stress and trauma. Sutherland et al. (2002) examine the relationship between domestic violence, injuries, psychosocial stress, depression, and physical health problems in a contemporary population. The authors write, "Women who reported higher rates of abuse had higher levels of stress, depression, and physical health symptoms compared to women who had no or lower rates of abuse" (Sutherland et al., 2002:627). These results indicate that abused women's physical health is affected in three ways: inflicted injures, psychosocial stress from abuse, and the combined effects of stress and depression (Sutherland et al., 2002:629). This research is specific to the abuse of women, but it appears to hint at a relationship between trauma, psychosocial stress, and resulting biological status that is not frequently discussed in bioarchaeological literature.

Timeline of Biological Status

The skeletal markers used to analyze biological status in this study create a timeline of stress for when an individual's teeth and skeletal system are susceptible to stress for each different marker. Linear enamel hypoplasias on permanent teeth are a marker of nonspecific systemic physiological stress during the development of adult teeth which is a period ranging from birth to seven years of age. Although the etiology of PH is debated, it is accepted that this is a marker of nonspecific stress based on dietary nutritional deficiency and/or infections that mainly targets individuals under the age of fifteen, because this is when the highest percentage of active lesions of PH are found in prehistoric populations. Adult stature is an indicator of nutritional stress, and to a lesser extent nonspecific infection, which affects individuals in the first few years of life and/or in the broad timeframe of ten to twenty years of age, depending on their sex. Periosteal reactions indicate evidence of nonspecific disease and/or infection or acute trauma and may affect an individual during one's entire lifetime. Likewise, antemortem skeletal trauma may occur as the result of an accident, or from interpersonal violence during an individual's entire lifetime.

Biological Status and Social Status: Previous Studies in the Eastern Woodlands

This section reviews studies that have previously examined the relationship between skeletal health/stress and social status in populations from the Eastern Woodlands, and are pertinent to this study's examination of Ohio Hopewell biological status. This literature review is organized into the following sections: change in subsistence behavior over time, social complexity, and regional studies from the Ohio River Valley.

Change in Subsistence Behavior

A common topic of skeletal health studies in the Eastern Woodlands concerns the transition from societies focused on hunting and gathering subsistence to agricultural societies that were dependant on maize. An example is the analysis of the quality of skeletal health which accompanies the intensification of agriculture through time in west-central Illinois sites ranging from the Middle Archaic to Mississippian period (Cook, 1984). The Mississippian period was associated with a transition from foraging subsistence to intensive agriculture. Maize is considered to be the primary food staple during the Mississippian time period and an important staple even in the preceding Late Woodland period. Cook (1984) reports individuals from the Late Woodland period demonstrate a slower decrease in juvenile growth that may be the result of a decrease in nutritional status accompanied by the shift towards a maize-dependent, low protein diet. Interestingly, Cook does not find a trend for a decrease in adult stature through time related to subsistence strategies. Cook (1984) proposes that reduced juvenile growth associated with a maize-dependent diet may be reflected in the growth of juveniles, but it does not necessarily lead to the reduction in adult stature in the same population. However, shorter children for their age have higher frequencies of cribra orbitalia.

The relationship between subsistence and settlement changes and its effect on different markers of skeletal health of Late Woodland and Middle Mississippian populations has also been examined at Dickson Mounds in west-central Illinois. There is an increase in the frequency of PH over time, as populations became more dependent on maize based diet (Goodman et al., 1984). The frequency of periosteal reactions also increases over time, and affects both sexes equally and all age groups (Goodman et al., 1984; Lallo and Rose, 1979). Lallo's study found that the rate of infections changed from slight to moderate, or even to severe over this timeframe as a result of an accompanying increase in maize consumption, an increase in population density, and a decrease in mobility (as cited in Larsen, 1997). In general, this is consistent with the observation that the transition in North America from foraging to farming is accompanied by an increased rate of periosteal infections (Larsen, 1997).

Goodman and his colleagues (1984) conclude that the general pattern at Dickson Mounds is that stress increased over time, and was accompanied by an increase in sedentism and increased reliance on a maize diet. This is despite the fact that environmental studies and archaeological evidence of hunting and foraging strategies reveal that nutrition during this time could have been acceptable based on the supply of local resources available to the local populations. Instead, there is skeletal evidence of nutritional and infectious stress on this population.

Social Complexity

Another focus in the study of skeletal health involves the relationship between diet, nutrition, and social and political complexity. The small number of biological status studies on prehistoric egalitarian societies in the Eastern Woodlands reveals no differences in nutritional status between males and females (e.g., Cassidy, 1984). The nature of prehistoric egalitarian societies obscures nutritional status differences (Danforth, 1999). However, in trans-egalitarian (e.g. Pueblo and Illinois Middle Woodland societies) and ranked chiefdom-level societies (e.g. Mississippian), there are contradictory, site-specific results concerning the relationship between individuals of ranked status and their dietary and nutritional status (Danforth, 1999). Some studies have shown a correlation between social status and dietary/nutritional skeletal stress for certain markers, while other studies reveal a completely different or non-existent relationship for these variables. As sociopolitical complexity increases, such as in prehistoric, stratified state-level societies (e.g. Mayan), the pattern is very similar to contemporary populations in which there is generally a positive relationship between socioeconomic status and health (Danforth, 1999).

The relationship between social status and biological variability of Illinois Havana Hopewell societies at the Klunk-Gibson site has been examined by several researchers. Individuals of high social status had a lower frequency of LEH than those of low status (Cook, 1981). However, the difference in LEH did not associate with differences in juvenile growth, as individuals of high status and low status had similar rates of juvenile growth (Cook, 1981). However, Buikstra (1976) detects a statistical significance between social status and stature. This study demonstrates that high status adult males buried in the most elaborate and uncommon graves are taller than other adult males. This information along with mortuary evidence contributes to the hypothesis that ranked status by ascription is characteristic of the Havana Hopewell (Buikstra, 1976). A decreased frequency of osteoarthritis in the major joints of adult males and females of high status is used as evidence to propose that the division of labor in the Havana Hopewell is the result of ascribed social status (Tainter, 1980).

The relationship between the frequency of LEH and different levels of social rank has also been studied at the multicomponent Dickson Mounds site in west-central Illinois. Goodman and Armelagos (1988) determine that LEH are more frequent in the teeth of juveniles from lower social ranks than in juveniles with higher social status. They hypothesize that the higher social status of these individuals in a stratified society buffered these individuals from the stress placed on the individuals of lower social status. However, there are no statistically significant differences in LEH frequencies based on sex (Goodman et al., 1980).

In chiefdom-level Mississippian societies skeletal stress has been studied by several researchers. Powell (1991) reports that there is no statistically significant difference in adult body size between elite and nonelite females at Moundville in Alabama where three categories of rank are present. Elite male stature is slightly larger than non-elites, but this is not statistically significant. There is also not a statistically significant difference at Moundville for the frequency of CO, or periosteal reactions, or LEH based on age, sex, or rank of individuals (Powell, 1991). The overall frequency of bone fractures is very low (under 1%) and most fractures are found in individuals of low status. There are no fractures evident in females of elite status, but Powell cautions the samples may be biased as these may be based on fewer elite males in the burial population. At a Mississippian site nearby Moundville, Powell (1991) reports that elite males have a higher frequency of bone fractures than non-elite males. Blakeley (1980, 1988) does not find a clear differentiation between high and low status and frequency of periosteal reaction at different Mississippian sites in Georgia. Additionally, Blakely (1988) does not detect a difference in the frequency of LEH based on social status.

However, at Cahokia, which is a large Mississippian chiefdom and thought to be the center of the most elite individuals who had access to certain prestige items, differences in skeletal health based on social status have been detected. Rose and Hartnady detect that individuals of middle status at Mound 72 have a frequency of five times more infections from periosteal reactions than those of high status (as cited in Larsen, 1997). Additionally, high status individuals do not exhibit porotic hyperostosis, while 12.5% of low status female sacrificial victims display these lesions. These results from Cahokia suggest that at this site, individuals of high status may have been buffered from non-specific infections such as periostitis, and lesions such as PH which indicate dietary and/or nutritional deficiency. Differing conclusions by Mississippian bioarcheologists regarding the association between status and skeletal health reveals the likely possibility that the relationship between these two variables is site-specific or best understood at the regional level. Powell concludes that at Moundville, “ranked status may have mandated certain behavioral and dietary differences within the community, but general health seems to have been little affected" (Powell, 1991:50).

Ohio River Valley Regional Studies

Previous research studies have not focused extensively on the skeletal health of the Ohio Hopewell. However, several analyses of skeletal populations from the Ohio River Valley have been conducted. A decline in skeletal markers of health and nutrition during the transition from hunting and gathering to agriculture is also detected in skeletal populations from southwest Ohio along the Ohio River Valley (Perzigian et al., 1984). The skeletal samples include the following: Late Archaic populations who were mobile hunter-gatherers, a Middle Woodland Hopewell population, and Late Woodland Fort Ancient populations. The Fort Ancient populations are associated with fortified sedentary villages, and were focused agriculturalists with maize and beans as the primary crops. Their subsistence strategies included hunting for only a few specific species of animals. Based on small sample sizes, the health and nutrition of these populations increased slightly over time from the Late Archaic to Middle Woodland period, but then declined in the Late Woodland Fort Ancient group. Stature increased from the Late Archaic to Middle Woodland and then decreased in the Late Woodland groups for both males and females. The frequencies of caries, linear enamel hypoplasias, and tibial periosteal reactions all increased over time. The pattern of declining quality of skeletal health with an increased dependence on maize and increased population density in the Ohio Valley is similar to the relationship between these factors in other regions of the Eastern Woodlands.

The skeletal health of seven Ohio Valley populations (including two Hopewell populations) over a 2,500 year time frame spanning from the Late Archaic to the Late Prehistoric period (ca. 800 – 400 BP) has also been studied as part of the health and nutrition project in the Western Hemisphere (Steckel and Rose, eds., 2002). The results of this study reveal that these people were fairly healthy, and that if stress was common, it was not severe (Sciulli and Oberly, 2002). All the populations exhibit large average stature, but stature does decrease over time and is the smallest for the populations from the Late Prehistoric period. In each time period, individuals buried in higher calcium soils (lime) have higher average stature values (see Figure 15.3 and Table 15.4 in Sciulli and Oberly, 2002). This may indicate that ecological differences related to differences in soil calcium levels are as important factors in growth and development as changes in dietary strategies (i.e. hunting and gathering vs. agriculture) (Sciulli and Oberly, 2002).

In the Ohio River Valley, LEH rates also increase over time and likely indicate the periods of systemic stress that also resulted in the smaller statures of the populations from the Late Prehistoric period (Sciulli and Oberly, 2002). The data from the Late Archaic populations shows an association between stature, LEH, anemia (represented by PH and CO), and infections (periosteal reactions of the tibia) that reveals that shorter individuals have higher frequencies of these biological stress markers, while taller individuals have much lower frequencies of these same skeletal stress indicators. Sciulli and Oberly (2002) suggest that since LEH, anemia, and infection are all associated with shorter adults, that these markers represent periods of stress that affect growth and development in the Late Archaic Ohio valley populations. In the samples from the Late Prehistoric period, however, only LEH are associated with shorter stature. Additionally, anemia and infection are more frequent in children from the Late Prehistoric than from the

Archaic. This temporal variation for the presence of different biological stress markers may be the result of dietary differences, as Late Prehistoric populations had a diet lower in protein (Sciulli and Oberly, 2002).

The trend of increasing LEH frequency in the Late Prehistoric population may also be related to a shift in dietary strategies. Dental pathologies (caries and antemortem tooth loss) as a result of maize agriculture are the most common dental pathologies. Sciulli and Oberly note that maize was not used in this region until the last 500 hundred years, and even then there was still a heavy dependence on hunting and gathering as a subsistence strategy. There is little evidence for maize being a staple of the Late Prehistoric diet in the Ohio Valley and the low rate of caries and antemortem tooth loss also demonstrates that it is unlikely that maize was a staple of the Ohio Hopewell diet (Sciulli and Oberly, 2002).

The evidence of trauma is also quite rare in these Ohio Valley populations. Violent trauma to the face and hands is found in less than 1% of adults; healed cranial and fractures of the upper and lower limbs occur, but not more than 6% in the seven samples and the majority of limb fractures are healed (Sciulli and Oberly, 2002). In general, healed fractures of the limbs and cranial vault are more common in males than in females, but none of these differences are statistically significant (see Table 15.11 in Sciulli and Oberly, 2002).

The Ohio Hopewell study which focuses on the analysis of different activity patterns of males and females from the Turner site in the southwest region by Rodrigues (2005) was discussed in the previous chapter. However, Rodrigues also finds evidence of CO and/or PH in 90% of the small sample (n = 10) of individuals who could be assessed for this pathology. Furthermore, the results reveal that individuals buried with high status artifacts are associated with severe cases of CO or PH in half of the cases, whereas individuals associated with low status artifacts, or none, are more likely to show evidence of mild cases of CO or PH (Rodrigues, 2005). Unfortunately, Rodrigues does not address the issue that most PH and CO cases affect subadults, or consider the healing process. These CO or PH lesions may appear more severe when an individual is a young adult, but as the healing process proceeds, the lesions may then appear milder as the individual ages into middle and old adult age categories.

Summary: Previous Studies of Biological Status and Social Status

The review of previous studies that have examined skeletal health (or skeletal stress) in the Eastern Woodlands demonstrates that differences in skeletal health typically accompany an increased reliance on agriculture as a subsistence strategy. This is caused by a complex relationship between many factors: increased population density, poor sanitation, and increased rate of infectious diseases, as well as the dietary and nutritional stresses associated with being dependant on maize. Conversely, the relationship between differing levels of social status and indicators of skeletal health reveals mixed results. In some instances, individuals with elevated levels of social status are afforded “better” skeletal health, lower frequencies of indicators of skeletal stress, when compared to the rest of the society’s population; whereas, in other studies there no association between social status and skeletal health. Previous research studies in the Ohio River Valley have not focused specifically or extensively on the relationship between social status and skeletal health in Ohio Hopewell skeletal populations.

The inconsistent relationship between skeletal health and social status in the Eastern Woodlands is similar to what bioarcheologists have found to be the case in comprehensive reviews of this relationship across the World (e.g. Danforth, 1999; Larsen, 1997). This is a complex relationship, and results can differ based on many factors: skeletal markers of stress examined, specific archaeological sites, different levels of sociopolitical structure, and the archaeological data used to assess social status. Robb and his colleagues assert that skeletal analysis must be "contextualized socially and historically… which skeletal features emerge as socially significant depends on the locally specific nature of the biological stresses and their social allocation" (Robb et al., 2001:220).

This research study builds on the work of these previous studies of skeletal health/stress, but it examines the association between biological status and social status in two Ohio Hopewell skeletal collections who represent complex egalitarian societies. The next chapter describes the two skeletal samples used in this study, and the methods used for data collection and analysis.

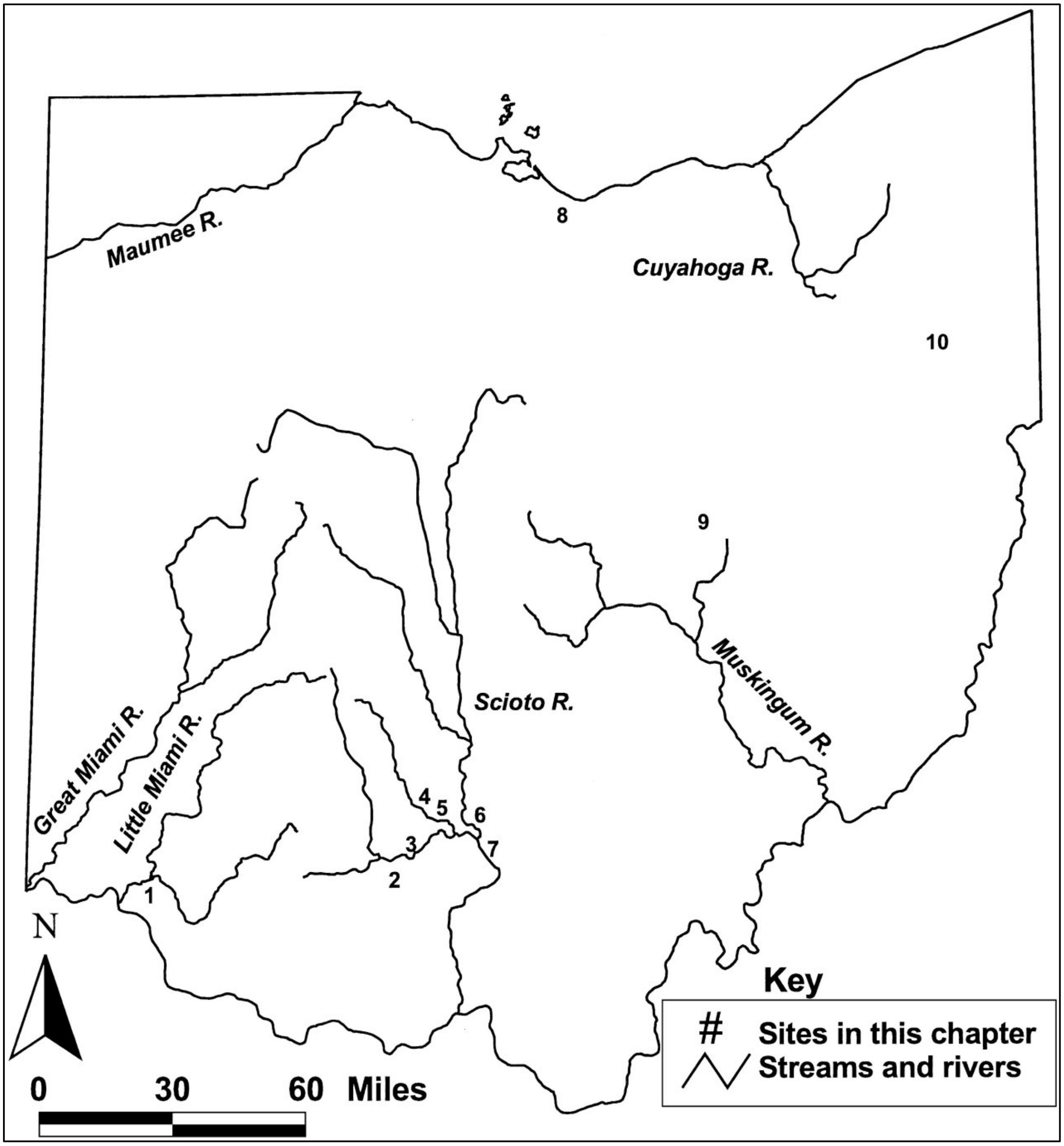
Chapter 4: Skeletal Sample and Methods of Skeletal Biological Analysis

This chapter discusses the skeletal samples that comprise the two Ohio Hopewell regions, the south-central (SC) and southwest (SW) regions, analyzed in this study. This chapter also summarizes important archaeological information about the sites from where the skeletal collections were excavated, and describes the data collection protocols and methods used during the collection phase of this research. The specific research hypotheses that were tested in the analysis phase of this study are listed at the end of this chapter.

Skeletal Sample

The first goal of this study is to evaluate interregional and intraregional differences in the relationship between biological status and social status of male and female adults. Therefore, this study utilizes Hopewell skeletal collections from the SW and SC geographical regions of Ohio based on river drainages (see Figure 1). These Ohio Hopewell populations are assigned to the Middle Woodland cultural period, which dates from ca. 100 BC to 400 AD (Greber and Ruhl, 1989) and ca. 1 to 400 AD (Seeman, 1995).

Figure 1 Map of locations of sites used in this study (Field et al., 2005:387).
Key SW Ohio: (1) Turner. SC Ohio: (2) Rockhold, (3) Seip, (4) Ater, (5) Hopewell and (7) Liberty (Harness Mound).

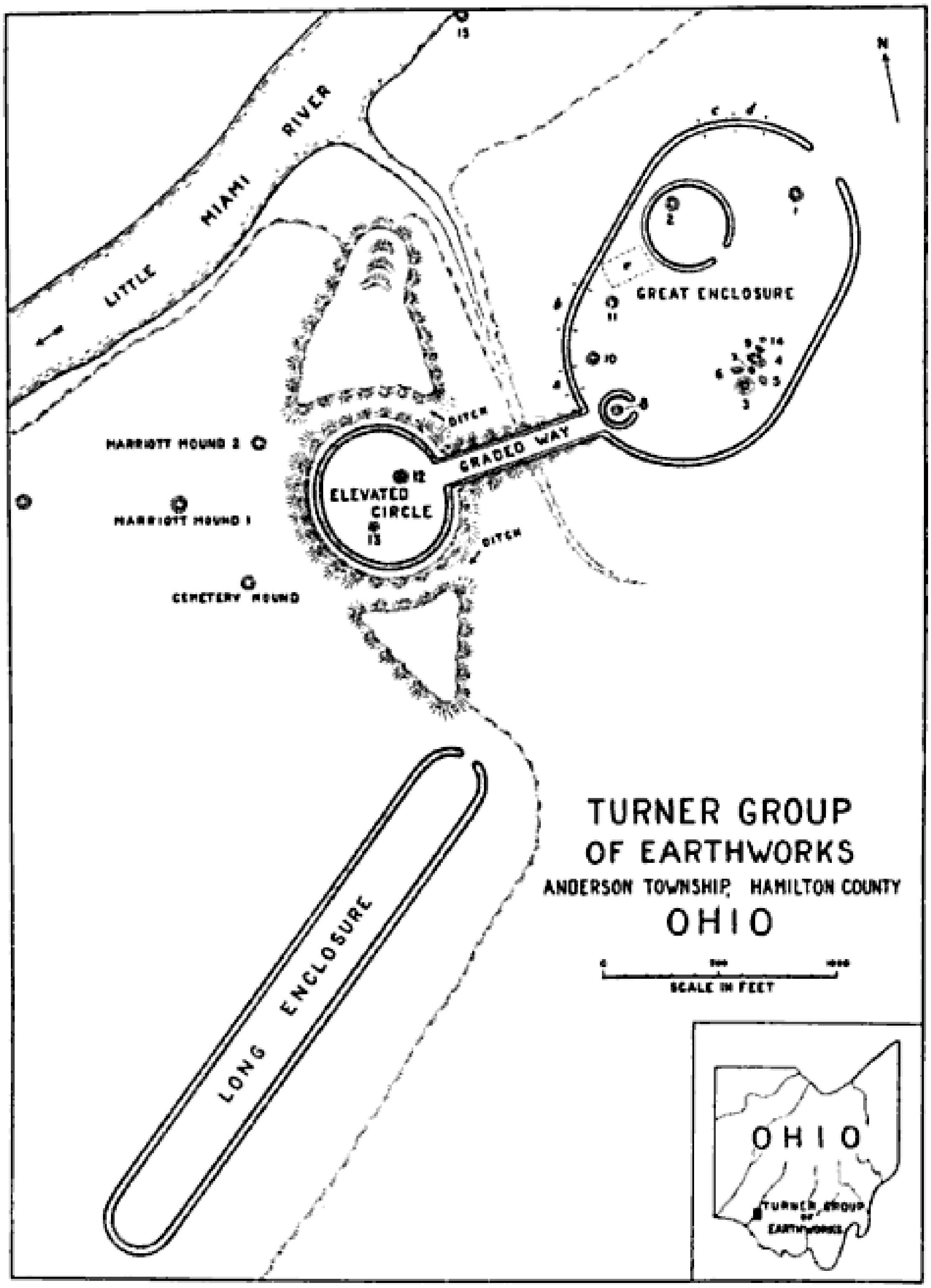


Southwest Ohio

The SW region of Ohio is geographically defined as land areas along the Little Miami and Great Miami River drainages. The key Hopewell site for this region is the Turner Group Complex which is the largest ceremonial center from this region. The Turner site is represented by mounds and earthworks that are located in southwestern Ohio on the southeast bank of the Little Miami River, about 13 kilometers from its junction with the Ohio River (see Figure 1). Greber's (2003) analysis of radiocarbon dates indicates Turner was used between ca. AD 100 and AD 300. It was excavated from 1882 to 1911 under the direction of Frederick W. Putnam for the Peabody Museum of Archaeology and Ethnology and the site report was published by Charles C. Willoughby in 1922. The archaeological artifacts, skeletal remains, and field notes for Turner are curated by the Peabody Museum at Harvard University.

The Turner Earthworks are composed of a large oval with walls made of earth called the Great Enclosure (457 meters long by 290 meters wide) that is connected by the Graded Way (183 meters long) to a large Elevated Circle, which is 146 meters in diameter and at an elevation of 9 meters above that of the Great Enclosure (see Figure 2). Case and Carr (2008) report a total of 18 mounds (14 within the earthworks and four outside) for the Turner Complex, which is consistent with the map in Willougby's (1922) report.

Figure 2 Map of the Turner Earthworks (Willoughby, 1922: Plate 1)
The text in the figure is not meant to be readable, but is for visual reference only.



Plan of the Turner Group of Earthworks from the survey by D. S. and J. A. Hosbrook, made for the Peabody Museum in 1887.

There are 101 documented noncremated and cremated burials identified at this site from 6 different mounds, but Greber (1979a) notes there were most likely many more burials that were not excavated. Many of the mounds contained altars, which were usually less than 1 meter by 1 meter in size, made of clay mixed with ash. They contained burned artifacts such as beads, mica, flint tools, and human remains decorated by intricate carvings. The largest group of burials was found in the "Burial Place" which was an area within the Great Enclosure that contained 32 graves. These were typically shallow graves that contained extended burials and were outlined with upright flat limestone and covered by stones (Willoughby, 1922). Case and Carr (2008) report a total of 91 individuals, composed of 74 inhumations (primary burials: typically extended) and 17 cremations.

Ernest Hooton analyzed the skeletal remains from Turner and his findings are published in Willoughby's 1922 report on the Turner site. Hooton identified at least 90 individuals. Eight had been cremated, and 30 individuals were represented by very few bone fragments. Hooten also identified 35 skeletons that were in fragmentary condition that he was able to analyze. Willoughby (1922) notes that Mounds 1, 3, and 5 had intrusive burials in their respective mounds. It can be inferred from his report this would represent a total of 23 individuals, but this is never clearly written in his report. The most notable was an intrusive pit in Mound 3 that contained two extended adult skeletons buried at the bottom of the pit and was surrounded by 16 crania and a flat sheet of mica which is commonly found in Hopewell burials. During Hooten's analysis, he treated the 12 individuals who came from these intrusive or secondary burials as a different group, but the cranial morphology of this group that he called the "secondary series" did not differ significantly from the "primary series" (Willoughby, 1922). Rodrigues (2005:410-11) reports that she did not analyze any individuals from intrusive burials in her research analyzing Turner skeletal remains for markers of occupational stress. However, Pennefather-O'Brien (2006) notes that since the intrusive burial in Mound 3 did include a sheet of mica this may indicate that these intrusive burials were from after the mound was constructed, but still during the Middle Woodland period.

In this study, ten individuals from what Willoughby terms intrusive burials from Mound 3 are included in the skeletal analysis. Table 5.1 summarizes the number of adults from the Turner mounds that were analyzed in this study, and the dimensions of the mounds with human remains provided by Willoughby (1922). The SW skeletal sample in this study is composed of 46 adults from the Turner Group Complex: 25 adults from five different mounds (see Table 1), 16 adults from the Burial Place within the Great Enclosure (see Figure 2), and 5 adults without specific burial provenience.

Table 1 The dimensions of Turner Mounds that contain human skeletal remains analyzed in this study.

Turner Mound Number	**Adults analyzed *n***	**Approximate Dimensions**	**Approximate Height**	**Notes**
1	*7*	17 m in diameter	1.5 m	Located in Great Enclosure
3	*12*	30.5 m in diameter	4 m	Largest of 7 connected mounds in the Great Enclosure
4	*1*	33 m long by 20 m wide	2 m	A connected mound in the Great Enclosure
12	*3*	16 m in diameter	1.5 m	Located in Elevated Circle
Marriot Mound 1	*2*	18 m in diameter	61 cm	Located West of Elevated Circle, disturbed by plows

The investigation of the geology and archaeology at Turner indicates that the earthworks were also associated with a village site that was overlooked by Willoughby, but recorded on an earlier survey of Turner completed by Charles Metz in 1911 (Tankersley, 2007). The radiocarbon dates for Turner result in a date of ca. AD 53 to AD 537 calibrated calendar years at two-sigma, and leads to the assertion by Tankersley (2007) that the village was occupied between ca. AD 290 to AD 320. This chronology of the site reveals "that the Turner village was inhabited at the same time as the construction of the Elevated Circle and Graded Way and before the construction of the Great Oval [around Mound 2], Mound 3, and possibly Mound 15" (Tankersley, 2007:290).

Turner is the source of the mortuary data used by Field et al. (2005) to hypothesize that the SW region was the center of female leadership and prestige in Ohio Hopewell communities. In order to maximize skeletal sample data and to encompass cultural variation within each region, a regional mortuary perspective was proposed for this research. However, there are no other sites from the SW region that have skeletal remains available for analysis. Burials from West Mound are located at the Ohio Historical Society, but there are no skeletal remains available for analysis that fit the criteria established for this research study (Ohio Historical Society, personal communication, 2009). None of the burials from West Mound are used in Field et al.'s research, but West Mound is used by Carr and Case (2005) for the determination of social roles.

South-Central Ohio

The SC region of Ohio is geographically defined as land areas along the Scioto River and its tributaries, particularly Paint Creek (see Figure 1). This region has skeletal collections from numerous ceremonial centers. The large skeletal collection from the Hopewell Mound Group is split between the Ohio Historical Society in Columbus, Ohio, and the Field Museum of Natural History in Chicago, Illinois. Seip Earthworks, Liberty Earthworks and Edwin Harness Mound, Raymond Ater Mound, and Rockhold Mound Group are all sites that are curated by the Ohio Historical Society.

Hopewell Mound Group

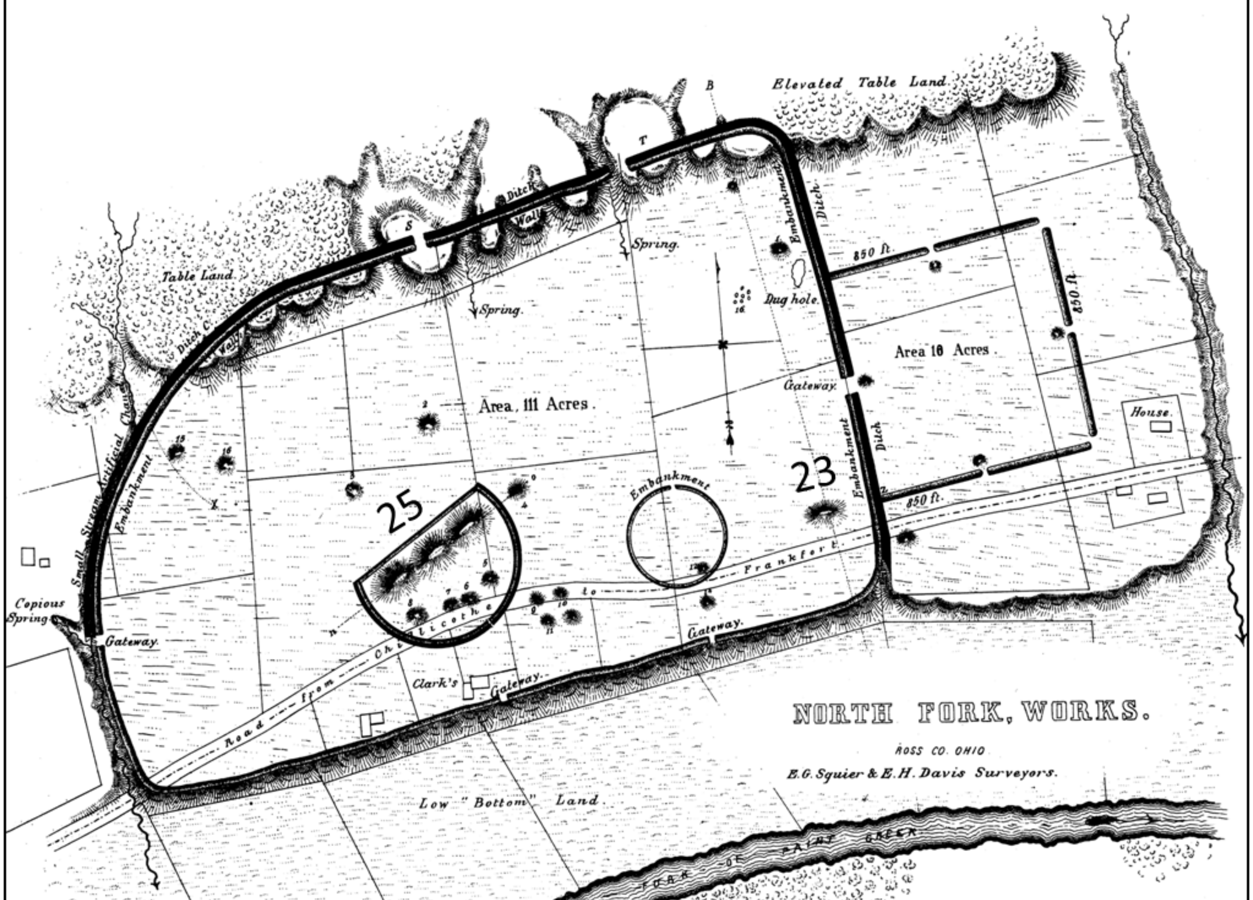
The Hopewell Mound Group is located in Union Township, Ross County, along the North Fork of Paint Creek, which is part of the south-central Scioto River drainage, approximately seven miles northwest of Chillicothe (Moorehead, 1922). This site has been excavated by several different researchers over a period spanning from 1845 to 1925 (Greber and Ruhl, 1989). It was first surveyed, mapped, and minimally excavated by Ephraim Squier and EH Davis in 1845. This site was first extensively excavated by William K. Moorehead for the Field Museum of Natural History from 1891-1892 in order for the artifacts to be publically displayed at the 1893 World's Colombian Exposition (a.k.a. The Chicago World's Fair). The field notes, artifacts, and skeletal remains from Moorehead's excavations are curated by the Field Museum of Natural History. The Hopewell site was also excavated by Henry C. Shetrone of the Ohio Historical Society between 1922 and 1925. The field notes, artifacts, and skeletal remains from Shetrone's Hopewell excavations (Accession #A283) are curated by the Ohio Historical Society.

The earthworks at the Hopewell Mound Group contain two large geometric structures with 38 associated mounds (see Figure 3). The largest part of the earthwork is the Great

Enclosure which is roughly rectangular and contains an area of 111 acres. The smaller square-shaped earthwork is located to the east and contains six openings and encloses 16 acres (Case and Carr, 2008). In 1845, the walls of the Great Enclosure were estimated to be about 10 meters wide at the base and two meters high (Greber and Ruhl, 1989). The excavations at the Hopewell Mound Group have discovered wooden structures (most notable at Mound 25), pits, tombs, rich deposits of artifacts made from both local and exotic materials, and clay basins that others have called "altars" or "crematory basins" (Greber and Ruhl, 1989).

Case and Carr (2008) identify 216 total individuals with provenience from the Hopewell Mound Group. This includes 136 individuals from primary burials, 46 cremated individuals, and 34 partially cremated individuals. Individual burial is the most common form of burial, as Shetrone's and Moorehead's field notes report a total of 176 individual burials, 20 double burials, and two triple burials (Johnston, 2002). Johnston (2008:Appendix 10.1) documents that human skeletal remains have been excavated from 16 of the 38 associated mounds (Mound numbers 2, 3, 4, 7, 8, 9, 11, 16, 17, 18, 20, 23, 24, 25, 26, and 27). Johnston (2002) notes there were only 11 subadults excavated from the entire Hopewell site, and Carr (2005c:278) notes very few subadult burials (less than 3% of individuals) of known age are buried at Mound 23 and 25. Carr also finds that identified males from the Hopewell site outnumber identified females. Johnston (2002, 2008) provides a detailed osteological summary of each of the 74 burials from the Hopewell Mound Group with identifiable mound and burial number information that are located at the Ohio Historical Society or Field Museum. Case and Carr (2008) provide a detailed bibliography of both the published papers and the unpublished manuscripts at the Ohio Historical Society and Field Museum concerning the Hopewell Mound Group.

Figure 3 Map of the Hopewell Earthworks (Squier and Davis, 1848: Plate XXI)
Key The label "25" indicates the location of Mound 25,
and the label "23" indicates the location of Mound 23.
The rest of the text in the figure is not meant to be readable, but is for visual reference only.



In this study, the SC sample is composed of 91 adults. Skeletal remains of 60 adults were analyzed from nine different mounds (Mound numbers 2, 4, 7, 18, 23, 24, 25, 26, and 27), and 31 adults did not have provenience to a specific mound. Table 2 summarizes the number of adults from mounds analyzed in this study and the dimensions of these mounds at the Hopewell Mound Group.

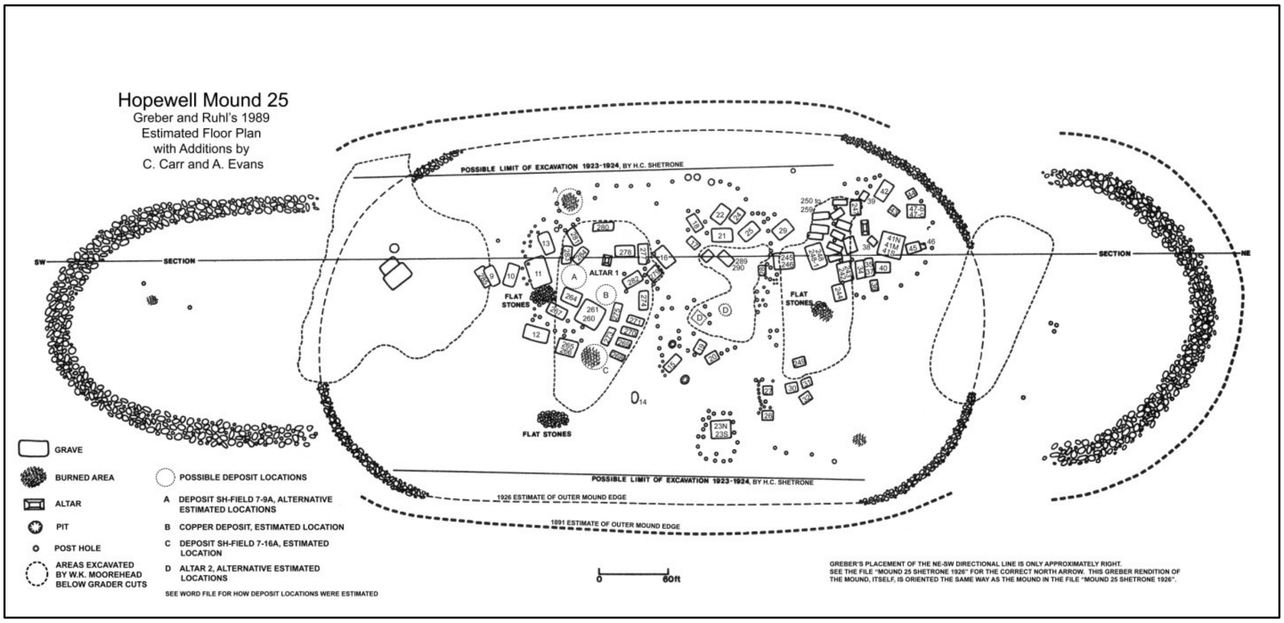
Table 2 The dimensions of Hopewell Mounds that contain human skeletal remains analyzed in this study. Dimensions are from Case and Carr (2008).

Hopewell Mound Number	Adults Analyzed *n*	Approximate Dimensions	Approximate Height	Notes
2	*6*	2 m in diameter	2 m	
4	*4*	14 m in diameter	2 m	
7	*2*	26 m long by 23 m wide	3 m	Estimated - mound was destroyed by railroad workers
18	*3*	23 m long by 17 m wide	1 m	Partially destroyed by cultivation
23	*10*	46 m long	3 m	
24	*1*	15 m in diameter	76 cm	Part of the mound had been disturbed before Moorehead's excavation
25	*31*	152 m long and 67 m wide	9 m	
26	*2*	12 m long by 10.5 m wide		Disturbed by the construction of a house
27	*1*	17 m long by 15 m wide		

At the Hopewell site, Mound 25 is of particular note (see Figure 4). This is the largest mound made by Hopewellian people (Greber and Ruhl, 1989). Squier and Davis recorded Mound 25 as 152 meters long and 67 meters wide and the prepared floor of this mound was 143 feet by 40 meters wide (Case and Carr, 2008). Other than the deposit of thousands of flint discs at Mound 2, Mound 25 has the two largest ceremonial caches of artifacts at any of the mounds at the Hopewell site (Greber and Ruhl, 1989:78). Both of these caches were located at two "altars" (clay basins) in the central part of Mound 25 and contained numerous rich artifacts, e.g. over 500 copper and other metal earspools; 19,000 pearls; over 1,000 shell beads; and approximately 300 bear claws.

Although not as large as Mound 25, Mound 23 shares several characteristics with Mound 25. Mound 25 and Mound 23 are the two largest mounds, are loaf shaped (other mounds are more circular), and contain the most number of burials at the Hopewell Mound Group (Carr, 2008e). Greber and Ruhl (1989:43-44) note that the construction of the floors of Mounds 25 and 23 is similar, and that both mounds have evidence for ceremonial activities focused at the center of the mound with public areas ("plazas") located on either side. Hopewell Mound 25 also contained a three room charnel house (Carr, 2005a), and Carr (2008e:659) speculates that Mound 23 may have also had a charnel house based on the remains of posts found under Mound 23. Both mounds have a high percentage of extended burials. Specifically, 76% of the burials at Hopewell Mound 25 and 94% of Hopewell Mound 23 burials are extended burials, while 12 of the remaining 20 smaller mounds have at least 50% of their burials as extended burials (Carr, 2005c:279).

Figure 4 Map of the floor of Hopewell Mound 25
Original map by Greber and Ruhl (1989), modified by Carr and Evans
(Case and Carr, eds., 2008)
The text in the figure is not meant to be readable, but is for visual reference only.

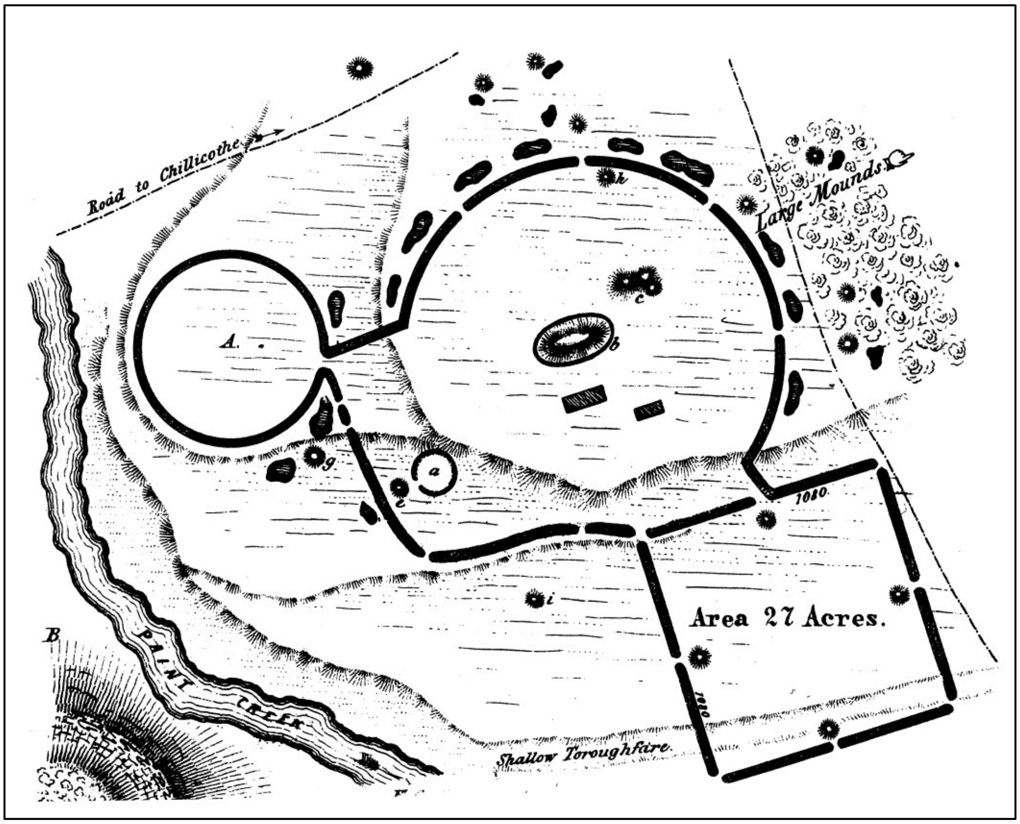


There are also several contrasts between Mounds 25 and 23. The burials at Mound 25 contain many more grave goods, particularly prestigious copper artifacts, and/or display elaborate tomb construction about a third of the time (Carr, 2005c:272). Greber and Ruhl (1989:292) also find that all the burial groups at Mound 25 have many exotic grave goods and the prestigious social status associated with these artifacts. The burials at Mound 23 contain few to no grave goods and only have the presence of breast plates from the prestigious class of copper artifacts, and in general contain the burials of fewer leaders than Mound 25 (Carr, 2008e:626, 659). At Mound 25, identified males outnumber identified females 3:2 (Carr, 2008e). Whereas at Mound 23, Johnson (2008) identifies the sex of only four adults buried with provenience to a specific burial number, and they are all female (Johnson, 2008:Appendix 10.1). Another difference is that of the large percentage of primary burials at Mound 23 (94% of all burials), 64% (29 of 45) of these individuals have evidence of being "charred or probably charred" which Carr interprets as a mixture of symbolism between primary burial and cremation (Carr, 2005c:280). Case and Carr (2008) document a total of 34 charred remains from the entire Hopewell Mound Group, thus it appears this type of burial treatment is fairly unique to Mound 23.

Seip Earthworks

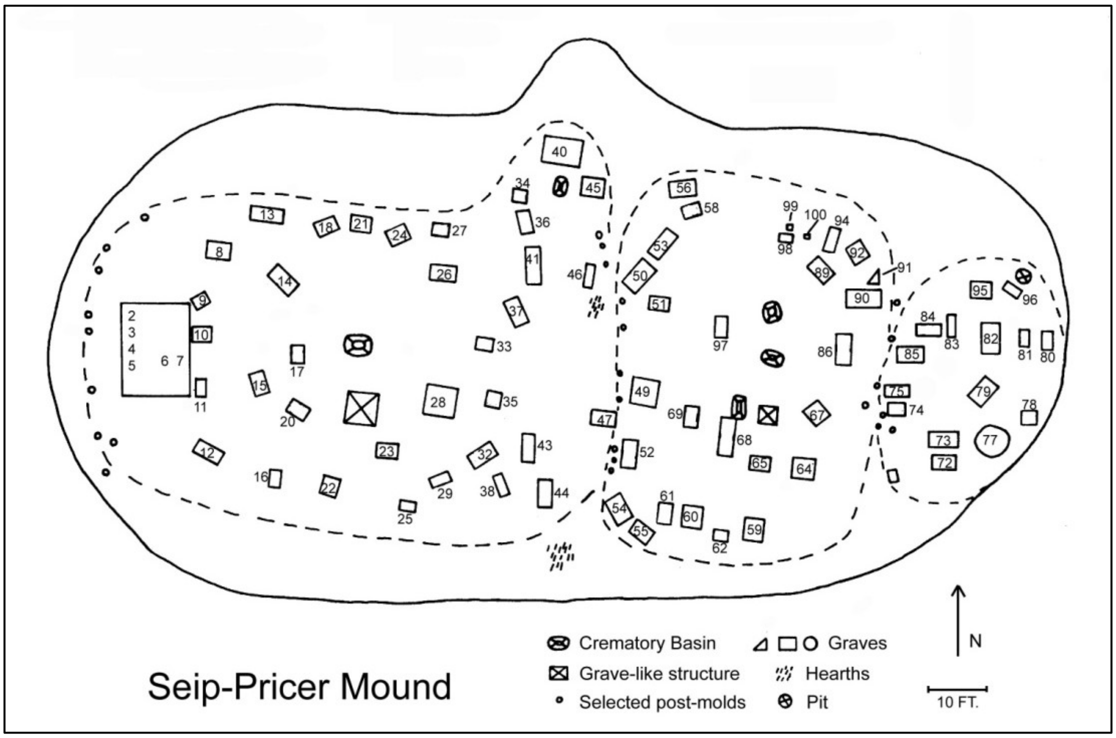
The Seip Earthworks (see Figure 1) and associated mounds are located in Paxton Township, Ross County, along Paint Creek, which is part of the south-central Scioto River drainage, approximately 17 miles southwest of Chillicothe (Greber, 1979a). The earthworks are associated with 18 different mounds with eight found within the enclosures and ten nearby, but only four mounds have been excavated (see Figure 5). Seip-Pricer Mound (originally called Mound 1) was excavated by Henry Shetrone of the Ohio Historical Society from 1925-1928, and Seip-Conjoined (originally called Mound 2) was excavated by William Mills of the Ohio Historical Society from 1906 – 1908 (Baby and Langlois, 1979), but the field notes from Seip-Conjoined have been lost (Greber (1979a). The field notes from Seip-Pricer and the artifacts and skeletal remains from both Seip mounds (Accession #957) are curated by the Ohio Historical Society.

Figure 5 Map of Seip Earthworks and Mounds (Squier and Davis, 1848:Plate XXI) The text in the figure is not meant to be readable, but is for visual reference only.



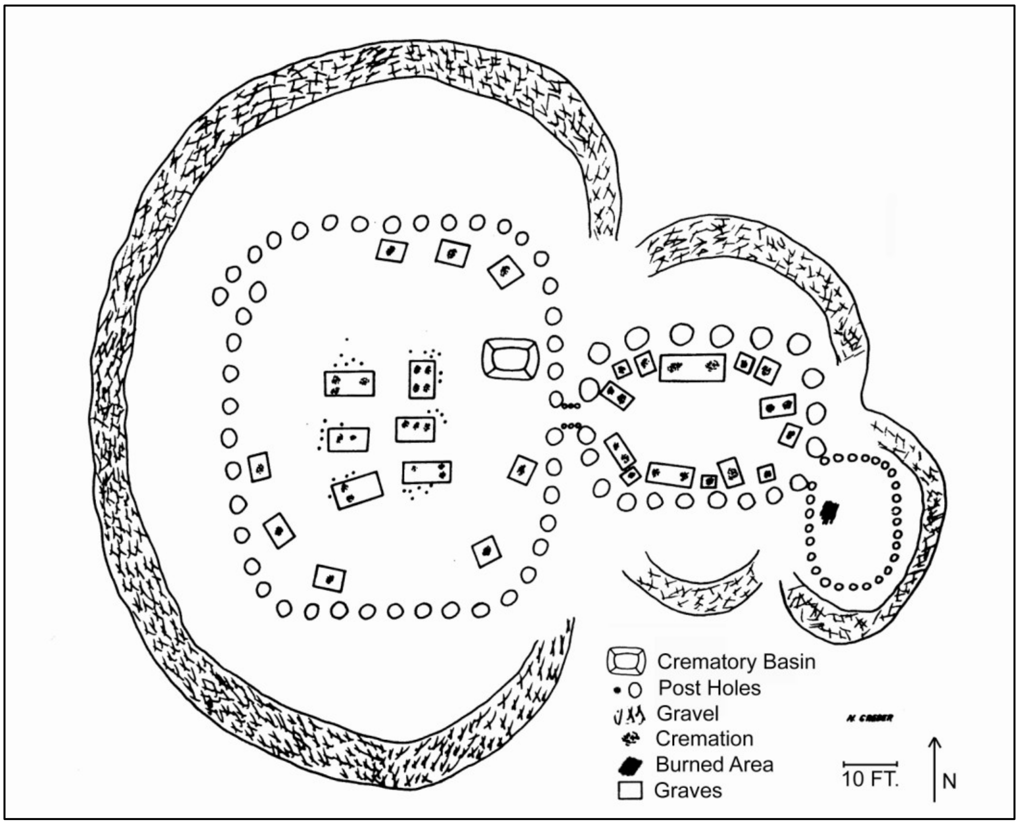
The Seip Earthworks form a large tripartite structure, composed of three sections, and the Seip-Pricer Mound is located almost in the center of the largest circular part of the earthwork (see Figure 5). The Seip-Pricer Mound also has a "tripartite "shape, and was estimated by Squier and Davis to be 73 meters long, 49 meters wide, and 9 meters tall (see Figure 6). Most of the graves were log tombs, but some were different combinations of wood, stone, earth or clay, and the majority of the burials were cremations in the floor of the mound (Greber, 1979a). Greber (1979b) reports that Seip-Pricer (Mound 1) contains 94 burials and 123 total individuals, of which 112 are cremations and 11 are inhumations in extended burials. Carr and Case (2008) report 125 individuals, composed of 113 cremations and 12 primary burials. Konigsberg (1985) reports the analysis of 87 individuals from Seip-Pricer (Mound 1). He notes that subadults and adults were both buried at Seip-Pricer and finds a balanced sex ratio that is in contrast to Greber (1979a) who reports a 2 to 1 sex ratio in favor of males based on osteological analysis by previous researchers. Konigsberg (1985) also notes that cremated individuals appear to have been burned in the flesh, rather than disarticulated before cremation.

Figure 6 Map of the floor of Seip-Pricer Mound
(Carr, 2008b:130) adapted from (Greber, 1979a:58)
The text in the figure is not meant to be readable, but is for visual reference only.



The Seip-Conjoined Mound (Mound 2) also follows the tripartite shape of both the Seip Earthworks and the Seip-Pricer Mound (see Figure 7). The three sections of Seip-Conjoined are estimated to be 37 meters, 21 meters, and 12 meters in diameter with a peak height of 5.5 meters. Greber (1979a) records 43 cremated individuals buried in the floor of the mound and five noncremated individuals buried above the floor. Case and Carr (2008) provide a detailed bibliography of both the published papers and the unpublished manuscripts at the Ohio Historical Society concerning the Seip Earthworks.

Figure 7 Map of the floor of Seip-Conjoined Mound
(Carr, 2008b:130) adapted from (Greber, 1979a:66)
The text in the figure is not meant to be readable, but is for visual reference only.



Edwin Harness Mound

The Edwin Harness Mound, also called Harness Mound**,** is the largest of the 14 mounds that are associated with the Liberty Earthworks that are located in Liberty Township, Ross County, eight miles south of Chillicothe, along the Scioto River (see Figures 1 and 8). Artifacts from this site are curated by the British Museum, Cleveland Museum of Natural History, Ohio

Historical Society, and the Peabody Museum. The field notes and skeletal remains are curated by the Ohio Historical Society (Accession #A7) and Cleveland Museum of Natural History. According to Case and Carr (2008), the mound was tested and excavated by many different researchers beginning with Squier and Davis in 1848, and followed by Putnam in 1885, Moorehead in 1897, and William C. Mills in 1903 and 1905. Greber conducted salvage excavations in 1976 and 1977, and Greber (1983) provides a complete report of these excavations.

Based on field notes by Squier, Davis, and Mills, Case and Carr (2008) estimate that the Harness Mound measured 49 meters long, 27 meters wide, and was 3 to 6 meters tall. Harness Mound is located roughly in a north-south orientation (Greber, 1979b). Similar to Seip-Pricer and Seip-Conjoined, Harness also has post-hole evidence for a three room charnel houses on the floor of the mound (see Figure 9). The largest section of the structure at the north end (14 x 11.5 m) is rectangular and joined by a narrow passageway to the rectangular middle section (12 x 10.5 m), and the south end is formed by a circular floor plan (diameter of 6 m) (Greber, 1979b). Posts lined both rectangular sections and there were also central posts in the circular sections at the south end. Greber (1979b:28) concludes that this architectural pattern is representative of the type of "big-house" that was used by the Shawnee. Greber (1979b) notes there were 170 burials containing 178 individuals of which only 11 were noncremated. More recently, Case and Carr (2008) list Harness Mound as containing 15 individuals from primary burials, 153 burned or cremated individuals, and six individuals of unknown treatment. Case and Carr (2008) also provide a detailed bibliography of the published manuscripts concerning the Liberty Earthworks and Harness Mound.

Figure 8 Map of the Liberty Earthworks (Squier and Davis, 1848:Plate XX) The text in the figure is not meant to be readable, but is for visual reference only.

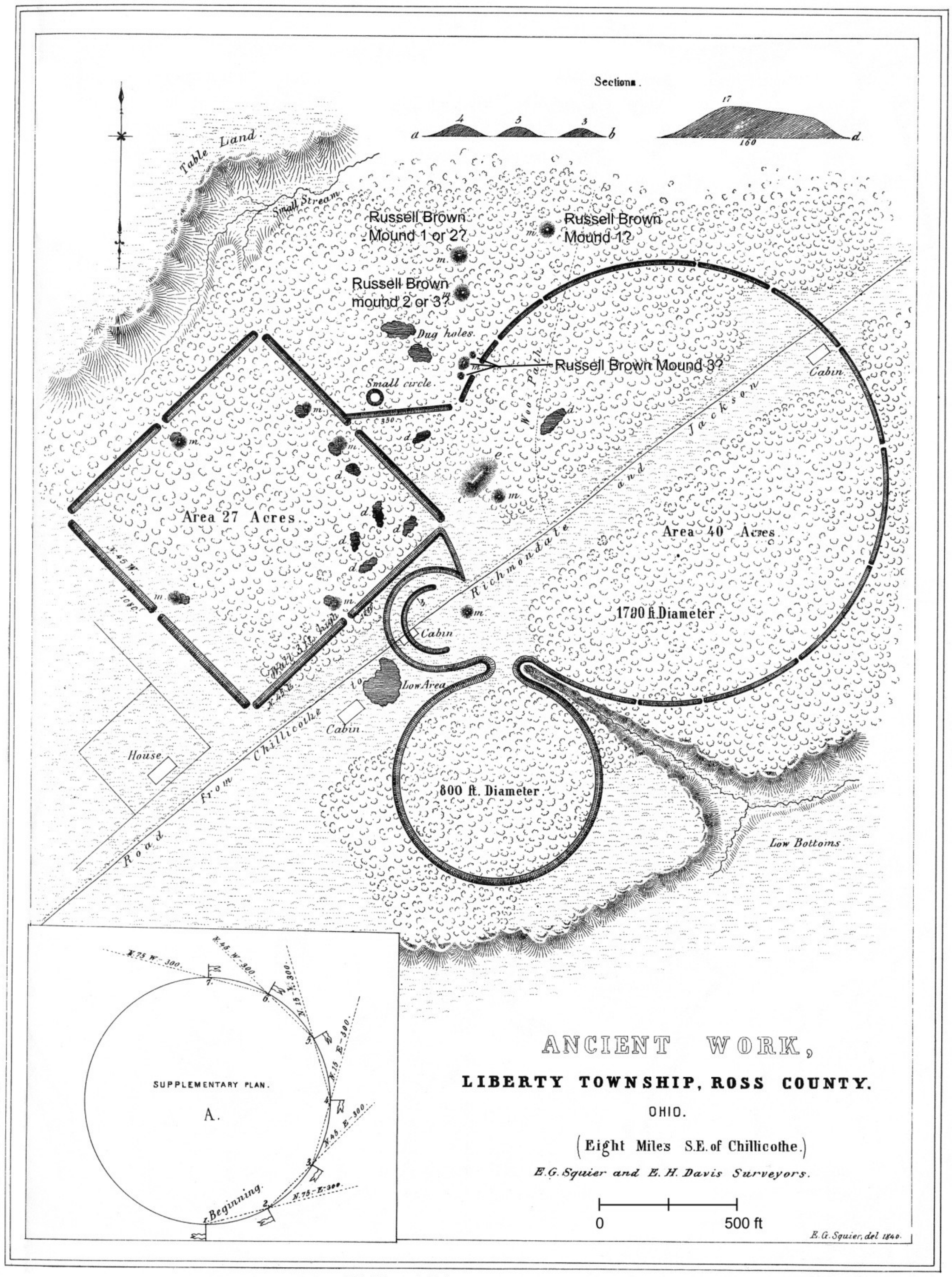
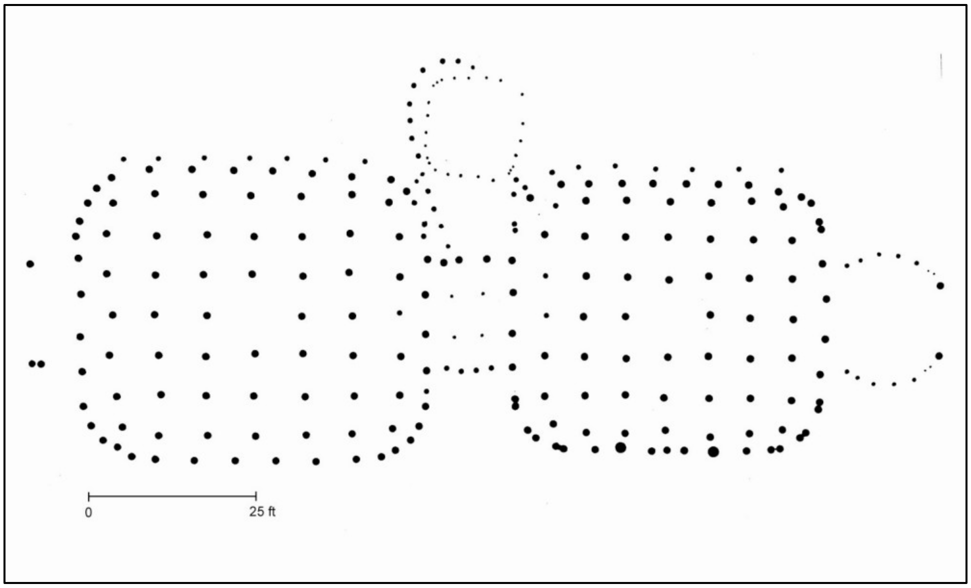


Figure 9 Floor plan of the charnel house under the floor of the Edwin Harness Mound. (Carr, 2008b:131) adapted from (Greber, 1983:28)
The text in the figure is not meant to be readable, but is for visual reference only.



Carr (2005c) summarizes the similarities between five different earthworks (Seip, Baum, Frankfort, Liberty and Works East) all located within 50 miles of each other along the Scioto River and Paint Creek in south-central Ohio (see Figure 1). These earthworks all follow a similar tripartite morphology and are approximately the same sizes. Each contains a large circular earthwork enclosing approximately 40 acres, a small circle enclosing 10 acres and a square enclosing 27 acres (see Seip in Figure 5 and compare to Liberty in Figure 8). Additionally, at the Seip-Pricer, Seip-Conjoined, and Harness Mound sites the mounds all contain three sections which have evidence of post mold holes for three room charnel houses, although Seip-Conjoined only had burials in two of the rooms (see Figures 6, 7, and 9). Greber (1983) cautions against interpreting the big houses at these sites as being used as only charnel houses because it may limit the interpretation of these buildings as only being related to rituals or ceremonies focused on mortuary practices. The Shawnee used such rectangular houses for dance ceremonies (Greber, 1979b). Greber also proposes that the big houses at Seip-Pricer and Seip-Conjoined were later covered by three mounds, and speculates that the Harness Mound may have been as well. Greber (2003) dates the floor of the charnel house at Seip-Pricer to be AD 310 and both Greber (1979b) and Carr (2008e) propose that the Seip-Conjoined Mound was built after Seip-Pricer.

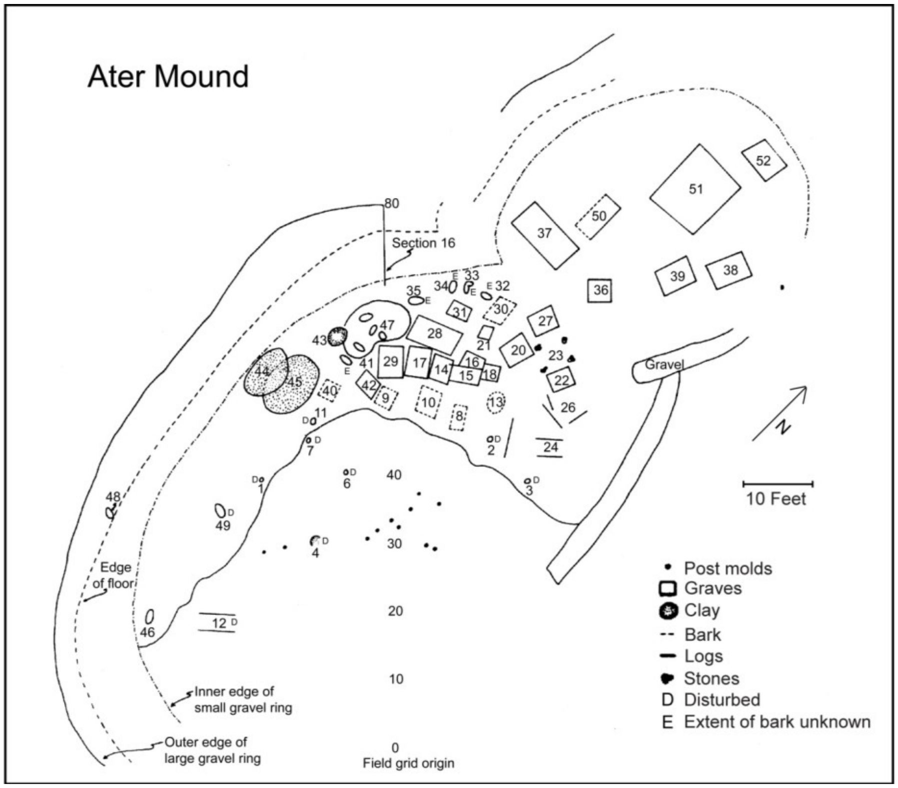
Raymond Ater Mound

The Raymond Ater mound, also called Ater mound, is located in Concord Township, Ross County, along the North Fork of Paint Creek, which is part of the south-central Scioto River drainage, approximately three and a half miles northwest of the Hopewell site (see Figure 1). The field notes, artifacts, and skeletal remains associated with Ater (Accession #3062) are curated by the Ohio Historical Society. Greber (1979a) reports that Raymond Baby of the Ohio Historical Society led the salvage excavation of this site in 1948. At the time of the salvage excavations, Baby estimated that mound was oval in shape and was 37 meters long, 23 meters wide, and 1.8 meters tall, but the mound had been disturbed by a bulldozer prior to excavation.

Carr (2005c) notes that this site is unique when compared to Seip-Pricier, Seip-Conjoined, Edwin Harness, or Hopewell Mound 25, because it is not associated with an earthwork. Furthermore, Ater mound has only two lobes located along a north-south axis that covers two burial areas, not three like at the former sites (see Figure 10). Carr (2005a, 2008d) reports there is evidence of post holes that he interprets as representing a two-room charnel house which covered each of the two burial areas and was not yet completed. There seems to be disagreement on whether there was a charnel house at Ater, as Greber (1979a:48) notes that the post holes do not follow a recognizable pattern.

Greber also notes that all but two of the graves were from the mound floor and that “the graves varied from simple bone deposits on bark to more elaborate log outlined areas. Many had bark coverings, as well as bark floors” (Greber, 1979a:48). According to Greber (1979b), there is a 2 to 1 ratio of males to females represented in the burials at Ater and very few infants and children. Overall, Ater Mound includes 60 individuals that were excavated, 8 extended burials and 52 cremations, from 50 different burials, and it is estimated that 40% of the site was not excavated Case and Carr (2008). There are no available radiocarbon dates from Ater, but the seriation of earspools puts the use of the Ater Mound floor later in time than Hopewell 25, Seip-Pricer, and Harness Mound (Carr, 2005a; Carr, 2008e). Carr writes “The charnel house at Ater appears to have been the last, large intercommunity building project undertaken in the area, and one that was not architecturally completed with an enclosure.” (Carr, 2008e). Case and Carr (2008) provide a bibliography of the unpublished manuscripts detailing Ater Mound located at the Ohio Historical Society.

Figure 10 Map of the floor of Ater Mound
(Carr, 2008c:254) adapted from (Greber, 1979a:68)
The text in the figure is not meant to be readable, but is for visual reference only.



Rockhold Mound Group

The Rockhold Mound Group is located in Paxton Township, Ross County, along Paint Creek, which is part of the south-central Scioto River drainage (see Figure 1). The field notes, artifacts, and skeletal remains associated with Rockhold (Accession #1020) are curated by the Ohio Historical Society in Columbus. The site consists of four mounds, but little is known about the dimensions of these mounds. There is no evidence of associated earthworks. Mounds 1 and 2 were excavated by Emerson Greenman of the Ohio Historical Society in 1929, and Mound 3 was excavated by Donald McBeth in 1944 when the mound was only 35 cm tall (Case and Carr, 2008). Five individuals from five different graves were excavated but only one of these is an extended burial. Case and Carr (2008) provide a detailed bibliography of the unpublished manuscripts about the Rockhold group located at the Ohio Historical Society.

Burials from the Hopewell Mound Group, Seip, Harness, Ater, and Rockhold were all included as sources of the mortuary data used by Field et al. (2005) to hypothesize that in the SC region, Ohio Hopewell women did not have access to the most powerful positions of prestige, but were considered for some positions of leadership. Utilizing a regional mortuary perspective, adults from these sites comprise the SC skeletal sample for this study. Burials from the Turner is the source of mortuary data used by Field and her colleagues (2005) to hypothesize that the SW region was the center of female leadership and prestige in Ohio. The research questions of this study require that the sex and age of individuals be able to be estimated for analysis, therefore data collection utilized only adults. All available adults from the two regions were analyzed from each skeletal collection. See Table 3 for a summary of the skeletal sample used in this research study.

There are some potential limitations of the skeletal collections from these regions. First, several of the sites used in this research, most notably Turner and Ater were not completely excavated. This could potentially affect the results of this research as these missing burial areas may have been representative of a segment of Ohio Hopewell community not represented in the burial areas that have been excavated. Secondly, the distribution of skeletal samples across different levels of social status could be problematic. According to Carr (2005c), the Hopewell in SC Ohio appear to have practiced primarily cremation for individuals from a broader social spectrum buried at Seip, Harness, and Ater, while extended burial (especially at Hopewell Mounds 23 and 25) was primarily reserved for those of higher prestige and leadership. For example, 87.9% (153 of 174) of the individuals excavated from Harness Mound were from cremated or burned burials, and 75.5% (77 of 102) of the individuals from Hopewell Mound 25 were from extended burials (Car 2005:279). This potential differential mortuary treatment based on social status could skew the analysis of markers of skeletal stress and trauma, because this data was derived from the skeletal remains of individuals from extended burials. Thus, the correlation between biological and social status may not necessarily be representative of all the social groups who lived within these communities.

Table 3 Summary of the skeletal samples used in this study.

Site	**Region**	**Adults analyzed in this study *n***	**Total Individuals**	**Reference**
Turner Mound Group	SW	46	91	(Case and Carr, 2008)
Hopewell Mound Group	SC	77	216	(Case and Carr, 2008)
Edwin Harness	SC	3	174	(Case and Carr, 2008)
Seip-Pricer	SC	3	123	(Greber, 1979b)
Seip-Conjoined	SC	1	48	(Greber, 1979a)
Raymond Ater	SC	6	60	(Case and Carr, 2008)
Rockhold	SC	1	5	(Case and Carr, 2008)

Methods of Skeletal Biological Analysis

The objectives of this study were accomplished by examining skeletal remains for sex, age estimation, and evidence of biological status. As previously discussed in Chapter 3, skeletal markers used for the analysis of biological status include the following: LEH (nonspecific systemic physiological stress), PH (dietary nutritional deficiency and nonspecific infection/disease), periosteal reactions of long bones (nonspecific disease/ infection or acute trauma), and evidence of skeletal (cranial and post-cranial) trauma. In addition, long bone measurements were used for stature (dietary nutritional deficiency and nonspecific infection/disease). Chapter 3 provides a detailed discussion of each marker of biological status used in this study.

Sex Determination

Sex determination was obtained by following the guidelines in *Standards for Data Collection from Human Skeletal Remains* (Buikstra and Ubelaker, 1994) for analyzing and scoring the morphology of the pelvis and the skull. Skull features used for sex assessment were scored from 1-5, with 1 the most female and 5 the most male version of each of the following traits: nuchal crest, mastoid process, supraorbital margin, glabella, and mental eminence. Additionally, two morphological features of the skull were scored following Bass (1995) on a scale of 1-3 with 1 representing a female trait, 2 an ambiguous trait, and 3 a male trait. These traits were the zygomatic crest and its relationship to the external auditory meatus, and gonial eversion of the mandible. The skull was then assessed an overall sex determination from 1-5 based on cranial morphology, with 1 representing a female, 2 a probable female, 3 ambiguous, 4 a probable male, and 5 a male.

Morphological features of the pelvis used for sex assessment were the ventral arc, subpubic concavity, ischiopubic ramus ridge, and subpubic angle. These features were scored on a scale of 1-3, following Phenice (1969) and *Standards*, in which 1 represents the most female, 2 an ambiguous trait, and 3 the most male version of each trait. The width of the greater sciatic notch was scored 1-5 and the preauricular sulcus was scored 0-4 both following the protocols in *Standards* for these traits. The pelvis was then assessed a sex estimation from 1-5 based on pelvic morphology with 1 representing a female, 2 a probable female, 3 ambiguous, 4 a probable male, and 5 a male.

The assessment of sex from individuals who did not have cranial or pelvic features present for morphological analysis was conducted by using measurements for the humeral and femoral heads. Specifically how these measurements were obtained and recorded is detailed later in this chapter in the section on the methods used to obtain long bone measurements. Individuals with a maximum diameter of the humeral head measurement greater than 47 mm were classified as probable male, while an individuals with a value below 43 mm were classified as probable females (Bass, 1995:156). For the maximum diameter of the femoral head, an individual with a measurements greater than 46.5 mm were classified as probable males, while values less than 43.5 mm were classified as probable females (Bass, 1995:231).

Each adult was assigned a sex category based on the available cranial and pelvic morphology data with greater weight given to pelvic morphology when both sources of data were present for the same individual, as it is generally accepted that pelvic sex indicators are more reliable. When neither cranial nor pelvic morphology was available for analysis or ambiguous, sex determination was based on metric analysis of long bone measurements. For individuals assigned sex based on long bone measurements, the given bone measurement had to fit within the female or male range who were assigned sex based on cranial and/or pelvic morphology. For example, an adult could not be determined to be female based on maximum femoral head diameter if this individual's maximum femoral head diameter and maximum femur length did not fall within the range of each measurement of individuals who were assigned sex by cranial and/or pelvic morphology. For the purposes of data analysis of the different biological status markers in this research, females and probable females were all grouped into a category representing females, and likewise for males and probable males. The undetermined sex category was used for adults who had ambiguous morphological features and adults of unknown sex determination due to poor skeletal preservation.

Age Estimation

Age estimation was obtained by following the guidelines in *Standards* and the skeletal features used for age assessment were scored following the specific criteria in *Standards*. Age estimation was conducted by utilizing cranial suture closure, pubic symphysis assessment, and auricular surface assessment. Four broad age categories were utilized for classification: adult (20+ years, not enough data to be more specific); young adult (20-34 years); middle adult (35-49 years); and old adult (50+ years).

Cranial suture closure was scored following *Standards* in which 0 indicates an open suture, 1 minimal closure, 2 significant closure, and 3 complete closure. When possible, each skull had ten external vault sutures scored, four palate sutures, and five internal cranial vault sutures scored. The protocols in *Standards* call for the scoring of internal cranial vault sutures for the sagittal, lambdoid and coronal sutures. In addition to these sutures, lambda and bregma internal vault sutures closure were also scored. The written descriptions and photos of cranial suture closure in *Standards* (1994: 32-34) were used to assist in the scoring of sutures which is based on the work by Meindl and Lovejoy (1985). Age estimation was based on the composite scores from the vault sutures and from the sutures of the lateral-anterior cranium and these totals were compared to the figure related to chronological age in *Standards* (1994: Figure 14) to classify an individual as a young, middle, or old adult. When cranial suture data was available from both the vault and lateral-anterior cranium regions, more weight was placed on the age estimation from the lateral-anterior sutures which follows the recommendations of Meindl and Lovejoy (1985).

The pubic symphysis was analyzed and scored following the procedures of the Suchey-Brooks method (Brooks and Suchey, 1990). Each pubic symphysis was assigned to one of the six phases using the photos in *Standards* (1994:23-24), the written description of morphological stages by Brooks and Suchey (1990), and the Suchey-Brooks pubic symphysis casts made by France casting. In cases when a pubic symphysis from both the right and left side were available for analysis, the left side was recorded. The descriptive statistics from Brooks and Suchey (1990: Table 1) and the figure related to pubic symphysis chronological age in *Standards* (1994: Figure 134) were utilized to classify an individual as a young, middle, or an old adult. In this research study, phases one, two and three are representative of a young adult, phases four and five represent a middle adult, and phase six represents an old adult.

The auricular surface of the ilium was also assessed following the protocols in *Standards*. Each auricular surface available for analysis was assigned to one of eight possible phases. For bones with both sides of the auricular surface present, the left side was recorded. The auricular surface phases were scored using the photos and written descriptions present in *Standards* (1994: 24-32). In this study, auricular surface phases one, two, and three are representative of a young adult, phases four, five, and six represent a middle adult, and phases seven and eight represent an old adult.

When an individual had skeletal elements that allowed for all three methods of age estimation to be used, the skeletal age of each method was considered and the adult was assigned to one of the following four categories: adult (20+ years, not enough age date to be more specific), young adult (20-34), middle adult (35-49), and old adult (50+). The estimation of age for each adult was multifactorial and considered available age-related information from cranial suture closure, pubic symphysis, and auricular surface analysis, although when pubic symphysis aging information was available this method received the strongest consideration.

Linear Enamel Hypoplasias

In order to assess teeth for the presence of enamel hypoplasias, a dental inventory for each individual was completed. Each tooth number for an individual had its presence or absence recorded based on the guidelines and scoring methods noted in *Standards* (1994: Table 2). The total number of teeth that were lost antemortem and the total number of teeth that were loss postmortem were both recorded. Teeth that were missing without any alveolar bone were not included in the latter category. Teeth that were present but did not have any association with alveolar bone were ignored for data analysis, because it was not possible to ensure that these teeth were associated with this individual during life.

To assess the presence or absence of enamel hypoplasias, all permanent tooth crowns were examined for evidence of any of the different types of enamel hypoplasia (e.g. single pits, linear horizontal grooves, nonlinear pits) following the protocols detailed in *Standards*. Teeth that were present, but could not be analyzed for enamel hypoplasias because they did not have enough enamel for observation, because of either excessive dental wear or postmortem loss of enamel, were scored as present, but not observable. Although teeth in this research were analyzed for all six possible types of enamel hypoplasias, this study focuses only on true linear enamel hypoplasias (LEH). LEH are most frequently analyzed by osteologists since they are an excellent indicator of growth interruption. In this study, LEH were the most common enamel defect, and were recorded the most confidently by this observer. In *Standards*, "linear horizontal grooves" (1994:56) is the terminology that refers LEH.

Teeth were analyzed for the presence of LEH by using an incandescent light (Goodman and Rose, 1990) and holding the tooth up to low-angle light (Fenton, personal communication). Visible examination was utilized, and the only magnification used was a hands lens with 10x magnifying power, but magnification was only used to confirm a LEH that could be observed with the naked eye. This method is consistent with the best practices for recording LEH recommended by Goodman and Rose (1990). Both the labial/buccal and lingual side of each tooth were examined for the presence of an enamel defect. If an enamel hypoplasia was detected, the specific type of enamel hypoplasia was recorded using the scoring system provided in *Standards* (1994:56).

This study examined the frequency of LEH at the individual level. Each individual was scored for the absence or presence of LEH as long as the individual had at least one tooth observable for LEH. One limitation of this individual method, however, is that it does not account for the differential preservation of teeth in each individual, nor does it account for the fact that some teeth are more susceptible to metabolic stress than others. Previous researchers report that different teeth are more susceptible to enamel hypoplasias, as anterior teeth have higher frequencies of enamel hypoplasias (Goodman and Armelagos, 1985). With this in mind, the analysis of the frequency of LEH in this study focused on the anterior teeth at the individual level, thus if an individual had at least one observable anterior maxillary or mandibular tooth, the absence or presence of LEH was determined for this individual. In this study, the individual frequency of LEH equals the total number of individuals with at least one observable LEH on anterior maxillary or mandibular teeth divided by the total number of individuals with at least one observable anterior maxillary or mandibular tooth (see Temple, 2007, 2010).

Previous researchers report that maxillary teeth are more frequently affected than mandibular teeth, and that the specific adult teeth that are most frequently the location of enamel hypoplasias are the maxillary central incisors (teeth #8 and #9) and the mandibular canines (teeth #22 and 27) (e.g. Goodman and Armelagos, 1985). Goodman and Rose (1990) recommend that enamel hypoplasia data always be collected from at least the permanent maxillary central incisors and mandibular canines. In order to increase sample size and because enamel hypoplasias are typically expressed bilaterally when they are the result of metabolic stress (Goodman and Rose, 1990), a substitution method was utilized to analyze the LEH frequency for a specific anterior tooth, or its antimere. For example, the right maxillary central incisor (#8) replaces a left maxillary central incisor if the individual does not have an observable left central incisor, and likewise the right mandibular canine (tooth #27) replaces the left mandibular canine if the latter is not observable for LEH. This same analysis is conducted for all of other anterior teeth and each antimere: #9 (#8), #10 (#7), #11 (#6), #22 (#27), #23 (#26), and #24 (#25). This substitution method of analysis allows an individual to be analyzed for the absence or presence of LEH by a specific anterior tooth type and compared to all other observable individuals by the same specific tooth number. In this study, the individual prevalence of LEH for a specific tooth number equals the total number of individuals with at least one observable LEH for a specific anterior left tooth, or its antimere, divided by the total number of individuals with at least one observable specific anterior left tooth, or its antimere.

Porotic Hyperostosis

Individuals were examined for evidence of porotic hyperostosis (PH), the expansion of the spongy bone of skull located between the inner and outer table. The frontal, parietal, and occipital bones were examined for evidence of PH. Due to the low rate of preservation of bony orbits in the skeletal samples observed during data collection and the strong evidence presented in Chapter 3 that lesions associated with cribra orbitalia are not caused by the same etiology as PH (see Walker et al., 2009), cribra orbitalia is not analyzed in this study.

Porotic hyperostosis was analyzed and scored following the protocols and photographs printed in *Standards* (1994:120-121, 151-153). For each different cranial vault bone that had PH present, the side of the bone was recorded, as were the following three observations: degree of severity of PH (barely discernible, porosity only, porosity with coalescence of foramina, and coalescing foramina with increased thicknesses); the location of PH (adjacent to sutures, near bosses or within squamous part of occipital, or both adjacent to sutures and near bosses/in squamous); and the activity of PH (active, healed, or mixed reaction). For the first observation concerning the degree of PH, the greatest degree of severity for that bone was recorded. The cranial vault of each individual was treated as a unit, so if PH was evident on one of the cranial vault bones that individual was scored as present for PH. The analysis of whether an individual had the presence of PH was based only on individuals with observable cranial vault bones. If an individual did not have at least half of the skull vault bones available for analysis because they were missing, or had extensive taphonomic destruction to the outer table of the vault bones, this individual was treated as unobservable and not used in the analysis of PH.

Inventory of Long Bones

The presence or absence of each of the major twelve long bones of the upper and lower limb was recorded during the skeletal inventory. Each present long bone was scored based on the completeness of its shaft using the coding protocol displayed in Table 4. The total number of long bones classified at stage two or three of completeness for each individual was also determined. This is important information when analyzing long bones for the presence of periosteal reactions or trauma of long bones. This study only analyzes the absence or presence of periosteal reactions and fractures on long bones that are at least two-thirds complete (stage two or three).

Table 4 Data codes used to record the completeness of long bones.

Data code	Description of data code
0	Long bone absent or only represented by an epiphysis or less than 1/3 complete shaft
1	At least 1/3 of a complete shaft present
2	At least 2/3 of a complete shaft present
3	At least an entire complete shaft present, epiphyses do not have to be present

Periosteal Reactions

The humerus, radius, ulna, femur, tibia, and fibula of each adult were analyzed and scored for the presence of either remodeled, active periosteal reactions, or a combination of both, following the guidelines outlined in *Standards* (1994:114-15, 136). Only long bones that were at the completeness stage of two or three were used for data analysis. Thus, if an individual was not associated with long bones that were at least two-thirds complete this individual was treated as unobservable for periosteal reactions. Similar to other biological status markers, data analysis of periosteal reactions is conducted at the individual level. If an individual had at least one long bone at the completeness stage of two or three that exhibited a periosteal reaction the individual was scored as present for this marker, or absent for this marker if the one bone did not have evidence of a periosteal reaction. This same method was also applied to analyze the frequency of periosteal reactions in only the tibia and fibula. If an individual has a specific long bone fracture, this was not recorded as a periosteal reaction, but rather as a long bone fracture. In this study, periosteal reactions were reserved for nonspecific disease/infection or nonspecific acute trauma.

Antemortem Trauma

The presence of antemortem (healed) postcranial and cranial skeletal trauma was examined on the major appendicular long bones and on the bones of the calvaria. In archaeological skeletal remains it is difficult to distinguish between perimortem (unhealed) and postmortem trauma (Goodman and Martin, 2002; Larsen, 1997), thus antemortem trauma was the focus of analysis in this study. Similar to the methods used to examine each humerus, radius, ulna, femur, tibia, and fibula for the evidence of periosteal reaction, each one of these long bones was examined for any evidence of antemortem trauma. Only bones that were at the completeness stage of two or three were treated as observable, and if trauma was observed, it was recorded following the data protocols detailed in *Standards* (1994:120-121 and Table 6). It was noted whether the antemortem trauma was healed or healing. Measurements of the traumatic area, other descriptive notes, and photographs were also recorded. The absence or presence of long bone trauma was also done at the individual level. If an individual had at least one long bone at the stage of two or three of completeness that exhibited trauma, the individual was scored as present for this marker, or absent for this marker, if the one bone did not have evidence of trauma.

Similar methods for the identification and recording of long bone trauma were employed for the examination of antemortem trauma of the bones of the calvaria which is composed of the frontal, parietal, temporal, occipital, sphenoid and ethmoid bones. If trauma was observed, it was recorded following the data protocols detailed in *Standards* (1994:120-121 and Table 6: 114-115). It was noted whether the antemortem trauma was healed or healing. Measurements of the traumatic area, other descriptive notes, and photographs were also recorded. Due to the lack of preservation of the facial skeleton of most of the individuals analyzed in this research, the analysis of skull trauma in this research focused on the bones of the calvaria. Each calvaria was treated as a unit and trauma to any bone of the cranial vault resulted in that individual being scored as present for cranial vault trauma, while an individual was scored as absent if none of the present cranial vault bones had evidence of trauma. An individual lacking any bones of the calvaria or who was only represented by a few vault fragments was treated as unobservable for the presence of cranial trauma and excluded for analysis.

Long Bone Measurements

In order to assess adult body size, four long bone measurements were collected. In lieu, of assessing overall stature, measurements of the maximum length of the femur and tibia length were recorded following the protocols in *Standards* (1994: 80-83) using an osteometric board to the nearest millimeter. The maximum diameter of the femoral head was collected with the use of a sliding caliper to the nearest tenth of a millimeter. The measurement of the maximum diameter of the head of the humerus was recorded using a sliding caliper to the nearest tenth of a millimeter following Bass (1995: 152-153) which differs slightly from the protocols for the measurement of the vertical head of the humerus published in *Standards*. When possible, measurements were recorded for both right and left sides. If a measurement was estimated from a bone that was not entirely complete, this was noted. For each of the four measurements, the best measurement for analysis was entered into the database for each individual. In cases where both a right and left measurement were available, the measurement from the left side was recorded for the best measurement for analysis variable. In the case where an individual had a measurement from the left side of a bone that was estimated, but had the right side complete, the best measurement for analysis was entered into the database from the right side, rather than from the estimated left side.

Research Hypotheses

As outlined at the end of Chapter 2, this study examines the biological status of Ohio Hopewell populations at the regional level. Biological status, as previously explained in this chapter, was assessed through an analysis of markers of nonspecific systemic physiological stress, dietary nutritional stress, nonspecific infection and/or disease, or trauma to the skeletal system.

The first set of research questions evaluates intraregional and interregional differences in the relationship between biological status and social status of male and female adults from the SW and SC regions of Ohio. The model of Ohio Hopewell leadership proposed by Carr and Case has previously been discussed in Chapter 2. In summary, Carr and Case (2005) believe that leadership was diversified, primarily based on religion, decentralized, and slightly institutionalized. As detailed in Chapter 2, the archaeological model proposed by Field and her colleagues (2005) argues that male and female access to leadership and prestige in local Ohio Hopewell societies differs by region. In the SC region, males predominantly filled social positions of leadership and prestige. "The overall pattern was one of male dominance in the sociopolitical and ritual realms, with equivalence among the genders in personal forms of prestige and/or wealth" (Carr, 2008c:244). Conversely, in the SW region at the Turner site females predominately held leadership and prestige positions. "The possibility of a more powerful place for women in the societies of the southwestern Ohio area compared to the Scioto [SC] region is also apparent" (Field et al., 2005:395). In the SW region, Greber (1979a) found similar ranking of males and females at the Turner site which seems to fit with the results of Field and her colleagues. Indicators of the biological status of adult males and females from these two regions is used in the first three research questions to test the hypotheses of whether increased social status marked by leadership and prestigious social positions is associated with differences in biological status from a skeletal biology perspective.

The second set of questions examines whether differences in the biological status of adults are related to differences in social status at prestigious burial mounds within the SC region. Carr (2005c:280) hypothesizes that Ohio Hopewell communities buried their most prestigious community members, "special persons", at Hopewell Mound Group and less prestigious members of their communities at other SC sites: Seip, Edwin Harness, and Ater mounds which "served to contain a broader but still incomplete society". Carr (2005c:278-280) cites several lines of reasoning to support this viewpoint: high percentage of exotic grave goods at Hopewell mounds, disproportionate number of adult males buried at Hopewell compared to females (particularly at Mound 23 and 25), very few subadult burials, and a high percentage of extended burials rather than cremations at the Hopewell Mounds. This is a much different pattern than at Seip, Edwin Harness Mound, or Ater Mound, where cremations are by far the most common type of burial. The uniqueness of the Hopewell site compared to other Ohio Hopewell sites is also noted by Greber and Ruhl (1989:272) who comment on the large size of Mound 25, architectural design of Mounds 23 and 25, and the rich deposits of exotic artifacts. They also note the "striking quality of the artisanship" of Hopewell metal and bones artifacts and that "the apex of this style is expressed in objects from the Hopewell site" (Greber and Ruhl, 1989:272-273).

Hopewell Mound 25 and Mound 23 share several key architectural and mortuary characteristics, and are quite different from the other smaller mounds with burials at Hopewell Mound Group. Mounds 25 and 23 share a similar loaf shape (other mounds are more circular), are the two largest mounds by volume, and have the two largest burial populations (Carr, 2008e). These two mounds also have the largest percentage of burials which are predominantly extended burials, as discussed above, when compared to the other mounds at the Hopewell site. Additionally, Mound 25 covered charnel houses, and it is possible that Mound 23 did as well based on posts discovered by Moorehead (Carr, 2008e:659). Greber and Ruhl (1989:43-44) note that the construction of the floors of Mounds 25 and 23 is similar, and that both mounds have evidence for ceremonial activities focused at the center of the mound with public areas ("plazas") located on either side. These differences lead Carr (2008e:659) to question whether there is evidence for social ranking between these two groups (Mound 25 and 23 versus other 15 Hopewell mounds).

Conversely, there are several contrasting mortuary features between Mounds 25 and 23. The burials at Mound 25 contain many more grave goods, particularly prestigious copper artifacts, and/or display elaborate tomb construction about a third of the time (Carr, 2005c:272). On the other hand, the burials at Mound 23 contain few to no grave goods and only have the presence of breast plates from the prestigious class of copper artifacts, and in general contain the burials of fewer leaders than Mound 25 (Carr, 2008e:626, 659). Mound 25 also contains five large ceremonial caches of exotic artifacts, while Mound 23 has none of these deposits (Carr, 2008e:689). Greber and Ruhl (1989:292) also find that all the burial groups at Mound 25 have many grave goods and associated prestigious social status.

Based on these differences, Carr (2005c:337) speculates that individuals buried at Mound 25 have a higher social ranking than individuals buried at Mound 23. However, Carr (2005c:337) does not believe the current data supports the hypothesis that Hopewell Mound 25 is a burial place for ranked individuals. Carr suggests that another interpretation of the differences between Mounds 25 and 23 is that burial at Mound 25 was "restricted to particular, largely important classes of individuals", but "Mound 23 contained spouses or other affines of the persons not eligible for burial in Mound 25" (Carr, 2008e:626-627).

Based on much of the mortuary evidence presented above, Hopewell Mound 25 is unique when compared to the other mounds of the Hopewell Mound Group, even when compared to Mound 23. Other than the deposit of thousands of flint discs at Mound 2, Mound 25 has the two largest ceremonial caches of artifacts at any of the mounds at the Hopewell site (Greber and Ruhl, 1989:78). Mound 25 has the largest mound volume of any mound constructed by Hopewell people, the most elaborate tomb construction, rich deposits of artifacts with fine craftsmanship, and a predominantly male burial population associated with social positions of leadership and prestige.

Indicators of the biological status of adult males and females buried at different mounds in the SC region is used in the final four research questions to test the hypotheses of whether increased social status marked by leadership and prestigious social positions is associated with differences in biological status from a skeletal biology perspective. As first explained at the end of Chapter 3, this research uses the working null hypothesis that there should be no statistically significant differences among the skeletal indicators of biological status compared in each research question. This research focuses on the biological status of adult males and adult females from the SW and SC regions. All references to regions of Ohio with increased access to male or female leadership or prestige social positions are based on Field et al.'s (2005) hypotheses generated from mortuary data.

Each of the biological status markers involve binary scored data (absence or presence), while the four long bone measurements are continuous data. These different types of data require different methods of statistical analysis, thus the hypotheses for biological status markers of nominal variables are listed first for each question, followed by research hypotheses for the long bone measurements. The different variables involving biological status markers were analyzed by comparing frequencies of the presence and absence of each different variable. The continuous data for the four long bone measurements was analyzed by comparing mean values of these measurements. The statistical testing of these hypotheses is presented in Chapter 5.

Research Questions and Hypotheses

Question 1) Is there an association between indicators of biological status and greater access to leadership and prestige for each sex in a specific region?

Question 1A) In the SW region, it has been proposed that females have increased access to leadership and prestige. As a result, does biological status differ between males and females in the SW region?

Analysis 1A) Compare the biological status and long bone measurement data of females to males from the SW region.

Hypotheses 1A: Biological status markers

H0: There is no statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between females and males in the SW region.

H1: There is a statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between females and males in the SW region.

Hypotheses 1A: Long bone measurements

H0: There is no statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between females and males in the SW region.

H1: There is a statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between females and males in the SW region.

Question 1B) In the SC region, it has been proposed that males have increased access to leadership and prestige. As a result, does biological status differ between males and females in the SC region?

Analysis 1B) Compare the biological status and long bone measurement data of females to males from the SC region.

<u>Hypotheses 1B: Biological status markers</u>

H0: There is no statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between females and males in the SC region.

H1: There is a statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between females and males in the SC region.

<u>Hypotheses 1B: Long bone measurements</u>

H0: There is no statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between females and males in the SC region.

H1: There is a statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between females and males in the SC region.

Question 2) Do interregional differences between the biological statuses of females associate with the hypothesized differences of female access to leadership and prestige?

In the SW region, it has been proposed that females have increased access to leadership and prestige. As a result, does the biological status of SW and SC females differ?

Analysis 2) Compare the biological status and long bone measurement data of females from the SW region to the biological status and long bone measurement data of females from the SC region.

Hypotheses 2: Biological status markers

H0: There is no statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between SW females and SC females.

H1: There is a statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between SW females and SC females.

Hypotheses 2: Long bone measurements

H0: There is no statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between SW females and SC females.

H1: There is a statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between SW females and SC females.

Question 3) Do interregional differences between the biological statuses of males associate with the hypothesized differences of male access to leadership and prestige?

In the SC region, it has been proposed that males have increased access to leadership and prestige. As a result, does the biological status of SC and SW males differ?

Analysis 3) Compare the biological status and long bone measurement data of males from the SC region to the biological status and long bone measurement data of males from the SW region.

Hypotheses 3: Biological status markers

H0: There is no statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between SC males and SW males.

H1: There is a statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between SC males and SW males.

Hypotheses 3: Long bone measurements

H0: There is no statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between SC males and SW males.

H1: There is a statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between SC males and SW males.

Question 4) There are several key architectural and mortuary features which makes the Hopewell Mound Group unique when compared to other nearby SC sites. Is the biological status of adults buried at Hopewell Mounds different than the biological status of adults buried at Seip, Harness, Ater, and Rockhold Mounds?

Analysis 4A) Compare the biological status and long bone measurement data of adults from the Hopewell Mounds to adults from Seip, Harness, Ater, and Rockhold Mounds.

Analysis 4B) Compare the biological status and long bone measurement data of males from the Hopewell Mounds to males from Seip, Harness, Ater, and Rockhold Mounds.

Analysis 4C) Compare the biological status and long bone measurement data of females from the Hopewell Mounds to females from Seip, Harness, Ater, and Rockhold Mounds.

The following hypotheses are tested for question 4: 4A compares all adults, 4B compares males, and 4C compares females.

<u>Hypotheses 4: Biological status markers</u>

H0: There is no statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between adults from Hopewell Mounds and adults from Seip, Harness, Ater, and Rockhold Mounds.

H1: There is a statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between adults from Hopewell Mounds and adults from Seip, Harness, Ater, and Rockhold Mounds.

<u>Hypotheses 4: Long bone measurements</u>

H0: There is no statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between adults from Hopewell Mounds and adults from Seip, Harness, Ater, and Rockhold Mounds.

H1: There is a statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between adults from Hopewell Mounds and adults from Seip, Harness, Ater, and Rockhold Mounds.

Question 5) Within the Hopewell Mound Group, Mounds 23 and 25 stand out from the other mounds with burials because of their similar size and shape, large burial populations, and shared mortuary features. Is the biological status of adults buried at Hopewell Mounds 23 and 25 different than the biological status of adults buried with provenience at the other Hopewell Mounds?

Analysis 5A) Compare the biological status and long bone measurement data of adults from Hopewell Mounds 23 and 25 to adults buried with provenience at the other Hopewell Mounds.

Analysis 5B) Compare the biological status and long bone measurement data of males from Hopewell Mounds 23 and 25 to males buried with provenience at the other Hopewell Mounds.

Analysis 5C) Compare the biological status and long bone measurement data of females from Hopewell Mounds 23 and 25 to females buried with provenience at the other Hopewell Mounds.

The following hypotheses are tested for question 5: 5A compares all adults, 5B compares males, and 5C compares females.

<u>Hypotheses 5: Biological status markers</u>

H0: There is no statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between adults from Hopewell Mounds 23 and 25 and adults with provenience from other Hopewell Mounds.

H1: There is a statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between adults from Hopewell Mounds 23 and 25 and adults with provenience from other Hopewell Mounds.

<u>Hypotheses 5: Long bone measurements</u>

H0: There is no statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between adults from Hopewell Mounds 23 and 25 and adults with provenience from other Hopewell Mounds.

H1: There is a statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between adults from Hopewell Mounds 23 and 25 and adults with provenience from other Hopewell Mounds.

Question 6) Hopewell Mound 25 burials have more prestigious and numerous grave goods and evidence of more elaborate mortuary rituals than burials at Mound 23. Is the biological status of adults buried at Hopewell Mound 25 different than the biological status of adults buried at Hopewell Mound 23?

Analysis 6A) Compare the biological status and long bone measurement data of adults buried at Mound 25 to adults from Mound 23.

Analysis 6B) Compare the biological status and long bone measurement data of males buried at Mound 25 to males from Mound 23.

Analysis 6C) Compare the biological status and long bone measurement data of females buried at Mound 25 to females from Mound 23.

The following hypotheses are tested for question 6: 6A compares all adults, 6B compares males, and 6C compares females.

<u>Hypotheses 6: Biological status markers</u>

H0: There is no statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between adults from Hopewell Mound 25 and adults from Hopewell Mound 23.

H1: There is a statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between adults from Hopewell Mound 25 and adults from Hopewell Mound 23.

Hypotheses 6: Long bone measurements

H0: There is no statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between adults from Hopewell Mound 25 and adults from Hopewell Mound 23.

H1: There is a statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between adults from Hopewell Mound 25 and adults from Hopewell Mound 23.

Question 7) Hopewell Mound 25 is unique when compared to the other mounds of the Hopewell Mound Group because of its large size, rich deposits of exotic artifacts, and the most elaborate mortuary rituals. Is the biological status of adults buried at Hopewell Mound 25 different than the biological status of adults buried with provenience at the other Hopewell Mounds?

Analysis 7A) Compare the biological status and long bone measurement data of adults from Hopewell Mound 25 to adults buried with provenience at the other Hopewell Mounds.

Analysis 7B) Compare the biological status and long bone measurement data of males from Hopewell Mound 25 to males buried with provenience at the other Hopewell Mounds.

Analysis 7C) Compare the biological status and long bone measurement data of females from Hopewell Mound 25 to females buried with provenience at the other Hopewell Mounds.

The following hypotheses are tested for question 7: 7A compares all adults, 7B compares males, and 7C compares females.

<u>Hypotheses 7: Biological status markers</u>

H0: There is no statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between adults from Hopewell Mound 25 and adults with provenience from other Hopewell Mounds.

H1: There is a statistically significant association in the frequency of each biological status marker (LEH, porotic hyperostosis, periosteal reaction, long bone trauma, or cranial trauma) between adults from Hopewell Mound 25 and adults with provenience from other Hopewell Mounds.

<u>Hypotheses 7: Long bone measurements</u>

H0: There is no statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between adults from Hopewell Mound 25 and adults with provenience from other Hopewell Mounds.

H1: There is a statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between adults from Hopewell Mound 25 and adults with provenience from other Hopewell Mounds.

Chapter Summary

This chapter defines the skeletal sample used to represent the SW region of Ohio Hopewell as 46 adults from the Turner Group Complex, while 91 adults from the Hopewell Mound Group, Seip Earthworks, Edwin Harness Mound, Raymond Ater Mound, and Rockhold Mound Group represent the SC region. Key archaeological features of these SW and SC sites are also highlighted. As previously stated, this research only focuses on the biological status of adult males and females, because of the problems with assigning sex to the skeletal remains of subadults. Sex determination is critical to address the research questions of this study. The data collection protocols and methods of skeletal biological analysis for sex determination, age estimation, LEH, PH, periosteal reactions, antemortem trauma, and long bone measurements are explained. These protocols are all consistent with standards established in the field of human osteology. Finally, the specific research hypotheses of this study are introduced before the results of the statistical testing of these hypotheses are presented in Chapter 5.

Chapter 5: Results

This chapter addresses the results of the statistical analyses performed in this study. The chapter is divided into three parts. The first part summarizes the demography of the skeletal samples from the two regions: the southwest (SW) and south-central (SC) regions. It also provides overview statistics that detail the frequency of the different markers of biological status in the two regional skeletal collections. The second part of the chapter contains the results of the statistical testing of the research hypotheses for the first three questions that examine the intraregional and interregional differences of biological status markers between adult males and females from the SW and SC regions. Finally, this chapter contains the results of the statistical testing of the last four research hypotheses that examine whether there is a difference in markers of biological status based on prestigious burial mound location in the SC region.

Demography of Skeletal Sample

Adult Demography

The skeletal sample analyzed for this dissertation consists of 137 total adults. Ninety-one adults are from the SC region of Ohio and 46 adults are from the SW region. As discussed in Chapter 4, this study uses a regional perspective, thus the SC region consists of adults from the following sites: Hopewell Mounds, Raymond Ater Mound, Seip Mounds, Edwin Harness Mound, and Rockhold Mound. Table 5 displays the number of adults from each SC site. Skeletal remains of adults from the Hopewell Mounds constitute 84.6% of the SC sample. Due to a lack of the availability of skeletal remains from other archaeological sites in the SW region, which was discussed in Chapter 4, this region is represented by the skeletal remains of 46 adults from the Turner Group Complex.

Table 5 Number of adults from each SC site

Site	*n*	Percentage %
Hopewell Mound Group	77	84.6
Ater Mound	6	6.6
Seip Mounds	4	4.4
Harness Mound	3	3.3
Rockhold Mound	1	1.1
Total	**91**	**100**

The age and sex of the skeletal sample examined in this study are summarized for the two different regions in Tables 6 and 7. Sex classifications are collapsed together for statistical analysis. For example, the classification of males represents adults identified as both probable males and males. The undetermined sex category includes adults who had ambiguous morphological features, and adults of unknown sex determination because of poor skeletal representation. In the SC region, 50.5% (n = 46) of the total of 91 adults are female, while in the SW region 47.8 % (n = 22) of the total sample of 46 adults are also female. In the SC region, males compose 41.7% (n = 38) of the sample, and in the SW region males constitute 45.7% (n = 21) of the total sample. In both regions, less than 8% of the adults are of undetermined sex. Figure 11 displays the percentage of adults assigned to each sex category by region. Even though the SC sample is two times larger than the SW sample, the sex ratio of males to females is fairly balanced in both regions.

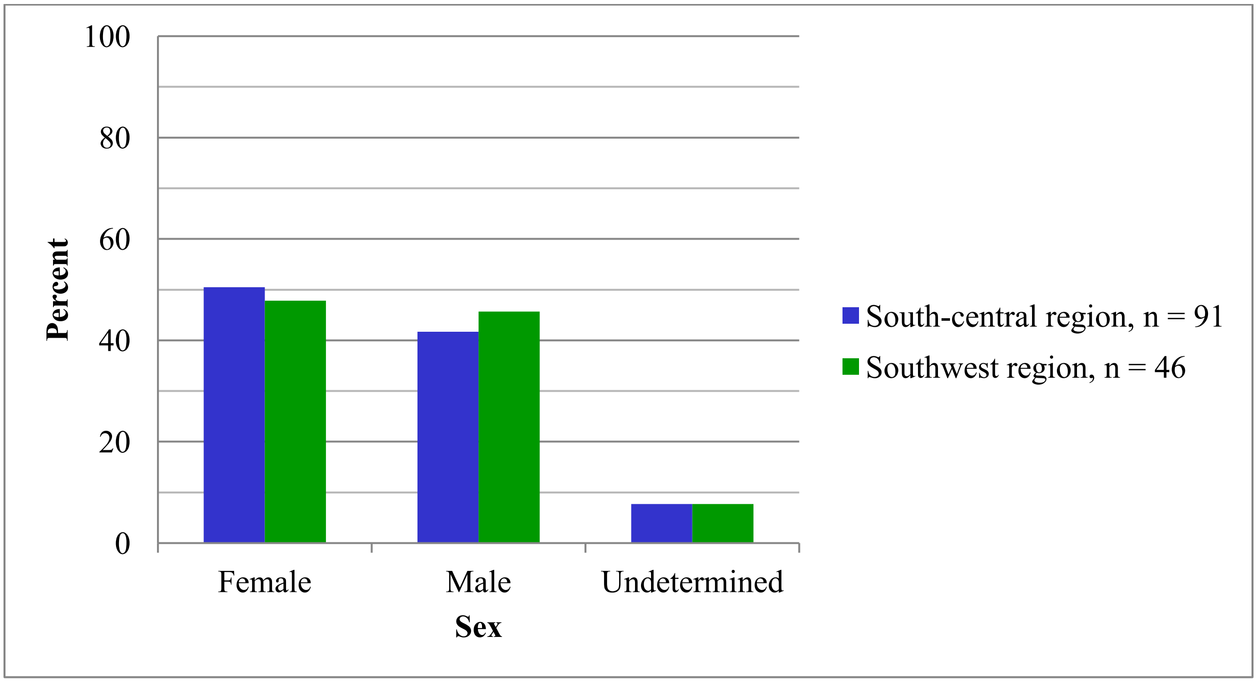
Table 6 SC adult sex and age demographics

Sex / Age		*n*	Percentage %
Female	Adult	8	8.8
	Young	16	16.0
	Middle	19	20.9
	Old	3	3.3
Sub-total		*46*	*50.5*
Male	Adult	2	2.2
	Young	2	2.2
	Middle	33	36.3
	Old	1	1.1
Sub-total		*38*	*41.7*
Undetermined	Adult	6	6.6
	Young	0	0.0
	Middle	1	1.1
	Old	0	0.0
Sub-total		*7*	*7.7*
Total		**91**	**100.0**

Table 7 SW adult sex and age demographics

Sex / Age		*n*	Percentage %
Female	Adult	7	15.2
	Young	3	6.5
	Middle	10	21.7
	Old	2	4.3
Sub-total		*22*	*47.8*
Male	Adult	2	4.3
	Young	3	6.5
	Middle	11	23.9
	Old	5	10.9
Sub-total		*21*	*45.7*
Undetermined	Adult	2	4.3
	Young	0	0.0
	Middle	1	2.2
	Old	0	0.0
Sub-total		*3*	*6.5*
Total		**46**	**100.0**

Figure 11 Adult sex determination by region
Note: For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this dissertation.



Tables 6 and 7 summarize the percentage of the sample of males and females classified into different age groups in each region. The age categories used in this study are young adult (20 – 34), middle adult (35-49), and old adult (50+). Individuals who do not have enough skeletal indicators of age to be classified into one of these three main age categories are classified as adults (20+). In both regions, and for both males and females, adults of middle age are the most frequent age cohort. Young adults are the second most frequent age cohort. Only for males in the SW region are there more adults classified to the old adult age category (n = 5) than the young adult category (n = 3).

It should be noted that two females who were estimated to be about 18 years of age based on dental development are included in the young adult category. These two individuals from the SC region are represented only by a skull and teeth. They each have at least one third molar with roots that were not completely developed, but the third molars are in occlusion and have evidence of dental wear. They also each have a present third molar scored as having the apex of the root half-closed based on Moorees et al. (1963b). The mean age for a female with this stage of dental development for a mandibular third molar is 18 years of age, and the age range based on one standard deviation is 16.5 to approximately 20.5 years (Moorees et al., 1963b). Additionally, both individuals have minimal suture closure and their assessed age based on vault suture closure is to the young adult category.

Skeletal Markers of Biological Status: Overview Statistics

In the following section, the frequency of each binary scored (absence or presence) marker of biological status is summarized by region for all adults (identified as male, female, or undetermined) at the individual level. The statistical tests of nominal data were conducted using Pearson chi-square analysis or Fisher Exact probability test, when expected cell counts were less than five. All nominal data analysis was completed using IBM SPSS Statistics version 19 and the VassarStats website for Statistical Computation, Clinical Research Calculator 3 (http://faculty.vassar.edu/lowry/VassarStats.html). Statistical significance was set at the $p <$ 0.05 level, and $p < 0.10$ for near statistical significance. All significance tests were two-tailed.

Linear Enamel Hypoplasias

The methods used for the observation of linear enamel hypoplasias (LEH) are explained in Chapter 4 and a discussion of the different variables used to analyze LEH in this research study is also included. The absence or presence of LEH in each skeletal sample was analyzed in two different ways (maxillary and mandibular anterior teeth vs. substitution method for each anterior tooth) in this study and is explained below.

The analysis of the absence or presence of LEH in maxillary and mandibular anterior teeth was possible for 62.6% (57 of 91) of SC adults, and 76.1% (35 of 46) of SW adults. This analysis was done at the individual level, and is not based on total teeth, thus each individual must have had at least one anterior tooth available for observation in order to be analyzed and counted as observable for the absence or presence of LEH. The frequency of LEH is 26.3% in the SC region for all adults. In the SW region, the frequency of LEH is 45.7% for all adults. Table 8 displays the frequency of LEH of all adults by region. This difference is near statistically significant ($\chi^2 = 3.65$, $p = 0.06$, df = 1).

Table 8 LEH frequency of anterior maxillary and mandibular teeth by region for all adults

LEH	Region	Frequency (%)	Present	Absent	Total Sample (*n*)
	SW	45.7	16	19	35
	SC	26.3	15	42	57
	Total	**33.7**	**31**	**61**	**92**

Chapter 4 also discusses the methods involved for the analysis of the absence or presence of each individual anterior tooth by the substitution method for the following tooth numbers, or its antimere: #9 (#8), #10 (#7), #11 (#6), #22 (#27), #23 (#26), and #24 (#25). The substitution method was used in the testing of the seven specific research hypotheses, and the results will be detailed in the second part of this chapter.

Porotic Hyperostosis

The methods used for the analysis of porotic hyperostosis (PH) in this study are explained in Chapter 4. The bones of the cranial vault were treated as a unit and the frontal, parietals, and occipital were all examined for evidence of PH at the individual level. In the SC region 83.5% (76 of 91) of all adults, and 80.4% (37 of 46) of all SW adults have cranial vault surfaces that are observable for PH. Table 9 displays the frequency data for PH at the individual level for all observable adults grouped by region. In the SW region, the frequency is 51.4% (19 of 37) for all adults. In the SC region the frequency of PH is 47.4% (36 of 76) for all adults. The difference in the frequency of PH by region is not statistically significant.

Table 9 Frequency of PH for all adults by region

Porotic Hyperostosis	**Region**	**Frequency (%)**	**Present**	**Absent**	**Total Sample (*n*)**
	SW	51.4	19	18	37
	SC	47.4	36	40	76
	Total	**48.7**	**55**	**58**	**113**

Periosteal Reactions

The methods used for the analysis of periosteal reactions on the humerus, radius, ulna, femur, tibia, and fibula in this study are explained in Chapter 4. Only long bones that are at the completeness stage of two (at least 2/3 of shaft is present) or three (complete shaft) were examined for the evidence of periosteal reactions. Table 10 depicts the distribution of periosteal reactions by bone type for all adults. Overall, 4.9% (n = 24) of 493 long bones exhibit periosteal reactions. The tibiae and fibulae have the highest frequency of periosteal reactions, as 13.2% (n = 12) of 91 tibiae and 12.1% (n = 8) of 66 fibulae have periosteal reactions.

Many of the adults who have a periosteal reaction in the tibia or fibula also display this pathology bilaterally. Seven adults represent the 12 tibiae that have a periosteal reaction. Five of these adults have a periosteal reaction present in both the right and left tibiae, while one individual only has one tibia for analysis, and the final individual has a periosteal reaction on only one of the two tibiae. Five adults represent the eight fibulae with periosteal reactions. Three of these adults have a periosteal reaction present in both fibulae, while two adults only have one fibula available for analysis. Overall, there are two adults who have periosteal reactions on both their tibia and fibula.

Table 10 Frequency of periosteal reactions for all adults by bone type in each region

	Both Regions			**SC**		**SW**	
Bone	**Frequency (%)**	**Total Periosteal Reaction Present**	**Total Sample (*n*)**	**Periosteal Reaction Present**	**Sample (*n*)**	**Periosteal Reaction Present**	**Sample (*n*)**
Tibia	13.2	12	91	10	61	2	30
Fibula	12.1	8	66	7	54	1	12
Radius	4.4	3	68	1	50	2	18
Femur	0.9	1	112	1	81	0	31
Humerus	0.0	0	81	0	62	0	19
Ulna	0.0	0	75	0	56	0	19

Table 11 displays the frequency of all observable long bones with periosteal reactions for all adults grouped by region. In the SC region, 5.2% (n = 19) of 364 long bones exhibit a periosteal reaction. In the SW region, 3.9% (n = 5) of 129 long bones have a periosteal reaction. The difference in the frequency of periosteal reactions for all long bones by region is not statistically significant.

Table 11 Frequency of periosteal reactions for all adults by region

Periosteal reactions – all long bones	Region	Frequency (%)	Present	Absent	Total Sample (*n*)
	SC	5.2	19	347	364
	SW	3.9	5	123	129
	Total	**4.9**	**24**	**470**	**493**

As previously discussed in Chapters 3 and 4, many researchers have found that the tibia is the bone that most frequently exhibits periosteal reactions. Because analysis of this skeletal sample revealed that the frequency of periosteal reactions for the tibia and fibula are the most common, the tibia and fibula were selected for further statistical analysis.

The absence or presence of a periosteal reaction on the tibia was also analyzed at the individual level because many of the adults who have a periosteal reaction on the tibia or fibula display this bilaterally. If an individual has at least one tibia at the completeness stage of two or three, the individual was scored as absent or present for periosteal reaction. Due to the fragmented nature of the skeletal collections, the analysis of tibial periosteal reactions at the individual level for adults of known sex was possible for 37.8% (n = 48) of 127 adults of the entire skeletal sample. Table 12 displays the frequency of tibial periosteal reactions for each observable individual, organized by region. In the SC region, 18.2% (n = 6) of 33 adults have a tibial periosteal reaction. In the SW region, 5.2% (n =1) of 18 adults exhibit a tibia periosteal reaction. The difference in the frequency of tibial periosteal reactions by region is not statistically significant.

Table 12 Frequency of tibial periosteal reactions for all adults by region

Tibial Periosteal Reaction	Region	Frequency (%)	Present	Absent	Total Sample (*n*)
	SC	18.2	6	27	33
	SW	5.2	1	17	18
	Total	**13.7**	**7**	**44**	**51**

Trauma

The methods used for the analysis of antemortem trauma of the humerus, radius, ulna, femur, tibia, and fibula in this study are explained in Chapter 4. Only long bones that are at the completeness stage of two (at least 2/3 of shaft is present) or three (complete shaft) were examined for the absence or presence of an antemortem trauma. The only type of long bone trauma detected during analysis was fractures, thus fractures were the focus of statistical analysis. Table 13 displays the frequency of antemortem long bone fractures of all adults in each region. Only one of the 363 long bones from the SC region has evidence of a fracture. This specific pathology is a healed antemortem spiral fracture of the right femur. In the SW region, two of 129 long bones have evidence of a fracture. Both of these fractures are healed antemortem mid-shaft fractures of the right and left ulnae of the same individual. The difference in the frequency of long bone fractures by region is not statistically significant.

Table 13 Frequency of long bone fractures for all adults by region

Fractures – all long bones	Region	Frequency (%)	Present	Absent	Total Sample (*n*)
	SW	1.6	2	127	129
	SC	0.3	1	363	364
	Total	**0.6**	**3**	**490**	**493**

The methods used for the analysis of antemortem fractures of the bones of the calvaria (frontal, parietal, temporal, occipital, sphenoid and ethmoid bones) are explained in Chapter 4. The calvaria of each individual was treated as a unit for the examination of the absence or presence of an antemortem fracture at the individual level. In the SC region, 81.3% (74 of 91 adults) of the sample could be examined for the absence or presence of cranial fractures. In the SW, 82.6% (38 of 46 adults) of the sample could be examined.

Table 14 displays the frequency of antemortem calvaria fractures for each observable individual, organized by region. In the SC region, 13.5% (n = 10) of 74 adults have cranial vault fractures. In the SW region, 5.2% (n = 2) of 38 adults exhibit calvaria fractures. The difference in the frequency of calvaria fractures by region is not statistically significant. Of the 12 adults with calvaria fractures, three adults have two different fractures. The present calvaria fractures are generally depressed, oval or round fractures of the outer table, and all fractures were either located on the frontal or parietal bones.

Table 14 Frequency of adults at the individual level with calvaria fractures by region

Calvaria fractures	Region	Frequency (%)	Present	Absent	Total Sample (*n*)
	SC	13.5	10	64	74
	SW	5.2	2	36	38
	Total	**10.7**	**12**	**100**	**112**

Table 15 lists the frequency of calvaria fractures at the individual level grouped by sex and region. SC males have the highest frequency of calvaria fractures at 15.2% (n = 5) of 33 adults. Females from the SC region have the second highest frequency of calvaria fractures at 12.8% (n = 5) of 34 adults. The analysis of the frequency of calvaria fractures did not detect any statistically significant differences amongst these four groups when they were compared by region and by sex.

Table 15 Frequency of adults with calvaria fractures by sex and region

Calvaria fractures	Region / Sex	Frequency (%)	Present	Absent	Total Sample (*n*)
	SC Males	15.2	5	28	33
	SC Females	12.8	5	34	39
	SW Females	5.9	1	16	17
	SW Males	5.0	1	19	20

Table 16 displays the frequency of any type of antemortem fracture (long bone or calvaria) for each observable individual, organized by region. In the SC region, 12.4% (n = 11) of 89 adults have any type of antemortem fracture. In the SW region, 7.3% (n = 3) of 41 adults exhibit any type of antemortem fracture. The difference in the frequency of any type of antemortem fracture at the individual level by region is not statistically significant.

Table 16 Frequency of adults at the individual level with any type of fracture by region

Any type of fracture	Region	Frequency (%)	Present	Absent	Total Sample (*n*)
	SC	12.4	11	78	89
	SW	7.3	3	39	41
	Total	**10.7**	**14**	**117**	**131**

Table 17 lists the frequency of any type of fracture (long bones or calvaria) at the individual level grouped by sex and region. SC males have the highest frequency of fractures at 13.2% (n = 5) of 38 adults. Females from the SC region have the second highest frequency of cranial fractures at 11.4% (n = 5) of 44 adults. The analysis of the frequency of any type of fracture at the individual level did not detect any statistically significant differences amongst these four groups when they were compared by region and by sex.

Table 17 Frequency of adults with any type of fracture by sex and region

Any type of fracture	Region / Sex	Frequency (%)	Present	Absent	Total Sample (*n*)
	SC Males	13.2	5	33	38
	SC Females	11.4	5	39	44
	SW Females	10.0	2	18	20
	SW Males	4.8	1	20	21

Long Bone Measurements

The methods used to obtain four different long bone measurements (maximum diameter of the humeral head, maximum diameter of the femoral head, maximum length of the femur, and tibia length) are explained in Chapter 4. Table 18 displays the mean, standard deviation and sample size of each of the four measurements for all adults grouped by region. The distribution of the measurements for maximum diameter of the humeral head, maximum diameter of the femoral head, and tibia length are normal in each region when tested by the Shapiro-Wilk test for normality ($p > 0.05$). Femur length in the SW region is also distributed normally, but femur length distribution in the SC region is not normal ($p = 0.014$) for the Shapiro-Wilk test. A statistically significant p-value ($p < 0.05$) in this study for the Shapiro-Wilk test means there is not a normal distribution of continuous data.

Table 18 Long bone measurements (mm) for all adults grouped by region
Key: Humerus MDH = maximum diameter of the humeral head
Femur MDH = maximum diameter of the femoral head

	SC			*SW*		
Measurement	**Mean**	**Standard Deviation**	**(*n*)**	**Mean**	**Standard Deviation**	**(*n*)**
Humerus MDH	42.9	3.5	14	40.9	2.7	11
Femur MDH	44.5	2.8	40	43.5	3.8	17
Femur Max Length	454.6	22.1	27	441.0	19.7	16
Tibia Length	375.2	21.6	20	362.1	24.7	13

One-way analysis of variance for maximum diameter of the humeral head, maximum diameter of the femoral head, and tibia length did not detect any statistically significant difference for all adults when compared by region (see Table 19 for summary of results, and Table 57 in Appendix for complete ANOVA table). In accordance with the rules for one-way ANOVA, all three of these measurements are not statistically significant ($p < 0.05$) for Levene's test of equality of error variances which means that there is homogeneity of variances of each measurement (dependant variable) across the two groups (region) (see Table 58 in Appendix). Since maximum femur length is not distributed normally, the nonparametric test of independent samples, the Mann-Whitney U test, was conducted. There is no statistically significant difference between the mean values of maximum femur length between SC and SW regions for all adults ($U = 145$, $P = 0.074$; see Tables 59 and 60 in Appendix for complete results table). Thus, when all adults are pooled together for each of the different long bone measurements, there is no statistically significant difference for any of the four measurements between the two regions.

Table 19 One-way ANOVA showing the effect of region on each long bone measurement (mm) of all adults

Measurement	One-way ANOVA *F* statistic	df	*P*-value	Significant? *P* < 0.05
Humerus MDH	2.5	1, 23	0.13	No
Femur MDH	1.2	1, 55	0.27	No
Tibia Length	2.6	1, 31	0.12	No

Table 20 displays the mean, standard deviation and sample size of each of the four measurements for males and females from both regions grouped by sex. The distribution of the measurements for maximum diameter of the humeral head, maximum diameter of the femoral head, and femur maximum length are normal for each when tested by the Shapiro-Wilk test. Tibia length for males is also distributed normally, but tibia length distribution for females is not normal (Shapiro-Wilk $p = 0.03$; see Tables 55 and 56 in Appendix).

Table 20 Long bone measurements (mm) for all adults grouped by sex

	Females			*Males*		
Measurement	Mean	Standard Deviation	(*n*)	Mean	Standard Deviation	(*n*)
Humerus MDH	40.2	2.0	15	44.8	3.2	8
Femur MDH	42.2	2.4	29	46.5	2.4	26
Femur Max Length	435.8	12.2	21	462.9	21.4	20
Tibia Length	355.1	16.4	15	383.2	21.5	15

One-way analysis of variance for maximum diameter of the humeral head, maximum diameter of the femoral head, and femur maximum length does not detect any statistically significant difference between males and females from both regions (see Table 21 for summary of results, Table 61 in Appendix for complete ANOVA table). In accordance with the rules for one-way ANOVA, maximum diameter of the humeral head and maximum diameter of the femoral head are not statistically significant for Levene's test of equality of error variances (see Table 62 in Appendix). This means that there is homogeneity of variances of each measurement (dependant variable) across the two groups (sex is the independent variable). Femur maximum length is statistically significant ($p = 0.002$) for Levene's test which means that there is not homogeneity of variances of each measurement across the two groups. In this case, the Welch test was utilized as a robust test of equality of means instead of ANOVA analysis. The Welch test reveals a statistically significant difference between males and females for femur maximum length [F =24.3, (df 1, 29.9), $p < 0.000$] (see Table 63 in Appendix).

Since tibia length is not distributed normally, the nonparametric test of independent samples, the Mann-Whitney U test, was conducted. There is a statistically significant difference between the mean values of tibia length between males and females from the combined regions ($U = 31.5$, $p = 0.001$; see Tables 64 and 65 in Appendix for complete results). In summary, there is a statistically significant difference for each of the four long bone measurements between males and females for the combined regions.

Table 21 One-way ANOVA showing the effect of sex on each long bone measurement (mm)

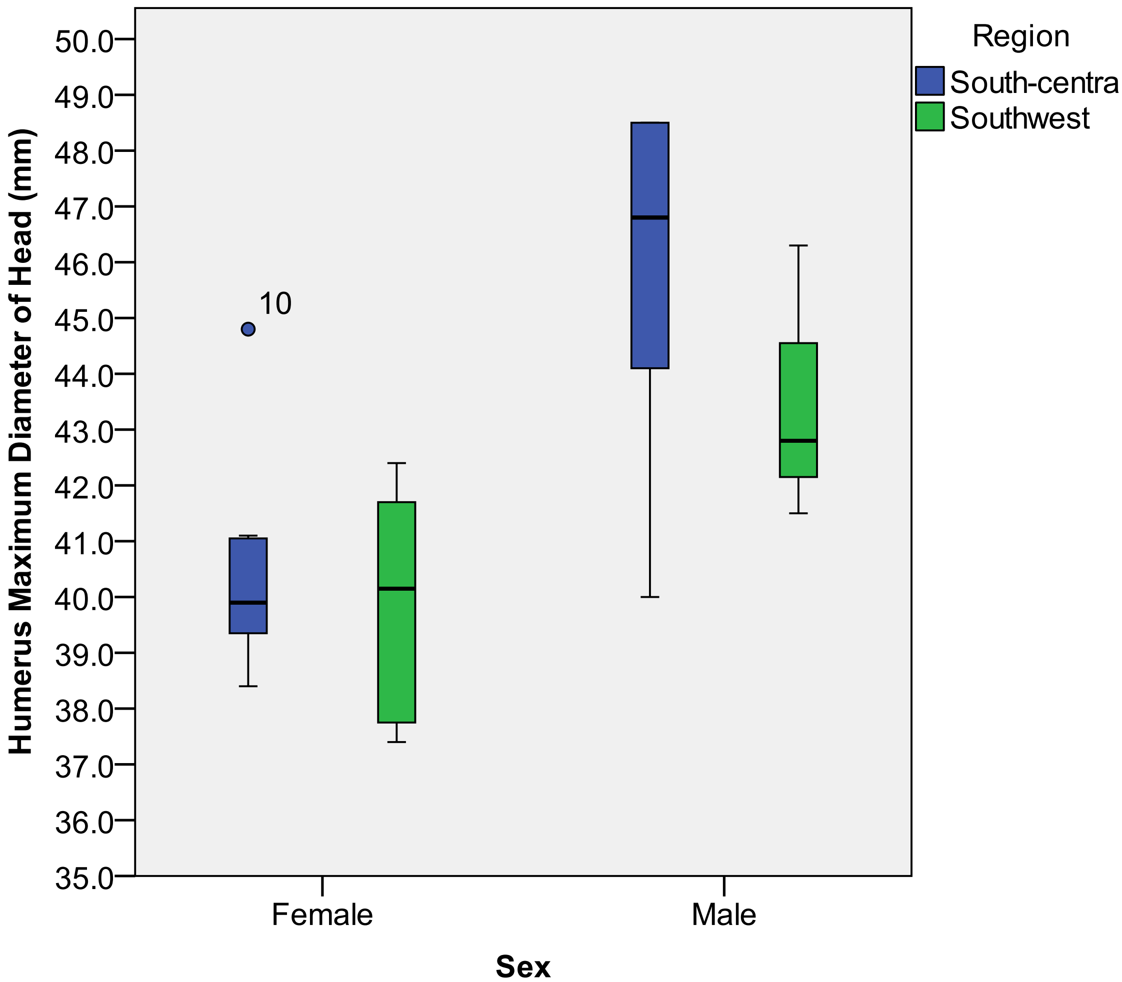
	One-way ANOVA			
Measurement	***F* statistic**	**df**	***P*-value**	**Significant? *P* < 0.05**
Humerus MDH	18.1	1, 21	0.00	YES
Femur MDH	46.3	1, 53	0.00	YES

When each of the four long bone measurements was split by region and sex and tested for normality, each measurement is distributed normally (Shapiro-Wilk $p > 0.05$). The descriptive statistics and graphic displays of the four different long bone measurements for each group (SC males, SC females, SW males, and SW females) are displayed: maximum diameter of the humeral head (Table 22, Figure 12), maximum diameter of the femoral head (Table 23, Figure 13), maximum length of the femur (Table 24, Figure 14), and tibia length (Table 25, Figure 15).

Table 22 Humerus maximum diameter of the head (mm) by sex and region

Region / Sex	Mean	Standard Deviation	Number (*n*)	Min.	Max.
SC Males	45.6	3.6	5	40.0	48.5
SW Males	43.5	2.5	3	41.5	46.3
SC Females	40.6	2.1	7	38.4	44.8
SW Females	39.9	2.0	8	37.4	42.4

Figure 12 Boxplot[1] of humerus maximum diameter of head (mm) by sex for each region



[1] The top and bottom line of each box mark the interquartile range. The upper line is the 75th quartile and lower line is the 25th quartile. The dark line in the box is the median value. The whiskers mark the largest and smallest values that are not outliers. Circles mark outliers.

Table 23 Femur maximum diameter of the head (mm) by sex and region

Region / Sex	Mean	Standard Deviation	Number (*n*)	Min.	Max.
SW Males	47.0	3.5	6	42.9	52.2
SC Males	46.4	2.0	20	43.0	50.4
SC Females	42.6	2.3	18	38.4	47.1
SW Females	41.6	2.5	11	37.5	44.4

Figure 13 Boxplot of femur maximum diameter of head (mm) by sex for each region

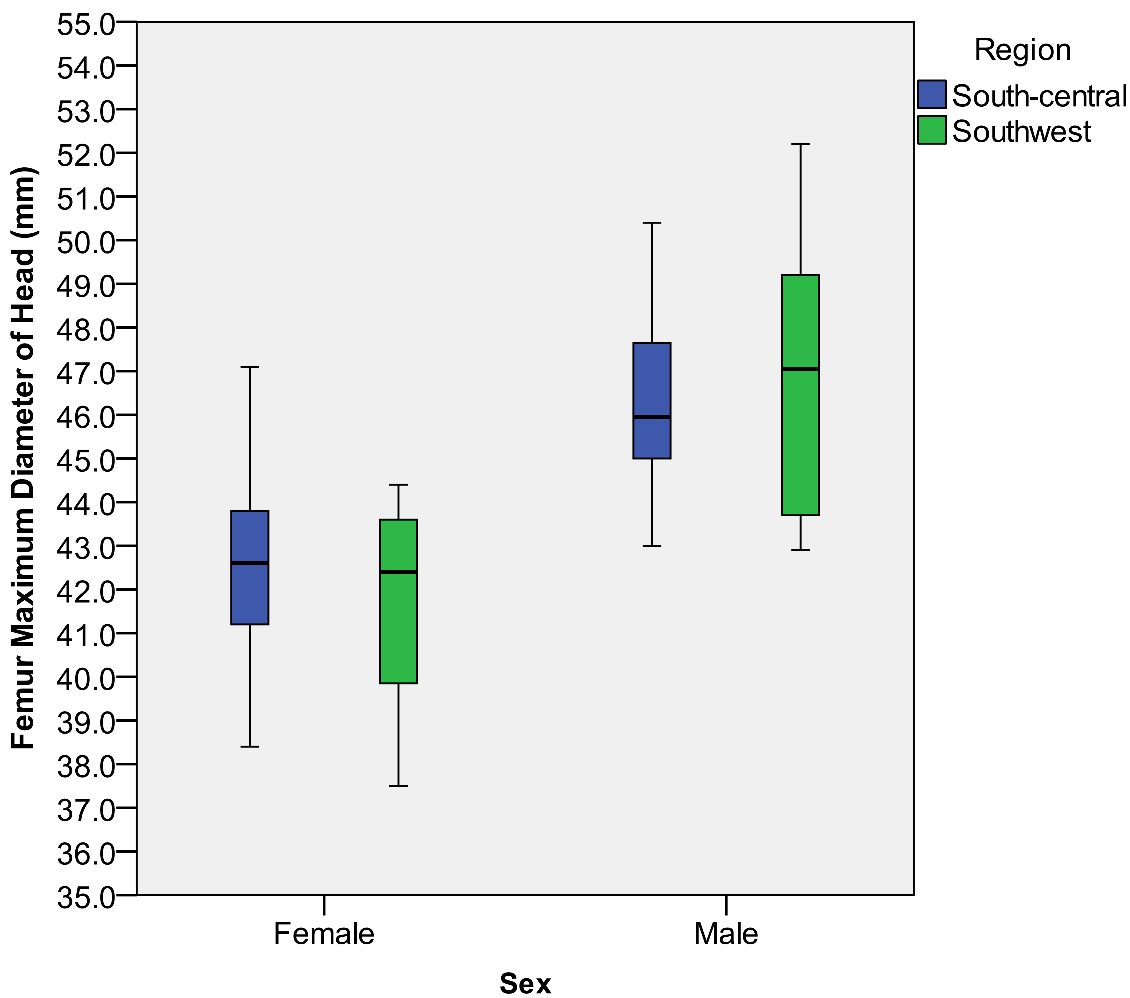


Table 24 Femur maximum length (mm) by sex and region

Region / Sex	Mean	Standard Deviation	Number (n)	Min.	Max.
SC Males	466.4	21.5	14	428.0	499.0
SW Males	454.7	20.7	6	430.0	488.0
SC Females	438.6	9.6	11	428.0	462.0
SW Females	432.8	14.5	10	414.0	453.0

Figure 14 Boxplot of femur maximum length (mm) by sex for each region

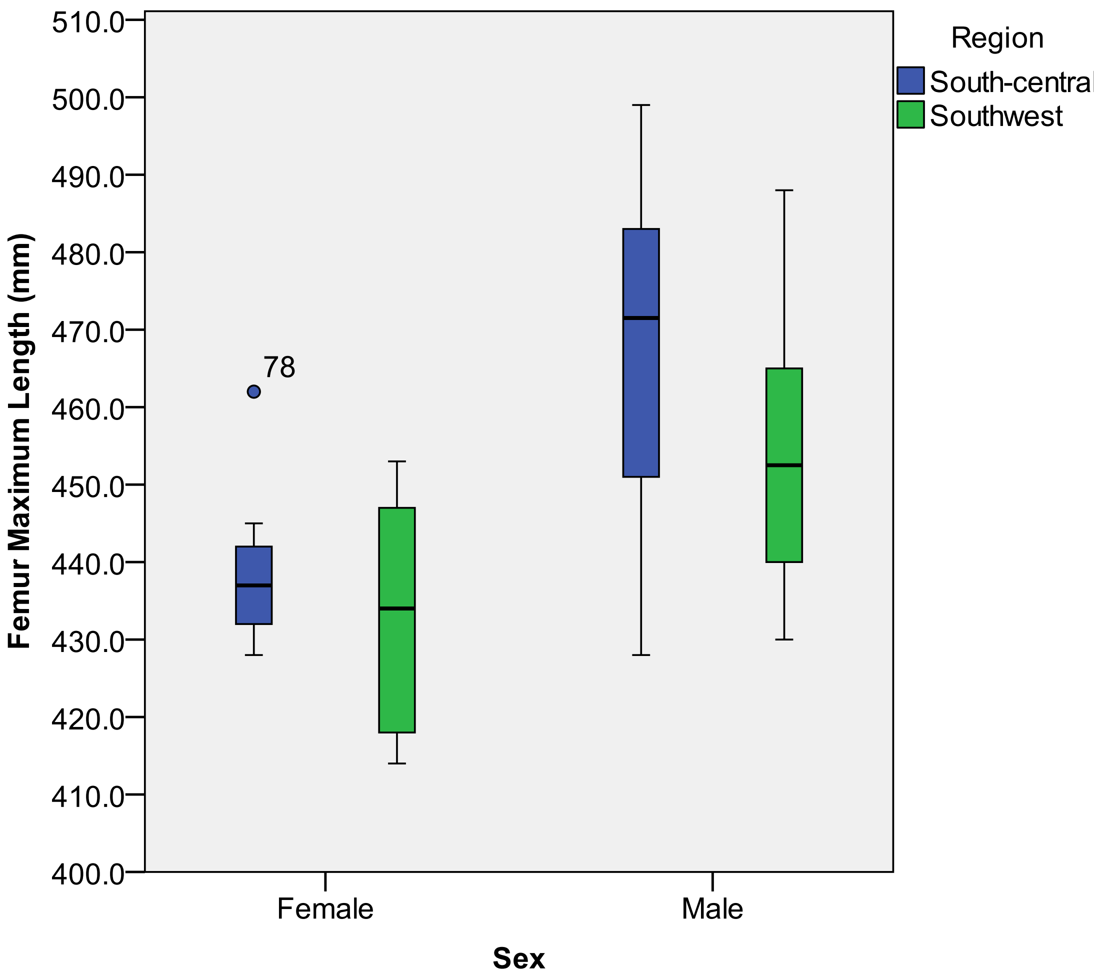
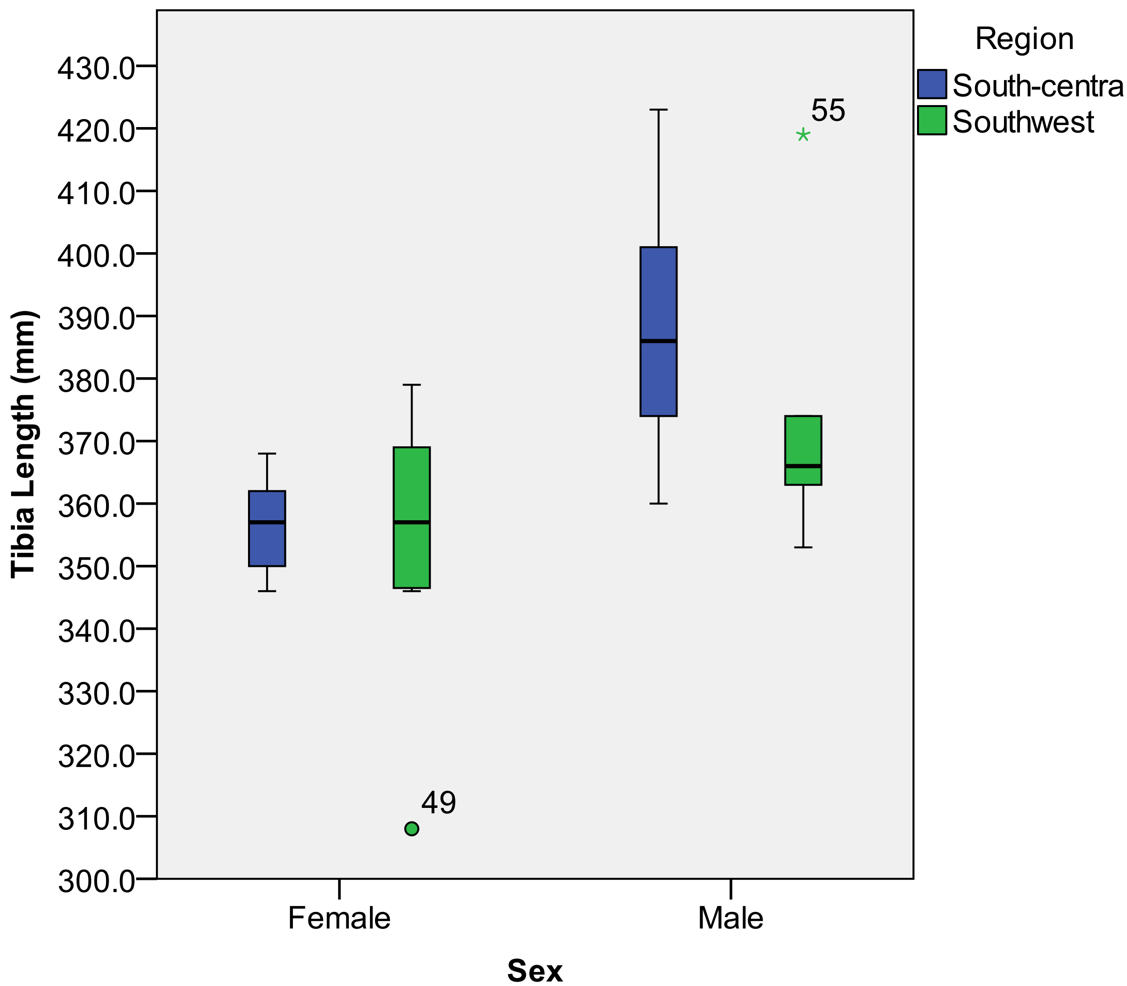


Table 25 Tibia length (mm) by sex and region

Region / Sex	Mean	Standard Deviation	Number (*n*)	Min.	Max.
SC Males	387.3	19.3	10	360.0	423.0
SW Males	375.0	25.7	5	353.0	419.0
SC Females	356.4	8.2	7	346.0	368.0
SW Females	354.0	21.9	8	308.0	379.0

Figure 15 Boxplot of tibia length (mm) by sex for each region



Intraregional and Interregional Variation: Results of Hypothesis Testing

As previously stated in Chapter 4, biological status in this study was evaluated by analyzing the frequencies of LEH, PH, periosteal reactions, and fractures at the individual level by sex within and between the SW and SC regions. The mean values of each of the four postcranial long bone measurements were compared by sex within and between regions. Each different variable of the biological status markers were employed to test the different research hypotheses. Similarly, each of the four different long bone measurements was used to test the different research hypotheses.

Each different biological status marker was used to test each hypothesis, because previous researchers (e.g. Robb et al., 2001) have noted that different regions of the world may have different skeletal variables that are more revealing for skeletal health status in that specific region. Furthermore, as discussed in Chapter 3, different biological status markers affect the skeleton at different stages of life. For example, LEHs affect the growth and development of the crowns of adult teeth between birth and seven years of age, and PH typically affects individuals under the age of fifteen. Conversely, an individual could suffer from antemortem skeletal trauma or a periosteal reaction on a long bone at any time during one’s life. All references in the research questions to regions of Ohio with increased male or female access to leadership are based on the hypotheses derived from mortuary analysis data and proposed by Field et al. (2005).

Binary Scored Markers of Biological Status

In the following section, each research question is restated. The statistical tests of each binary scored (absence or presence) marker of biological status are then summarized. The statistical tests of binary-scored data were conducted using Pearson chi-square analysis or the Fisher Exact probability test, when expected cell counts were less than five. All binary-scored data analysis was completed using IBM SPSS Statistics version 19 and the VassarStats website for Statistical Computation, Clinical Research Calculator 3 (http://faculty.vassar.edu/lowry/VassarStats.html). Statistical significance was set at the $p <$ 0.05 level, and $p < 0.10$ for near statistical significance. All significance tests were two-tailed. A statistically significant test allows the null hypothesis to be rejected, while a nonsignificant test results in the alternate hypothesis being rejected.

Below are the general research hypotheses that were tested for each binary scored (absence or presence) marker of biological status. The specific research hypotheses for each question are listed at the end of Chapter 4.

H0: There is no statistically significant association in the frequency of each biological status marker (LEH, PH, periosteal reaction, long bone trauma, or cranial trauma) between the two groups.

H1: There is a statistically significant association in the frequency of each biological status marker (LEH, PH, periosteal reaction, long bone trauma, or cranial trauma) between the two groups.

Intraregional Variation of Biological Status

Question 1A: SW Females vs. SW Males

In the SW region, it has been proposed that females have increased access to leadership and prestige. As a result, does biological status differ between males and females in the SW region?

Results of Hypothesis Testing for Question 1A

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between males and females in the SW region. The results of each significance test are summarized in Table 26.

Therefore, the alternate hypothesis for each biological status variable is rejected.

Table 26 Summary of significance tests of biological status variables[1] for Question 1A

Biological Status Variable	SW Females Ab (*n*)	SW Females Pr (*n*)	SW Females *Pr (%)*	SW Males Ab (*n*)	SW Males Pr (*n*)	SW Males *Pr (%)*	χ^{2*}	df	Two-tail *P*-value	*P* <0.05 Yes/No
LEH	6	8	*57.1*	11	7	*38.9*	1.05	1	0.31	No
LEH #9	4	2	*33.3*	4	1	*20*		1	1.0	No
LEH #10	6	1	*14.3*	5	0	*0*		1	1.0	No
LEH #11	9	1	*10*	9	2	*18.2*		1	1.0	No
LEH #22	11	2	*15.4*	10	3	*23.1*		1	1.0	No
LEH #23	10	2	*16.7*	8	2	*20*		1	1.0	No
LEH #24	9	0	*0*	6	0	*0*		1	1.0	No
PH	8	12	*60*	10	6	*37.5*	1.8	1	0.18	No
LB PSRXN	10	3	*23.1*	8	1	*1.6*		1	1.0	No
Tib PSRXN	9	1	*10*	8	0	*11.1*		1	1.0	No
Fib PSRXN	4	1	*20*	3	0	*0*		1	1.0	No
LB FX	12	1	*7.7*	9	0	*0*		1	1.0	No
CV FX	16	1	*5.9*	19	1	*5*		1	1.0	No
FX	18	2	*10*	20	1	*4.8*		1	0.61	No

*If Chi-square (χ^2) column is empty, it means that Fisher Exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

[1]Key: LEH = LEH in anterior maxillary and mandibular teeth
LEH #9 = LEH in maxillary central incisors (tooth #9) using substitution method
LEH #10 = LEH in maxillary lateral incisors (tooth #10) using substitution method
LEH #11 = LEH in maxillary canines (tooth #11) using substitution method
LEH #22 = LEH in mandibular canines (tooth #22) using substitution method
LEH #23 = LEH in mandibular lateral incisors (tooth #23) using substitution method
LEH #24 = LEH in mandibular central incisors (tooth #24) using substitution method
PH = porotic hyperostosis
LB PSRXN = periosteal reaction in any long bone
Tib PSRXN – tibial periosteal reaction
Fib PSRXN – fibular periosteal reaction
LB FX = antemortem fracture in any long bone
CV FX = antemortem fracture in calvaria
FX = antemortem fracture in long bone or calvaria

Question 1B: SC Females vs. SC Males

In the SC region, it has been proposed that males have increased access to leadership and prestige. As a result, does biological status differ between males and females in the SC region?

Results of Hypothesis Testing for Question 1B

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between females and males in the SC region. The results of each significance test are summarized in Table 27.

Therefore, the alternate hypothesis for each biological status variable is rejected.

The frequency of LEH in mandibular canines (LEH #22) is higher in SC females. This was detected by using the substitution method for LEH in mandibular canines (tooth #22). Fifteen percent (3 of 20) of females exhibit a LEH in this tooth, while 0% (0 of 22) of SC males has a LEH. The difference in the frequency of LEH in mandibular canines between SC females and males is near statistically significant (*p* = 0.10, see Table 27).

Table 27 Summary of significance tests of biological status variables for Question 1B

	SC Females			SC Males						
Biological Status Variable	**Ab (*n*)**	**Pr (*n*)**	***Pr* (%)**	**Ab (*n*)**	**Pr (*n*)**	***Pr* (%)**	**χ^{2*}**	**df**	**Two-tail *P*-value**	***P* < 0.05 Yes / No**
LEH	20	8	*28.6*	22	4	*15.4*	1.36	1	0.24	No
LEH #9	17	3	*15.0*	13	0	*0*		1	0.26	No
LEH #10	20	1	*4.8*	14	0	*0*		1	1.0	No
LEH #11	22	3	*12.0*	17	3	*15.0*		1	1.0	No
LEH #22	17	3	*15.0*	22	0	*0*		1	0.10	No
LEH #23	17	2	*10.5*	17	0	*0*		1	0.49	No
LEH #24	11	0	*0*	12	0	*0*		1	1.0	No
PH	19	22	*53.7*	20	14	*41.2*	1.16	1	0.28	No
LB PSRXN	17	4	*19.0*	19	3	*13.6*		1	0.70	No
Tib PSRXN	13	1	*7.1*	14	2	*12.5*		1	1.0	No
Fib PSRXN	11	2	*15.4*	16	1	*5.9*		1	0.56	No
LB FX	21	0	*0*	21	0	*0*		1	1.0	No
CV FX	34	5	*12.8*	28	5	*15.2*		1	1.0	No
FX	39	5	*11.4*	33	5	*13.2*		1	1.0	No

*If Chi-square (χ^2) column is empty, it means that Fisher Exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Question 2: SW Females vs. SC Females

Do interregional differences between the biological statuses of females associate with the interregional differences of hypothesized female leadership and prestige?

In the SW region, it has been proposed that females have increased access to leadership and prestige. As a result, does the biological status of SW and SC females differ?

<u>Results of Hypothesis Testing for Question 2</u>

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between females in the SC region and females in the SW region.

Therefore, the alternate hypothesis for each biological status variable is rejected.

The results of each significance test are summarized in Table 28. The frequency of LEH in maxillary and mandibular anterior teeth is higher in SW females than in SC females, as 57.1% (8 of 14) SW females exhibit a LEH, while 28.6% (8 of 28) of SC females have a LEH. This difference is near statistically significant (p = 0.07, see Table 28).

Table 28 Summary of significance tests of biological status variables for Question 2

Biological Status Variable	SC Females Ab (*n*)	SC Females Pr (*n*)	SC Females *Pr* (*%*)	SW Females Ab (*n*)	SW Females Pr (*n*)	SW Females *Pr* (*%*)	χ^{2*}	df	Two-tail *P*-value	*P* < 0.05 Yes / No
LEH	20	8	*28.6*	6	8	*57.1*	3.23	1	0.07	No
LEH #9	17	3	*15.0*	4	2	*33.3*		1	0.56	No
LEH #10	20	1	*4.8*	6	1	*14.3*		1	0.44	No
LEH #11	22	3	*12.0*	9	1	*10*		1	1.0	No
LEH #22	17	3	*15.0*	11	2	*15.4*		1	1.0	No
LEH #23	17	2	*10.5*	10	2	*16.7*		1	0.63	No
LEH #24	11	0	*0*	9	0	*0*		1	1.0	No
PH	19	22	*53.7*	8	12	*60*	0.22	1	0.64	No
LB PSRXN	17	4	*19.0*	10	3	*23.1*		1	1.0	No
Tib PSRXN	13	1	*7.1*	9	1	*10*		1	1.0	No
Fib PSRXN	11	2	*15.4*	4	1	*20*		1	1.0	No
LB FX	21	0	*0*	12	1	*7.7*		1	0.38	No
CV FX	34	5	*12.8*	16	1	*5.9*		1	0.66	No
FX	39	5	*11.4*	18	2	*10*		1	1.0	No

*If Chi-square (χ^2) column is empty, it means that Fisher Exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Question 3: SC Males vs. SW Males

Do interregional differences between the biological statuses of males associate with the hypothesized interregional differences of male leadership and prestige?

In the SC region, it has been proposed that males have increased access to leadership and prestige. As a result, does the biological status of SC and SW males differ?

Results of Hypothesis Testing for Question 3

A statistically significant association between the frequency of LEH in mandibular canines (LEH #22) exists between SC males and SW males ($p = 0.044$, see Table 29). In the SW region, 23.1% (3 of 13) of males have a LEH present in mandibular canines, while 0% ($n = 22$) of SC males have a LEH in the same tooth. For each other different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between males in the SC region and males in the SW region. The results of each significance test are summarized in Table 29.

Therefore, the null hypothesis for the frequency of LEH in mandibular canines is rejected.

The alternate hypothesis for each of the other biological status variables is rejected.

Table 29 Summary of significance tests of biological status variables for Question 3

Biological Status Variable	**SC Males** Ab (*n*)	Pr (*n*)	*Pr (%)*	**SW Males** Ab (*n*)	Pr (*n*)	*Pr (%)*	χ^{2*}	**df**	**Two-tail *P*-value**	***P* < 0.05 Yes / No**
LEH	22	4	*15.4*	11	7	*38.9*		1	0.15	No
LEH #9	13	0	*0*	4	1	*20*		1	0.28	No
LEH #10	14	0	*0*	5	0	*0*		1	1.0	No
LEH #11	17	3	*15.0*	9	2	*18.2*		1	1.0	No
LEH #22	22	0	*0*	10	3	*23.1*		1	0.044*	**YES**
LEH #23	17	0	*0*	8	2	*20*		1	0.13	No
LEH #24	12	0	*0*	6	0	*0*		1	1.0	No
PH	20	14	*41.2*	10	6	*37.5*	0.06	1	0.81	No
LB PSRXN	19	3	*13.6*	8	1	*1.6*		1	1.0	No
Tib PSRXN	14	2	*12.5*	8	0	*11.1*		1	0.54	No
Fib PSRXN	16	1	*5.9*	3	0	*0*		1	1.0	No
LB FX	21	0	*0*	9	0	*0*		1	1.0	No
CV FX	28	5	*15.2*	19	1	*5*		1	0.39	No
FX	33	5	*13.2*	20	1	*4.8*		1	0.41	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Long Bone Measurements

To address the research questions that involve long bone measurements (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length), two-way analysis of variance was used to the study the effect of two independent variables, sex and region, and their interaction on each of the four long bone measurements which are the dependent variables. The two-way ANOVA analysis compared the mean long bone measurement values between the four groups that are formed by the two independent variables. The four groups are: SC females, SC males, SW females, and SW males. Data analysis was completed using IBM SPSS Statistics version 19. Statistical significance was set at the $p < 0.05$ level. A statistically significant test allows the null hypothesis to be rejected, while a nonsignificant test results in the alternate hypothesis being rejected.

Below are the general research hypotheses that were used for this analysis. The specific research hypotheses are listed at the end of Chapter 4.

H0: There is no statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between the two groups.

H1: There is a statistically significant difference in the mean value of each long bone measurement (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) between the two groups.

There are two important assumptions required for two-way ANOVA tests. First, the dependant variable (each of the four long bone measurements) needs to be normally distributed when split into the four groups. Each of the four different long bone measurements (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, maximum length of the femur, or tibia length) is distributed normally when tested using the Shapiro-Wilk test for normality ($p > 0.05$; see Tables 66 – 69 in Appendix for normality statistics). The second assumption is homogeneity of variances between the groups formed by the independent variables. Analysis in this study used the Shapiro-Wilk test for normality and Levene's test for homogeneity of variances. Three measurements (maximum diameter of the head of the humerus, maximum diameter of the head of the femur, and tibia length) do have homogeneity of variances (Levene's test $p > 0.05$; see Tables 71. 73, 75, and 76 in Appendix). The maximum length of the femur measurement violates the homogeneity of variances assumption ($p = 0.03$, Table 21 in Appendix). This means that the variance across groups is significantly unequal [$F = 3.8$, df (3, 37), $p = 0.02$] (see Table 7 6 in Appendix). Thus, for purposes of analysis, the maximum length of the femur was analyzed by one-way ANOVA and the results are discussed later in this chapter.

A two-way ANOVA was conducted to examine the effect of sex and region on each of these long bone measurements as the dependent variables: maximum diameter of the head of the humerus, maximum diameter of the head of the femur, and tibia length. There is not a statistically significant interaction between the effects of sex and region on any of these three long bone measurements, nor is there a statistically significant difference based on region. However, for each of these three measurements there is a statistically significant difference based on sex (see Table 30 for summary test data and Tables 70, 72, and 74 in Appendix for complete ANOVA statistics). For these three measurements, the mean value for males is greater than for females. See Tables 22 – 25 and the boxplots in Figures 12 – 15 for the descriptive statistics for each of the four measurements divided by sex and by region.

Table 30 Two-way ANOVA showing the effect of sex and region on each long bone measurement

Measurement	Two-way ANOVA Factor	*F* statistic	df	*P*-value	Significant? *P* < 0.05
Humerus MDH	Sex	14.94	1	0.001*	YES
	Region	1.48	1	0.24	No
	Region*Sex	0.37	1	0.55	No
Femur MDH	Sex	41.56	1	0.000*	YES
	Region	0.04	1	0.84	No
	Region*Sex	1.15	1	0.29	No
Tibia Length	Sex	12.65	1	0.001*	YES
	Region	1.02	1	0.32	No
	Region*Sex	0.46	1	0.50	No

Since there is not homogeneity of variances for the maximum length of the femur measurement when split into the four groups by region and sex, this variable could not be analyzed using two-way ANOVA. To answer Question 1A which compares SW males to SW females and Question 1B which compares SC males to SC females, a one-way ANOVA with sex as the independent variable was conducted. In the SW region, there is homogeneity of variances (Levene's test $p = 0.37$; see Table 78 in Appendix). The one-way ANOVA analysis determined there is a statistically significant difference between SW male and female maximum femur length [$F = 6.23$, df (1, 14), $p = 0.03$] (see Table 77 in Appendix for complete ANOVA statistics). In the SC region, there is not homogeneity of variances (Levene's test $p = 0.003$; see Table 80 in Appendix). When the assumption of homogeneity of error variances is violated in one-way ANOVA analysis, Welch's test of equality of means can be employed when variances are unequal. Utilizing the Welch test, there is a statistically significant difference between SC male and female maximum femur length [$F = 18.63$, df (1, 18.85), $P = 0.000$] (see Table 81 in Appendix for complete ANOVA statistics). For this measurement, the mean value for males is greater than for females. See Table 24 and the boxplot in Figure 14 for the descriptive statistics for maximum femur length divided by sex and by region.

In order to analyze maximum femur length in Question 2 which compares SW females to SC females, and Question 3 which compares SW males to SC males, a one-way ANOVA with region as the independent variable was conducted. For maximum femur length there is homogeneity of variances in both regions for females (Levene's test $p = 0.13$) and for males (Levene's test $p = 0.65$; see Tables 83 and 85 in Appendix). There is not a statistically significant difference for maximum femur length between SW and SC females [$F = 1.17$, df (1, 19), $p = 0.29$] (see Table 82 in Appendix for complete ANOVA statistics). There is also not a statistically significant difference for femur maximum length between SW and SC males [$F = 1.27$, df (1, 18), $p = 0.28$] (see Table 84 in Appendix for complete ANOVA statistics).

Question 1A: SW Females vs. SW Males

The null hypothesis is rejected for each one of the four different long bone measurements.

For each of the four long bone measurements, the mean value of males is larger than in females, and this is statistically significant at the p-level less than 0.05.

Question 1B: SC Females vs. SC Males

The null hypothesis is rejected for each one of the four different long bone measurements.

For each of the four long bone measurements, the mean value of males is larger than in females, and this is statistically significant at the p-level less than 0.05.

Question 2: SW Females vs. SC Females

The alternate hypothesis is rejected for each one of the four different long bone measurements.

Question 3: SC Males vs. SW Males

The alternate hypothesis is rejected for each one of the four different long bone measurements.

Biological Status Between and Within Prestigious SC Mounds: Results of Hypothesis Testing

Binary Scored Markers of Biological Status

Question 4: Hopewell Mounds vs. Other SC Mounds

There are several key architectural and mortuary features which makes the Hopewell Mound Group unique when compared to other nearby SC sites. Is the biological status of adults buried at Hopewell Mounds different than the biological status of adults buried at Seip, Harness, Ater, and Rockhold Mounds?

The adults used in the analysis to address this question are a sub-sample of the SC sample. The Hopewell Mounds sample is composed of adults buried at any of the Hopewell Mounds, and includes adults without provenience to a specific mound at the Hopewell site. The other SC sample is composed of adults buried at either of the Seip Mounds, Harness Mound, Ater Mound, and Rockhold Mound. The distribution of these two samples by sex is displayed in Table 31. Question 4A compares all adults, 4B compares males, and 4C compares females.

Table 31 Sex distribution of adults analyzed in Question 4

Location	Female *n*	Male *n*	Undetermined *n*	Total *n*
Hopewell Mounds	40	30	7	77
Seip, Harness, Ater, and Rockhold Mounds	6	8	0	14
Total	**46**	**38**	**7**	**91**

Results of Hypothesis Testing for Question 4A

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between adults from the Hopewell Mounds and adults from Seip, Harness, Ater, and Rockhold. The results of each significance test are summarized in Table 32.

Therefore, the alternate hypothesis for each biological status variable is rejected.

Table 32 Summary of significance tests of biological status variables for Question 4A

Biological Status Variable	HW MD Adults Ab (*n*)	Pr (*n*)	*Pr (%)*	Other SC Adults Ab (*n*)	Pr (*n*)	*Pr (%)*	χ^{2*}	df	Two-tail *P*-value	*P* < 0.05 Yes / No
LEH	34	13	*27.7*	8	2	*20.0*		1	1.0	No
LEH #9	23	2	*8.0*	7	1	*12.5*		1	1.0	No
LEH #10	26	1	*3.7*	8	0	*0*		1	1.0	No
LEH #11	32	5	*13.5*	8	1	*11.1*		1	1.0	No
LEH #22	32	3	*8.6*	8	1	*11.1*		1	1.0	No
LEH #23	29	1	*3.3*	7	1	*12.5*		1	0.38	No
LEH #24	17	0	*0*	8	0	*0*		1	1.0	No
PH	33	31	*48.4*	7	5	*41.7*	0.186	1	0.67	No
LB PSRXN	31	7	*18.4*	6	2	*25.0*		1	0.65	No
Tib PSRXN	19	6	*24.0*	8	0	*0*		1	0.30	No
Fib PSRXN	23	2	*8.0*	6	2	*25.0*		1	0.24	No
LB FX	36	1	*2.7*	8	0	*0*		1	1.0	No
CV FX	55	8	*12.7*	9	2	*18.2*		1	0.64	No
FX	66	9	*12.0*	12	2	*14.3*		1	1.0	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Results of Hypothesis Testing for Question 4B

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between males from the Hopewell Mounds and males from Seip, Harness, Ater, and Rockhold. The results of each significance test are summarized in Table 33.

Therefore, the alternate hypothesis for each biological status variable is rejected.

Table 33 Summary of significance tests of biological status variables for Question 4B

Biological Status Variable	HW MD Males Ab (*n*)	HW MD Males Pr (*n*)	HW MD Males *Pr* (*%*)	Other SC Males Ab (*n*)	Other SC Males Pr (*n*)	Other SC Males *Pr* (*%*)	χ^{2*}	df	Two-tail *P*-value	*P* < 0.05 Yes / No
LEH	17	4	*19.0*	5	0	*0*		1	0.56	No
LEH #9	10	0	*0*	3	0	*0*		1	1.0	No
LEH #10	11	0	*0*	3	0	*0*		1	1.0	No
LEH #11	13	3	*18.8*	4	0	*0*		1	0.58	No
LEH #22	18	0	*0*	4	0	*0*		1	1.0	No
LEH #23	13	0	*0*	4	0	*0*		1	1.0	No
LEH #24	8	0	*0*	4	0	*0*		1	1.0	No
PH	16	11	*40.7*	4	3	*42.9*		1	1.0	No
LB PSRXN	16	3	*15.8*	3	0	*0*		1	1.0	No
Tib PSRXN	10	3	*23.1*	3	0	*0*		1	1.0	No
Fib PSRXN	13	1	*7.1*	3	0	*0*		1	1.0	No
LB FX	18	0	*0*	3	0	*0*		1	1.0	No
CV FX	23	3	*11.5*	5	2	*28.6*		1	0.56	No
FX	27	3	*10.0*	6	2	*25.0*		1	0.56	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Results of Hypothesis Testing for Question 4C

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between females from the Hopewell Mounds and females from Seip, Harness, Ater, and Rockhold. The results of each significance test are summarized in Table 34.

Therefore, the alternate hypothesis for each biological status variable is rejected.

Table 34 Summary of significance tests of biological status variables for Question 4C

Biological Status Variable	HW MD Females Ab (*n*)	Pr (*n*)	*Pr* (%)	Other SC Females Ab (*n*)	Pr (*n*)	*Pr* (%)	χ^{2*}	df	Two-tail *P*-value	*P* < 0.05 Yes / No
LEH	17	6	*26.1*	3	2	*40.0*		1	0.56	No
LEH #9	13	2	*13.3*	4	1	*20.0*		1	1.0	No
LEH #10	15	1	*6.2*	5	0	*0*		1	1.0	No
LEH #11	18	2	*10.0*	4	1	*20.0*		1	1.0	No
LEH #22	13	2	*13.3*	4	1	*20.0*		1	1.0	No
LEH #23	14	1	*6.7*	3	1	*25.0*		1	0.39	No
LEH #24	7	0	*0*	4	0	*0*		1	1.0	No
PH	16	20	*55.6*	3	2	*40.0*		1	0.65	No
LB PSRXN	14	2	*12.5*	3	2	*40.0*		1	1.0	No
Tib PSRXN	8	1	*11.1*	5	0	*0*		1	1.0	No
Fib PSRXN	8	0	*0*	3	2	*40.0*		1	0.13	No
LB FX	16	0	*0*	5	0	*0*		1	1.0	No
CV FX	30	5	*14.3*	4	0	*0*		1	1.0	No
FX	33	5	*13.2*	6	0	*0*		1	0.59	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Question 5: Hopewell Mounds 23 & 25 vs. Other Hopewell Mounds

Within the Hopewell Mound Group, Mounds 23 and 25 stand out from the other mounds with burials because of their similar size and shape, large burial populations, and shared mortuary features. Is the biological status of adults buried at Hopewell Mounds 23 and 25 different than the biological status of adults buried with provenience at the other Hopewell Mounds?

The adults used in the analysis to address this research question are a sub-sample of the SC sample. The Hopewell Mounds 23 and 25 sample is composed of adults buried at either of these mounds. The other Hopewell Mounds sample is composed of adults with provenience to a specific mound at the Hopewell site other than Mounds 23 or 25, and includes adults from Mounds 2, 4, 7, 18, 24, 26, and 27. These adults have provenience to a specific mound, but they do not necessarily have provenience to a specific burial number at their mound. The distribution of these two samples grouped by sex is displayed in Table 35. Question 5A compares all adults, 5B compares males, and 5C compares females.

Table 35 Sex distribution of adults analyzed in Question 5

Location	**Female** ***n***	**Male** ***n***	**Undetermined** ***n***	**Total** ***n***
Hopewell Mounds 23 & 25	22	16	3	41
Other Hopewell Mounds	7	9	3	19
Total	**29**	**25**	**6**	**60**

Results of Hypothesis Testing for Question 5A

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between adults from Hopewell Mounds 23 and 25 and adults with provenience from other Hopewell Mounds. The results of each significance test are summarized in Table 36.

Therefore, the alternate hypothesis for each biological status variable is rejected.

Table 36 Summary of significance tests of biological status variables for Question 5A

Biological Status Variable	**HW MD 23 & 25 Adults** **Ab (*n*)**	**Pr (*n*)**	***Pr* (%)**	**Other HW MD Adults** **Ab (*n*)**	**Pr (*n*)**	***Pr* (%)**	χ^{2*}	**df**	**Two-tail *P*-value**	***P* < 0.05 Yes / No**
LEH	22	6	*21.4*	9	6	*40.0*		1	0.29	No
LEH #9	15	0	*0*	6	2	*25.0*		1	0.11	No
LEH #10	18	0	*0*	7	1	*12.5*		1	0.31	No
LEH #11	20	2	*9.1*	9	2	*18.2*		1	0.59	No
LEH #22	21	2	*8.7*	9	1	*10.0*		1	1.0	No
LEH #23	18	1	*5.3*	10	0	*0*		1	1.0	No
LEH #24	10	0	*0*	7	0	*0*		1	1.0	No
PH	19	15	*44.1*	9	6	*40.0*		1	1.0	No
LB PSRXN	20	2	*9.1*	10	3	*23.1*		1	0.34	No
Tib PSRXN	13	2	*13.3*	6	3	*33.3*		1	0.33	No
Fib PSRXN	12	2	*14.3*	9	0	*0*		1	0.50	No
LB FX	22	0	*0*	12	1	*7.7*		1	0.37	No
CV FX	31	3	*8.8*	14	1	*6.7*		1	1.0	No
FX	38	3	*7.3*	16	2	*11.1*		1	1.0	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Results of Hypothesis Testing for Question 5B

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between males from Hopewell Mounds 23 and 25 and males with provenience from other Hopewell Mounds. The results of each significance test are summarized in Table 37.

Therefore, the alternate hypothesis for each biological status variable is rejected.

Table 37 Summary of significance tests of biological status variables for Question 5B

Biological Status Variable	HW MD 23 & 25 Males Ab (*n*)	Pr (*n*)	*Pr (%)*	Other HW MD Males Ab (*n*)	Pr (*n*)	*Pr (%)*	χ^{2*}	df	Two-tail *P*-value	*P* < 0.05 Yes / No
LEH	10	2	*16.7*	6	2	*25.0*		1	1.0	No
LEH #9	6	0	*0*	4	0	*0*		1	1.0	No
LEH #10	7	0	*0*	4	0	*0*		1	1.0	No
LEH #11	8	1	*11.1*	4	2	*33.3*		1	0.53	No
LEH #22	11	0	*0*	7	0	*0*		1	1.0	No
LEH #23	7	0	*0*	6	0	*0*		1	1.0	No
LEH #24	4	0	*0*	4	0	*0*		1	1.0	No
PH	9	5	*35.7*	6	2	*25.0*		1	0.67	No
LB PSRXN	9	1	*10.0*	6	2	*25.0*		1	0.56	No
Tib PSRXN	6	1	*14.3*	4	2	*33.3*		1	0.56	No
Fib PSRXN	6	1	*14.3*	7	0	*0*		1	1.0	No
LB FX	10	0	*0*	8	0	*0*		1	1.0	No
CV FX	13	1	*7.1*	6	1	*14.3*		1	1.0	No
FX	15	1	*6.3*	8	1	*11.1*		1	1.0	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Results of Hypothesis Testing for Question 5C

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between females from Hopewell Mounds 23 and 25 and females with provenience from other Hopewell Mounds. The results of each significance test are summarized in Table 38.

Therefore, the alternate hypothesis for each biological status variable is rejected.

The frequency of LEH in maxillary central incisors (LEH #9) is higher in other Hopewell Mound females than in females from Hopewell Mounds 23 and 25. At the other Hopewell

Mounds, 50.0% (2 of 4) of females exhibit a LEH in maxillary central incisors, while 0% (0 of 9) of females from Hopewell Mounds 23 and 25 have a LEH on the same tooth (see Table 38). This difference is near statistically significant ($p = 0.08$).

Table 38 Summary of significance tests of biological status variables for Question 5C

Biological Status Variable	HW MD 23 &25 Females Ab (*n*)	Pr (*n*)	*Pr (%)*	Other HW MD Females Ab (*n*)	Pr (*n*)	*Pr (%)*	χ^{2*}	df	Two-tail *P*-value	*P* < 0.05 Yes / No
LEH	12	3	*20.0*	3	2	*40.0*		1	0.56	No
LEH #9	9	0	*0*	2	2	*50.0*		1	0.08	No
LEH #10	11	0	*0*	3	1	*25.0*		1	0.27	No
LEH #11	12	1	*7.7*	4	0	*0*		1	1.0	No
LEH #22	9	2	*18.2*	2	0	*0*		1	1.0	No
LEH #23	10	1	*9.1*	3	0	*0*		1	1.0	No
LEH #24	5	0	*0*	2	0	*0*		1	1.0	No
PH	9	10	*52.6*	3	4	*57.1*		1	1.0	No
LB PSRXN	11	0	*0*	3	1	*25.0*		1	0.27	No
Tib PSRXN	7	0	*0*	1	1	*50.0*		1	0.22	No
Fib PSRXN	6	0	*0*	1	0	*0*		1	1.0	No
LB FX	11	0	*0*	4	0	*0*		1	1.0	No
CV FX	17	2	*10.5*	7	0	*0*		1	1.0	No
FX	20	2	*9.1*	6	0	*0*		1	1.0	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Question 6: Hopewell Mound 25 vs. Hopewell Mound 23

Hopewell Mound 25 burials have more prestigious and numerous grave goods and evidence of more elaborate mortuary rituals than burials at Mound 23. Is the biological status of adults buried at Hopewell Mound 25 different than the biological status of adults buried at Hopewell Mound 23?

The adults used in the analysis to address this research question are a sub-sample of the SC sample. The Hopewell Mound 25 sample is composed of adults buried at this mound, and the Mound 23 sample is composed of adults buried at Mound 23. These adults have provenience to a specific mound, but they do not necessarily have provenience to a specific burial number at their mound. The distribution of these two samples by sex is displayed in Table 39. Question 6A compares all adults, 6B compares males, and 6C compares females.

Table 39 Sex distribution of adults analyzed in Question 6

Location	**Female *n***	**Male *n***	**Undetermined *n***	**Total *n***
Hopewell Mound 25	15	14	2	31
Hopewell Mound 23	7	2	1	10
Total	**22**	**16**	**3**	**41**

Results of Hypothesis Testing for Question 6A

A statistically significant association ($p = 0.02$) in the frequency of LEH in mandibular canines (LEH #22) exists between Mound 25 adults and Mound 23 adults. At Mound 23, 50% (2 of 4) of adults have a LEH present in mandibular canines, while 0% ($n = 19$) of Mound 25 adults have a LEH (see Table 40).

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between adults from Mound 25 and adults from Mound 23. The results of each significance test are summarized in Table 40.

Therefore, the null hypothesis for the frequency of LEH in mandibular canines (LEH #22) is rejected.

The alternate hypothesis for each of the other biological status variables is rejected.

Table 40 Summary of significance tests of biological status variables for Question 6A

Biological Status Variable	HW MD 25 Adults Ab (*n*)	Pr (*n*)	*Pr* (%)	HW MD 23 Adults Ab (*n*)	Pr (*n*)	*Pr* (%)	χ^{2*}	df	Two-tail *P*-value	*P* <0.05 Yes/ No
LEH	18	3	*14.3*	4	3	*42.9*		1	0.29	No
LEH #9	13	0	*0*	2	0	*0*		1	1.0	No
LEH #10	15	0	*0*	3	0	*0*		1	1.0	No
LEH #11	17	2	*10.5*	3	0	*0*		1	1.0	No
LEH #22	19	0	*0*	2	2	*50*		1	0.02	**YES**
LEH #23	14	0	*0*	4	1	*20*		1	0.26	No
LEH #24	9	0	*0*	1	0	*0*		1	1.0	No
PH	15	11	*42.3*	4	4	*50*		1	1.0	No
LB PSRXN	17	2	*10.5*	3	0	*0*		1	1.0	No
Tib PSRXN	11	2	*15.4*	2	0	*0*		1	1.0	No
Fib PSRXN	11	2	*15.4*	1	0	*0*		1	1.0	No
LB FX	19	0	*0*	3	0	*0*		1	1.0	No
CV FX	23	3	*11.5*	8	0	*0*		1	0.57	No
FX	28	3	*9.7*	10	0	*0*		1	0.56	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Results of Hypothesis Testing for Question 6B

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between males from Mound 25 and males from Mound 23. The results of each significance test are summarized in Table 41.

Therefore, the alternate hypothesis for each of the biological status variables is rejected.

Table 41 Summary of significance tests of biological status variables for Question 6B

Biological Status Variable	HW MD 25 Males Ab (*n*)	Pr (*n*)	*Pr (%)*	HW MD 23 Males Ab (*n*)	Pr (*n*)	*Pr (%)*	χ^{2*}	df	Two-tail *P*-value	*P* < 0.05 Yes / No
LEH	9	2	*18.2*	1	0	*0*		1	1.0	No
LEH #9	5	0	*0*	1	0	*0*		1	1.0	No
LEH #10	6	0	*0*	1	0	*0*		1	1.0	No
LEH #11	8	1	*11.1*	0	0					
LEH #22	10	0	*0*	1	0	*0*		1	1.0	No
LEH #23	6	0	*0*	1	0	*0*		1	1.0	No
LEH #24	4	0	*0*	0	0					
PH	8	4	*33.3*	1	1	*50.0*		1	1.0	No
LB PSRXN	9	1	*10.0*	0	0					
Tib PSRXN	6	1	*14.3*	0	0					
Fib PSRXN	6	1	*14.3*	0	0					
LB FX	10	0	*0*	0	0					
CV FX	11	1	*8.3*	2	0	*0*		1	1.0	No
FX	13	1	*7.1*	2	0	*0*		1	1.0	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Results of Hypothesis Testing for Question 6C

A statistically significant association ($p = 0.02$) in the frequency of LEH in mandibular canines (LEH #22) exists between Mound 25 females and Mound 23 females. At Mound 23, 100% (2 of 2) of adults have a LEH present in mandibular canines, while 0% ($n = 9$) of Mound 25 adults have a LEH on the same tooth (see Table 42).

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between females from Mound 25 and females from Mound 23. The results of each significance test are summarized in Table 42.

Therefore, the null hypothesis for the frequency of LEH in mandibular canines (LEH #22) is rejected.

The alternate hypothesis for each of the other biological status variables is rejected.

Table 42 Summary of significance tests of biological status variables for Question 6C

	HW MD 25 Females			HW MD 23 Females						
Biological Status Variable	**Ab (*n*)**	**Pr (*n*)**	***Pr* (%)**	**Ab (*n*)**	**Pr (*n*)**	***Pr* (%)**	χ^{2*}	**df**	**Two-tail *P*-value**	***P* < 0.05 Yes / No**
LEH	9	1	*10.0*	3	2	*40.0*		1	0.51	No
LEH #9	8	0	*0*	1	0	*0*		1	1.0	No
LEH #10	9	0	*0*	2	0	*0*		1	1.0	No
LEH #11	9	1	*10.0*	3	0	*0*		1	1.0	No
LEH #22	9	0	*0*	0	2	*100*		1	0.02	**YES**
LEH #23	8	0	*0*	2	1	*33.3*		1	0.27	No
LEH #24	5	0	*0*	0	0					
PH	6	7	*53.8*	3	3	*50.0*		1	1.0	No
LB PSRXN	8	0	*0*	3	0	*0*		1	1.0	No
Tib PSRXN	5	0	*0*	2	0	*0*		1	1.0	No
Fib PSRXN	5	0	*0*	1	0	*0*		1	1.0	No
LB FX	8	0	*0*	3	0	*0*		1	1.0	No
CV FX	11	2	*15.4*	6	0	*0*		1	0.54	No
FX	13	2	*13.3*	7	0	*0*		1	0.55	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Question 7: Hopewell Mound 25 vs. Other Hopewell Mounds (including Mound 23)

Hopewell Mound 25 is unique when compared to the other mounds of the Hopewell Mound Group because of its large size, rich deposits of exotic artifacts, and the most elaborate mortuary rituals. Is the biological status of adults buried at Hopewell Mound 25 different than the biological status of adults buried with provenience at the other Hopewell Mounds?

The adults used in the analysis to address this research question are a sub-sample of the SC sample. The other Hopewell Mounds sample is composed of adults with provenience to a specific mound at the Hopewell site other than Mound 25 and includes adults from Mounds 2, 4, 7, 18, 23, 24, 26, and 27. These adults have provenience to a specific mound, but they do not necessarily have provenience to a specific burial number at their mound. The distribution of these two samples by sex is displayed in Table 43. Question 7A compares all adults, 7B compares males, and 7C compares females.

Table 43 Sex distribution of adults analyzed in Question 7

Location	**Female** ***n***	**Male** ***n***	**Undetermined** ***n***	**Total** ***n***
Hopewell Mound 25	15	14	2	31
Other Hopewell Mounds with provenience	14	11	2	29
Total	**29**	**25**	**4**	**60**

Results of Hypothesis Testing for Question 7A

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between adults from Mound 25 and adults from the other Hopewell Mounds. The results of each significance test are summarized in Table 44.

Therefore, the alternate hypothesis for each of the other biological status variables is rejected.

Table 44 Summary of significance tests of biological status variables for Question 7A

Biological Status Variable	HW MD 25 Adults Ab (*n*)	Pr (*n*)	*Pr (%)*	Other HW MD Adults Ab (*n*)	Pr (*n*)	*Pr (%)*	χ^{2*}	df	Two-tail *P*-value	*P* < 0.05 Yes / No
LEH	18	3	*14.3*	13	9	*40.9*	3.79	1	0.09	No
LEH #9	13	0	*0*	8	2	*20.0*		1	0.18	No
LEH #10	15	0	*0*	10	1	*9.1*		1	0.42	No
LEH #11	17	2	*10.5*	12	2	*14.3*		1	1.0	No
LEH #22	19	0	*0*	11	3	*21.4*		1	0.07	No
LEH #23	14	0	*0*	14	1	*6.7*		1	1.0	No
LEH #24	9	0	*0*	8	0	*0*		1	1.0	No
PH	15	11	*42.3*	13	10	*43.5*	0.01	1	0.92	No
LB PSRXN	17	2	*10.5*	13	3	*18.8*		1	0.64	No
Tib PSRXN	11	2	*15.4*	8	3	*27.3*		1	0.63	No
Fib PSRXN	11	2	*15.4*	10	0	*0*		1	0.49	No
LB FX	19	0	*0*	15	1	*6.3*		1	0.46	No
CV FX	23	3	*11.5*	22	1	*4.3*		1	0.61	No
FX	28	3	*9.7*	26	2	*7.1*		1	1.0	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Results of Hypothesis Testing for Question 7B

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between males from Mound 25 and males from the other Hopewell Mounds. The results of each significance test are summarized in Table 45.

Therefore, the alternate hypothesis for each of the other biological status variables is rejected.

Table 45 Summary of significance tests of biological status variables for Question 7B

Biological Status Variable	HW MD 25 Males Ab (*n*)	Pr (*n*)	*Pr (%)*	Other HW MD Males Ab (*n*)	Pr (*n*)	*Pr (%)*	χ^{2*}	df	Two-tail *P*-value	*P* <0.05 Yes/ No
LEH	9	2	*18.2*	7	2	*22.2*		1	1.0	No
LEH #9	5	0	*0*	5	0	*0*		1	1.0	No
LEH #10	6	0	*0*	5	0	*0*		1	1.0	No
LEH #11	8	1	*11.1*	4	2	*33.3*		1	0.53	No
LEH #22	10	0	*0*	8	0	*0*		1	1.0	No
LEH #23	6	0	*0*	7	0	*0*		1	1.0	No
LEH #24	4	0	*0*	4	0	*0*		1	1.0	No
PH	8	4	*33.3*	7	3	*30.0*		1	1.0	No
LB PSRXN	9	1	*10.0*	6	2	*25.0*		1	0.56	No
Tib PSRXN	6	1	*14.3*	4	2	*33.3*		1	0.56	No
Fib PSRXN	6	1	*14.3*	7	0	*0*		1	1.0	No
LB FX	10	0	*0*	8	0	*0*		1	1.0	No
CV FX	11	1	*8.3*	8	1	*11.1*		1	1.0	No
FX	13	1	*7.1*	10	1	*9.1*		1	1.0	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Results of Hypothesis Testing for Question 7C

For each different variable testing the biological status markers of LEH, PH, long bone periosteal reactions, long bone fractures, calvaria fractures, or any type of fracture there is no statistical difference in the frequencies of these markers between females from Mound 25 and females from the other Hopewell Mounds. The results of each significance test are summarized in Table 46.

Therefore, the alternate hypothesis for each of the other biological status variables is rejected.

Table 46 Summary of significance tests of biological status variables for Question 7C

Biological Status Variable	HW MD 25 Females Ab (*n*)	Pr (*n*)	*Pr* (*%*)	Other HW MD Females Ab (*n*)	Pr (*n*)	*Pr* (*%*)	χ^{2*}	df	Two-tail *P*-value	*P* < 0.05 Yes / No
LEH	9	1	*10.0*	6	4	*40.0*		1	0.30	No
LEH #9	8	0	*0*	3	2	*40.0*		1	0.13	No
LEH #10	9	0	*0*	5	1	*16.7*		1	0.40	No
LEH #11	9	1	*10.0*	7	0	*0*		1	1.0	No
LEH #22	9	0	*0*	2	2	*50.0*		1	0.08	No
LEH #23	8	0	*0*	5	1	*16.7*		1	0.43	No
LEH #24	5	0	*0*	2	0	*0*		1	1.0	No
PH	6	7	*53.8*	6	7	*53.8*		1	1.0	No
LB PSRXN	8	0	*0*	6	1	*14.3*		1	0.47	No
Tib PSRXN	5	0	*0*	3	1	*25.0*		1	0.44	No
Fib PSRXN	5	0	*0*	2	0	*0*		1	1.0	No
LB FX	8	0	*0*	7	0	*0*		1	1.0	No
CV FX	11	2	*15.4*	13	0	*0*		1	0.48	No
FX	13	2	*13.3*	13	0	*0*		1	0.48	No

*If Chi-square (χ^2) column is empty, it means that Fisher exact probability test was utilized because excepted cell counts were lower than 5 for any cell.

Long Bone Measurements

Question 4: Hopewell Mounds vs. Other SC Mounds

Based on biological status indicators, were the Hopewell Mounds a burial place for "special persons" (Carr, 2005c)? Is the biological status of adults buried at Hopewell Mounds different than the biological status of adults buried at Seip, Harness, Ater, and Rockhold Mounds?

This question cannot be addressed for part 4A which focuses on all adults as it was for biological status variables because the sex ratios for the two samples are unequal (see Table 5.36). The sample with the larger percentage of males will be biased because the mean value of each of the measurements is larger in males than in females. The independent variable for where an adult was buried is termed “burial location” for this research question, and refers to whether an adult was buried at one of the Hopewell Mounds, or at Seip, Harness, Ater, and Rockhold which are the other SC sites. Therefore, one-way analysis of variance with the data set split by sex so that males are compared to males and females to females was used to study the effect of burial location on mean values of long bone measurements. When these two groups were split by sex, all long bone measurements are distributed normally (Shapiro-Wilk test $p > 0.05$), except for maximum diameter of the head of the femur in females (see Tables 88 and 89 in Appendix for complete normality statistics). The three measurements that are normally distributed (maximum diameter of the head of the humerus, maximum length of the femur, or tibia length) allowed for these measurements to be analyzed by one-way ANOVA, because they also exhibit homogeneity of variances when split by sex (Levene’s test $p > 0.05$; see Tables 90 and 92 in Appendix for Levene’s test statistics). The fourth measurement, maximum diameter of the head of the femur, was tested using nonparametric analysis because it is not normally distributed.

A one-way ANOVA with the data set split by sex was conducted to examine the effect of burial location on three long bone measurements as the dependant variables (maximum diameter of the head of the humerus, maximum length of the femur, or tibia length). In the analysis of males, there is no statistically significant effect of burial location on any of these three long bone measurements (see Table 47 for a summary of the one-way ANOVA statistics and Table 93 in Appendix for complete ANOVA results). Likewise in females, there is no statistically significant effect of burial location on any of these three long bone measurements (see Table 48 for a summary of the one-way ANOVA statistics and Table 91 in Appendix for complete ANOVA results). See Tables 86 and 87 in Appendix for the male and female descriptive statistics of the four long bone measurements grouped by burial location.

Table 47 One-way ANOVA results of the effects of burial location on long bone measurements in males for Question 4B

	One-way ANOVA			
Measurement	***F* statistic**	**df**	***P*-value**	**Significant? *P* < 0.05**
Humerus MDH	0.112	1, 4	0.76	No
Femur Max Length	0.807	1, 12	0.39	No
Tibia Length	0.658	1, 8	0.44	No

Table 48 One-way ANOVA results of the effects of burial location on long bone measurements in females for Question 4C

	One-way ANOVA			
Measurement	***F* statistic**	**df**	***P*-value**	**Significant? *P* < 0.05**
Humerus MDH	0.641	1, 5	0.46	No
Femur Max Length	1.294	1, 9	0.29	No
Tibia Length	1.689	1, 5	0.25	No

Since the measurement maximum diameter of the head of the femur is not distributed normally, it was tested using the nonparametric Mann-Whitney U Test. The data set was split by sex, so that males were compared to males and females to females. In females, the difference in the mean size of the maximum diameter of the head of the femur is not statistically significant between females buried at the Hopewell Mounds and females buried at Seip, Harness, Ater, and Rockhold ($U = 28$, $p = 0.66$; see Tables 94 and 95 in Appendix for complete Mann-Whitney ranks and statistics). The mean maximum diameter of the head of the femur is also not statistically significant between males buried at Hopewell Mounds and males buried at Seip, Harness, Ater, and Rockhold ($U = 25$, $p = 0.96$; see Tables 69 and 97 in Appendix for complete Mann-Whitney ranks and statistics).

Hypotheses 4B: Long bone measurements: Males vs Males

The alternate hypothesis is rejected for each of the four long bone measurements.

Hypotheses 4C: Long bone measurements: Females vs. Females

The alternate hypothesis is rejected for each of the four long bone measurements.

Question 5: Hopewell Mounds 23 & 25 vs. Other Hopewell Mounds

Within the Hopewell site, Hopewell Mounds 23 and 25 stand out from the other mounds because of their vast array of rich artifacts. Is the biological status of adults buried at Hopewell Mounds 23 and 25 different than the biological status of adults buried with provenience at the other Hopewell Mounds?

This question cannot be addressed for part 5A which focuses on all adults as it was for biological status variables because the sex ratios for the two samples are unequal (see Table 35). The sample with the larger percentage of males will be biased because the mean value of each of the measurements is larger in males than in females. The independent variable for where an adult was buried is termed "burial location" for this research question, and it refers to whether an individual was buried at Hopewell Mounds 23 and 25, or at one of the other Hopewell Mounds with provenience. Therefore, one-way analysis of variance with the data set split by sex so that males were compared to males and females to females was used to study the effect of burial location on mean values of long bone measurements. When these two groups were split by sex, only the maximum diameter of the head of the femur in females is normally distributed, and maximum length of the femur and tibia length for males (Shapiro-Wilk test $p > 0.05$; see Tables 99 and 103 in Appendix for normality statistics). Since none of the same four long bone measurements are distributed normally in both males and females, the nonparametric Mann-Whitney U Test was used to analyze the difference in mean values of the four long bone measurements between the two groups.

In males, none of the four long bones measurements are statistically significant between the two groups (see Table 49 for a summary of the Mann-Whitney Test results and Tables 100 and 101 in Appendix for complete Mann-Whitney ranks and statistics). In females, none of the four long bone measurements are statistically significant between the two groups as tested by Mann-Whitney (see Table 50 for a summary of the Mann-Whitney Test results and Tables 104 and 105 in Appendix for complete Mann-Whitney ranks and statistics). See Tables 98 and 102 in the Appendix for the male and female descriptive statistics of the four long bone measurements grouped by burial location.

Table 49 Mann-Whitney U results of the effects of burial location on long bone measurements in males for Question 5B

	Mann-Whitney U Test		
Measurement	***U* statistic**	***P*-value (two-tailed)**	**Significant? *P* < 0.05**
Humerus MDH	1	0.64	No
Femur MDH	16	0.54	No
Femur Max Length	9	0.35	No
Tibia Length	6	1.0	No

Table 50 Mann-Whitney U results of the effects of burial location on long bone measurements in females for Question 5C

	Mann-Whitney U Test		
Measurement	***U* statistic**	***P*-value (two-tailed)**	**Significant? *P* < 0.05**
Humerus MDH	0	0.22	No
Femur MDH	8	0.31	No
Femur Max Length	1	0.38	No
Tibia Length	1	0.44	No

Hypotheses 5B: Long bone measurements: Males vs. Males

The alternate hypothesis is rejected for each of the four long bone measurements.

Hypotheses 5C: Long bone measurements: Females vs. Females

The alternate hypothesis is rejected for each of the four long bone measurements.

Question 6: Hopewell Mound 25 vs. Hopewell Mound 23

Hopewell Mound 25 burials have more prestigious and numerous grave goods and evidence of more elaborate mortuary rituals than burials at Mound 23. Is the biological status of adults buried at Hopewell Mound 25 different than the biological status of adults buried at Hopewell Mound 23?

The entire sample size of the Mound 25 group is 31 adults, while Mound 23 is represented by 10 adults, and only 2 of these are males (see Table 39). Additionally for each of the four long bone measurements, Mound 23 only has a sample size of 1 individual. Therefore, this question cannot be addressed for part 6A which focuses on all adults as it was for biological status variables. This question also cannot be addressed for both part 6B and 6C because of the very small Mound 23 sample sizes. See Tables 106 and 107 in the Appendix for the male and female descriptive statistics of the four long bone measurements grouped by burial location.

Question 7: Hopewell Mound 25 vs. Other Hopewell Mounds (including Mound 23)

Hopewell Mound 25 is unique when compared to the other mounds of the Hopewell Mound Group because of its large size, rich deposits of exotic artifacts, and the most elaborate mortuary rituals. Is the biological status of adults buried at Hopewell Mound 25 different than the biological status of adults buried with provenience at the other Hopewell Mounds?

This question cannot be addressed for part 7A which focuses on all adults as it was for biological status variables because the sex ratios are unequal (see Table 43). The sample with the larger percentage of males will be biased because the mean value of each of the measurements is larger in males than in females. The independent variable for where an adult was buried is termed "burial location" for this research question, and it refers to whether an individual was buried at Hopewell Mound 25, or with provenience at the other Hopewell Mounds (Mound 2, 4, 7, 18, 23, 24, 26, and 27). Therefore, one-way analysis of variance with the data set split by sex so that males are compared to males and females to females is used to study the effect of burial location on mean values of long bone measurements.

When these two groups were split by sex, only maximum length of the femur and tibia length are distributed normally for both male groups (Shapiro-Wilk test $p > 0.05$, see Table 109 in Appendix for complete normality statistics). The maximum diameter of the head of the femur was tested using nonparametric analysis because it is not normally distributed. The maximum diameter of the head of the humerus measurement was dropped from analysis because the sample size for the Mound 25 group was zero. See Table 108 in the Appendix for the male descriptive statistics of the four long bone measurements grouped by burial location.

A one-way ANOVA with the data set split by sex was conducted to examine the effect of burial location on two long bone measurements as the dependant variables (maximum length of the femur and tibia length) for the analysis of males. In accordance with the rules for one-way ANOVA, maximum length of the femur for the male groups is not statistically significant for Levene's test of equality of error variances (see Table 110 in Appendix for Levene's test statistics). However, tibia length is statistically significant (p = 0.02) for Levene's test of equality of error variances which means that there is not homogeneity of variances of this measurement across the two groups. In this case, the Welch test can be utilized as a robust test of equality of means instead of ANOVA analysis. The Welch test does not reveal a statistically significant difference between the two male groups for tibia length [F =0.28, (df 1, 3.4), p = 0.63] (see Table 112 in Appendix). In the ANOVA analysis of males, there is no statistically significant effect of burial location on maximum length of the femur (see Table 51 for summary statistics, and Table 111 in Appendix for complete ANOVA results).

Since the measurement maximum diameter of the head of the femur for the male group is not distributed normally, it was tested using the nonparametric Mann-Whitney U Test. The difference in mean size of the maximum diameter of the head of the femur is not statistically significant between males buried at Mound 25 and males buried at the other Hopewell Mounds

($U = 16$, $p = 0.56$; see Tables 113 and 114 in Appendix for complete Mann-Whitney ranks and statistics).

Table 51 One-way ANOVA results of the effects of burial location on long bone measurements in males for Question 7B

	One-way ANOVA			
Measurement	***F* statistic**	**df**	***P*-value**	**Significant? *P* < 0.05**
Femur Max Length	0.566	1, 9	0.47	No

When these two groups were split by sex and assessed for normality for each of the three long bone measurements (maximum diameter of the head of the femur, maximum length of the femur, or tibia length), only maximum diameter of the head of the femur is distributed normally for both female groups (Shapiro-Wilk test $p > 0.05$, see Table 116 in Appendix for complete normality statistics). The maximum diameter of the head of the humerus measurement was dropped from analysis because the sample size for the Mound 25 female group was zero. The one measurement that is normally distributed (maximum diameter of the head of the femur) also exhibits homogeneity of variances when split by sex (Levene's test $p > 0.05$, see Table 117 in Appendix for Levene's test statistics). The female measurements maximum length of the femur and tibia length were tested using nonparametric analysis because they are not normally distributed. See Table 115 in the Appendix for the female descriptive statistics of the four long bone measurements grouped by burial location.

A one-way ANOVA with the data set split by sex was conducted to examine the effect of burial location on maximum diameter of the head of the femur as the dependant variable for the analysis of the female groups. In accordance with the rules for one-way ANOVA, maximum diameter of the head of the femur for the female groups is not statistically significant for Levene's test of equality of error variances. In the analysis of females, there is no statistically significant effect of burial location on maximum diameter of the head of the femur (see Table 52 for a summary statistics, and Table 116 in Appendix for complete ANOVA results).

The measurements maximum length of the femur and tibia length for the female group are not distributed normally; therefore, they were tested using the nonparametric Mann-Whitney U Test. The difference in mean size of the maximum length of the femur is not statistically significant between females buried at Mound 25 and females buried at the other Hopewell Mounds ($U = 4$, $p = 1.0$; see Tables 119 and 120 in Appendix for complete Mann-Whitney ranks and statistics). The difference in mean size of the length of the tibia is also not statistically significant between the two female groups ($U = 1$, $p = 0.66$; see Tables 119 and 120 in Appendix for complete Mann-Whitney ranks and statistics).

Table 52 One-way ANOVA results of the effects of burial location on long bone measurements in females for Question 7C

	One-way ANOVA			
Measurement	***F* statistic**	**df**	***P*-value**	**Significant? *P* < 0.05**
Femur MDH	3.327	1, 10	0.10	No

<u>Hypotheses 7B: Long bone measurements: Males vs. Males</u>

The alternate hypothesis is rejected for each of the four long bone measurements.

<u>Hypotheses 7C: Long bone measurements: Females vs. Females</u>

The alternate hypothesis is rejected for each of the four long bone measurements.

Chapter Summary

The results presented in this chapter are divided into three parts. In the first part, the markers of biological status of adults from the SC and SW Ohio Hopewell regions are compared. LEH is the only biological status marker that has a near significant statistical difference between the two regions (p = 0.06, see Table 8). Adults from the SW region (45.7%) have a higher frequency of LEH in anterior maxillary and mandibular anterior teeth than SC adults (26.3%). Although not statistically significant, the frequency of PH is also higher in SW adults (51.4%) than in SC adults (47.4%) (see Table 9). The tibia (13.2%) is the long bone most frequently found with a periosteal reaction (see Table 10), and the frequency of periosteal reactions is higher in adults from the SC region (18.2%) than in SW adults (5.2%) (see Table 12). The frequency of antemortem long bone fractures is less than 1% in both regions (see Table 13). SC adults (13.5%) have a higher frequency of calvaria fractures than SW (5.2%) adults (see Table 14).

In part two of this chapter, the results of the hypothesis testing of the first three research questions that examine the intraregional and interregional differences of biological status markers between adult males and females from the SW and SC regions are presented. There is only one question with statistically significant results. In the analysis of SC males vs. SW males (Question 3), the frequency of LEH in mandibular canines is statistically significant (p = 0.044, see Table 29). SW males (23.1%) have a higher LEH frequency than SC males (0%).

Based on the lack of statistically significant differences, the alternate hypotheses for each biological status marker in Questions 1A (SW females vs. SW males), 1B (SC females vs. SC males), and 2 (SC females vs. SW females) are all rejected. With the exception of the frequency of LEH in mandibular canines, the alternate hypotheses for the other markers of biological status in Question 3 (SC males vs. SW males) are also rejected. The null hypothesis for the frequency of LEH in mandibular canines is rejected in Question 3 (SC males vs. SW males).

The analysis of long bone measurements within and between the two regions reveals that statistically significant differences only exist when the long bone measurements of males were compared to females in Questions 1A (SW females vs. SW males) and 1B (SC females vs. SC males). These results are expected, however, as males have larger mean long bone measurements than females. When SC female long bone measurements are compared to SW female long bone measurements in Question 2 and SC males and SW male long bone measurements are compared in Question 3, there are no statistically significant differences. Therefore, the null hypotheses for the four long bone measurements in Questions 1A and 1B are all rejected. The alternate hypotheses for the four long bone measurements in Questions 2 and 3 are all rejected.

The third part of this chapter presents the results of the hypothesis testing of the last four research questions that examine whether there is a difference in markers of biological status based on prestigious burial mound location in the SC region. The result of this analysis reveals that for the majority of the hypotheses there is no statistical significance between the groups that are compared. Therefore, the alternate hypotheses for each biological status marker in Questions 4 (Hopewell Mounds vs. other SC sites), 5 (Hopewell Mounds 23 and 25 vs. other Hopewell Mounds), and 7 (Hopewell Mound 25 vs. other Hopewell Mounds) are all rejected.

There are only two hypotheses with statistically significant differences. Question 6 which compares the biological status of adults from Hopewell Mound 25 to Hopewell Mound 23 is statistically significant for both all adults and females for the frequency of LEH in mandibular canines. Mound 23 adults have a frequency of LEH in mandibular canines of 50% (2 of 4), while the frequency is 0% (*n* = 19) for Mound 25 adults (*p* = 0.02, see Table 40). Mound 23 females have a frequency of LEH in mandibular canines of 100% (2 of 2), while the frequency is 0% (*n* = 9) for Mound 25 females (*p* = 0.02, see Table 42). Thus, the null hypothesis for the frequency of LEH in mandibular canines is rejected in Question 6A, which compares Mound 25 to Mound 23 adults, and 6C, which compares females. The frequency of LEH in mandibular canines is not statistically significant when Mound 25 and Mound 23 males are compared. The alternate hypotheses for all biological status markers are rejected when Mound 25 males are compared to Mound 23 males in Question 6B. With the exception of the frequency of LEH in mandibular canines, the alternate hypotheses for the other markers of biological status in Questions 6A for all adults and 6C for females are also rejected.

The analysis of long bone measurements based on prestigious burial mound location in the SC region reveals that there are no statistically significant differences when males are compared to males, and females are compared to females for any of the different research hypotheses. Question 6 (Mound 25 vs. Mound 23) cannot be addressed because the sample sizes of long bone measurements are too small. Therefore, the alternate hypotheses for the four long bone measurements in Questions 4 (Hopewell Mounds vs. other SC sites), 5 (Hopewell Mounds 23 and 25 vs. other Hopewell Mounds), and 7 (Hopewell Mound 25 vs. other Hopewell Mounds) are all rejected.

Chapter 6: Discussion

This study has three main goals. It documents the markers of biological status that indicate skeletal stress and trauma for Ohio Hopewell people from the south-central (SC) and southwest (SW) regions of Ohio. Secondly, it tests the research hypotheses that examine the intraregional and interregional differences in the relationship between biological status and social status of male and female Ohio Hopewell adults. The final part of this study tests the research hypotheses that collectively investigate whether differences in biological status are related to differences in social status at prestigious burial mounds within the SC region. This chapter focuses on integrating the results of this study into a discussion of whether Ohio Hopewell biological status is in accord with the expectations of archaeological hypotheses for Ohio Hopewell social status. Does biological status reflect variation in social status within Ohio Hopewell society?

Overview of Ohio Hopewell Lifeways

Ohio Hopewell populations represent a regional tradition from the Middle Woodland period dated to ca. 100 BC to 400 AD (Greber and Ruhl, 1989), or ca. 1 to 400 AD (Seeman, 1995). Hopewell people are known for the construction of large geometric earthworks and associated mounds that were used as public ceremonial and mortuary centers. They also traded nonlocal raw materials all over the eastern half of North America, and used these materials to create exotic stone, shell, and copper artifacts that are found in mortuary contexts.

Ohio Hopewell settlement and subsistence models indicate small residential communities, each composed of a few families scattered across the landscape. These small communities utilized different ecological niches around their homestead to hunt for white-tailed deer and other mammals, fish in lakes and rivers, gather nuts from hardwood forests, and gather wild and domesticated plants (Carr, 2008a; Dancey, 2005; Pacheco and Dancey, 2006; Smith, 2001). Based on archaeological, paleobotanical, and osteological evidence, the Ohio Hopewell people did not depend on a maize-based diet (Bender et al, 1981; Beehr, 2011; Sciulli, 1997; Smith, 2001; Wymer, 1997). Furthermore, this broad based hunting and gathering subsistence pattern did not lead to the existence of large agricultural food surpluses (Ford, 1979; Yerkes, 2006).

Debate surrounds the mobility of the Ohio Hopewell. Some researchers argue that they were seasonally mobile (e.g. Cowan, 2006; Yerkes, 2006), while others propose they were sedentary and lived in dispersed homesteads (e.g. Pacheco and Dancey, 2006). Researchers have noted that settlement was most likely based at homesteads during the growing season, and then shifted to the uplands during the hunting season (e.g. Smith, 2006). It has been postulated there was a greater chance that settlement was more permanent if their homestead was located in a more productive and diverse ecological niche (Carr, 2008b; Abrams, 2009).

Overview of Ohio Hopewell Social Status

This study is based on the perspective that Ohio Hopewell communities represent complex egalitarian societies. Ohio Hopewell mortuary centers contain burials associated with flamboyant mortuary architecture and rituals, and the presence of prestigious nonlocal artifacts, particularly made from copper. Carr and Case (2005) propose that an individual's social role of leadership or high prestige is reflected at death by the inclusion of specific bundles of artifacts in their burial. Leaders fill important social roles, such as ritual or religious leaders (shamans), war or hunt leaders, corpse processors, healers, public ceremonial leaders, or have obtained prestige based on individual achievement (Carr and Case, 2005). Carr and Case summarize that Ohio leadership and prestige emphasized religious roles, was segregated by roles to many different types of leaders, and moderately institutionalized. The latter implies that these individuals had formally recognized positions of power and authority.

Other contemporary archaeologists also agree that there were many different types of leaders in Ohio Hopewell society. They postulate that the primary process of gaining a social position of high prestige and/or leadership was by achievement, and there was in general a lack of institutionalized hierarchies through which leadership could be inherited (i.e. ascription) (e.g. Seeman, 2004; Pacheco and Dancey, 2006). The scenario in which leaders controlled access to food resources is most likely not the case for complex egalitarian Ohio Hopewell societies, as archaeologists have hypothesized that large food surpluses did not exist (Ford, 1979: Yerkes, 2006). Without these surpluses, there is no major economic mechanism for one group to acquire large food surpluses and control the access of others to these food resources. Furthermore, the settlement pattern of dispersed hamlets across the landscape involving small family bands makes it unlikely that access to food surpluses was controlled by a few select prestigious leaders.

Archaeologists have examined the social status of males and females from the SC and SW regions of Ohio based on the Carr and Case (2005) model for social status. The model proposed by Field et al. (2005) hypothesizes that male and female access to leadership and prestige in local Ohio Hopewell societies differs by region. The emphasis was on female leadership and prestige in the SW region (Field et al., 2005; Rodrigues, 2005), whereas males predominantly filled these high status social positions in the SC region (Field et al., 2005).

Greber (1979a) finds evidence for the similar social ranking of males and females at the Turner site in the SW which appears to agree with the hypotheses of Field and her colleagues.

Overview of Biological Status

In this study, the phrase biological status refers to the assessment of skeletal markers of nonspecific systemic physiological stress, dietary nutritional stress, nonspecific infection and/or disease, or trauma to the skeletal system. Linear enamel hypoplasias (LEH) are caused by nonspecific systemic stress, such as nutritional deficiency and/or childhood illnesses, and affect the growth and development of an individual's teeth. Porotic hyperostosis (PH) affects the spongy bone of the cranial vault and is the result of nonspecific systemic stress from dietary nutritional deficiency and/or infection. Adult stature is an indicator of nutritional stress and to a lesser extent, nonspecific infection. Periosteal reactions on long bones are caused by nonspecific disease and/or infection, or trauma related to activity. Skeletal trauma is the result of accidents or interpersonal violence.

Previous bioarchaeological studies have examined the relationship between skeletal stress and differences in social status in Native American skeletal populations (e.g. Buikstra, 1976; Cook, 1981; Goodman and Armelagos, 1988; Powell, 1991). However, most of these studies have focused on groups that were ranked societies or chiefdoms, which is a level of greater social complexity than the Ohio Hopewell. Several of these studies reveal that people from higher levels of social status are associated with lower levels of skeletal stress (e.g. Buikstra, 1976; Cook, 1981; Goodman and Armelagos, 1988). On the contrary, other studies do not detect a statistical significance between social status and skeletal stress (e.g. Powell, 1991; Blakely, 1988). In this study, the relationship between social status and biological status was examined in the Ohio Hopewell, a complex egalitarian society.

Skeletal Sample and Methods Overview

The two geographical regions of Ohio utilized in this study are defined as relating to river drainages. The SW region is comprised of adults from the Turner Mound Group which is located along the Little Miami River. The SC region is represented by adults buried at Hopewell Mound Group, Seip Earthworks, Edwin Harness Mound, Raymond Ater Mound, and Rockhold Mound Group. These SC sites are all located on the Scioto River or Paint Creek, one of its tributaries. Only the skeletal remains of adults were analyzed in this study.

The methods employed for the data collection and analysis of the skeletal markers of biological status are detailed in Chapter 4. Chapter 5 contains the results of the statistical testing of all 14 different markers of biological status. All of these markers were analyzed at the individual level. In this chapter, several comprehensive skeletal markers of biological status have been selected to use in the comparison of adults from the SC and SW regions. These include the frequency of LEH in anterior (canines and incisors) maxillary and mandibular teeth, PH, periosteal reactions of the tibia, and any type of antemortem long bone or calvaria fracture. The statistical tests of nominal data were conducted using Pearson chi-square analysis or Fisher Exact probability test, when expected cell counts were less than five. Statistical significance was set at the $p < 0.05$ level, and $p < 0.10$ for near statistical significance. All significance testes were two-tailed.

The methods used to obtain the four different long bone measurements that indicate adult body size and stature (maximum diameter of the humeral head, maximum diameter of the femoral head, maximum length of the femur, and tibia length) are explained in Chapter 4. The results of the statistical analysis of long bone measurements are detailed in Chapter 5. Analysis involved ANOVA when data was distributed normally, and the Mann-Whitney U Test when it was not distributed normally. Statistical significance was set at the $p < 0.05$ level.

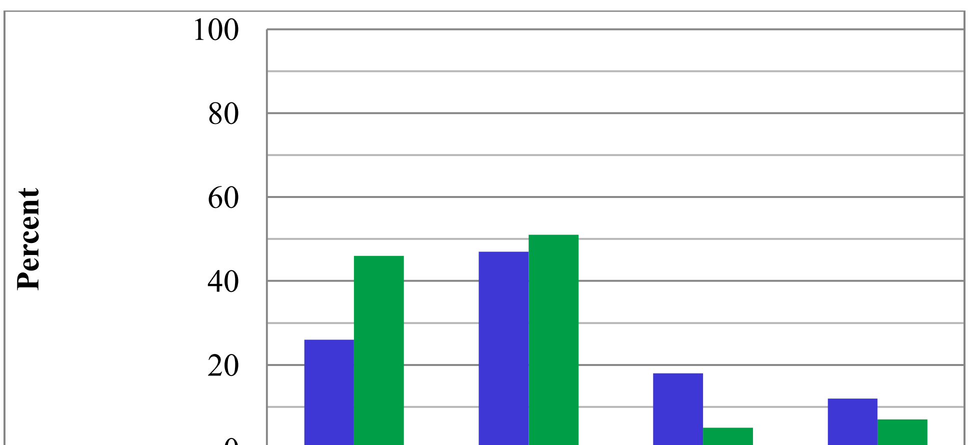
The use of the term "better" biological status in this dissertation means there is a lower prevalence of binary scored (absence or presence) skeletal indicators for LEH, PH, periosteal reactions, or antemortem trauma, or larger mean measurements for the four long bone measurements which were used for the assessment of adult stature and body size. Alternatively, the use of the term "poor" biological status means there is a greater prevalence of these binary scored skeletal markers, or smaller mean long bone measurements.

Interregional Variation of Biological Status

The results of this study reveal there is interregional variation of the biological status between adults from the SW region and the SC region. This is consistent with the work of archaeologists who have detected differences between these two regions based on ceramics, stone tools, and copper earspools (Hawkins, 1996; Nolan et al., 2007; Ruhl and Seeman, 1998). Additionally, research has indicated evidence between these regions for differences between gender and the access of social positions of leadership and prestige in the Ohio Hopewell (Field et al., 2005; Rodrigues, 2005), and the orientation of political economy (Coon, 2009). These different types of interregional variability refute the notion there was a pan-Hopewellian interaction sphere that resulted in similar cultural features across the geographic spread of the Hopewell in North America (Carr and Case, 2005). The results of this study demonstrate that the biological status of Ohio Hopewell populations is not the same in all regions of Ohio.

The frequency of each of the four comprehensive markers of biological status at the individual level is displayed in Figure 16 by region, and includes all adults from within the two regions (males, females, and adults of unidentified sex). The differences in the frequency of these markers by region are not statistically significant for any of the four comprehensive markers of biological status. However, the frequency of LEH is higher in the SW region (46%) than the SC region (26%), and this difference is near statistical significance ($\chi^2 = 3.65$, $p = 0.06$, df = 1).

Figure 16 Frequency of each marker of biological status for all adults by region
Key: LEH = LEH in anterior maxillary and mandibular teeth; PH = Porotic hyperostosis; Tib PSRXN = Tibial periosteal reaction; FX = Antemortem fracture of long bone or calvaria
Note: ^Indicates near statistical significance at the $p < 0.10$ level



	LEH^	PH	Tib PSRXN	FX
South-Central	26	47	18	12
Southwest	46	51	5	7

The frequency of each marker of biological status provides information about the skeletal stress that affected SW and SC Ohio Hopewell populations. **T**he two most prevalent markers of biological status are LEH and PH**.** The high frequency of LEH in adults from both regions indicates these adults suffered from nonspecific systemic physiological and/or metabolic stress as children. LEH lesions affect permanent teeth during their growth and development between birth and seven years of age. LEH lesions can be caused by nutritional stress, childhood illnesses, or a combination of both.

PH has been linked by researchers to multiple etiologies including iron-deficiency anemia, parasite load, increased population density, and vitamin B12 deficiency (e.g. Stuart-Macadam, 1992; Ubelaker, 1992; Walker et al, 2009). A diet low in B12 has been linked to megaloblastic anemia (Walker et al, 2009). B12 is only found in foods that come from animals, such as fish, shellfish, meat, poultry, eggs, or dairy products. The Hopewell diet, which involved hunting and fishing, would have been rich in vitamin B12. Additionally, a diet low in folic acid can lead to megaloblastic anemia. Pregnant women who have low levels of folic acid due to problems absorbing folate from leafy vegetables and legumes are susceptible to developing megaloblastic anemia in this manner (Walker et al, 2009). Studies indicate that the highest rates of PH are found in children under the age of fifteen (Walker et al, 2009), and the majority of PH lesions in adults are healed (Larsen, 1997).

Previous interobserver error studies have shown there is difficulty in distinguishing the presence of PH, classifying porosities, and determining active from healed PH cases, even amongst experienced bioarcheologists (Jacobi and Danforth, 2002). Agreement on the presence of PH was greater than 80% when lesions existed, however when PH was absent about half of the observers still scored it as present (Jacobi and Danforth, 2002). During the collection phase of this study, an attempt was made to record whether PH lesions were healed, active, or combined both responses. In this study, 53% of PH was scored as healed and barely discernible. This most likely indicates that these individuals suffered these lesions during childhood.

The frequency of LEH and PH indicates that these Ohio Hopewell populations, especially those from the SW region, were under periods of nonspecific systemic stress that could have included nutritional deficiency, periodic illnesses, and infections during their childhood. Although the frequency of LEH is higher in the SW region, there is no significant statistical difference in the mean long bone measurements between SW and SC males, or between SW and SC females. This indicates that the nonspecific stress affecting the SW population occurred early in childhood, under the age of seven, and not during the second period of rapid growth of long bones in adolescence.

In contrast, the pattern of prevalence of tibial periosteal reactions is different than for LEH and PH. Although not statistically significant, the frequency of tibial periosteal reactions is higher in adults from the SC region (see Figure 16). Periosteal reactions on long bones are typically the result of nonspecific disease (often infection) or acute trauma, although they could also result from metabolic diseases, infectious diseases, neoplastic diseases, circulatory disorders, joint disease, hematological disease, or skeletal dysplasias (Weston, 2008). There is no specific age in a general population when periosteal reactions occur most frequently. The majority of the tibial reactions in this research study occurred bilaterally (five of seven adults, and one of the adults without bilateral symmetry only had one tibia). This appears to support an etiology based on nonspecific disease and/or infection rather than acute trauma.

Trauma to the skeleton is a different indicator of biological status than the markers of skeletal stress discussed above. Trauma is the result of either accidental injury, or interpersonal violence, and can happen at any time during an individual's life. Although not statistically significant, the frequency of healed antemortem long bone or calvaria fractures is higher in adults from the SC region (see Figure 16). Fractures of the calvaria are more common in both regions. Only one individual from each region exhibits an antemortem fracture of a long bone. Overall, 86% of the adults with antemortem trauma have fractures of the calvaria. These were typically healed, depressed fractures which may have been the result of accidents that could have occurred during numerous types of activities, or from violence. Previous studies have not documented high rates of fractures in other skeletal populations from the Ohio Valley over a period of 2,500 years (e.g. Sciulli and Oberly, 2002).

The absence of high rates of skeletal trauma detected in this study supports the hypothesis that violence which affects the skeletal system does not appear to have been a common occurrence in Ohio Hopewell life. Seeman (1988) identifies isolated skulls found in several burials at the Hopewell Mound Group as those of young males and hypothesizes that these represent "trophy skulls". A study by Johnston (2002) reanalyzes these skulls and all other human skeletal remains with postmortem modifications at the Hopewell Mounds. Johnston rejects the trophy skull hypothesis because the skulls were not all those of young males. Johnston (2002) proposes that these modified human remains represent revered ancestors. Carr (2008d) notes that isolated skulls do occur more frequently with male burials in the SC region, but projectile points and weapons are not also found in the burials with these isolated skulls. According to Carr (2008e), low rates of interpersonal violence at SC sites and the evidence that several communities shared ceremonial centers supports his conclusion that that the SC region was marked by cooperation more than competition.

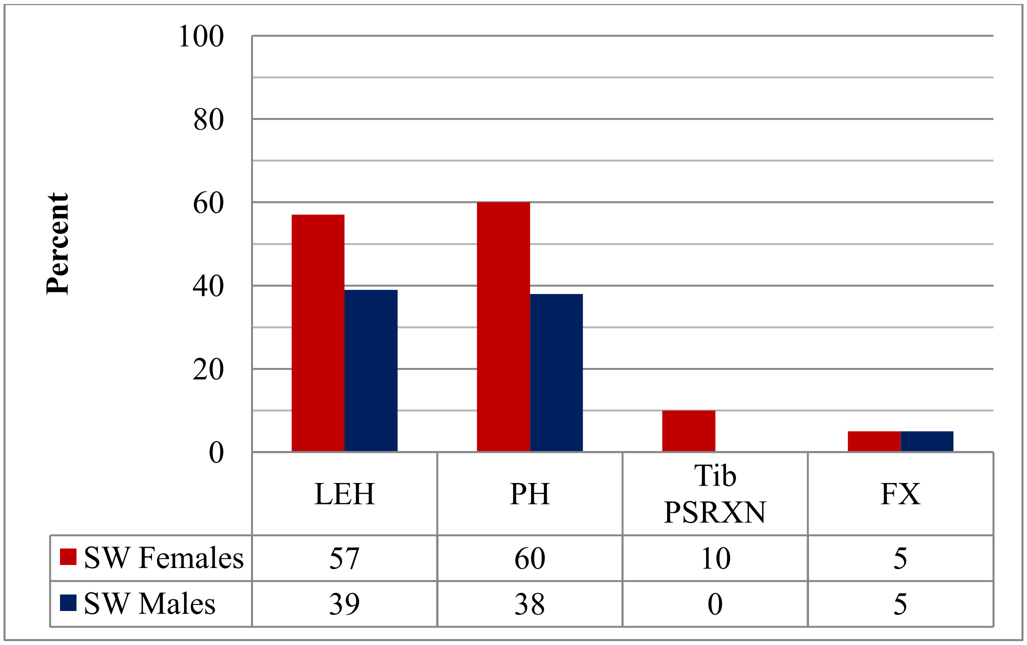
Intraregional Variation of Biological Status by Sex

SW Region: Females vs. Males

It has been hypothesized that in the SW region women had greater access than men to social positions of prestige and leadership (Field et al, 2005, Rodrigues, 2005). The emphasis on leadership in the SW region was on females. Men were present in high status positions, but never more frequently than women. The results of this study demonstrate that increased female access to these high status social positions did not result in SW females having better biological status than SW males. Females did not have statistically significant lower frequencies of markers of biological status (see Figure 17). There is no evidence to support the hypothesis that differential access to nutrients during growth and development was based on sex differences in the SW region.

For each of the 14 markers of biological status, there is no statistically significant difference in the frequencies of these markers between males and females in the SW region (see Table 26). Figure 17 displays the frequency of the four comprehensive markers of biological status for SW males and females.

Figure 17 SW Females vs. SW Males: Frequency of each marker of biological status



The results of this study in the SW region meet the expectations of the research hypotheses that there would not be a statistical difference in the markers of biological status between males and females. The theoretical basis for this expectation is the concept of complementary gender roles. In a society in which complementary gender roles are present, men and women have different roles and responsibilities in the domestic, economic, religious, and political spheres of their community (Ackerman, 1995). The distinct roles of men or women do not overlap.

Previous ethnohistorical research has proposed that in several Native American Indian matrilineal societies, gender roles were complementary, not hierarchical (e.g. Ackerman, 1995; Bilharz, 1995; Knack, 1995; Maltz and Archambault, 1995; Sattler, 1995; Tooker, 1984). The Iroquois, a matrilineal horticultural society from the Eastern Woodlands, are an example of a society for whom researchers have documented the presence of complementary gender roles

(Bilharz, 1995; Tooker, 1984; Perrelli, 2009). These complementary gender roles did not lead to either sex being subordinate to the other (Bilharz, 1995).

Likewise, Sattler (1995) also finds a pattern of complementary gender roles in the Cherokee; a matrilineal chiefdom that exhibits minimal social ranking. Differences in prestige were based on achievement and age, rather than ascription which gave greater equality to women (Sattler, 1995). Additionally, the analysis of the gender roles of Plateau Indians, hunter-gatherers from the northwest, also supports the notion that complementary gender roles did not lead to male superiority in this society (Ackerman, 1995). The conclusions of these studies counter the notion that complementary gender roles lead to gender stratification which has been proposed by Lamphere (1977). On the contrary, complementary gender roles do not necessarily lead to gender stratification (Ackerman, 1995).

The expectation of complementary gender roles in the SW region was based on archaeological and osteological evidence. There are several aspects of SW Ohio Hopewell society used by researchers to support the hypothesis that this region utilized matrilineal descent. According to Field et al (2005), the increased access of women to prestigious social positions, including shamanic positions, in the SW region and the association of females with the majority of clan artifacts are important indicators that the power and autonomy exhibited by SW females is typical of matrilineal societies. Several other lines of archaeological research suggest cultural connections between SW Ohio Hopewell groups and Southeastern Woodlands Native American groups who historically practiced matrilineal descent (Thomas et al., 2005; Ruby and Shriner, 2005). Furthermore, there is evidence that gender stratification was not reflected in the mortuary practices at Turner in the SW region. Greber (1979a) does not find any differences in mortuary treatment based on status associated with sex, age, or grave goods at Turner.

Additionally, a study on the activity patterns of individuals from the Turner site in the SW region utilizing musculoskeletal markers of stress identifies distinct activities performed by SW males and females (Rodrigues, 2005). Females may have been involved in the following activities: “nut and seed grinding and pulverizing using a nutting stone and pestle, food and/or material preparation using a knife, hide preparation using a side scraper, flintknapping using a hammerstone, and running” (Rodrigues, 2005:426). Whereas, males may have performed the following activities: “nut, seed, and grain grinding with a mano and metate, and hide preparation using an end scraper” (Rodrigues, 2005:426). This osteological data appears to support the premise that males and females were involved in different domestic and economic activities which is consistent with the concept of complementary gender roles.

There is both archaeological evidence of an emphasis on female social status and an osteological indication of different subsistence related activities for each sex in the SW region. These different lines of evidence are both supportive of the expectation of complementary gender roles in SW Ohio Hopewell society. Therefore, the biological status of males and females should be similar in the SW region. There should not be a statistically significant difference in the frequencies of indicators of skeletal stress between males and females, because complementary gender roles do not have to lead to gender stratification. The mean long bone measurements of SW males are statistically significantly larger than SW females. This result was expected based on male and female sexual dimorphism. Other than stature, the results of this intraregional study do not reveal any statistically significant differences in the markers of biological status between SW males and females (see Figure 17).

It was not the goal of this study to determine whether the SW region was indeed marked by a matrilineal pattern of kinship as Field and her colleagues (2005) have cautiously proposed because of the small sample size of the Turner mortuary data. A previous study demonstrates that determining whether a group practiced matrilineal or patrilineal descent based on the archaeological record is problematic (O'Shea, 1981). Mitochondrial DNA (mtDNA) studies of Illinois Havana populations conclude that the mortuary pattern at these sites was not based on matrilineal kinship (Bolnick and Smith, 2007; Raff, 2008). This was the same conclusion reached for the Hopewell Mound Group in the SC region of Ohio using mtDNA (Mills, 2003). Unfortunately, mtDNA analysis has not yet been conducted for Turner in the SW region. However, the results of the intraregional analysis of male and female skeletal biology demonstrate that an emphasis on female leadership in the SW region did not result in the differential treatment of males or females that was reflected in their biological status.

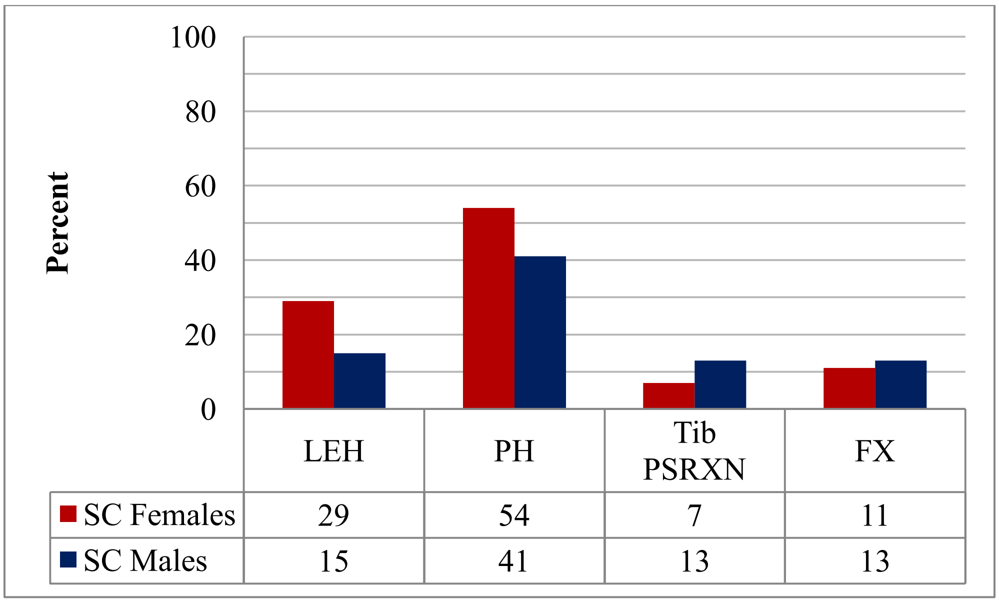
SC Region: Males vs. Females

It has been hypothesized that in the SC region social positions of prestige and leadership were filled primarily by men (Field et al., 2005). Although women did have access to some of these social positions, they did so less frequently than men. Only males, however, had access to the most powerful social positions. Thus, the SC region was characterized by a male bias for access to high prestige and leadership roles. The results of this study demonstrate that increased male access to these high status social positions did not result in SC males having better biological status than SC females. Males did not have statistically significant lower frequencies of markers of biological status (see Figure 18).

For each of the 14 markers of biological status there is no statistically significant difference in the frequencies of these markers between males and females in the SC region (see

Table 27). Figure 18 displays the frequency of the four comprehensive markers of biological status for SC males and females. The mean long bone measurements of SC males are statistically significantly larger than SC females. This result was expected based on male and female sexual dimorphism.

Figure 18 SC Females vs. SC Males: Frequency of each marker of biological status



The social status evidence derived from mortuary analysis demonstrates that women were not subordinate to men in the SC region. Women may not have had equal access to positions of leadership and prestige as males, but they were not completely absent from these positions. "Although male domination [of social roles] was a feature of Scioto Hopewell social life, extensive female depreciation was not the result" (Carr, 2008c:250). The skeletal evidence resulting from the analysis of biological status in this intraregional study supports the premise that there is not a biological benefit to the male bias for positions of prestige and leadership in the SC region. Even though women did not have equal access to social positions of high status, this did not result in them being more susceptible to skeletal stress. There is no evidence to support the hypothesis that differential access to nutrients during growth and development was based on sex differences in the SC region.

Ethnohistorical research on the relationship between gender and power in Native North America reveals that in societies in which men were dominant over women, women had the ability to limit some of this power through influence (Maltz and Archambault, 1995). In the case of the Iroquois, this influence was not the result of formal positions of sociopolitical power, but involved the ability of women to influence which men would hold sociopolitical power (Bilharz, 1995). Iroquois women were involved in the selection of clan leaders which gave women high political influence, but not necessarily major positions of formal power (Tooker, 1984). The results of this study indicate that although males in the SC region dominated many of the positions of leadership, this did not mean that women received differential treatment that was reflected in their biological status. On the contrary, the biological status of SC males and females was not statistically different.

Interregional Variation of Biological Status by Sex

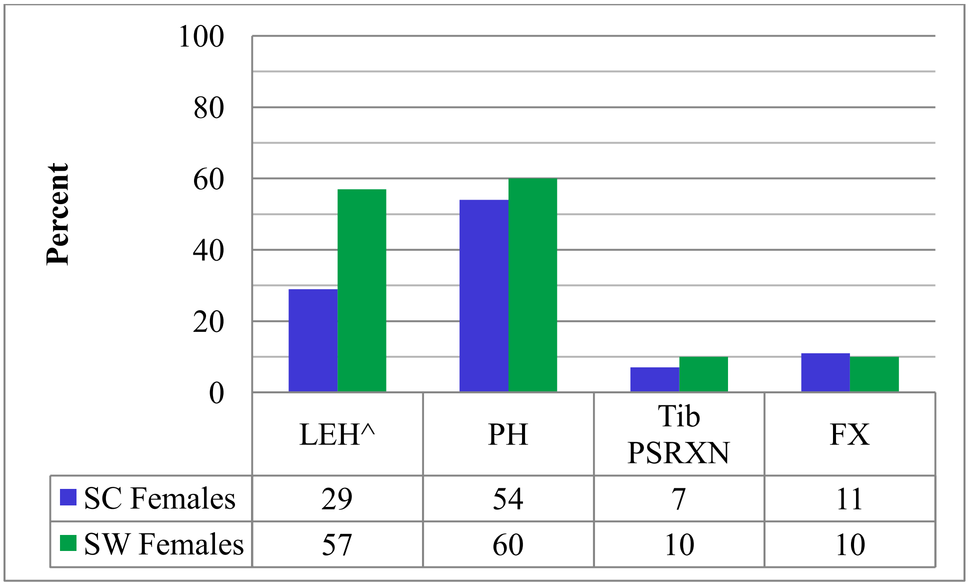
SW Females vs. SC Females

The social status of Ohio Hopewell women varies between the SW and SC regions. In the SW region, there is an emphasis on female access to social positions of leadership and prestige, while in the SC region there is a male bias for these high status social positions (Field et al., 2005). However, the results of the interregional analysis of the biological status of SW and SC females reveal that there are no statistical differences between the two female populations.

For each of the 14 markers of biological status there is no statistically significant difference in the frequencies of these markers between SW females and SC females (see Table 28). Figure 19 displays the frequency of the four comprehensive markers of biological status. There is also no statistically significant difference between the mean long bone measurements of SW and SC females. The descriptive statistics and graphic displays of the four different long bone measurements are displayed in Chapter 5 (Tables 22 – 25; Figures 12 – 15).

However, the frequency of LEH is higher in SW females (57.1%, 8 of 14) than in SC females (28.6%, 8 of 28). This difference is near statistical significance ($p = 0.07$, $\chi^2 = 3.23$, df = 1). The higher frequency of LEH in SW females is unexpected based on the differences between the regions for female social status. SC females had relatively less access to high social status positions in their community than SW females. The frequency of LEH between SW and SC populations will be discussed in a following section of this chapter.

Figure 19 SC Females vs. SW Females: Frequency of each marker of biological status
Note: ^ Indicates near statistical significance at the $p < 0.10$ level

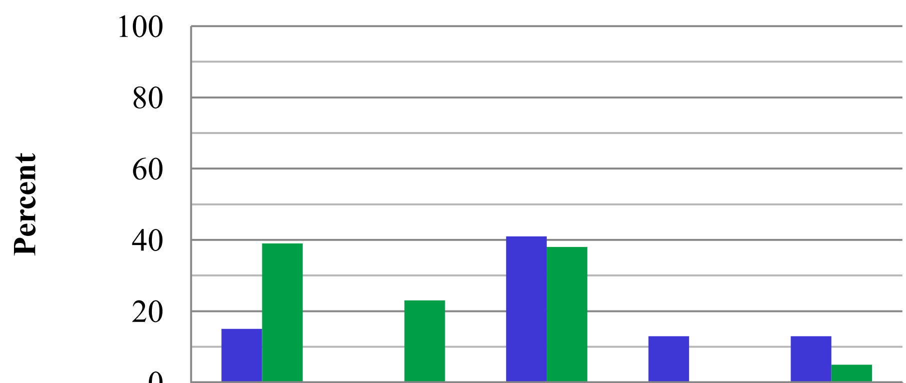


SW Males vs. SC Males

Interregional variation for the social status of Ohio Hopewell men also exists. In the SC region, males did have increased access to leadership and prestige social positions, and only males in the SC regions filled the highest social status positions (Field et al., 2005). While in the SW region, there was an emphasis on female social status (Field et al, 2005; Rodrigues, 2005). It was expected that the biological status of SC males would be better than SW males, because of the interregional differences for social status in their respective communities. The higher frequency of LEH in mandibular canines of SW males meets the expectation of the research hypothesis for this marker of biological status.

The difference in the frequency of LEH in mandibular canines is statistically significant ($p = 0.04$, 1 df). SW males (23.1%, 3 of 13) have a higher frequency of LEH in mandibular canines than SC males (0%, 0 of 22). This is the only one of the 14 markers of biological status that shows a statistical significant difference between SC males and SW males (see Table 29). Figure 20 displays the frequency of the four comprehensive markers of biological status and the frequency of LEH in mandibular canines. There is no statistically significant difference between the mean long bone measurements of SW and SC males, but the two measurements related to stature (maximum length of the femur and tibia length) are larger in SC males. The descriptive statistics and graphic displays of the four different long bone measurements are displayed in Chapter 5 (Tables 22 – 25; Figures 12 – 15).

Figure 20 SC Males vs. SW Males: Frequency of each marker of biological status
Key: LEH #22 = LEH in mandibular canines
Note: * Indicates statistical significance at the $p < 0.05$ level



	LEH	LEH #22*	PH	Tib PSRXN	FX
SC Males	15	0	41	13	13
SW Males	39	23	38	0	5

The statistically significant findings for LEH in mandibular canines provides skeletal evidence that indicates SW male children were under more nonspecific systemic stress than SC male children during similar stages of dental development for this tooth. Although the stress that causes LEH is nonspecific, its timeframe is not. The crowns of adult mandibular canines develop between 0.5 to 6.5 years (Massler et al., 1941). The mandibular canines are also the adult tooth type that is most susceptible to LEH (Goodman and Armelagos, 1985).

The difference in LEH frequency between SC and SW males indicates there was some type of nonsystemic stress that affected the dental development of SW males under the age of seven. However, the results of this interregional analysis indicate that this nonspecific stress did not also result in statistically significant differences for adult long bone measurements between SW and SC males. It is possible that SW males suffered long bone growth interruptions at the same time they experienced the stress that affected the growth and development of their adult teeth. However, it is plausible that during their later adolescent rapid growth period, “catch-up growth” allowed SW males to close the gap in stature with SC males. This could be one explanation for the lack of statistical significance of the long bone measurements related to stature between SC and SW males.

LEH Frequency: Interregional Variation

The examination of the relationship between social status and biological status between the SC and SW regions yields conflicting results. The frequency of LEH is higher in both SW males and SW females. For males, this meets the expectations of the research hypotheses based on different levels of male social status in the regions. On the contrary, the higher frequency of LEH in SW females than SC females does not meet the expectations based on increased female access to high status social positions in the SW region. However, the expectations for these hypotheses were based on there being an association established between increased male social status and resulting better biological status of SC males compared to SC females. This association was not established, because there is no skeletal evidence for statistically significant differences in biological status between SC males and females. As previously noted in this chapter, there is a higher frequency of LEH in SW adults than in SC adults (see Figure 16). This difference is near statistical significance ($p = 0.06$, df = 1).

Intraregional and interregional analysis indicates that biological status within and between the SW and SC regions does not reflect differences in social status. Based on the contradictory results of the association between biological status and social status in this study, it is inferred that the differences in the frequency of LEH between the two regions is most likely related to factors other than social status differences related to sex. Possible explanations include change over time, ecological variation, regional variation in diet, or social status differences between the regions that are not based on sex. The results also support the premise that Ohio Hopewell social status probably emphasized achievement, which further clouds the association between social status and biological status.

Temporal Change

There is little evidence to suggest that temporal variation is the main factor for a difference in the frequency of LEH between SW and SC adults. The Hopewell assemblage at the Turner Mound Group in the SW region is dated to ca. 53 to 537 AD based on radiocarbon dating (Tankersley, 2007). It has also been estimated by radiocarbon dating that the Turner village was occupied between ca. 290 to 320 AD (Tankersley, 2007). Recent radiocarbon dates for the Hopewell Mound Group in the SC region result in a range of ca. 140 to 389 AD (Beehr, 2011). Radiocarbon dating reveals that Mound 3 at Turner is older than Hopewell Mound 25, but there is an overlap of approximately 70 years (Greber, 2003). Greber notes this period of overlap is several generations long, and would have allowed for the interaction of people between these regions. The analysis of the seriation of earspools does not show a statistically significant difference between Turner and the Hopewell Mounds (Greber, 2003; Ruhl and Seeman, 1998). This indicates that earspools from the two sites did not change over time and space, and is another line of evidence to support the contemporaneity of these two regions.

Ecological Variation and Regional Variation in Diet

The variation in the frequency of LEH between SW and SC adults could involve ecological and dietary differences between the two regions. This could be related to differences in ecological niches, types of available food resources, or regional food shortages. Another possibility is an increased prevalence of childhood illness in the SW region. Furthermore, the response of how a population adapts to changes in their local environment could have an effect on the ability of the group to buffer the increased stress associated with environmental change.

The distance from the Hopewell Mound Group in SC Ohio to the Turner Mound Group in SW Ohio is no more than 70 miles (see Figure 1). The physical geography between the SC and SW regions is similar (Otto, 1979; Ruby et al., 2005). The eastern part of the SC region is located in the Alleghany Plateau portion of the Appalachian Plateaus physiographic region and includes both glaciated and unglaciated regions. The western portion of the SC region, which contains the Hopewell Mound Group, is located in the glaciated Till Plains section of the Central Lowland region. The Turner Mound Group of SW Ohio is also located in the Till Plains region. The SW region and western part of the SC region in the Till Plains region are both marked by rolling hills with fertile high-lime soil (Otto, 1979). The eastern parts of the SC region in the Alleghany Plateaus along the Paint Creek and Scioto River have broad valleys, and most of the SC sites in this study are located along these bottomlands and terraces (Ruby et al., 2005). Both regions along the Scioto (SC) and Miami Rivers (SW) contained hardwood forests in the bottomlands and uplands (Otto, 1979; Ruby et al., 2005).

These adjacent physiographic regions appear to provide similar ecological niches for Hopewell subsistence strategies that were focused on hunting, fishing, and gathering fruit, berry seeds, and nuts. The Hopewell diet was also supplemented with domesticated plants, such as goosefoot and maygrass. Models of Ohio Hopewell subsistence have not documented major differences between the SW and SC regions. However, no paleobotanical research has been conducted at the SW and SC sites used in this study. To date, paleobotanical studies have focused on the central region of Ohio, in the river valleys to the east of the Scioto River (Wymer, 1996; 1997). Maize has not been found to be a major component of the diet based on isotopic research at Seip, Harness, and Hopewell in the SC region (Bender et al, 1981; Beehr, 2011). There has not been isotopic analysis of the diet at Turner in the SW region. There is also a lack of dental evidence for a maize-based diet in Ohio Hopewell populations (Sciulli, 1997; Sciulli and Oberly, 2002). Researchers have suggested that the central Scioto River Valley was the focus of Ohio Hopewell public ceremonial events and prestigious mortuary rituals, because it was located in a productive ecological niche (Abrams, 2009; Carr, 2008d).

Since it appears that ecological niches were not all that different between the two regions, there is the possibility that the environment affected the niches of the two regions in different manners. An example of a change in the environment that may have shaped the ecological niches occupied by SC and SW populations is the Post Holocene Climatic Optimum. This climatic event resulted in a colder and dryer environment around ca. 200 AD (Abrams, 2009; Tankersley, 2007). Tankersley (2007) speculates that the resulting cooler climate would have had a negative effect on the ability of the Hopewell to utilize indigenous seed crops, such as goosefoot, to supplement their hunting and gathering diet. Tankersley also hypothesizes that the geometric design of parts of the Turner earthworks could have been created as components of an irrigation system for the collection of water. A colder climate and demand for water may be an indication that the SW region faced environmental stress that resulted in increased skeletal stress on the region's population.

In addition to colder temperatures, Ohio Hopewell subsistence could also be a factor in the differences of ecological niches between the regions. The lack of large agricultural food surpluses involving maize (Ford, 1979; Yerkes, 2006) combined with little evidence for large storage pits indicates that Ohio Hopewell subsistence was likely at the level of homestead consumption (Carr, 2005e). Thus, any seasonal fluctuation in hunted or gathered food had the potential to lead to food shortages and increased nutritional stress on a population. It is plausible that colder temperatures played a role in the increased environmental stress and resulting skeletal stress in the SW region.

Furthermore, changes in climate also have the potential to negatively affect the ability of domesticated and wild plants to be a reliable food source for Hopewell populations. Wymer (1996) asserts that plant cultigens were a major component of the Ohio Hopewell diet, and Smith (2006) characterizes the Hopewell as low-level food producers. Others counter that plants chiefly supplemented the diet (e.g. Carr, 2008a; Pacheco and Dancey, 2006). Depending on how much the Hopewell relied on these plants as part of their daily diet, changes in the climate could result in food shortages. Additionally, it could be hypothesized that perhaps the people from the

SW region relied more on horticulture as a subsistence strategy. Thus, seasonal fluctuations due to limited or unreliable food resources from plants may have been related to the higher frequency of LEH in the SW region.

The importance of nuts, such as hickory, black walnut, hazelnuts, and acorns from a variety of tree species has been noted for the Hopewell diet by several researchers (e.g. Ford, 1979, Wymer, 1996). Ford (1979) argues that nuts were a significant component of the Hopewell diet and an important nutritional resource, as they are rich in vegetable protein and high in calories per gram. However, he notes that nut harvests are high yield, but involve low predictability. There are many environmental factors that could deleteriously affect nut production in a given year which creates seasonal variation (Ford, 1979). The importance of nuts in the diets of Hopewell communities in the SW and SC regions is unknown, and warrants further investigation. This seasonal uncertainty of a food source represents another potential difference between the SW and SC region that may have contributed to the increased nonspecific stress that affected the growth and development of the teeth of SW children.

Climatic change and ecological differences between the two regions may have also influenced the political economies of the two regional groups. Coon (2009) proposes that the political economy of the SW and SC regions were different based on site architecture, lithic and textile analysis, and mortuary analysis of ceremonial centers. The SC region is marked by burials of varying levels of prestige. However, an individual's social status at death in the SW region was not expressed through the same type of prestigious mortuary practices used in the SC region. Coon (2009) hypothesizes that the SC region was focused on a more exclusionary political economy that emphasized prestigious individuals; whereas, the SW region was more focused on egalitarian behavior characteristic of corporate political economy.

Increased environmental stress and resulting food shortages may represent important reasons for communities in the SW region to utilize a corporate political economy that emphasized the group more than prestigious individuals. A corporate political ideology of shared reciprocal obligations could represent a cultural adaptation of the SW communities in an attempt to buffer increased environmental and nutritional stress. Abrams (2009) also suggests that the cooling period may have been a driving force for increased regional cooperation between different Hopewell groups in an attempt to counteract the ecological changes associated with colder temperatures.

Differences in Social Status Related to Age

The difference in the frequency of LEH between SW and SC populations could also be related to differences in social status between the regions based on attributes other than sex, such as age. Differential access to food resources based on age is a possible explanation for the nonspecific stress that affected SW children during their early childhood years. If the SW population at Turner was under increased nutritional stress, perhaps related to climatic changes, it is possible that children were given a different diet that contributed to the increased prevalence of LEH. Differences in diet may have been intentional. Foods with higher nutrient content may have been given preferentially to older children and/or adults who performed the critical labor of hunting and gathering in Hopewell societies.

Alternatively, differences in the diet of children could have been unintentional and related to weaning stress. Some modern hunting and gathering societies breast-feed children up to three and four years of age (Schurr and Powell, 2005). The ethnographic evidence for weaning is between two to four years of age for Native American groups which is the time frame when the nutrient demands of a child exceed what breast milk can supply (Gardner et al., 2011). A stable carbon isotope study of several preagricultural Native American populations establishes that children five years and older have the same diet as their mothers (Schurr and Powell, 2005). This indicates weaning had stopped in these populations by the age of five.

Previous research has linked the age of weaning stress to the development of LEH (e.g. Goodman et al., 1984). However, researchers note that because peak LEH frequencies occur during the same time ranges as weaning (between two to four years of age) bioarcheologists have erroneously singled out weaning stress as the primary factor for the presence of LEH (e.g. Katzenberg et al., 1996; Larsen, 1997). It is beyond the scope of this study to examine the relationship between weaning stress and LEH frequency in Ohio Hopewell populations. However, it is plausible that the cultural practice of giving children of weaning age food that was easier for them to eat, but less nutritious, was a contributing factor in the nutritional stress faced by Ohio Hopewell children. An example of a possible weaning food is cereal gruel which is high in carbohydrates, but low in protein (Goodman et al, 1984). All of these cultural practices, whether intentional or unintentional, have the potential to result in dietary and nutritional stresses that affected children in the SW region. Additionally, LEH lesions can be caused by an increased prevalence of childhood illness in a population.

If SW male children and male adolescents were both denied adequate levels of the nutrients it can be hypothesized that this would result in statistically significant differences in stature between SW and SC males. Since this is not evident in this study, it potentially supports the premise that once SW males were in their adolescent years they played a more important role in the subsistence of their community, and in turn received the same diet as adults. Adequate nutrition during this time period would provide them the critical nutrients required to use "catch-up growth" to maximize their genetic potential for height, thus negating any differences in stature between SW and SC males.

Achievement of adult social status in Ohio Hopewell society is another possible explanation for why differences in the biological status of adults are not associated with variation in social status. The social status that an adult has acquired through personal achievement during adolescence and adulthood has no effect on the susceptibility of this individual to the stress that causes LEH, PH, or stature during childhood and adolescence. Thus, a strong case can be made that better biological status involving these skeletal indicators is dependent on the social status of an individual's parents. It is the social status of a child's parents that has the potential to buffer increased stress that affects the individual during childhood.

If differential access to food resources and nutrients based on social status was the driving force for the nonspecific stress that caused increased LEH frequencies in the SW population, it is probable the social status of a child's family was a factor in this differential access. An individual is susceptible to nonspecific stress that causes LEH in adult teeth during childhood under the age of seven. During periods of increased nutritional stress, perhaps caused by changing environmental conditions that led to food shortages, it would be the social status of an individual's parents that would be instrumental in attempting to buffer increased stress from affecting their children. If a child's parents were of lower social status this may have given the family less access to food resources that thereby increased the nutritional stress on their children. Alternatively, a child with parents of higher social status may have been buffered from nutritional stress as their family may have had the ability to obtain required food resources.

The results of the intraregional and interregional analysis of biological status in this study may strengthen the premise that Ohio Hopewell social status emphasized achievement, because there are not significant differences of biological status related to different levels of adult social status based on sex. The evidence also indicates that if ascription of social status was emphasized in the SW region, it was not based on sex, as both SW males and females have high frequencies of LEH.

Summary: Intraregional and Interregional Biological Status and Social Status

There is little evidence that social status based on sex strongly influenced biological status in the SC and SW regions. Biological status in the SC and SW regions does not reflect differences in social status based on sex. The Ohio Hopewell represent a complex egalitarian society in which leadership and prestige may have resulted in differential social status for each sex in different regions, but it did not lead to gender stratification, particularly in the SC region where only males occupied the highest social positions of prestige and leadership. Differences in adult social status were noted at death and were most likely based on achievement, but these differences were not dramatic enough during life, particularly in childhood, to have a significant effect on an individual's resulting biological status. The analysis of biological status in this study does not support a model of Ohio Hopewell social status that is dependent on sex related ascription.

The results of this intraregional and interregional analysis of biological status reveal that the frequency of LEH is higher in both SW males and females. The most probable explanation for this is a regional increase in nutritional stress related to environmental changes and resulting food shortages in the SW region, or regional variation in diet. Future paleobotanical research in the SW region, and dietary isotopic research on the Turner population is warranted.

A limitation of this intraregional and interregional analysis of biological status and social status is that the Turner site was not completely excavated. Thus, it is unknown whether this burial population is an accurate representation of the whole society. Additionally, the SW skeletal population is only represented by the Turner site, as there are not other skeletal collections from this region available for analysis that fit the criteria of this study (Case and Carr, 2008). Therefore, the differences in the frequency of LEH detected between the SW and SC regions could be related to sampling bias. The SW region is only represented by one site, while the SC region utilizes a more regional approach, although the Hopewell Mound Group represents 85% of the SC adults in this study.

Biological Status Between and Within Prestigious SC Mounds

The third part of this study examines differences in the biological status of adults within and between different SC mound groups. Indicators of the biological status of adult males and females from within the SC region were used to test the hypotheses of whether increased social status is associated with differences in skeletal biology. Does biological status reflect differences in social status at different burial mound locations in the SC region?

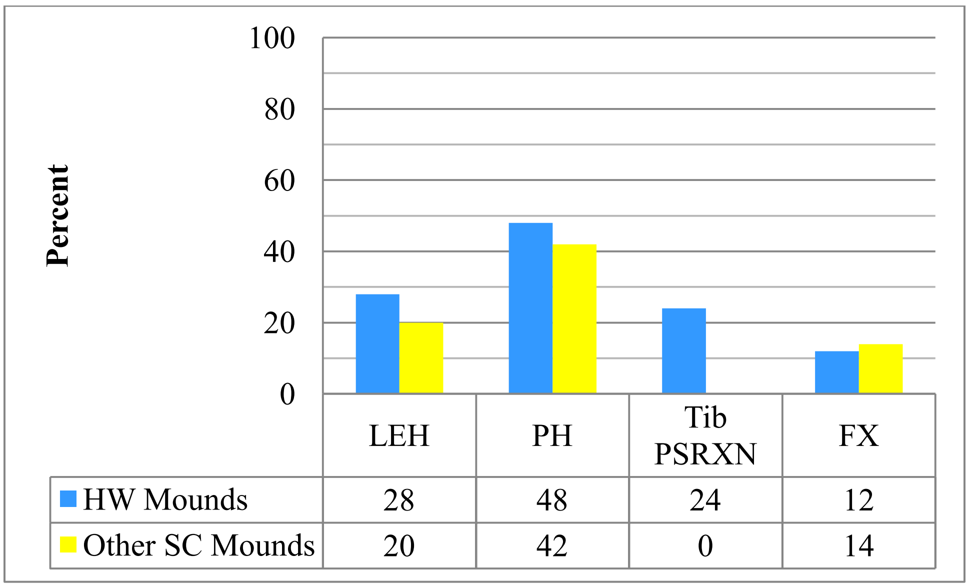
The Hopewell Mound Group is unique due to its large burial population, several large mounds, and rich deposits of exotic artifacts. Coon (2009) proposes that the SC region utilized an exclusionary political economy that resulted in select individuals gaining more prestige that was then reflected at death by elaborate mortuary rituals. Nowhere is this more visible than at the Hopewell Mounds. Several researchers note the richness and prestigious nature of artifacts found at the Hopewell Mounds, such as copper plates, celts, or headplates (e.g. Case and Carr, 2005; Greber and Ruhl, 1989; Seeman, 2004). Carr (2005c) hypothesizes that Ohio Hopewell communities buried their most prestigious community members, “special persons”, at Hopewell Mound Group. Less prestigious members of their communities were buried at other SC sites: Seip, Edwin Harness, and Ater mounds that “served to contain a broader but still incomplete society” (Carr, 2005c:280).

Hopewell Mounds vs. Other SC Mounds

Overall, the results of this intersite analysis in the SC region indicate that if the adults buried at the Hopewell Mounds were indeed prestigious community leaders, it did not result in better biological status. These results do not meet the expectations of the research hypotheses that the biological status of the adults buried at the Hopewell Mounds should be better than those buried at Seip, Harness, Ater, or Rockhold Mounds. There is no skeletal evidence involving markers of biological status to support the hypothesis by Carr (2005c) that those buried at the Hopewell Mounds were “special persons”. These adults may have filled high status social positions during life, and the mortuary rituals associated with their death may have been special, but their biological status was not also special.

For each of the 14 markers of biological status there is no statistically significant difference in the frequencies of these markers between adults buried at the Hopewell Mounds and adults buried at the other SC mounds (see Tables 32 – 34). Figure 21 displays the frequency of the four comprehensive markers of biological status for all adults. There is also no statistically significant difference between the mean long bone measurements of males compared to males, and females compared to females for the two groups. The descriptive statistics of the four long bone measurements are displayed in Tables 86 and 87 in the Appendix.

Figure 21 Hopewell Mounds vs. Other SC Mounds:
|Frequency of each marker of biological status for adults



Intrasite Analysis at the Hopewell Mound Group

Within the Hopewell Mound Group, Mound 23 and Mound 25 share similar architectural features and elaborate tomb construction, and are quite different from the other smaller mounds that contain burials. Both Mound 23 and Mound 25 share a similar loaf shape, are the two largest mounds by volume, have the two largest burial populations which contain primarily extended burials, and both have evidence for charnel houses (Carr, 2008e). The construction of the floors of Mounds 23 and 25 is similar, and both mounds have evidence for public ceremonial activities that were focused at the center of the mounds (Greber and Ruhl, 1989). When Mounds

23 and 25 are compared to the other smaller mounds with burials at Hopewell, Carr (2008e:659) questions whether there is evidence for social ranking between these two groups.

Conversely, there are several contrasting differences between Mounds 23 and 25. Mound 25 has the largest deposits of prestigious copper grave goods, several large ceremonial caches of exotic artifacts, and the most elaborate tomb construction (Carr, 2005c; Greber and Ruhl, 1989). Male burials outnumber female burials 3:2 at Mound 25 (Carr, 2008e), while the four adults with provenience to a specific burial number at Mound 23 are all female (Johnson, 2008). Carr (2005c:337) speculates whether adults buried at Mound 25 are from a higher social rank group than adults buried at Mound 23. However, Carr (2005c:337) believes the current archeological data does not support this hypothesis. Alternatively, Carr suggests that burial at Mound 25 was "restricted to a particular, largely important classes of individuals", whereas "Mound 23 contained the spouses or other affines of the persons not eligible for burial in Mound 25" (Carr, 2008e:626-627).

Based on the architectural features and mortuary rituals presented above and previously detailed in Chapter 4, this study proposes that the most prestigious burial mound at the Hopewell Mound Group is Mound 25, followed by Mound 23, and finally the least prestigious locations are the other Hopewell Mounds associated with burials. In this study, the other Hopewell Mounds are represented by adults from Mounds 2, 4, 7, 18, 24, 26, and 27. The expectations for these research hypotheses is that the adults buried at the more prestigious mounds will have better biological status than the adults from the less prestigious mounds.

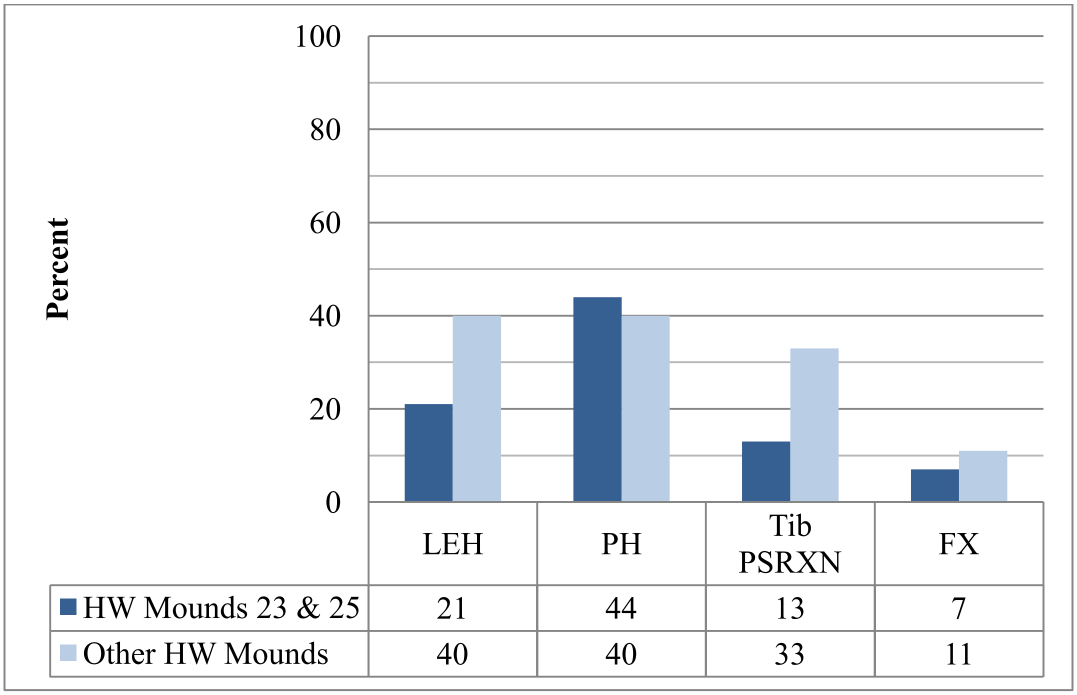
Overall, the results of this intrasite analysis at the Hopewell Mounds indicate there is not strong evidence to support the premise that adults buried at the most prestigious mounds had better biological status than those from less prestigious mounds. Biological status does not reflect differences in social status within the Hopewell Mound Group. There is no skeletal evidence involving markers of biological status that supports the various hypotheses by Carr that burial in Mound 25 was restricted to a certain class of important adults, or different social rank groups. The social positions filled by these adults during life, and the mortuary rituals associated with their death may have been more prestigious for the adults buried at Mound 25, but their biological status was not different than the adults buried at less prestigious mounds.

There is no statistically significant difference between the mean long bone measurements when males are compared to males, and females are compared to females in any of the intrasite analyses performed at the Hopewell Mound Group. The descriptive statistics of the four long bone measurements for the males and females are displayed in Tables 98, 102, 106, 107, 108, and 115 in the Appendix. The sample sizes for all analyses were small. The small Mound 23 sample size prevented the analysis of long bone measurements between Mound 23 and Mound 25 adults.

Hopewell Mounds 23 & 25 vs. Other Hopewell Mounds

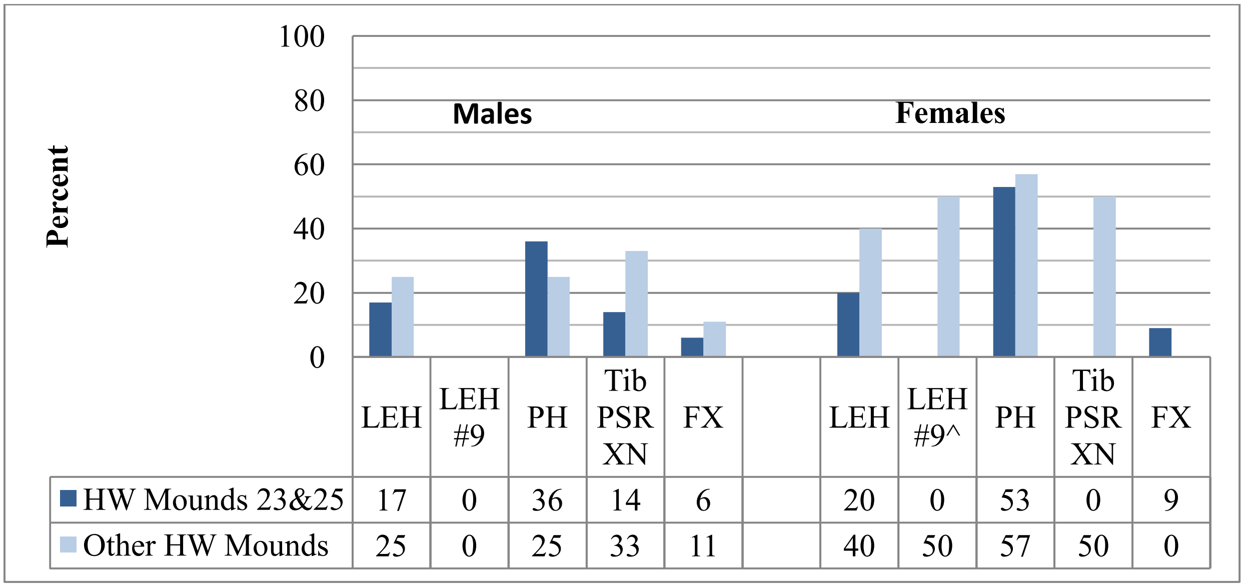
Hopewell Mounds 23 and 25 have several unique archaeological and mortuary features within the Hopewell Mound Group. However, the biological status of these two populations is similar. There is no statistically significant difference in the frequencies of the 14 markers of biological status between adults buried at Mounds 23 and 25 and adults buried at the other Hopewell Mounds (see Tables 36 - 38). Figure 22 displays the frequency of the four comprehensive markers for all adults.

Figure 22 Mounds 23 & 25 vs. Other Hopewell Mounds:
Frequency of each marker of biological status for adults



However, the frequency of LEH in maxillary central incisors is higher in the other Hopewell Mound females (50.0%, 2 of 4) than in females from Hopewell Mounds 23 and 25 (0%, 0 of 9). This difference is near statistically significant (p = 0.08, df = 1). Figure 23 displays the frequency of LEH in maxillary central incisors and the four comprehensive markers of biological status for both males and females. The only corresponding trend between the sexes is that both males and females from Mounds 23 and 25 have lower frequencies of LEH and tibial periosteal reactions.

Figure 23 Mounds 23 & 25 vs. Other Hopewell Mounds:
Frequency of each marker of biological status for males and females
Key: LEH #9 = LEH frequency in maxillary central incisors
Note: ^ Indicates near statistical significance at the $p < 0.10$ level



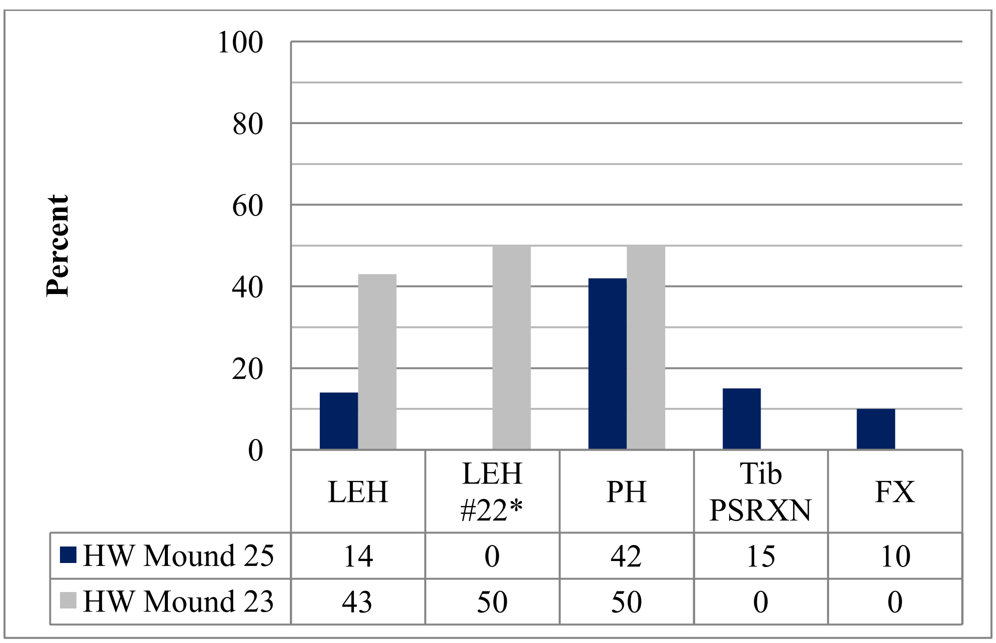
	LEH	LEH #9	PH	Tib PSR XN	FX		LEH	LEH #9^	PH	Tib PSR XN	FX
HW Mounds 23&25	17	0	36	14	6		20	0	53	0	9
Other HW Mounds	25	0	25	33	11		40	50	57	50	0

Hopewell Mound 25 vs. Hopewell Mound 23

Hopewell Mound 25 burials have more prestigious and numerous grave goods, and evidence of more elaborate mortuary rituals than burials at Hopewell Mound 23. There is no statistically significant difference in the frequencies of 13 of the 14 markers of biological status between adults buried at Mound 25 and adults buried at Mound 23 (see Tables 40 – 42). Figure 24 displays the frequency of the four comprehensive markers and of LEH in mandibular canines for all adults. The frequency of LEH in mandibular canines is lower in Mound 25 adults (0%, 0 of 19) than in Mound 23 adults (50%, 2 of 4). This difference is statistically significant (p = 0.02, df =1). However, caution must be used with the interpretation of this significance because of the small sample sizes involved in the analysis. This result does fit the expectations of the research hypotheses that adults from the more prestigious Mound 25 would have better biological status than adults from Mound 23.

The individual analysis of males and females reveals that none of the Mound 25 or Mound 23 males have a mandibular canine with the presence of a LEH lesion. Conversely, there is a statistical significance for LEH frequency in mandibular canines between the two female groups (p = 0.02, df = 1). The frequency of LEH in mandibular canines is higher in Mound 23 females (100%, 2 of 2) than in Mound 25 females (0%, 0 of 9). It is apparent that the high frequency of LEH in the mandibular canines of females leads to the statistically significant result for all adults, as males from either location do not have LEH lesions on these teeth.

Figure 24 Mound 25 vs Mound 23: Frequency of each marker of biological status for adults
Key: LEH #22 = LEH in mandibular canines
Note: * Indicates statistical significance at the $p < 0.05$ level

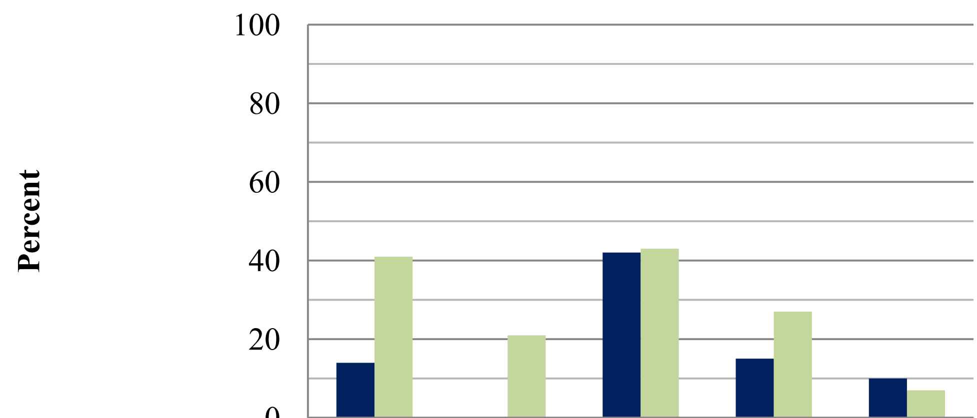


Hopewell Mound 25 vs. Other Hopewell Mounds (including Mound 23)

Although Hopewell Mound 25 shares some architectural and mortuary features with Hopewell Mound 23, there are also several contrasting features that have been noted above that make Mound 25 unique at the Hopewell Mound Group. It has been proposed by several archeologists that Hopewell Mound 25 is the most prestigious burial location at the Hopewell Mound Group, if not in all of Ohio (e.g. Carr, 2005c; Carr, 2008e; Greber and Ruhl, 1989). However, the biological status of adults buried at Mound 25 is not better than the adults buried at the other Hopewell Mounds (including Mound 23). In this intrasite analysis, the other Hopewell Mounds are represented by adults from Mounds 23, 2, 4, 7, 18, 24, 26, and 27

There is no statistically significant difference in the frequencies of each of the 14 markers of biological status between adults buried at Mound 25 and adults buried at the other Hopewell Mounds (see Tables 44 – 46). Figure 25 displays the frequency of the four comprehensive markers of biological status and LEH in mandibular canines for adults. The frequency of LEH in mandibular canines is lower in adults from Mound 25 (0%, 0 of 19) than in adults from the other Hopewell Mounds (21%, 3 of 14). This difference is near statistically significant (p = 0.07, df =1). Although not statistically significant, this result meets the expectations of the research hypotheses that adults buried at Mound 25 would have better biological status than those buried at the other less prestigious Hopewell Mounds.

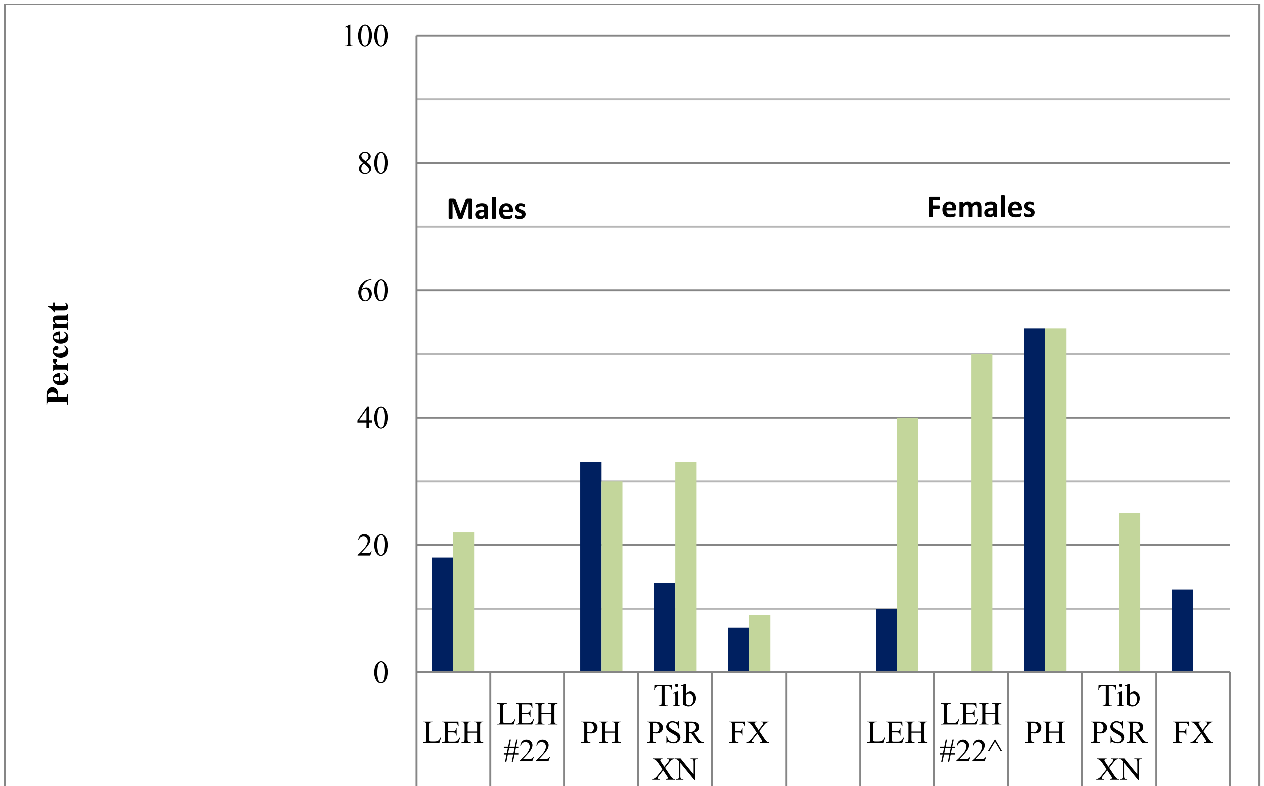
Figure 25 Mound 25 vs. Other Hopewell Mounds:
Frequency of each marker of biological status for adults
Key: LEH #22 = LEH in mandibular canines
Note: ^ Indicates near statistical significance at the $p < 0.10$ level



	LEH^	LEH #22^	PH	Tib PSRXN	FX
HW Mound 25	14	0	42	15	10
Other HW Mounds	41	21	43	27	7

The individual analysis of males and females from Mound 25 and the other Hopewell Mounds reveals a near statistical significance for the frequency of LEH in mandibular canines of females ($p = 0.08$, df =1). Females from the other Hopewell Mounds (50%, 2 of 4) have a higher frequency of LEH in mandibular canines than females from Mound 25 (0%, 0 of 9). Figure 26 displays the frequency of the four comprehensive markers of biological status and LEH in mandibular canines for both males and females. None of the males from either burial location have a LEH present on their mandibular canines. The small sample size and high percentage of LEH in females appears to influence the near statistical significance of LEH frequency of all adults from the other Hopewell Mounds. None of the other markers of biological status are statistically significant for either males or females, although both males and females from Mound 25 have lower frequencies of tibial periosteal reactions.

Figure 26 Mound 25 vs Other Hopewell Mounds: Frequency of each marker of biological status
Key: LEH #22 = LEH in mandibular canines
Note: ^ Indicates near statistical significance at the $p < 0.10$ level



	LEH	LEH #22	PH	Tib PSR XN	FX		LEH	LEH #22^	PH	Tib PSR XN	FX
HW Mound 25	18	0	33	14	7		10	0	54	0	13
Other Hopewell Mounds	22	0	30	33	9		40	50	54	25	0

Summary of LEH Frequency at the Hopewell Mound Group

The intrasite analysis of biological status and prestigious burial mound location at the Hopewell Mound Group reveals several markers of LEH that have statistically significant, or near statistically significant differences. However, all of the results with statistical significance are based on small sample sizes and need to be cautiously interpreted. There is a statistically significant lower frequency of LEH in mandibular canines for all adults, and for females buried at Mound 25 compared to Mound 23. Adult sample sizes for LEH in mandibular canines are:

Mound 25 (n = 19), and Mound 23 (n = 4). Females sample sizes for LEH in mandibular canines are: Mound 25 (n = 2), and Mound 23 (n = 9). Furthermore, a closer examination of these results reveals that the high frequencies of LEH in Mound 23 females (2 of 5) and LEH in mandibular canines (2 of 2) skews the results in the direction of always being more prevalent in whichever group the Mound 23 females are used during analysis.

These significant results do fit the expectations of the various research hypotheses that the frequency of LEH should be lower in adults from the more prestigious burial mound locations, i.e. Mound 25. However, the only conclusion that can be safely drawn from the LEH results in this intrasite analysis at the Hopewell Mound Group is that Mound 25 females (n = 10) have a low frequency of LEH. None of the Mound 25 females have the presence of LEH lesions on maxillary central incisors (n = 8), or on mandibular canines (n = 9). These are the two teeth types most susceptible to LEH (Goodman and Armelagos, 1985).

Additionally, the frequency of LEH in mandibular canines is lower in adults from Mound 25 (n = 19) than in adults from the other Hopewell Mounds, including Mound 23 (n = 14). This difference is near statistically significant (p = 0.07, df =1). Although the other Hopewell Mounds population does include Mound 23 females, this appears to be one of the more reliable results in the intrasite analysis. It involves a larger sample size than the other results with statistical significance. This result fits with the expectations of the research hypothesis that the frequency of LEH will be lower in adults buried at Mound 25, the most prestigious burial mound. This is interpreted as tentative evidence that adults buried at Hopewell Mound 25 may have been less susceptible to the nonspecific stress during childhood that caused LEH lesions than those buried at the other Hopewell Mounds.

Stature and Trauma: Between and Within Prestigious SC Mounds

In addition to LEH, stature is also an indicator of biological status that could be affected by the social status of an individual's parents. There are two periods of growth important for stature, one during childhood and the second one during adolescence. If an individual does not have the nutrients required to fuel growth they will not maximize their genetic potential for stature. In a society primarily based on ascription, the possibility exists that differential access to nutrients is allocated to individuals based on the social status they have inherited through their parents, especially during periods of increased environmental and nutritional stress. On the other hand, in a society emphasizing achievement, the differential access to nutrients is most likely affected by the social status that an individual's parents obtained based on personal characteristics or successes.

In this study, there are no statistically significant differences in any of the comparisons of long bone measurements used for stature in the interregional analysis (SC vs. SW), or the analysis between and within prestigious SC burial mounds. This is contrast to the study of Illinois Havana Hopewell which finds that high status males are taller than low status males (Buikstra, 1976). Based on these osteological results and other mortuary data, Buikstra proposes that Havana Hopewell ranked social status was based on ascription. Carr (2005c) has not found mortuary evidence for social ranking of the Ohio Hopewell. It is the premise of this study that Ohio Hopewell communities represent complex egalitarian societies. Therefore, the Havana Hopewell may not represent an ideal comparison for the Ohio Hopewell, but the results of the analyses in this study involving stature do not find any evidence to support the notion that prestigious mound burial was associated with a biological benefit for the growth and development of an individual's long bones during childhood and adolescence. This is further support of an Ohio Hopewell social status model that emphasized achievement of adult social status.

As previously discussed in this chapter, there is not strong archaeological evidence for violence or competition to be a common occurrence in Ohio Hopewell society. Therefore, the lack of statistically significant differences in the frequency of antemortem fractures between any of the intraregional, interregional, or different prestigious SC burial mounds is not overly surprising. However, it has been proposed by Carr and Case (2005) that certain social positions were based on hunting and/or warfare achievement or leadership. It can be hypothesized that the more activities related to hunting and violence that an individual is exposed to will lead to a greater chance this individual suffers an antemortem fracture. A previous study concludes that high status males participating in hunting and warfare activities increased their susceptibility to trauma in a late prehistoric population from Tennessee (Lahren and Berryman, 1984). It also must be noted that not all trauma will result in skeletal fractures. The lack of statistically significant differences in the frequency of trauma for any of the analyses in this study may suggest that achievement during hunting or warfare was not a primary factor for obtaining higher positions of leadership or prestige in Ohio Hopewell society. However, a better manner in which to examine this hypothesis would be to analyze the trauma of adults specifically identified by Case and Carr (2008) who filled these specific social positions.

Summary: Biological Status Between and Within Prestigious SC Mounds

Overall, the biological status of adults buried at the most prestigious burial mounds is not statistically different than those buried at the other less prestigious burials mounds. In the SC region, biological status does not reflect differences in social status at different burial mounds. The results of the analysis of the biological status between and within prestigious SC mounds provide little evidence that burial in a more prestigious mound indicates better biological status.

The result of the analysis of adults buried at the Hopewell Mound Group compared to the adults from all other SC mounds is particularly revealing. There are no statistically significant differences in biological status between these two burial mound populations (see Figure 21), despite the many different architectural and mortuary differences between these sites that indicates the Hopewell Mounds are a more prestigious burial location. The social status of the adults at the Hopewell Mounds may have been “special”, but their biological status was not better. Additionally, there is not compelling skeletal evidence to support the various hypotheses suggested by Carr (2005c, 2008e) that Hopewell Mound 25 adults represent a different social rank group, or a class of important adults. There is an indication that the frequency of LEH in adults from Hopewell Mound 25 is lower than in the other Hopewell Mounds, but these results are based on small sample sizes.

In a model of Ohio Hopewell social status based primarily on achievement, an adult’s social status would not have an impact on the nonspecific stress episodes they endured during their childhood. This would be reflected by markers of biological status that primarily affect children or adolescents, such as LEH, PH, or stature. For these markers of biological status, the social status of an individual’s parents may have been an important factor in the individual’s susceptibility to stress. In the analysis within and between prestigious SC mounds there is not compelling skeletal evidence that adults from the most prestigious mounds were treated differently in childhood during periods of stress than adults from other less prestigious mounds. This skeletal evidence supports the premise that achievement was an important sociocultural process for how adults obtained social status that resulted in burial at prestigious mounds. This skeletal evidence is consistent with an achievement model for social status based on archaeological data supported by several researchers (e.g. Seeman, 2004; Pacheco and Dancey, 2006). It is also consistent with the model of Ohio leadership by Carr and Case (2005) that proposes that leadership was only "moderately institutionalized". Additionally, the presence of very few subadults buried at Hopewell Mound 25 reinforces the notion that achievement was important for obtaining the social status needed to be buried in a prestigious burial mound.

Alternatively, if adults buried at the most prestigious burial mounds have better biological status this could represent evidence that the Ohio Hopewell utilized ascription as an important mechanism for the determination of social status. This would be particularly true for indicators of biological status that primarily affect children, such as LEH, PH, and stature. However, there is not overwhelming skeletal evidence to support ascription of social status in the analysis of biological status within the SC region. Adults from the more prestigious burial mounds did not have better biological status, particularly for PH and adult stature. There are some lower frequencies of LEH in the more prestigious burial mound populations that meet the expectations of the research hypotheses, but these involve small sample sizes and must be interpreted cautiously.

A limitation of the analysis of prestigious mound burial in the SC region is that the distribution of skeletal populations across different levels of social status could be problematic.

According to Carr (2005c), the Hopewell in the SC region appear to have practiced primarily cremation for individuals from a broader social spectrum who are buried at Seip, Harness, and Ater, while primary burial, especially at Hopewell Mounds 23 and 25, was reserved for those with social positions of prestige and leadership. For example, 88% (153 of 174) of the individuals excavated from Harness Mound were from cremated or partially burned burials; on the other hand, 76% (77 of 102) of the individuals excavated from Hopewell Mound 25 were from primary burials (Car 2005:279).

If differential mortuary treatment (primary burial vs. cremation) was based on social status, this has the potential to obscure the results of the analysis of markers of biological status utilized in this study. If primary burial was a mortuary treatment used for individuals of higher social status, then the analysis in this study of biological status within the SC region compared individuals of similar levels of elevated social status. Thus, the association between biological status and prestigious social status may not necessarily be representative of all the social groups who lived within these communities.

Chapter 7: Conclusions

This study examined the relationship between biological status and social status in the Ohio Hopewell who represent a prehistoric, complex egalitarian society. Overall, this study explored whether biological status reflects variation in Ohio Hopewell social status. This chapter notes the contributions of this study, its limitations, and identifies future lines of research.

Contributions of this Study

There are several contributions of this research to the bioarchaeology of Ohio Hopewell skeletal populations and the study of Ohio Hopewell social organization. First, it documents the skeletal markers of biological status for Ohio Hopewell people from the south-central (SC) and southwest (SW) regions of Ohio. The markers of biological status utilized in this research indicate nonspecific systemic physiological stress, dietary nutritional stress, nonspecific infection and/or disease, or trauma to the skeletal system. This data set of markers of biological status can complement the Ohio Hopewell bioarchaeological database in future research. The Hopewell database (HOPEBIOARCH) created by Case and Carr (2008) contains age and sex details, as well as information on mortuary treatment and associated artifacts for over 1,000 Hopewell individuals from 52 ceremonial centers (earthworks and mounds) across Ohio.

Perhaps more importantly, this study employed an approach based on skeletal biology for examining Ohio Hopewell social status. This study examined the intraregional and interregional relationships between Ohio Hopewell biological status and differences in social status of male and female adults. This study contributes to the understanding of the relationship between differing levels of social status, particularly those associated with sex, and biological status in a complex egalitarian society. This contribution is particularly significant because the majority of previous research on the relationship between skeletal stress and social status has focused on complex societies that exhibit large disparities in social status. The final part of this study investigated whether differences in biological status are related to differences in social status at prestigious burial mounds within the SC region.

Biological Status of Ohio Hopewell Leadership

The main focus of this study was the examination of the relationship between biological status and social status in Ohio Hopewell societies. This research tested the validity of a proposed archaeological model for prestige and leadership in Hopewell society from a skeletal biology perspective. The nonsignificant results detected in this study for differences in markers of biological status related to social status support the model of Ohio Hopewell leadership proposed by Carr and Case (2005).

Ohio Hopewell communities represent complex egalitarian societies in which people obtained different positions of social status based primarily on achievement. It has been proposed that Ohio leadership and prestige was based on many different types of leaders who performed specific important social roles, and that leadership was moderately institutionalized (Carr and Case, 2005). In such a model of social status where leadership is diversified and separated into many different roles it is difficult for a few select individuals to control the economic resources (i.e. food surpluses) of a group. Furthermore, there is little evidence to suggest that large agricultural food surpluses existed in Ohio Hopewell communities. Additionally, the settlement pattern of dispersed hamlets across the landscape that involved small bands of several families appears to make it unlikely that access to food surpluses or resources was differentially controlled by a few select prestigious community leaders.

Differences in Ohio Hopewell social status were noted at death in the mortuary record, and were most likely based on achievement, but these differences were not dramatic enough during life, particularly in childhood, to have a measurable effect on an individual's biological status. The overall nonsignificant differences in biological status detected in this study supports a model of Ohio Hopewell social status primarily based on the achievement of social status. This is consistent with an achievement model for social status based on archaeological evidence supported by several different researchers (e.g. Seeman, 2004; Pacheco and Dancey, 2006).

Intraregional Variation of Biological Status

There is little evidence that social status based on sex strongly influenced biological status in the SC and SW regions. The results of this intraregional analysis do not reveal a statistically significant difference in biological status between males and females within each region. Biological status within the SC and SW regions does not reflect differences in social status based on sex. Additionally, this study demonstrates that increased female access to social status in the SW region did not result in differential biological status of males or females. This is evidence derived from skeletal biology that supports the premise that complementary gender roles do not always lead to gender stratification (Ackerman, 1995).

The results of this intraregional analysis also provide skeletal evidence to reinforce the notion that women were not subordinate in Ohio Hopewell societies (Carr, 2005a). This is particularly evident in the SC region where it is hypothesized that only males filled the highest social positions. This male bias for positions of higher social status did not result in different biological status for males or females in the SC region. Furthermore, there is no skeletal stress evidence to support the premise that differential access to food resources and nutrients was based on sex differences within either region.

Interregional Variation of Biological Status

By examining the regional variation of biological status markers between two skeletal populations, this study contributes to the emerging archaeological literature examining aspects of Hopewellian societies at a local level. Additionally, the analysis of skeletal stress provides insight into Ohio Hopewell interregional differences regarding subsistence and habitation lifeways that cannot be addressed by analyzing archaeological artifacts and material culture alone. The SW region skeletal population is comprised of adults from the Turner Mound Group which is located along the Little Miami River. The SC region skeletal population is represented by adults buried at the Hopewell Mound Group, Seip Earthworks, Edwin Harness Mound, Raymond Ater Mound, and Rockhold Mound Group. These SC sites are all located on the Scioto River or Paint Creek, one of its tributaries.

The two most prevalent markers of biological status in both regions are linear enamel hypoplasias (LEH) and porotic hyperostosis. The frequency of these skeletal lesions indicates that these Ohio Hopewell populations, especially those from the SW region, were under periods of nonspecific systemic stress that could have included nutritional deficiency and/or periodic illnesses during their childhood. However, the frequency of tibial periosteal reactions or antemortem long bone or calvaria fractures is not particularly high in either region. Fractures of the calvaria are more common in both regions than long bone fractures. These were typically healed, depressed calvaria fractures that may have been the result of accidents, or violence. However, the absence of high rates of skeletal trauma detected in this study supports the hypothesis that violence which affects the skeletal system does not appear to have been a common occurrence in Ohio Hopewell life.

The results of this study reveal there is interregional variation of the biological status between adults from the SW region and the SC region. The frequency of LEH is higher in SW adults than in SC adults, and this difference is near statistical significance. This is evidence that adults from the SW suffered increased nonspecific stress during childhood (i.e. under the age of seven). In the SW region, the emphasis was on female leadership (Field et al., 2005; Rodrigues, 2005), whereas males predominantly filled these high status social positions in the SC region (Field et al., 2005).

The interregional analysis of biological status and social status based on sex differences leads to conflicting results. The frequencies of all the markers of biological status, other than LEH, are nonsignificant between SC and SW males despite the hypothesized differences for male social status between the two regions. However, the frequency of LEH is statistically significantly higher in SW males than SC males. The frequency of LEH is also higher in SW females than SC females, and this difference is near statistical significance; all other markers are nonsignificant. For males, this meets the expectations of the research hypotheses based on elevated male social status in the SC region. On the contrary, the higher frequency of LEH in SW females than SC females does not meet the expectations based on increased female access to high status social positions in the SW region. The increased access of SW females to high status social positions did not result in SW females having "better" biological status than SC females.

The interregional results indicate that biological status differences between the SW and SC regions do not reflect variation in social status. Based on the contradictory results of the association between biological status and social status in this study, it is inferred that the differences in the frequency of LEH between the two regions is most likely related to factors other than social status based on sex. The most probable explanation is a regional increase in nutritional stress related to environmental changes and resulting food shortages in the SW region, or regional variation in diet.

The biological status of Ohio Hopewell populations is not the same in all regions of Ohio. This variation in biological status aligns with the differences detected between the SW and SC regions for material culture artifacts (e.g. ceramics, stone tools, panpipes, and ear spools), and the ideology of political economy (Hawkins, 1996; Nolan et al., 2007; Turff and Carr, 2005; Ruhl and Seeman, 1998; Coon, 2009). As previously noted, archaeologists have also examined the social status of males and females from the SC and SW regions, and have proposed that male and female access to positions of leadership and prestige in local Ohio Hopewell societies differs by region (Field et al., 2005).

Furthermore, these interregional differences based on both osteological and archaeological data between groups of people from different river drainages in Ohio indicate that "Ohio Hopewell" may not be the best classification term for these groups. These local differences support the notion that there was not a pan-Hopewellian interaction sphere that resulted in similar cultural features across Hopewell regional traditions, or even in local regions within the same regional tradition. Perhaps calling these groups of people the Scioto Hopewell and the Little Miami Hopewell would better recognize the biological and cultural variation that existed between Hopewell groups from different river drainage areas in Ohio. For example, the difference in the frequency of LEH between SW and SC adults may be related to differences in subsistence strategies between the Scioto and Little Miami Hopewell groups. If the Little Miami group was more dependent on domesticated plants as a component of their diet, it is plausible that increased environmental stress, perhaps the result of climatic change, led to increased biological stress on this group that resulted in a higher frequency of LEH. Carr, Case, and their colleagues already employ the term Scioto Hopewell in their comprehensive edited volumes that focus on the Hopewell from the SC region of Ohio (Carr and Case, eds., 2005; Case and Carr, eds., 2008).

Biological Status Between and Within Prestigious SC Mounds

The final part of this study examined differences in the biological status of adults between and within different SC mound groups. Biological status does not reflect variation in social status at different prestigious burial mounds within the SC region. The results of the intersite analysis between adults buried at the Hopewell Mounds and adults buried at Seip, Harness, Ater, or Rockhold Mounds reveal there is no statistically significant difference in the biological status of these two populations. Likewise, there is no significant difference in the biological status of leaders buried in the most prestigious Hopewell Mounds (i.e. Mound 25) and adults buried in the other Hopewell Mounds. There is an indication that the frequency of LEH in adults from Hopewell Mound 25 is statistically significantly lower than in the other Hopewell Mounds, but these results are based on small sample sizes and must be interpreted cautiously. The results of the analysis of the biological status between and within prestigious SC mounds provide little evidence that burial in a more prestigious mound indicates “better” biological status.

Regional Variation of Biological Status: Illinois vs. Ohio

In this study of the Ohio Hopewell, there are no statistically significant differences between markers of biological status and social status, whether related to sex, or burial at prestigious SC mounds. This is in contrast to the Illinois Havana Hopewell in which a previous study detects a statistically significant difference between a marker of biological status (i.e. stature) and elevated social status. Buikstra (1976) finds that high status males are taller than low status males. Based on these osteological results and other mortuary data, Buikstra proposes that Havana Hopewell ranked social status was based on ascription (i.e. inherited).

In this study, there is no statistically significant difference between any of the long bone measurements of males or females used to assess stature and adult body size for any of the interregional analyses, or between and within the prestigious SC mounds. The results of the stature analyses in this study do not find any evidence to support the notion that prestigious mound burial was associated with a biological benefit for the growth and development of an individual’s long bones during childhood and adolescence. As previously discussed in this chapter and Chapter 6, this reinforces the notion that Ohio Hopewell groups emphasized achievement of adult social status in a complex egalitarian society. This is in contrast to the relationship between stature and ascribed, ranked social status in the Havana Hopewell. Furthermore, this is skeletal evidence that supports the viewpoint that major sociocultural differences existed between different Hopewell regional traditions.

Limitations of this Study

The first limitation of this study is methodological. The indicators of skeletal stress utilized in this study simply may not have been sensitive enough to reveal the nonspecific stresses that possibly affected the health of Ohio Hopewell adults of varying levels of social status.

As previously mentioned in other chapters in this dissertation, there are several limitations based on the incomplete excavation of a couple of the sites used in this study. A limitation of the intraregional and interregional analysis of biological status and social status is that the Turner Mound Group in the SW region was not completely excavated. Likewise, Raymond Ater Mound in the SC region was not completely excavated. This could potentially affect the results of this study because these missing burial areas may have been representative of a segment of Ohio Hopewell society not represented in the burial areas which have been excavated. This could be more problematic in the SW region because the skeletal population is only represented by the Turner site. There are not any other skeletal collections from this region available for analysis that fit the criteria of this study.

A second limitation is the nature of Ohio Hopewell mortuary practices that involved both primary burial and cremation. The Hopewell in the SC region appear to have practiced mainly cremation for individuals from a broader social spectrum buried at Seip, Edwin Harness, and Raymond Ater Mounds, while primary burial (especially at Hopewell Mounds 23 and 25) was chiefly reserved for those with social positions of prestige and leadership (Carr, 2005c). If primary burial was indeed a mortuary treatment reserved for individuals of elevated social status, then the results of the analysis of biological status in this study that utilized any of the SC skeletal populations may have actually compared individuals of similar levels of elevated social status.

Therefore, it is possible that adults from the primary burials in the SC region, especially those from the Hopewell Mound Group, used in this study had an elevated social status by their mere presence as primary burials in prestigious burial mounds. The comparison of the biological status of adults between the SC and SW regions could be flawed, because SC adults may have had elevated social status. Thus, it is plausible that the elevated social status and hence "better" biological status of all adults from the SC region, particularly from the Hopewell Mounds, is the explanation for the lower frequency of LEH in SC adults when compared to SW adults.

Finally, the population origins of the adults buried at Hopewell Mound Group is a potential limitation of this study. Recent analysis using strontium isotopes demonstrates that approximately fifteen percent of the adults buried at the Hopewell Mound Group did not have local isotopic signatures; they represent probable immigrants to the region (Beehr, 2011). If these individuals migrated to the SC region during adulthood, then the indicators of biological status that primarily affect a child or adolescent (i.e. LEH, porotic hyperostosis, or stature) may not be reflective of the association between biological and social status within the SC region.

Future Research

This study detected a higher frequency of LEH in adults from the SW region than in adults from the SC region. Whether this is the result of differences in regional ecological niches, diets, food shortages, or the result of differential access of children to important nutrients based on some factor other than sex warrants future investigation. Thus, future research should focus on the isotopic analysis of the diet of skeletal populations from different local regions of Ohio. This is especially needed for the Turner Mound Group in the SW region, because there has not been any isotopic research conducted at this site.

Another future line of research that may help to elucidate the differences in skeletal stress between the two regions is the analysis of the biological status of Ohio Hopewell subadults. The subadult sample sizes are small, particularly at Hopewell Mound 25, but the analysis of markers of skeletal stress combined with age-at-death information could provide useful data on the regional variation of skeletal stress. This data could also be utilized to determine whether the children of the SW region were afforded a biological benefit that accompanied increased female leadership in this region. Additionally, the evidence of skeletal stress in subadults could also be combined with mortuary analysis, as well as with ancient DNA analysis, to investigate whether social status in Ohio Hopewell society emphasized elements of achievement and/or ascription.

In order to better understand the relationship between biological status and social status in Ohio Hopewell societies, future research should also create osteobiographies of Hopewell prestigious community leaders. This echoes a similar suggestion by Carr (2008e) to develop life histories of these leaders utilizing multiple lines of skeletal investigation, such as ancient DNA and isotopic techniques. More specifically, future research should utilize osteobiographies to examine the biological status of individuals buried with distinct prestigious artifacts, such as copper headplates and copper celts, that have been proposed to denote community-wide leadership positions (Bernadini and Carr, 2005; Carr, 2005c; Carr, 2008c).

A similar line of future osteobiographies should focus on the isolated skulls that accompany several Hopewell Mound burials that have been interpreted differently as trophy skulls, or as revered ancestors (Seeman, 1988; Johnston, 2002). These isolated skulls could be treated as a type of a mortuary grave good, and the biological status of the individuals buried with these skulls could be analyzed. Additionally, the skeletal biology of the isolated skulls themselves should be examined for potential evidence of the skeletal stress these individuals encountered during their life. Finally, ancient DNA analysis has the potential to determine whether familial relationships existed between the individuals and the isolated skulls interred together, or elsewhere in the burial mound. Isotopic analysis could also be used to determine whether the individuals represented by isolated skulls are from a different geographical area.

APPENDICES

Appendix A

Long Bone Measurement Data Analyses

One-way ANOVA results for the long bone measurements of all adults

Table 53 Tests of normality for each long bone measurement for all adults in SC region

	Shapiro-Wilk		
	Statistic	df	Sig.
Humerus Max Diameter of Head	.910	14	.158
Femur Max Diameter of Head	.988	40	.940
Femur Max Length	.901	27	.014
Tibia Length	.934	20	.183

Table 54 Tests of normality for each long bone measurement for all adults in SW region

	Shapiro-Wilk		
	Statistic	df	Sig.
Humerus Max Diameter of Head	.937	11	.482
Femur Max Diameter of Head	.955	17	.548
Femur Max Length	.957	16	.600
Tibia Length	.909	13	.180

Table 55 Tests of normality for each long bone measurement for females in both regions

	Shapiro-Wilk		
	Statistic	df	Sig.
Humerus Max Diameter of Head	.938	16	.324
Femur Max Diameter of Head	.967	30	.470
Femur Max Length	.938	22	.178
Tibia Length	.909	16	.111

Table 56 Tests of normality for each long bone measurement for males in both regions

	Shapiro-Wilk		
	Statistic	df	Sig.
Humerus Max Diameter of Head	.929	8	.508
Femur Max Diameter of Head	.967	26	.550
Femur Max Length	.959	20	.515
Tibia Length	.943	15	.426

Table 57 One-way ANOVA showing the effect of region on each long bone measurement for all adults

		Sum of Squares	df	Mean Square	F	Sig.
Humerus Max Diameter of Head	Between Groups	24.608	1	24.608	2.488	.128
	Within Groups	227.510	23	9.892		
	Total	252.118	24			
Femur Max Diameter of Head	Between Groups	12.124	1	12.124	1.229	.272
	Within Groups	542.449	55	9.863		
	Total	554.573	56			
Femur Max Length	Between Groups	1866.308	1	1866.308	4.135	.049
	Within Groups	18506.296	41	451.373		
	Total	20372.605	42			
Tibia Length	Between Groups	1356.847	1	1356.847	2.599	.117
	Within Groups	16184.123	31	522.068		
	Total	17540.970	32			

Table 58 Levene's test of homogeneity of variances for all adults grouped by region

	Levene Statistic	df1	df2	Sig.
Humerus Max Diameter of Head	2.374	1	23	.137
Femur Max Diameter of Head	.868	1	55	.355
Femur Max Length	1.321	1	41	.257
Tibia Length	.104	1	31	.749

Table 59 Mann-Whitney U ranks for femur maximum length for all adults grouped by region

	Region	N	Mean Rank	Sum of Ranks
Femur Max Length	South-central	27	24.63	665.00
	Southwest	16	17.56	281.00
	Total	43		

Table 60 Mann-Whitney U test statistics for femur maximum length for all adults grouped by region

	Femur Max Length
Mann-Whitney U	145.000
Wilcoxon W	281.000
Z	-1.785
Asymp. Sig. (2-tailed)	.074

Table 61 One-way ANOVA showing the effect of sex on each long bone measurement from combined regions

		Sum of Squares	df	Mean Square	F	Sig.
Humerus Max Diameter of Head	Between Groups	111.322	1	111.322	18.092	.000
	Within Groups	129.218	21	6.153		
	Total	240.540	22			
Femur Max Diameter of Head	Between Groups	258.399	1	258.399	46.262	.000
	Within Groups	296.037	53	5.586		
	Total	554.436	54			
Femur Max Length	Between Groups	7490.212	1	7490.212	24.912	.000
	Within Groups	11725.788	39	300.661		
	Total	19216.000	40			
Tibia Length	Between Groups	5908.033	1	5908.033	16.114	.000
	Within Groups	10266.133	28	366.648		
	Total	16174.167	29			

Table 62 Levene's test of homogeneity of variances for sex

	Levene Statistic	df1	df2	Sig.
Humerus Max Diameter of Head	4.310	1	21	.050
Femur Max Diameter of Head	.068	1	53	.795
Femur Max Length	10.457	1	39	.002
Tibia Length	2.322	1	28	.139

Table 63 Welch Test results: robust tests of equality of means for sex

		Statistic[a]	df1	df2	Sig.
Humerus Max Diameter of Head	Welch	13.688	1	10.051	.004
Femur Max Diameter of Head	Welch	46.277	1	52.385	.000
Femur Max Length	Welch	24.285	1	29.857	.000
Tibia Length	Welch	16.114	1	26.160	.000

a. Asymptotically F distributed.

Table 64 Mann-Whitney U ranks for tibia length grouped by sex from combined regions

	Sex Identified	N	Mean Rank	Sum of Ranks
Tibia Length	Female	15	10.10	151.50
	Male	15	20.90	313.50
	Total	30		

Table 65 Mann-Whitney U test statistics for tibia length grouped by sex from combined regions

	Tibia Length
Mann-Whitney U	31.500
Wilcoxon W	151.500
Z	-3.363
Asymp. Sig. (2-tailed)	.001
Exact Sig. [2*(1-tailed Sig.)]	.000[a]

Analysis of Intraregional and Interregional Variation: Questions 1-3

Table 66 Tests of normality for each long bone measurement in SC females

	Shapiro-Wilk		
	Statistic	df	Sig.
Humerus Max Diameter of Head	.855	7	.136
Femur Max Diameter of Head	.974	18	.866
Femur Max Length	.880	11	.104
Tibia Length	.950	7	.734

Table 67 Tests of normality for each long bone measurement in SC males

	Shapiro-Wilk		
	Statistic	df	Sig.
Humerus Max Diameter of Head	.868	5	.260
Femur Max Diameter of Head	.960	20	.551
Femur Max Length	.960	14	.727
Tibia Length	.980	10	.967

Table 68 Tests of normality for each long bone measurement in SW females

	Shapiro-Wilk		
	Statistic	df	Sig.
Humerus Max Diameter of Head	.890	8	.235
Femur Max Diameter of Head	.896	11	.167
Femur Max Length	.921	10	.366
Tibia Length	.891	8	.239

Table 69 Tests of normality for each long bone measurement in SW males

	Shapiro-Wilk		
	Statistic	df	Sig.
Humerus Max Diameter of Head	.935	3	.506
Femur Max Diameter of Head	.962	6	.833
Femur Max Length	.968	6	.877
Tibia Length	.818	5	.113

Table 70 Two-way ANOVA showing the effects of region and sex on the maximum diameter of the head of the humerus

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	120.913[a]	3	40.304	6.401	.004
Intercept	35878.695	1	35878.695	5698.515	.000
REGION	9.294	1	9.294	1.476	.239
SEX_M_F	94.064	1	94.064	14.940	.001
REGION * SEX_M_F	2.324	1	2.324	.369	.551
Error	119.627	19	6.296		
Total	40427.060	23			
Corrected Total	240.540	22			

a. R Squared = .503 (Adjusted R Squared = .424)

Table 71 Levene's test of homogeneity of variances for sex and region for the maximum diameter of the head of the humerus

F	df1	df2	Sig.
1.176	3	19	.345

Table 72 Two-way ANOVA showing the effects of region and sex on the maximum diameter of the head of the femur

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	265.885[a]	3	88.628	15.665	.000
Intercept	86833.903	1	86833.903	15347.478	.000
REGION	.224	1	.224	.040	.843
SEX_M_F	235.141	1	235.141	41.560	.000
REGION * SEX_M_F	6.516	1	6.516	1.152	.288
Error	288.551	51	5.658		
Total	108225.750	55			
Corrected Total	554.436	54			

a. R Squared = .480 (Adjusted R Squared = .449)

Table 73 Levene's test of homogeneity of variances for sex and region for the maximum diameter of the head of the femur

F	df1	df2	Sig.
1.445	3	51	.241

Table 74 Two-way ANOVA showing the effects of region and sex on tibia length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6434.352[a]	3	2144.784	5.725	.004
Intercept	3819498.394	1	3819498.394	10195.981	.000
REGION	382.017	1	382.017	1.020	.322
SEX_M_F	4738.243	1	4738.243	12.649	.001
REGION * SEX_M_F	171.601	1	171.601	.458	.504
Error	9739.814	26	374.608		
Total	4104695.000	30			
Corrected Total	16174.167	29			

a. R Squared = .398 (Adjusted R Squared = .328)

Table 75 Levene's test of homogeneity of variances for sex and region on tibia length

F	df1	df2	Sig.
1.049	3	26	.387

Table 76 Levene's test of homogeneity of variances for sex and region on maximum length of the femur

F	df1	df2	Sig.
3.797	3	37	.018

Table 77 One-way ANOVA showing the effect of sex on the maximum length of the femur in the SW region

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1793.067	1	1793.067	6.234	.026
Within Groups	4026.933	14	287.638		
Total	5820.000	15			

Table 78 Test of homogeneity of variances for sex on the maximum length of the femur in the SW region

Levene Statistic	df1	df2	Sig.
.878	1	14	.365

Table 79 One-way ANOVA showing the effect of sex on the maximum length of the femur in the SC region

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4764.698	1	4764.698	15.764	.001
Within Groups	6951.942	23	302.258		
Total	11716.640	24			

Table 80 Test of homogeneity of variances for sex on the maximum length of the femur in the SC region

Levene Statistic	df1	df2	Sig.
10.730	1	23	.003

Table 81 Welch Test results: robust tests of equality of means for sex on the maximum length of the femur in the SC region

	Statistic[a]	df1	df2	Sig.
Welch	18.631	1	18.846	.000

a. Asymptotically F distributed.

Table 82 One-way ANOVA showing the effect of region on the maximum length of the femur in females

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	172.911	1	172.911	1.167	.293
Within Groups	2814.327	19	148.122		
Total	2987.238	20			

Table 83 Test of homogeneity of variances for region on the maximum length of the femur in females

Levene Statistic	df1	df2	Sig.
2.467	1	19	.133

Table 84 One-way ANOVA showing the effect of region on the maximum length of the femur in males

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	574.002	1	574.002	1.265	.275
Within Groups	8164.548	18	453.586		
Total	8738.550	19			

Table 85 Test of homogeneity of variances for region on the maximum length of the femur in males

Levene Statistic	df1	df2	Sig.
.208	1	18	.654

Analysis of Hopewell Mounds vs. Other SC Mounds: Question 4

Table 86 Long bone measurements (mm) for males from the Hopewell Mounds, or other SC Mounds

	HW MD Males			*Other SC Males*		
Measurement	**Mean**	**Standard Deviation**	**(*n*)**	**Mean**	**Standard Deviation**	**(*n*)**
Humerus MDH	45.3	4.1	4			1
Femur MDH	46.4	2.1	17	46.3	0.9	3
Femur Max Length	463.6	22.4	11	476.3	17.5	3
Tibia Length	384.0	21.9	7	395.0	10.5	3

Table 87 Long bone measurements (mm) for females from the Hopewell Mounds, or other SC Mounds

	HW MD Females			*Other SC Females*		
Measurement	**Mean**	**Standard Deviation**	**(*n*)**	**Mean**	**Standard Deviation**	**(*n*)**
Humerus MDH	41.1	2.6	4	39.8	1.3	3
Femur MDH	45.2	2.5	13	42.6	1.8	5
Femur Max Length	441.0	10.3	7	434.3	7.6	4
Tibia Length	359.8	6.4	4	352.0	9.5	3

Table 88 Tests of normality for each long bone measurement in males from the Hopewell Mounds and the other SC mounds

		Shapiro-Wilk		
		Statistic	df	Sig.
Humerus Max Diameter of Head	HW MD	.864	4	.275
Femur Max Diameter of Head	HW MD	.949	17	.440
	Seip, Liberty, Ater, and Rockhold	.930	3	.490
Femur Max Length	HW MD	.961	11	.789
	Seip, Liberty, Ater, and Rockhold	.947	3	.554
Tibia Length	HW MD	.932	7	.567
	Seip, Liberty, Ater, and Rockhold	.993	3	.843

Table 89 Tests of normality for each long bone measurement in females from the Hopewell Mounds and the other SC mounds

		Shapiro-Wilk		
		Statistic	df	Sig.
Humerus Max Diameter of Head	HW MD	.826	4	.157
	Seip, Liberty, Ater, and Rockhold	.996	3	.878
Femur Max Diameter of Head	HW MD	.954	13	.658
	Seip, Liberty, Ater, and Rockhold	.749	5	.029
Femur Max Length	HW MD	.852	7	.129
	Seip, Liberty, Ater, and Rockhold	.883	4	.350
Tibia Length	HW MD	.981	4	.909
	Seip, Liberty, Ater, and Rockhold	.794	3	.100

Table 90 Test of homogeneity of variances for burial location on each long bone measurement in females from the Hopewell Mounds and the other SC mounds

	Levene Statistic	df1	df2	Sig.
Humerus Max Diameter of Head	.951	1	5	.374
Femur Max Length	.084	1	9	.778
Tibia Length	1.076	1	5	.347

Table 91 One-way ANOVA showing the effect of burial location on each long bone measurement in females from the Hopewell Mounds and the other SC mounds

		Sum of Squares	df	Mean Square	F	Sig.
Humerus Max Diameter of Head	Between Groups	3.010	1	3.010	.641	.460
	Within Groups	23.487	5	4.697		
	Total	26.497	6			
Femur Max Length	Between Groups	115.977	1	115.977	1.294	.285
	Within Groups	806.750	9	89.639		
	Total	922.727	10			
Tibia Length	Between Groups	102.964	1	102.964	1.689	.250
	Within Groups	304.750	5	60.950		
	Total	407.714	6			

Table 92 Test of homogeneity of variances for burial location on each long bone measurement in males from the Hopewell Mounds and the other SC mounds

	Levene Statistic	df1	df2	Sig.
Humerus Max Diameter of Head	.[a,b]	0	.	.
Femur Max Length	.975	1	12	.343
Tibia Length	1.622	1	8	.239

a. Groups with only one case are ignored in computing the test of homogeneity of variance for Humerus Max Diameter of Head.
b. Test of homogeneity of variances cannot be performed for Humerus Max Diameter of Head because only one group has a computed variance.

Table 93 One-way ANOVA showing the effect of burial location on each long bone measurement in males from the Hopewell Mounds and the other SC mounds

		Sum of Squares	df	Mean Square	F	Sig.
Humerus Max Diameter of Head	Between Groups	1.860	1	1.860	.112	.760
	Within Groups	50.007	3	16.669		
	Total	51.868	4			
Femur Max Length	Between Groups	380.002	1	380.002	.807	.387
	Within Groups	5649.212	12	470.768		
	Total	6029.214	13			
Tibia Length	Between Groups	254.100	1	254.100	.658	.441
	Within Groups	3090.000	8	386.250		
	Total	3344.100	9			

Table 94 Mann-Whitney U ranks for maximum diameter of the head of the humerus grouped by burial location for females from the Hopewell Mounds and the other SC mounds

		N	Mean Rank	Sum of Ranks
Femur Max Diameter of Head	HW MD	13	9.85	128.00
	Seip, Liberty, Ater, and Rockhold	5	8.60	43.00
	Total	18		

Table 95 Mann-Whitney U test statistics for maximum diameter of the head of the humerus grouped by burial location for females from the Hopewell Mounds and the other SC mounds

	Femur Max Diameter of Head
Mann-Whitney U	28.000
Wilcoxon W	43.000
Z	-.444
Asymp. Sig. (2-tailed)	.657
Exact Sig. [2*(1-tailed Sig.)]	.703[a]
Exact Sig. (2-tailed)	.688
Exact Sig. (1-tailed)	.344
Point Probability	.021

a. Not corrected for ties.

Table 96 Mann-Whitney U ranks for maximum diameter of the head of the humerus grouped by burial location for males from the Hopewell Mounds and the other SC mounds

		N	Mean Rank	Sum of Ranks
Femur Max Diameter of Head	HW MD	17	10.47	178.00
	Seip, Liberty, Ater, and Rockhold	3	10.67	32.00
	Total	20		

Table 97 Mann-Whitney U test statistics for maximum diameter of the head of the humerus grouped by burial location for males from the Hopewell Mounds and the other SC mounds

	Femur Max Diameter of Head
Mann-Whitney U	25.000
Wilcoxon W	178.000
Z	-.053
Asymp. Sig. (2-tailed)	.958
Exact Sig. [2*(1-tailed Sig.)]	1.000
Exact Sig. (2-tailed)	.984
Exact Sig. (1-tailed)	.493
Point Probability	.025

Analysis of Hopewell Mounds 23 & 25 vs. Other Hopewell Mounds: Question 5

Table 98 Long bone measurements (mm) for males from Hopewell Mounds 23 & 25 and the other Hopewell Mounds

	HW MD 23 & 25			*Other HW MDs*		
Measurement	**Mean**	**Standard Deviation**	**(*n*)**	**Mean**	**Standard Deviation**	**(*n*)**
Humerus MDH			1	45.7	4.9	3
Femur MDH	45.6	1.9	9	47.4	2.1	8
Femur Max Length	456.8	18.8	4	467.6	24.8	7
Tibia Length	379.3	6.8	3	387.5	29.8	4

Table 99 Tests of normality for each long bone measurement in males from Hopewell Mounds 23 & 25 and the other Hopewell Mounds

		Shapiro-Wilk		
		Statistic	df	Sig.
Humerus Max Diameter of Head	Other HW MDs	.750	3	.000
Femur Max Diameter of Head	HW MD 23 & 25	.664	9	.001
	Other HW MDs	.885	8	.209
Femur Max Length	HW MD 23 & 25	.792	4	.089
	Other HW MDs	.959	7	.813
Tibia Length	HW MD 23 & 25	.912	3	.424
	Other HW MDs	.907	4	.465

Table 100 Mann-Whitney U ranks for each long bone measurement grouped by burial location for males from Hopewell Mounds 23 & 25 and the other Hopewell Mounds

		N	Mean Rank	Sum of Ranks
Humerus Max Diameter of Head	HW MD 23 & 25	1	2.00	2.00
	Other HW MDs	3	2.67	8.00
	Total	4		
Femur Max Diameter of Head	HW MD 23 & 25	9	6.78	61.00
	Other HW MDs	8	11.50	92.00
	Total	17		
Femur Max Length	HW MD 23 & 25	4	4.75	19.00
	Other HW MDs	7	6.71	47.00
	Total	11		
Tibia Length	HW MD 23 & 25	3	4.00	12.00
	Other HW MDs	4	4.00	16.00
	Total	7		

Table 101 Mann-Whitney U test statistics for each long bone measurement grouped by burial location for males from Hopewell Mounds 23 & 25 and the other Hopewell Mounds

	Humerus Max Diameter of Head	Femur Max Diameter of Head	Femur Max Length	Tibia Length
Mann-Whitney U	1.000	16.000	9.000	6.000
Wilcoxon W	2.000	61.000	19.000	16.000
Z	-.471	-1.928	-.945	.000
Asymp. Sig. (2-tailed)	.637	.054	.345	1.000
Exact Sig. [2*(1-tailed Sig.)]	1.000[a]	.059[a]	.412[a]	1.000[a]
Exact Sig. (2-tailed)	1.000	.056	.412	1.000
Exact Sig. (1-tailed)	.500	.028	.206	.571
Point Probability	.250	.004	.048	.143

a. Not corrected for ties.

Table 102 Long bone measurements (mm) for females from Hopewell Mounds 23 & 25 and other Hopewell Mounds

	HW MD 23 & 25			*Other HW MDs*		
Measurement	**Mean**	**Standard Deviation**	**(*n*)**	**Mean**	**Standard Deviation**	**(*n*)**
Humerus MDH			1	40.2	1.2	2
Femur MDH	42.6	2.7	9	43.5	0.4	3
Femur Max Length	441.0	12.5	5			1
Tibia Length	362.5	7.8	2	357.0	5.7	2

Table 103 Tests of normality for each long bone measurement in females from Hopewell Mounds 23 & 25 and other Hopewell Mounds

		Shapiro-Wilk		
		Statistic	df	Sig.
Humerus Max Diameter of Head	Other HW MDs			
Femur Max Diameter of Head	HW MD 23 & 25	.979	9	.958
	Other HW MDs	.923	3	.463
Femur Max Length	HW MD 23 & 25	.855	5	.212
Tibia Length	HW MD 23 & 25			
	Other HW MDs			

Table 104 Mann-Whitney U ranks for each long bone measurement grouped by burial location for females from Hopewell Mounds 23 & 25 and other Hopewell Mounds

		N	Mean Rank	Sum of Ranks
Humerus Max Diameter of Head	HW MD 23 & 25	1	3.00	3.00
	Other HW MDs	2	1.50	3.00
	Total	3		
Femur Max Diameter of Head	HW MD 23 & 25	9	5.89	53.00
	Other HW MDs	3	8.33	25.00
	Total	12		
Femur Max Length	HW MD 23 & 25	5	3.20	16.00
	Other known HW MDs	1	5.00	5.00
	Total	6		
Tibia Length	HW MD 23 & 25	2	3.00	6.00
	Other known HW MDs	2	2.00	4.00
	Total	4		

Table 105 Mann-Whitney U test statistics for each long bone measurement grouped by burial location for females from Hopewell Mounds 23 & 25 and other Hopewell Mounds

	Humerus Max Diameter of Head	Femur Max Diameter of Head	Femur Max Length	Tibia Length
Mann-Whitney U	.000	8.000	1.000	1.000
Wilcoxon W	3.000	53.000	16.000	4.000
Z	-1.225	-1.019	-.878	-.775
Asymp. Sig. (2-tailed)	.221	.308	.380	.439
Exact Sig. [2*(1-tailed Sig.)]	.667[a]	.373[a]	.667[a]	.667[a]
Exact Sig. (2-tailed)	.667	.350	.667	.667
Exact Sig. (1-tailed)	.333	.173	.333	.333
Point Probability	.333	.023	.167	.167

Analysis of Hopewell Mound 25 vs. Hopewell Mound 23: Question 6

Table 106 Long bone measurements (mm) for males from Hopewell Mound 25 and Hopewell Mound 23

	HW MD 25			*HW MD 23*		
Measurement	**Mean**	**Standard Deviation**	**(*n*)**	**Mean**	**Standard Deviation**	**(*n*)**
Humerus MDH			1			0
Femur MDH	45.6	1.9	9			0
Femur Max Length	456.8	18.8	4			0
Tibia Length	379.3	6.8	3			0

Table 107 Long bone measurements (mm) for females from Hopewell Mound 25 and Hopewell Mound 23

Measurement	*HW MD 25* Mean	Standard Deviation	(*n*)	*HW MD 23* Mean	Standard Deviation	(*n*)
Humerus MDH			0			1
Femur MDH	42.1	2.2	8			1
Femur Max Length	442.3	14.1	4			1
Tibia Length			1			1

Analysis of Hopewell Mound 25 vs. Other Hopewell Mounds: Question 7

Table 108 Long bone measurements (mm) for males from Hopewell Mound 25 and other Hopewell Mounds

Measurement	*HW MD 25* Mean	Standard Deviation	(*n*)	*Other HW MDs* Mean	Standard Deviation	(*n*)
Humerus MDH			0	45.7	4.9	3
Femur MDH	45.6	1.9	9	47.4	2.1	8
Femur Max Length	456.8	18.8	4	467.6	24.8	7
Tibia Length	379.3	6.8	3	387.5	29.8	4

Table 109 Tests of normality for each long bone measurement in males from Hopewell Mound 25 and other Hopewell Mounds

		Shapiro-Wilk		
		Statistic	df	Sig.
Humerus Max Diameter of Head	Other HW MDs	.750	3	.000
Femur Max Diameter of Head	HW MD 25	.664	9	.001
	Other HW MDs	.885	8	.209
Femur Max Length	HW MD 25	.792	4	.089
	Other HW MDs	.959	7	.813
Tibia Length	HW MD 25	.912	3	.424
	Other HW MDs	.907	4	.465

Table 110 Test of homogeneity of variances for burial location on each long bone measurement in males from Hopewell Mound 25 and other Hopewell Mounds

	Levene Statistic	df1	df2	Sig.
Femur Max Diameter of Head	.252	1	15	.623
Femur Max Length	.433	1	9	.527
Tibia Length	11.747	1	5	.019

Table 111 One-way ANOVA showing the effect of burial location on each long bone measurement in males from Hopewell Mound 25 and other Hopewell Mounds

		Sum of Squares	df	Mean Square	F	Sig.
Femur Max Diameter of Head	Between Groups	13.828	1	13.828	3.469	.082
	Within Groups	59.801	15	3.987		
	Total	73.629	16			
Femur Max Length	Between Groups	298.081	1	298.081	.566	.471
	Within Groups	4740.464	9	526.718		
	Total	5038.545	10			
Tibia Length	Between Groups	114.333	1	114.333	.208	.668
	Within Groups	2753.667	5	550.733		
	Total	2868.000	6			

Table 112 Welch Test results: robust tests of equality of means for burial location of each long bone measurement for males from Hopewell Mound 25 and other Hopewell Mounds

		Statistic[a]	df1	df2	Sig.
Femur Max Diameter of Head	Welch	3.423	1	14.237	.085
Femur Max Length	Welch	.664 .	1	7.963	.439 .
Tibia Length	Welch	.281	1	3.408	.629

a. Asymptotically F distributed.

Table 113 Mann-Whitney U ranks for each long bone measurement grouped by burial location for males

		N	Mean Rank	Sum of Ranks
Femur Max Diameter of Head	HW MD 25	9	6.78	61.00
	Other HW MDs	8	11.50	92.00
	Total	17		

Table 114 Mann-Whitney U test statistics for each long bone measurement grouped by burial location for males from Hopewell Mound 25 and other Hopewell Mounds

	Femur Max Diameter of Head
Mann-Whitney U	16.000
Wilcoxon W	61.000
Z	-1.928
Asymp. Sig. (2-tailed)	.054
Exact Sig. [2*(1-tailed Sig.)]	.059[a]
Exact Sig. (2-tailed)	.056
Exact Sig. (1-tailed)	.028
Point Probability	.004

a. Not corrected for ties.

Table 115 Long bone measurements (mm) for females from Hopewell Mound 25 and other Hopewell Mounds

Measurement	***HW MD 25***			***Other HW MDs***		
	Mean	**Standard Deviation**	**(*n*)**	**Mean**	**Standard Deviation**	**(*n*)**
Humerus MDH				41.7	2.8	3
Femur MDH	42.1	2.2	8	44.4	1.8	4
Femur Max Length	442.3	14.1	4	439.5	4.9	2
Tibia Length			1	360.7	7.5	3

Table 116 Tests of normality for each long bone measurement in females from Hopewell Mound 25 and other Hopewell Mounds

		Shapiro-Wilk		
		Statistic	df	Sig.
Humerus Max Diameter of Head	Other HW MDs	.954	3	.586
Femur Max Diameter of Head	HW MD 25	.974	8	.926
	Other HW MDs	.782	4	.073
Femur Max Length	HW MD 25	.916	4	.517
	Other HW MDs			
Tibia Length	Other HW MDs	.999	3	.927

Table 117 Test of homogeneity of variances for burial location on each long bone measurement in females from Hopewell Mound 25 and other Hopewell Mounds

	Levene Statistic	df1	df2	Sig.
Femur Max Diameter of Head	.241	1	10	.634
Femur Max Length	1.059	1	4	.362
Tibia Length	[a,b]	0		

a. Groups with only one case are ignored in computing the test of homogeneity of variance for Tibia Length.
b. Test of homogeneity of variances cannot be performed for Tibia Length because only one group has a computed variance.

Table 118 One-way ANOVA showing the effect of burial location on each long bone measurement in females from Hopewell Mound 25 and other Hopewell Mounds

		Sum of Squares	df	Mean Square	F	Sig.
Femur Max Diameter of Head	Between Groups	14.570	1	14.570	3.327	.098
	Within Groups	43.796	10	4.380		
	Total	58.367	11			
Femur Max Length	Between Groups	10.083	1	10.083	.065	.811
	Within Groups	619.250	4	154.813		
	Total	629.333	5			
Tibia Length	Between Groups	10.083	1	10.083	.179	.713
	Within Groups	112.667	2	56.333		
	Total	122.750	3			

Table 119 Mann-Whitney U ranks for each long bone measurement grouped by burial location for females from Hopewell Mound 25 and other Hopewell Mounds

		N	Mean Rank	Sum of Ranks
Femur Max Length	HW MD 25	4	3.50	14.00
	Other HW MDs	2	3.50	7.00
	Total	6		
Tibia Length	HW MD 25	1	2.00	2.00
	Other HW MDs	3	2.67	8.00
	Total	4		

Table 120 Mann-Whitney U test statistics for each long bone measurement grouped by burial location for females from Hopewell Mound 25 and other Hopewell Mounds

	Femur Max Length	Tibia Length
Mann-Whitney U	4.000	1.000
Wilcoxon W	7.000	2.000
Z	.000	-.447
Asymp. Sig. (2-tailed)	1.000	.655
Exact Sig. [2*(1-tailed Sig.)]	1.000[a]	1.000[a]

a. Not corrected for ties.

Appendix B

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Figure 9.1 Archaeological sites used in this study, divided by region. (Field et al., 2005:387) in (Carr and Case, eds., 2005).

Map of the floor of Hopewell Mound 25. Original map by Greber and Ruhl, 1989) modified by Carr and Evans. Found in Appendix 7.2 on CR-ROM that accompanies *The Scioto Hopewell and their Neighbors* (Case and Carr, eds., 2008).

Figure 3.9A Floor plan of the charnel house under the Pricer mound in the Seip earthwork (Carr, 2008b:130) in (Case and Carr, eds., 2008).

Figure 3.9B Floor plan of the charnel house under the Conjoined mound in the Seip earthwork (Carr, 2008b:130) in (Case and Carr, eds., 2008).

Figure 3.9C Floor plan of the charnel house under the Edwin Harness mound in the Liberty earthwork (Carr, 2008b:131) in (Case and Carr, eds., 2008).

Figure 4.22 Floor plan of the charnel house under the Ater mound (Carr, 2008c:254) in (Case and Carr, eds., 2008).

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