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SKELETAL MORPHOLOGY, GRAVE GOODS, AND CEMETERY ORGANIZATION:

MORTUARY ARCHAEOLOGY TO COMMUNITY LIFE

A Dissertation in

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by

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ABSTRACT

In order to access the daily lifeways of archaeological populations, this dissertation relies on three types of mortuary archaeological evidence: the skeleton, the grave and it's grave goods, and the cemetery. Skeletal morphology is used to measure asymmetric femoral torsion which is a byproduct of side sitting. This is contextualized at the regional level to document additional evidence of habitual side sitting in females through a broad range of time, potentially as far back as the Archaic and across the Midwest. Grave features and funerary objects from an Archaic period hunter-gatherer society are combined with new skeletal age-at-death estimation techniques to examine age- and sex-dependent social status. While males in this population lose social status with age, females maintain their status suggesting that post-menopausal women provide something to society that is not rooted in their reproductive potential. Finally, the spatial layout of a Mississippian period cemetery is studied to see how it reflects the social organization of the society that used it.

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LIST OF ABBREVIATIONS

AMH	Anatomically Modern Human
FAMD	Factor Analysis of Mixed Data
FNA	Femoral Neck Anteversion
FO	Funerary Object
MCA	Multiple Correspondence Analysis
PCA	Principle Component Analysis
PRLS	Post-Reproductive Lifespan
SI	Sacroiliac
TA	Transition Analysis

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Chapter 1

Introduction

To characterize the day-to-day lives of past peoples, this dissertation uses skeletal and mortuary archaeological remains. It aims to look at experiences that would impact an individual on a daily basis, such as the way people sit, the way people are treated depending on their age and sex, and the social structure of the community itself. It achieves these goals by utilizing three types of mortuary archaeological evidence: the skeleton, the grave and associated grave goods, and the cemetery. Each of the following chapters will focus on one of these topics but the information will be cumulative. In the second chapter, we will look at how the experiences of life, in this context habitual side sitting, are reflected in the human skeleton. In the third chapter we will build on knowledge of the human skeleton and add information about grave goods which are used as a proxy for social status. The application of the skeletal age-at-death estimation method, Transition Analysis, will facilitate an examination of age-related social rank. The fourth chapter will use features of the skeleton (age and sex) and of the burial (body position, grave orientation, and funerary object count) to see how the use of cemetery space reflects social organization. Finally, each of the chapters will be contextualized at the regional level to extract as much information as possible.

Prehistoric Illinois

The soil composition in many parts of southern Illinois offers unparalleled skeletal preservation making the area a distinctive location for bioarchaeological research. Three populations have been selected for their relative completeness of skeletal material, the large sample size of skeletons, and the abundance of literature available on the prehistoric cultural context enabling the creation of a regional framework for the human remains. The three populations are from Norris Farms No. 36, located on the Illinois River bluff in Fulton County near Lewistown, Illinois (AD 1300); the Middle Archaic component of Carrier Mills in southwestern Saline County (4000-3000 BC); and Kane Mounds in Madison County near the prehistoric site of Cahokia (AD 1200-1275) (Figure 1.1).

Native Americans would have reached southern Illinois in the Paleoindian period before 8000 BC, maybe as early as 10000-15000 BC. By the Early Archaic period (8000 – 6000 BC) the landscape was dotted with small, highly mobile groups whose main subsistence relied on hunting and gathering (Jefferies, 2013; Milner, 2004). It was important for these small groups to maintain contact with each other so they could access additional territory in times of hardship and to obtain mates. These groups had few possessions and moved often across the landscape leaving little evidence behind. The chert they did leave came from a wide range of geographic areas (all of southern Illinois and adjacent states) and different environmental settings (from floodplains to uplands) indicating that these people were highly mobile.

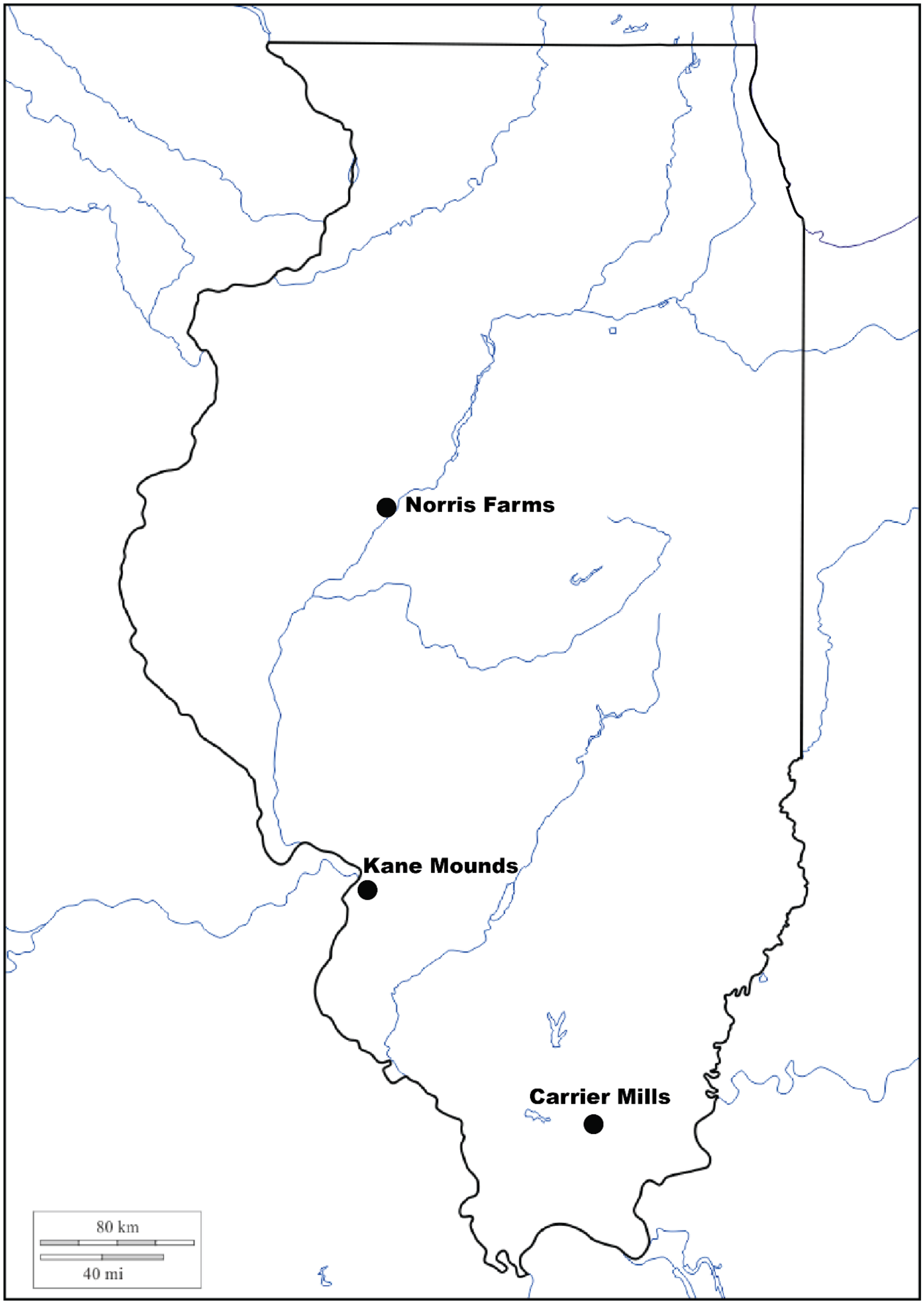

Figure 1.1 Map of Illinois with three cemeteries studied in this dissertation: Norris Farms (AD 1300), Carrier Mills (4000-3000 BC) and Kane Mounds (AD 1200-1275)

By the latter half of the Middle Archaic (6000-3000 BC) individuals were increasingly spending long periods in residential camps. People were still mobile but would stay in environmentally productive regions for longer periods of time instead of moving often to forage for seasonal resources (Brown and Vierra, 1983; Jefferies, 2013; Milner, 2004; Wiant et al., 2009). Archaeological evidence tells us that people ate a large variety of plants and animals including large and small mammals, fish, nuts, fruits, and seeds. Burials indicate that individuals used tool kits with stone projectile points, hammerstones, and choppers (Brown and Vierra, 1983). By the Late Archaic (3000-1000 BC), there was an increase in containers for storage and cooking (Milner, 2004; Newsom, 2002), and thus this period has been termed the “container revolution” by Bruce Smith (1986).

In Illinois, the start of the Early Woodland (1000-200 BC) is marked by thick clay pots and the continuation of a cultivation of native seeds and plants (Jefferies, 2013). The Middle Woodland (200 BC-AD 400) was defined by mound building, an increase in the use of cultivated plants (Milner, 2004), and a large exchange network, commonly referred to as the Hopewell Interaction Sphere (Brose and Greber 1979; Caldwell, 1964), through which objects made from a range of materials (e.g., copper, marine shell, mica, colorful chert, pipestone, and obsidian) were exchanged. Many of these materials are presumed to be highly prized as they were found in high status burials. In the Late Woodland period (AD 400-1000) long-distance trade declined, but there was an increase in the cultivation of plants and the introduction of the bow and arrow (Jefferies, 2013).

The Mississippian period (AD 1000-1450) was marked by large communities that often consisted of multiple towns, villages, and farmsteads (Jefferies, 2013). Some of these communities had chiefs who had a social position high above others. Mississippians grew maize as a major source of food as well as beans and squash, although they continued to hunt. Illinois was home to the largest settlement north of the Pre-Columbian cities in Mexico prior to European arrival, called Cahokia. Cahokia covers approximately 10 km^2 and contains over 100 mounds. Its population peaked in the 11^{th} and 12^{th} century and had experienced a substantial population decline and was all but abandoned by AD 1400.

Chapter Overviews

This work relies on three themes relating to the different types of mortuary archaeological evidence analyzed in this dissertation.. The three following chapters will each address one of these themes: 1) the body reflects the experiences of life, 2) the grave and the grave goods are a reflection of social status, and 3) the cemetery can be used to better understand social organization.

Asymmetric femoral torsion of the Oneota of Illinois

In addition to biological characteristics, like sex and age at death, that can be determined from a skeleton, bone can be used to study disease, trauma, and activities. Habitual activities that place stress on the bone can cause it to remodel and can be used to reconstruct lifeways. For example, professional athletes can develop enlarged muscle attachments (Brodelius, 1961; Wells, 1964) or people who regularly squat can develop squatting facets on the talus and tibia (Barnett, 1954; Boulle, 2001).

The Norris Farms population is remarkably well preserved because the skeletons were deeply buried in calcium-carbonate rich loess. The cemetery was located in the central Illinois River valley in west-central Illinois and consists of many graves, most of which are single burials (Santure et al., 1990). The skeletons are from a community of tribal, subsistence-level agriculturalists that used the cemetery for a brief period around AD 1300. The cemetery represents only one generation of individuals unlike most archaeological cemeteries which can be in use for centuries.

Chapter 2 examines what evidence the skeleton can provide about the daily lives of individuals within a population, as demonstrated in the Norris Farms site. Throughout the day, people maintain one of three postures, sitting, standing, and laying down. Posture is a learned behavior and side sitting is one that will be demonstrated here to only be found in North America among females. Side sitting leaves a measurable skeletal marker in the asymmetry in the angle of femoral torsion if it is maintained for large portions of the day, for many years, and starting at a young age. Chapter 2 quantifies this angle and compares it to other documentation to determine the geographic and temporal adoption of side sitting.

Side sitting causes asymmetric femoral torsion, which is noted in the literature infrequently (Westcott et al., 2014; Basgall, 2008). Femoral torsion causes physiologic changes, such as intoeing (Alvik 1962; Cibulka, 2004; Gulan, 2000; Gelberman et al., 1987; Kling and Hensinger, 1983; Weiner and Weiner, 1979), pain (Cibulka, 2004), and an unsightly gait (Alvik, 1962; Jani, 1979; LeVeau and Bernhardt, 1984; Shefelbine and Carter, 2004). A recent increase in online blogs from mothers and doctors has led to a surge in discussions of the impact of sitting postures on children, which makes the archaeological study of seated posture particularly relevant in today's world.

Post-menopausal women and social roles of the elderly

Burials, and grave goods in particular, are widely considered to be a reflection of an individual's "social persona" (Goodenough, 1965) defined by a combination of the social identities a person maintained in life. This often includes an individual's age, sex, job, position in society, or relationship to others (e.g., parent, sibling, or friend). These identities are numerous and the primary identity called forth in any situation, including in death, varies. Burial can also reflect the circumstances of death (Binford, 1971). Someone who died in an unusual way, such as being struck by lightning or drowning, a warrior killed in battle, or a sacrificial victim, may be treated unlike deaths caused by more common events. Additionally, burials reflect the activities and statuses of the people who constitute the mourners, surviving members of the immediate family, extended lineage, and community who select where the body will be interred, how it will be handled, and the items that accompany the deceased.

Grave treatment and burial goods are dependent on multiple factors, but there remains a strong correlation between how an individual was regarded in life and the way he or she was treated upon their death. Decades ago, Bendann's (1930) survey of ethnographic literature showed that the grave goods are reflection of an individual's sex, age, status, physical condition of the dead and the broader society's social organization, religion, myth conception, and belief in life after death. Chapter 3 examines what grave goods, used as a proxy for social status, can tell us about the social roles of individuals of different ages and sexes. Age-at-death estimation techniques have been criticized as being inaccurate, imprecise, and having terminal, open-ended age categories making the elderly invisible to archaeologists (Aiello and Molleson, 1993; Bocquet-Appel and Masset, 1982; Bocquet-Appel and Masset, 1985; Jackes, 1992; Milner et al., 2018; Milner and Boldsen, 2012). A new age estimation technique, Transition Analysis (TA), allows researchers to investigate the social roles of individuals past their productive and reproductive prime (Boldsen et al., 2002; Milner and Boldsen, 2012). For skeletal age, TA provides point estimates with confidence intervals tailored to individual skeletons. TA age estimates are based on age-progressive changes in the pubic symphysis, iliac auricular surface, and cranial sutures (Boldsen et al., 2002; Milner and Boldsen, 2012). The procedure is structured around age-at-transition curves for each trait that, when combined, yield an overall age estimate.

Since TA provides age estimates throughout the lifespan we can apply it to a population to study post-menopausal individuals. Humans are the only primate to undergo menopause, but it has been hypothesized that women in prehistory did not live sufficiently past menopause to warrant studying its evolution in humans (Austad 1994). TA will be applied to skeletons from the site of Carrier Mills to test if people in this archaeological sample are surviving beyond middle age. If elderly individuals are found in the population, grave goods will be used as a proxy for status, to examine their social roles. The cemetery of Carrier Mills was used by quasi-sedentary hunter-gatherer groups throughout much of the Archaic, possibly as early as 8000 BC (Jefferies, 2013), but the skeletons date to ca. 4000-3000 BC. From this research, it is evident that a significant portion of this hunter-gatherer population lived into old age. Males lost status with increasing age, while females maintained theirs, warranting further investigation into the societal value of post-menopausal women.

Social organization and cemetery structure

Finally, formal cemeteries are considered an integral part of society and it has been suggested that mortuary patterning reflects social organization. Saxe's dissertation (1971:119) stated, "to the degree that corporate group rights to use and/or control crucial but restricted resources are attained and/or legitimized by means of lineal descent from the dead (i.e., lineal ties to ancestors), such groups will maintain formal disposal areas for the exclusive disposal of their dead and conversely." Following his work, Lynne Goldstein's (1977) dissertation supported the idea that cemeteries were used to mark control over critical resources on the landscape by a group of people.

Chapter 4 of this dissertation looks at skeletons from Kane Mounds to better understand how the arrangement of cemetery space reflects social organization. During excavation in the early 1960s, detailed notes were taken about the location and position of each burial. In the early 1980s, George Milner (1982) completed a detailed map that could be digitized to examine the spatial structure to look for information about the social organization of the populations that used the cemetery.

The cemetery at Kane Mounds was associated with a sedentary and hierarchically structured society. Kane Mounds was located on a bluff consisting of deep loess overlooking a segment of the Mississippi River floodplain known as the American Bottom. It is spatially and temporally associated with the Cahokia chiefdom. In this area about 800 years ago, there was a select group of elite individuals who occupied the main mound centers, but most people, regardless of where they lived, never held positions of any great influence and were buried in cemeteries much like Kane (Milner, 1982; Milner, 1998; Pauketat, 1997).

Conclusion

Relying on the assumption that mortuary remains are a reflection of the once living individuals, this work will use skeletal morphology, grave goods, and the layout of the cemetery to study the everyday lives of past peoples. The interest of this research extends beyond a characterization of the skeleton and the mortuary remains, instead using these artifacts to recreate an account of how these individuals would have experienced their daily lives. The manner in which people sit, the way they are treated based on age and sex, and the organization of society are dictated by culture and are reflected in the skeleton, grave goods, and decisions about the use of cemetery space made by mourners at the time of death.

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Chapter 2

Asymmetric femoral torsion among the Oneota of Illinois

Introduction

Sitting, standing, and laying down are the three positions that encompass most of the day. Of these, sitting and standing are products of learned behavior. Practicing learned behaviors, which range from posture and facial expressions (Matsumoto and Kudoh, 1987) to the way we prepare and eat food (Kittler et al., 2011), are a part of culture, and cross-cultural variation in sitting posture has long been recognized as culturally significant (Mauss, 1935; Hewes, 1955). In fact, long ago, Alfred Kroeber (1925: 728) described the sitting postures of the Mohave to be “[o]ne of the most interesting matters in the whole range of customs”. Yet despite the cultural significance of such behavior, few studies, and none recent, have attempted to systematically describe postural variation around the globe (Hewes, 1955; Irizawa, 1920; Mead and MacGregor, 1951; Bailey, 1942).

Habitual side sitting is thought to only be found in North America among females. It is sitting with the knees positioned in front of the body and bent such that both feet lie together and outside of the hips (Figure 2.1). The posture is documented in historic narratives (Catlin, 1857; Colhoun, 1823), captured in photographs and paintings, and discussed in both the medical (Staheli et al., 1980; Fabry et al., 1973; Gulan, 2000) and bioarchaeological literature (Westscott et al., 2014; Basgall, 2008). Side sitting is the only documented cause for extreme asymmetry in femoral angle (Wescott et al. 2014; Basgall, 2008). This posture is of interest because it can lead to medical consequences such as in-toeing (Alvik 1962; Cibulka, 2004; Gulan, 2000; Gelberman et al., 1987; Kling and Hensinger, 1983; Weiner and Weiner, 1979), forefoot abduction (Alvik, 1962; Cibulka, 2004; Brunarski, 1979), a clumsy or unsightly gait (Alvik, 1962; Jani, 1979; LeVeau and Bernhardt, 1984; Shefelbine and Carter, 2004), and sacroiliac (SI) joint pain (Cibulka, 2004).

Figure 2.1 Side sitting - Adapted from Hewes (1955)

This paper will quantify the asymmetry in a skeletal sample from Norris Farms, Illinois (AD 1300) (11F2167). It will additionally document recordings of this posture to show that among Native American groups it is widespread both temporally and geographically and will determine if it is indeed a female characteristic, as suggested by the historical record.

Background

Skeletal development is strongly affected by forces on the musculoskeletal system over an organism's life (LeVeau and Bernhard 1984). Identifying and studying unique or atypical skeletal anatomy can provide information about habitual activities in past and present societies. Biomedical and bioarchaeological research has identified many skeletal signatures linked to specific activities. Culturally instituted beauty standards that can leave skeletal evidence include foot binding (Wang, 2002), brass neck rings worn by Paduang women which cause a depression of the clavicles (Keshishian, 1979), corsets worn by Victorian women that affect the lower ribs (Stone, 2012), dental modifications such as filing and chipping (Mower, 1999), and cradle boarding which alters the shape of the cranium (Coon and Hunt, 1965; Dunn, 1974; Moss 1958; Romero and Stewart, 1970; Gerszten and Gerszten, 1995). Habitual activities have been linked to osteological changes such as tailor's notches in the teeth (Ben-Bassat and Vrin, 2001) and squatting facets on the talus and tibia (Barnett, 1954; Boulle, 2001). Finally, when performed at a professional level, sports can lead to skeletal alterations such as the enlarged dominant humerus in tennis players (Wells, 1964), and arthritis in the ankles of dancers and soccer players (Brodelius, 1961). Another skeletal modification that can occur, but is less studied than the others, is called femoral neck anteversion, and is linked to habitual side sitting (Wescott et al., 2014; Basgall, 2008).

FNA – Femoral Neck Anteversion

Femoral torsion (Figure 2.2) is defined by the rotation of the femoral head relative to the distal end of the femur when looking up the shaft from the knee. The femoral head normally inclines upwards at an angle of about 15° for an adult (Table 2.1), as measured when a femur is laid down with the posterior surfaces of its condyles resting on a flat surface. In the anthropological literature, that orientation of the femoral neck and head is referred to as femoral neck anteversion (FNA) (Crane, 1959; Fabry et al., 1973), or the neck-shaft angle (Laplaza et al., 1993), femoral neck torsion angle (Mesgarzadeh et al., 1987), and acetabular anteversion angle (Maruyama et al., 2001). Healthy men have been reported as having a femoral angle between 8°-15°, while women exhibit angles between 14°-18° (Table 2.1). There is generally less than a 5° difference in the left and right angles in the same individual (Alvik, 1962, Anderson and Trinkhaus, 1998).

Figure 2.2 Two left femora are shown looking up the femoral shaft from the distal end of the femur to the proximal femoral head. The angle of femoral torsion is the incline of the femoral head in relation to the horizontal line of the distal femur. The femur on the left shows 10° of femoral torsion while the femur on the right shows 34°.

Adult			Reference
Both	Male	Female	
12			Alvik (1962)
	<15	18	Cibulka (2004)
8-15			Crane (1969)
11.9			Durham (1915)
11.86 +- 1.05			Elftman (1945)
	8	14	Gulan (1999)
12			Ingalls (1924)
12			Jani (1978)
8-15			Kingsley (1948)
12			Kingsley and Olmstead (1948)
11-14			LeDamany (1903)
11.67+-.88			Mikuliez (1878)
10-15			Morscher (1967)
11-18			Parsons (1914)
11.6-14.7			Pearson and Bell (1919)
14			Pick et al. (1941)
8-15			Soutter (1914)
8-15			Soutter (1903)

Table 2.1 "Normal" FNA angle as reported by different sources

Changes in FNA with growth and development

The femoral angle changes through early life but stops its progression between puberty and the complete fusion of the femoral epiphyses (Staheli et al., 1980). At birth, the angle of the femoral neck is approximately 31° (Fabry et al., 1973; Jani, 1979; Morscher, 1976; Gulan, 2000). At the age of two, as an individual begins to walk, the hip abductor muscles cause a lessening of the femoral angle (Morgan & Somerville, 1960). By age five, the angle reaches approximately 26° (Fabry et al., 1973). When epiphyseal fusion occurs in adolescence (14-16 years), changes in the pelvis associated with puberty cause alterations to the walking gait, and the femoral angle decreases further (Engel & Staheli, 1974; Staheli, 1977). The final, "normal" angle for adults (males or females) is around 15°

(Cibulka, 2004; Crane, 1959; Fabry et al., 1973). As people age and the hip joint degenerates, there can be a further decrease in the angle of the femoral head (Yin et al., 2018; Waisbrod et al., 2017; Reikeras and Høiseth, 1982; Tönnis and Heinecke, 1991).

Why the femur rotates in childhood is not known, but it is believed that it occurs when forces are applied perpendicularly to the epiphyseal growth plate. The Heuter-Volkmann Law of epiphyseal pressure states that an increase in pressure across the epiphysis will decrease its growth and vice versa (Hueter, 1862; Volkman, 1862; Arkin and Katz, 1956; Mehlman et al., 1997). The greatest force that acts upon any bone and can alter its form is transmitted directly from surrounding muscle, either in its passive elastic state or as a contractile force (LeVeau and Bernhard, 1984). Bone growth will be advanced in the direction of tensile forces. As an individual grows, and as walking develops, the forces from the muscles surrounding the femoral head will cause a decrease in the FNA angle.

Abnormal FNA

Some pathological conditions are specifically associated with changes to the femoral head and femoral angle. These include congenital dislocation of the hip, cerebral palsy affecting skeletal muscle development (Fabry et al., 1973), and Legg-Calvé-Perthes' disease where blood flow to the femoral head is interrupted (Gulan, 2000). Staheli (1977) reports that most conditions cause bilateral rotation of the femoral angle affecting both femora equally, although a slipped capital epiphysis can cause unilateral alterations. Compressive forces can act on one or both femora independently.

An increase in femoral neck angle can lead to a multitude of problems. The most commonly listed effects are in toeing (Alvik 1962; Cibulka, 2004; Gulan, 2000; Gelberman et al., 1987; Kling and Hensinger, 1983; Weiner and Weiner, 1979), forefoot abduction (Alvik, 1962; Cibulka, 2004; Brunarski, 1979), and a clumsy or unsightly gait (Alvik, 1962; Jani, 1979; LeVeau and Bernhardt, 1984; Shefelbine and Carter, 2004) among others (Table 2.2). In cases where the femoral neck angle is asymmetric between the left and right femur, there can be additional problems of a squinting patella (Brunarski, 1979; James and Bates, 1978), and sacroiliac (SI) joint pain (Cibulka, 2004).

Sitting and sleeping postures that hold the femur at a medial or lateral extreme can produce permanent changes in the FNA angle (Crane, 1959; Staheli et al., 1980; Pitkow, 1975; Alvik, 1962; Cibulka, 2004). In addition to anecdotal evidence from humans, animal studies have experimented with holding animal hind limbs fixed in medial rotation and produced permanent changes to FNA (Bernbeck, 1951; Salter, 1966; Wilkinson, 1962). Maintaining an extreme posture can also produce soft tissue changes including the shortening of the hip joint capsule and surrounding muscles. Changes in FNA develop naturally with walking and puberty but other major changes to FNA may stem from unusual activities or postures that are maintained for prolonged periods.

The sitting posture that is associated with increased FNA and is well documented is W sitting (Figure 2.3). This posture has both legs bent at the knees with the ankles folded towards the lateral sides of the hips. This posture is a natural position for small children to

Condition	Reference
Intoeing	Alvik 1962; Cibulka, 2004; Gulan, 2000; Gelberman et al., 1987; Kling and Hensinger, 1983; Weiner and Weiner, 1979
Forefoot abduction	Alvik, 1962; Cibulka, 2004; Brunarski, 1979
Clumsy or unsightly gait	Alvik, 1962; Jani, 1979; LeVeau and Bernhardt, 1984; Shefelbine and Carter, 2004
Difficulty running	Alvik, 1962
Pain	Cibulka, 2004; Alvik 1962
Osteoarthritis of the knee or hip	Alvik, 1962; Gulan, 2000
Congenital hip dislocation	Cibulka, 2004; LeVeau and Bernhardt, 1984; Gulan, 2000; Getz 1955; Jani, 1979; Staheli, 1985; Shefelbine and Carter, 2004
Tibial torsion	Cibulka, 2004; Brunarski, 1979
Genu valum (knock kneed)	Cibulka, 2004; Brunarski, 1979; Jani 1979
Genu varum (bow legged)	Cibulka, 2004
Pes planus or flat footed	Cibulka, 2004; Brunarski, 1979; James and Bates, 1978; Jani 1979
Pes equinus (shortened calf muscles)	Cibulka, 2004
Coxa plana	Cibulka, 2004
Slipped capital femoral epiphyses	Cibulka, 2004
Acetabular labral tears	Cibulka, 2004

Table 2.2 Additional side effects of increase angle of FNA.

take and has therefore been well studied and criticized by medical doctors (Weiner and Weiner, 1979), physical therapists (Askins, 2014; Gagnon, 2014; McNamara, 1995), occupational therapists (Coley, 2015), and mothers in online forums (Pathways.org, 2019; BabySparks, 2019; Schweitzer, 2018) for the potential damage it poses. However, these physical changes will not manifest unless W-sitting is maintained for many hours a day, or for years after puberty. When W sitting is adopted beyond puberty, it will increase the FNA angle bilaterally. Side sitting, in contrast, will increase femoral angle unilaterally. The increase in angle occurs in the femur that mimics the femur in W sitting, whereas the opposite femoral angle is decreased.

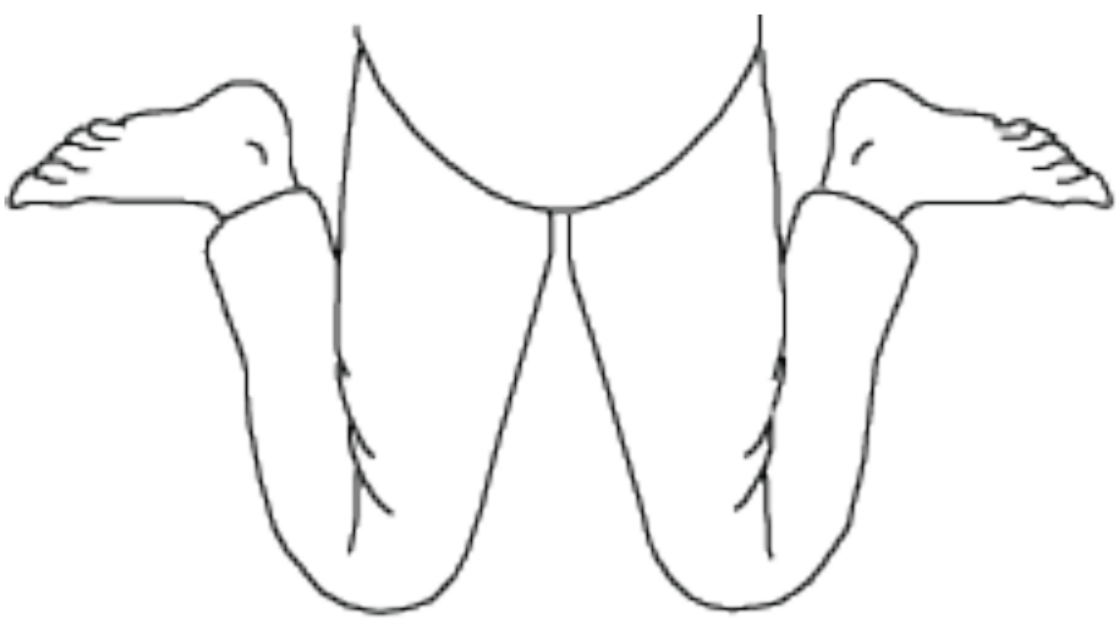

Figure 2.3 Aerial view of a child W-Sitting. Adapted from Cuellar (2017)

Materials and Methods

Skeletal Material

The Norris Farms No. 36 skeletal sample is attributed to a variant of the Oneota tradition, a community of tribal agriculturalists who occupied the central Illinois River valley in west-central Illinois at approximately AD 1300 (Santure et al., 1990). The Norris Farms individuals were part of an expansion of the Oneota southward into Illinois, and were heavily involved in warfare: 16% of the skeletons (33% of adults) exhibit evidence of decapitation, dismemberment, arrow/spear/axe wounds, scalping, or carnivore damage of exposed bodies (Milner et al., 1991; Milner & Ferrell, 2011).

The cemetery includes 264 Oneota individuals, most of which were from single burials in a low mound on the western bluff overlooking the Illinois River floodplain. The site was excavated in the mid-1980s by the Illinois State Museum prior to road construction (Santure et al., 1990). Bone preservation is extraordinary for an archaeological sample, being every bit as good as what is found in a modern anatomical collection. That is because the skeletons were deeply buried in calcium-carbonate rich loess. The sample for this analysis includes 83 skeletons, including both males (n=32) and females (n=51). All individuals who met the selection criteria were examined: individuals ≥15 years of age at death, for whom both femora were present and exhibited both full epiphyseal fusion and no signs of disease or infection.

Skeletal Methods

The angle of femoral torsion, was measured using a goniometer protractor (Figure 2.4) following Hartel et al. (2016) and Kingsley and Olmsted (1948). To measure the angle of femoral anteversion, the distal end of the femur is placed on an osteometric board (Figure 2.4.A) while the proximal end rests on a protractor. Both the osteometric board and the base of the protractor are the same height. The movable bar of the protractor is then aligned with the orientation of the femoral neck. The center of the lesser trochanter is aligned with the mid-point of the protractor (Figure 2.4.B), and the angle is measured to the fovea of the femoral head (Figure 2.4.C).

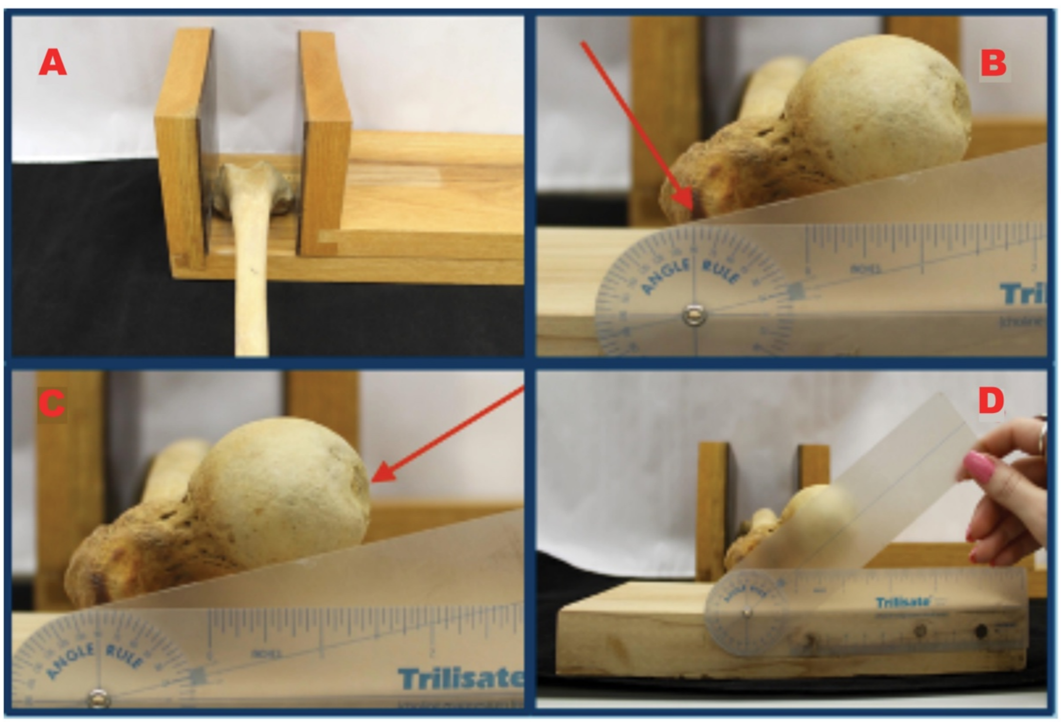

Figure 2.4 The device shown above illustrates how the angle of femoral torsion was measured

The angle of femoral torsion was measured for the left and the right femora of each individual. The angle was measured and recorded blindly in regard to age and sex. An absolute value of the difference between femora was used for computational purposes. Intra-observer error was minimal. After the initial data collection, a random subsample of individuals ≥15 years of age at death were selected for remeasurement. After a month, the data were recollected; these values were plotted against the original FNA plotted and were nearly identical (r^2=0.97; p <0.001).

To examine the potential causes of asymmetry, the degree of asymmetry was tested for a correlation with age, shaft width (medial-lateral measurement mid shaft), and shaft depth (anterior-posterior measurement mid shaft) using a correlation coefficient and with sex using a t-test. Sex was tested to see if there is a male/female difference, age to see if FNA increases (or decreases) through the lifespan, and shaft width/depth to see if bone size impacts the femoral angle.

Ethnohistoric/Visual Materials and Methods

To examine the geographic and temporal spread of this seated position, historic collections of photographs, paintings, and journals were surveyed from the National Anthropological Archives, the University of Wyoming photography collection, paintings from early Euroamerican contact by George Catlin and others, and journals from early Euro-American explorers of the United States. For prehistoric periods, the literature on human figurines in a range of sitting and standing postures was surveyed. For each source, date, location, seated posture, and sex of the subject were recorded to provide as comprehensive a look as possible about who adopted side sitting.

Results

Skeletal

No correlation was found with age ($r^2 = 0.007$) (Figure 2.5), bone shaft width ($r^2 = 0.027$), or bone shaft depth ($r^2 = 0.019$), but there was a strong correlation between asymmetry and sex (Figure 2.6). T-tests revealed that average angles of anteversion for the sexes were statistically different (*$p<0.001$),* and that a strong relationship exists between asymmetry and sex. Males exhibit very little asymmetry (average of 6.3°), while females exhibit greater amounts of asymmetry (average 12.4°).

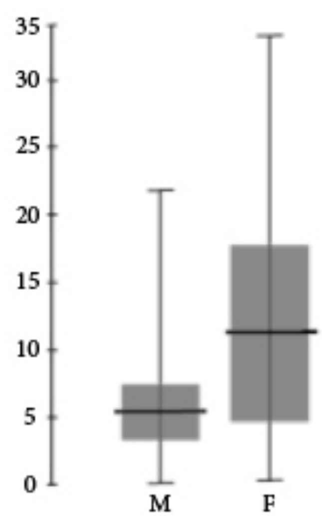

Figure 2.6 IQR for both male and female asymmetry. There is a significant ($p<0.001$) difference between the two sexes.

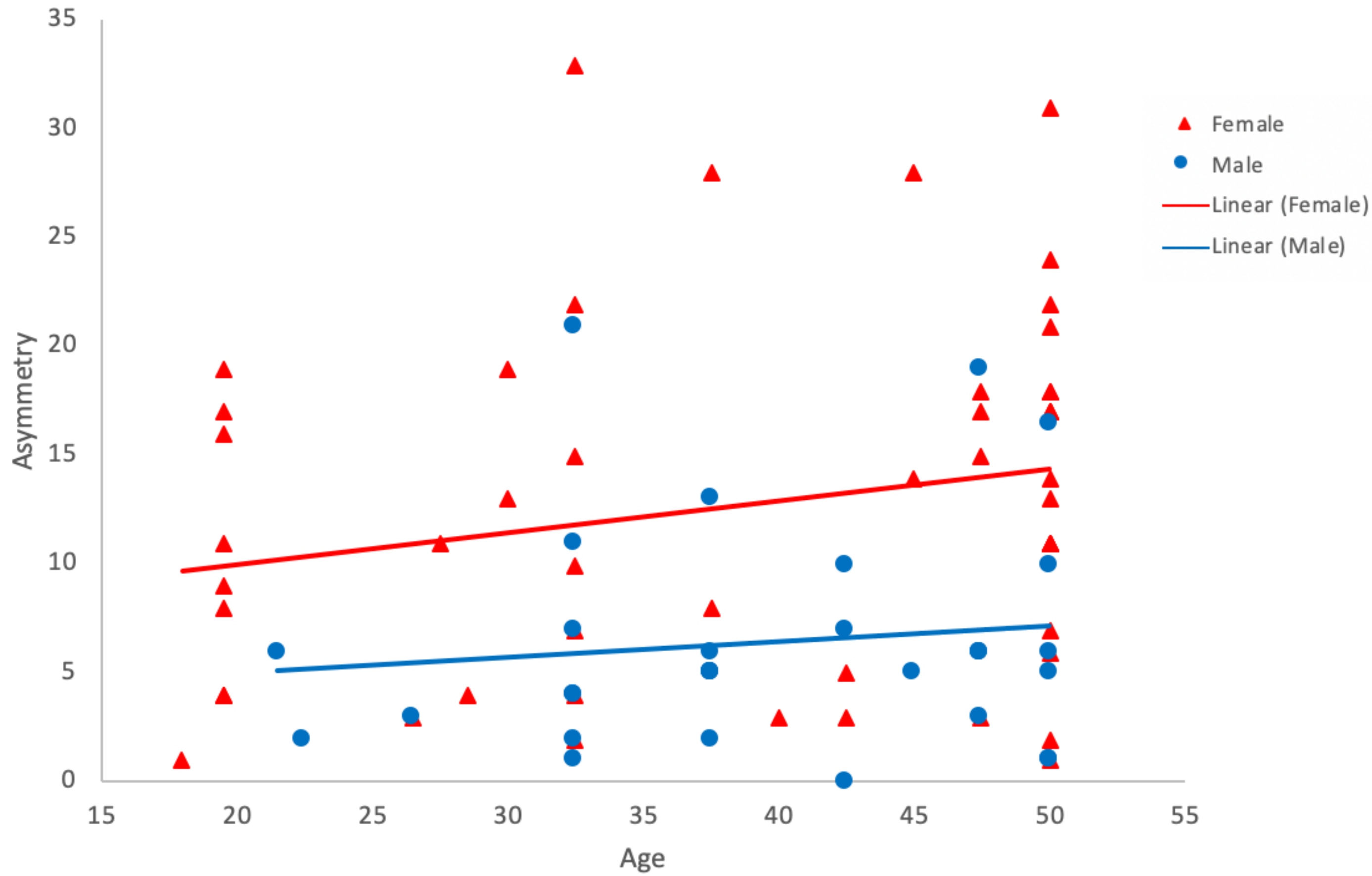

Figure 2.5 Degree of asymmetry is plotted against age and a trend line is shown for each sex. There is no significant change in asymmetry with increased age but there is a large difference between male and female.

Ethnohistoric/Visual

Sixty-nine archaeological figurines were identified in texts (Appendix A) dating to the late Archaic (3000 – 1000 BC) through the Mississippian (AD 1050 – 1700) periods. Of these 69 figurines, 17 were female, 50 were male, 2 were unknown. One figurine was from the Archaic, 14 were Woodland, 38 were Mississippian, and 16 were unknown (Table 2.3). The majority of them were sitting or kneeling (Figure 2.7). Only a minority of the figurines were side sitting (n=3), but all were female and they dated to the Middle Woodland period (ca. 200 BC to AD 400) (Figure 2.8). Two were from west-central Illinois and one from southwestern Illinois.

	Archaic		Woodland		Mississippian		Unknown	
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Kneeling	0	0	2	0	13	4	2	0
Sitting	0	1	2	0	9	3	10	2
Side Sitting	0	0	0	3	0	0	0	0
Squatting	0	0	1	0	6	1	1	0
Standing	0	0	2	2	0	0	0	0
Unknown	0	0	0	0	0	0	0	1

Table 2.3 Counts of archaeological figurines sorted by posture and time period.

From the national archives, nine photos, all from the Great Plains, showed individuals in the side seated posture (Appendix A Figures A.2-A.10). Eight of these photos are of women, while the ninth photo is not clear enough to determine the sex of the subject. Five other images of females demonstrating this posture are from a collection at the University of Wyoming (Appendix A Figures A.11-A.15).

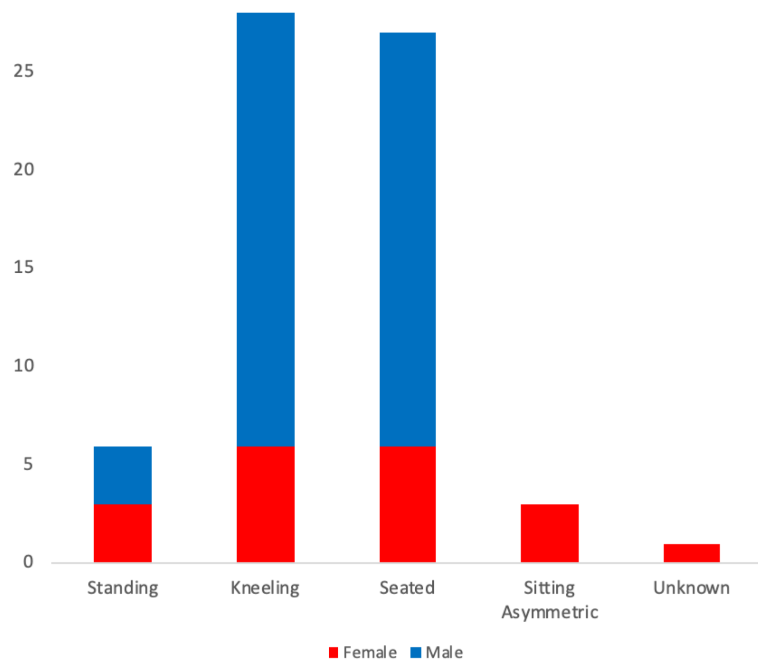

Figure 2.7 Counts of male and female archaeological figurines in different postures.

Additional documentation of this sitting posture was found in the paintings of George Catlin (Figure 2.9). Most of his work are staged portraits, scenery, and depictions of ceremonies. However, one of his paintings and one sketch show females side sitting. The painting is a portrait of a group in which a female is seated on the ground with both of her legs tucked to her right side with a child hugging her from behind and an infant swaddled in her arms. One adult male is seated (perhaps on a chair-like object) in the center while two other men stand. Side sitting is also noted in a sketch of Catlin feasting with chief Four Bears. Two women in the background of the sketch are side sitting. While in South Dakota, Catlin (1857) wrote a letter to his family in which he describes the way in which women assume this posture as does James Colhoun (1823) in his personal journal while traveling in Minnesota.

Figure 2.8 Three archaeological figurines demonstrating the side sitting posture. Left *from Knight Mound – Mound 10,* Center *from Twenhofel Site,* Right *from Knight Mound – Mound 9.*

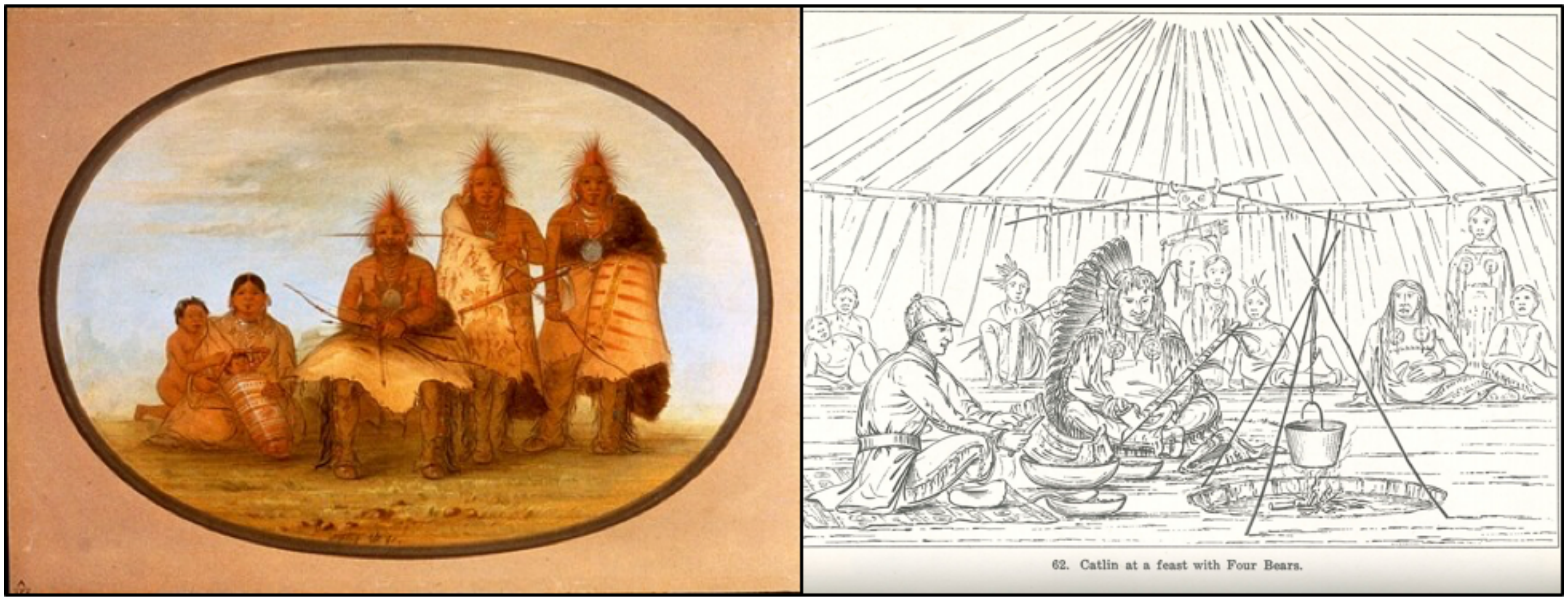

Figure 2.9 Two images from George Catlin. Left *Pawnee Warrior c 1832 by George Catlin, female on the left is side sitting.* Right *Catlin at a feast with Four Bears, two females on the are right side sitting.*

Discussion

Side sitting is widely documented in Native American women of the American Midwest and Northern Plains at the time of European contact, but the antiquity of this practice prior to European arrival is unknown. Significant differences in femoral torsion among men and women in the Norris Farms skeletal assemblage indicates that side sitting can be traced back to the prehistoric period in the American Midwest.

Asymmetric femoral torsion has received some passing attention in the bioarchaeolgical literature. Daniel Westcott et al. (2014) looked at 273 skeletons from the historic Arikara of South Dakota. He concluded that there was a significant difference between males and females with females having a larger degree of asymmetry than males. A second scholar, Ashly Basgall (2008) examined 13 skeletons from Wyoming of which 12 were declared to be asymmetric. She used a 5° difference between left and right femora as a cutoff for asymmetry. Of the 12 skeletons, they were all reported as female. Dates were determined by radiocarbon dating and reported as 1 skeleton from the Archaic, 1 from the Woodland, 1 from the Late Prehistoric, 3 were listed as generally prehistoric, and 8 historic. Skeletal evidence may be supported by archaeological figurines that push the practice back another thousand years. The historic period has numerous photographs, paintings, and written documentation. We can confidently say that there is evidence of side sitting dating as far back as two millennia.

Geographically, we have evidence for side sitting spread across the American Midwest and the Northern Plains. The three archaeological figurines and the Norris Farms skeletal sample are from western Illinois. Additional skeletons are from South Dakota and Wyoming, the two written accounts of the sitting posture are from Minnesota (James Colhoun) and South Dakota (George Catlin), and the photographs are from a range of states including Oklahoma, Oregon, Montana, Minnesota, New Mexico, and South Dakota.

The impacts of increased femoral neck anteversion have been studied in modern populations where the FNA is bilateral as is the case of W-sitting or some medical conditions. Side sitting causes unilateral increases in the FNA angle and can cause many potential medical problems an awkward gate, difficulty running, possible unilateral arthritis, and patellofemoral pain. The important impacts of side sitting make the posture even more important to understand who was assuming this posture and looking for clues in the historic literature into why it was adopted.

Two characteristics of the individuals side sitting are that they are predominately female, and severity of asymmetry was not linked to age. This suggests that side sitting is a gender dominated practice and is learned from a very young age. James Colhoun (1823; 298) documented this posture in his personal journal and notes that males and adopted different seated positions:

> *"I observed one of them sit for sometime with his legs crossed like an East-Indian. Hitherto that posture seems not to be the habitual one; I believe it never has been with any of the North American tribes. In cabins that have a raised seat, the legs are sometimes pendent; but they usually sit on the right buttock with the right leg bent & lying horizontally, the left leg doubled vertically & resting on the sole of the foot. The women d[ou]ble their legs & lay then horizontally both towards the same side."*

A majority of the Norris Farms skeletons and most of the other documentation show that individuals were sitting with their legs swung off to the right side. In Norris Farms

92% of females and 93% of males had their legs swung off to the right (Appendix A). Of the paintings, photographs and figures 20 women (80%) were depicted with their legs off to the right. Not only is side sitting an enduring practice but the preference for side remains the same. These percentages are similar to the percentage of individuals in the modern global population of left (10%) and right (90%) handed individuals (McManus, 2009). If Basgall (2008) is correct that side sitting was primarily utilized for the task of tanning hides, handedness might make pushing the legs to the left or right side more advantageous. If prehistoric individuals have similar percentage of handedness as modern Americans, this might explain the difference in individuals swinging their legs to either the left or the right side.

There are very few explanations given as to why females took this posture. One explanation is that females wore skirts made of leather or other tight-fitting material. In order to sit on the ground, the woman would have to swing her legs off to the side or risk exposing herself (Hewes, 1955). Another explanation is given by Basgall (2008) who suggests that the women sat with their legs off to the side while they tanned hides. In the description that George Catlin offers, he hints that there is a graceful quality to this position that allows women to keep their hands free.

> *"The position in which the women sit at their meals and on other occasions is different from that of the men, and one which they take and rise from again, with great ease and much grace, by merely bending the knees both together inclining the body back and the head and shoulders quite forward, they squat entirely down to the ground, angling both feet either to the right or the left. In this position they always rest while eating, and it is both modest and graceful, for they seem, with apparent ease, to assume the position and rise out of it, without using their hands in any way to assist them."*
>
> (Catlin, 1857 *Letter no. 17 – Mandan Village, Upper Missouri, pg 123)*

Conclusion

Side sitting, where an individual swings both legs off to the same side, is a posture that is widely adopted in North American prehistory and history among Native Americans. It is seen in prehistoric figurines, early European contact era paintings, photographs, and documents, and the evidence for it is found in skeletal remain. Compared to what was already known about side sitting from previous scholars, the work here with skeletons and documentation of evidence shows that we can somewhat expand the geographic distribution of side sitting and the temporal distribution by over a millennia. The documentation demonstrates that this is a clearly female trait and medical literature of increased FNA show that these females may have experienced major side effects from their sitting position.

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Chapter 3

Is there evidence for post-menopausal women in the archaeological record?: Social Roles of the elderly

Introduction

It has long been assumed that individuals in archaeological populations did not live long enough to warrant the study of older people (Austad 1994; Trinkaus and Thompson, 1987). Life expectancy at sexual maturity in hunter-gatherer and traditional agricultural populations has been estimated from skeletal remains at 16.5 to 29 additional years (Austad, 1994; Lovejoy et al., 1977; Trinkhaus & Thompson, 1987; Weiss, 1973; Willey & Mann, 1986), suggesting that only a small fraction of the population lived into old age (the post-reproductive state in females). However, many researchers (Cohen, 2004; Mattern, 2019) have argued that this claim is a byproduct of the poor resolution of skeletally based aging methods for individuals over 25 years of age.

Age-at-death estimates of adults over age 25 are notoriously inaccurate, and individuals whose true age is over 40 years are commonly underestimated, sometimes by decades (Milner and Boldsen, 2012; Bocquet-Appel and Masset, 1982; Bocquet-Appel and Masset, 1985; Aiello and Molleson, 1993; Jackes, 1992). Most techniques have age estimates that are biased, having overly wide intervals, and terminal, open-ended categories (e.g., 45+ or 50+) (Milner et al., 2008). The aging technique Transition Analysis (TA) (Boldsen and Milner, 2002; Milner and Boldsen, 2012) has increased precision and accuracy over other methods and, most importantly, it can successfully provide age estimates throughout the lifespan. With TA, it can be confirmed if an appreciable portion of the population survived past 50 and, if so, we can examine the social roles of those individuals.

The existence and social position of the elderly has been a puzzle for both biological and cultural anthropologists. Why are humans alone among primates in living far beyond their reproductive years? How does the presence of the elderly affect communities? There are many explanations for these questions but one of the more popular is the Grandmother Hypothesis, which suggests that longevity is evolutionarily beneficial due to the role grandmothers can play in child care and food provisioning (Hawkes et al., 1989; O'Connell et al., 1999; Hawkes, 2003; Hawkes and Coxworth, 2013; Hawkes and Finlay, 2018).

This study has two aims. The first is the application of TA to show that lengthened lifespans in modern humans can be seen paleodemographically from the site of Carrier Mills in Illinois (11-Sa-87), home to a group of semi-sedentary, hunter gatherers. If it is demonstrable that individuals were routinely surviving beyond age 45, the second aim is to examine their role in society. Of the theories that address post-menopausal women, the Grandmother Hypothesis is one of the only that discusses the role these women play. Grandmothers increase their inclusive fitness by providing a caloric contribution to their adult daughters and grandchildren. It is impossible to know what a specific archaeological individual did in life, but the use of burial goods tells us how they were treated in death. Although the study of funerary objects cannot directly test the Grandmother Hypothesis, by drawing upon a combination of accurate age estimates and burial goods, this analysis can evaluate whether males and females past their reproductive and productive prime (45+) are treated differentially in death.

Background

Senescence seems counterintuitive to natural selection as it removes individuals from a population. However, it seems linked to the fact that even without senescence, there would be fewer people at later ages due to external risks (Promislow, 1991; Kirkwood and Austad, 2000; Kirkwood and Shanley, 2010). The byproduct of having fewer older people than younger means the strength of selection on age-specific fitness that acts in old age will be weaker (mutation theory) (Hamilton, 1996; Medawar, 1952; Partridge and Barton, 1993; Croft et al., 2015). Therefore, there will be stronger selection for alleles that are beneficial in younger ages even if they are detrimental in later life (optimality theory of aging) (Williams, 1957; Wood et al., 2001; Charlesworth, 1994; Partridge and Barton, 1993; Croft et al., 2015).

In most species, overall senescence and senescence of the reproductive system are linked. However, humans are unique among primates in that females experience menopause (Kirkwood and Shanley, 2010; Kim et al., 2014; Mattern, 2019). Menopause is the hormonal cessation of reproduction. Females cease reproductive capabilities around the age of 50 but can live twice that long. A few other, non-primate species also experience a post-reproductive life span (PRLS). PRLS differs from menopause in that menopause is a cessation in the ability to reproduce while PRLS is the amount of time lived after last birth (Mattern, 2019). Taxa that have PRLSs include mammals (Cohen, 2004; Packer et al., 1998), fish (Reznick et al., 2006), birds (Jones et al., 2014; Holmes and Ottinger, 2003), invertebrates (Jones et al., 2014), and even microscopic organisms (Jones et al. 2014). However, unlike humans, these species experience PRLSs that are short, occur in only some individuals (Packer et al., 1998; Lahdenpera et al., 2014; Moss, 2001), or occur only in captivity (Reznick et al., 2006; Jones et al., 2014). The only species that have prolonged PRLSs in natural environments are humans, short-finned pilot whales (Croft et al. 2015; Marsh and Kasuya, 1986), and killer whales (Croft et al. 2015; Brent, 2015; Olesiuk et al. 1990; Foster et al., 2012). The cessation of fertility and a lengthened PRLS are unusual and certainly unique to humans among primates. Therefore, researchers have long focused on finding an explanation.

There are many theories as to how menopause developed in human evolution (Table 3.1). These theories can be generally classified as adaptive and non-adaptive (Mattern, 2019). The former suggest that women cease reproduction because it has associated benefits for their biological fitness and the latter that menopause is a byproduct of recently lengthened lifespans (Peccei, 2001; Gosden and Faddy, 1998). These "non-adaptive" hypotheses are most often supported by paleodemographic studies (Lovejoy et al., 1977; 1977; Weiss, 1973; Willey & Mann, 1986; Trinkaus & Thompson, 1987; Austad, 1994) that, based on poor age-estimation techniques (Milner and Boldsen, 2012; Bocquet-Appel and Masset, 1982; Bocquet-Appel and Masset, 1985; Aiello and Molleson, 1993;

Alternatives hypotheses to menopause	**Description**	**References**
The Mother Hypothesis	By ending fertility, you increase the likelihood of existing children surviving.	Williams 1957; Pavard et al., 2008; Peccei 2001; Penn and Smith, 2007; Kirkwood, 1977; Kirkwood, 2002
Follicular Depletion Hypothesis	Women have a set number of eggs. Menopause occurs when eggs are depleted. Wood et al. (2001) expand that this is likely the result of "antagonistic pleiotropy" from the maintenance of ovarian function at younger ages.	Atsalis and Videan, 2009; Van Valen, 2003; Gosden & Faddy, 1998; Gosden and Telfer, 1987; Gosden, 1985; Austad, 1994; Peccei, 2001; Wood et al., 2001; Weiss, 1981; Washburn, 1981
Senescence (Mutation Accumulation) Hypothesis-	Menopause is a natural effect of aging. Unlike other physiological functions which senesce gradually and can function at less than 100%, reproduction evolved as a threshold trait.	Ward et al., 2009; Cohen, 2004; Packer et al., 1998
The Patriarch Hypothesis	The origin of menopause allowed men to mate with younger women which results in increased longevity (for men and women) and increased status in society (for men).	Morton et al., 2013; Marlowe, 2000
Reproductive Conflict Hypothesis	There is resource-based competition between generations, specifically grandmothers and daughters-in-law who are not related. Overall fitness can be optimized if the daughters-in-law reproduces and grandmothers help.	Lahdenpera et al., 2014

Table 3.1 Alternative hypotheses to explain menopause.

Jackes, 1992), show that very few individuals lived sufficiently past menopause to warrant an evolutionary explanation.

Age-at-death estimation methods

The first goal of this study is to evaluate whether there is evidence for post-menopausal-aged women in the skeletal collection from Carrier Mills (ca. 4000-3000 BC) in southern Illinois, using an age-at-death estimation technique called Transition Analysis (TA) (Boldsen et al., 2002; Milner and Boldsen, 2012). Historically, skeletal age-estimation techniques have often suffered from overly wide intervals, terminal, open-ended categories (Milner and Boldsen, 2012; Bocquet-Appel and Masset, 1982; Bocquet-Appel and Masset, 1985; Aiello and Molleson, 1993; Jackes, 1992), fixed age intervals that vary depending on the assigned phase (or stage) of a skeletal characteristic (Milner and Boldsen, 2012), and age-mimicry – where age estimates mimic the known-age reference sample (Bocquet-Appel and Masset, 1982; Konigsberg and Frankenberg, 1994).

These four criticisms of age-estimation methods impact the ability of bioarchaeologists and forensic anthropologists in extracting meaningful age information from skeletal data. The first criticism, overly wide age intervals are a means of increasing accuracy and showing the uncertainty of relating a single trait to a specific age. Because of the lack of precision in many age estimation methods, it is near impossible to apply these methods to individual skeletons, and very flawed when applied to larger samples. The second criticism, terminal open-ended age estimate is a reflection of utilizing skeletal traits that stop providing valuable age-related information after a certain point or deteriorate with senescence and become increasingly difficult to define. More recent work (Milner and Boldsen, 2012) demonstrates that it actually becomes easier to age skeletons in really old age, but that is not widely recognized. The third criticism is fixed-age intervals which makes the assumption that all skeletons assigned to a phase have an equal likelihood of being in that phase as the other skeletons. The fourth and final criticism is that many of these methods impose the age structure of the reference sample onto the population of study. This means that if a reference sample has more young individuals, a skeleton of unknown age is more likely to be assigned a younger age.

Stemming from these flaws in skeletal aging methods, paleodemography suffered a series of harsh criticisms in the 1980s (Bocquet-Appel and Masset, 1982; Bocquet-Appel and Masset, 1985; Greene et al., 1986) that existing age-estimation methods were insufficient to produce reliable age-at-death distributions and that the field itself could not produce any results worth pursuing. The discussion in the 80s motivated work that addressed the flaws in age-estimation techniques in both the areas of skeletal and statistical analysis (Hoppa and Vaupel, 2002), and lead to the formation of TA.

The goals of TA, as outlined by Boldsen et al. (2002) are to: 1) represent the uncertainty of adult age estimates, 2) avoid age mimicry, 3) effectively combine different skeletal traits, and 4) to score traits in the most effective way that captures morphological data. It tackles these problems with a two-pronged approach, statistical and osteological.

Transition Analysis represents the uncertainty of age estimate by providing a probability density function for each skeleton, $\Pr(a|c_j)$. This is the probability that a skeleton died at age a if that skeleton has skeletal trait c_j. Boldsen et al. (2002) outline the problem with this probability function as being highly susceptible to age mimicry. The opposite, Pr $(c_j|a)$, the probability of having a trait at a given age is easier to estimate but does not achieve the goals of age estimation.

To avoid age mimicry, Boldsen et al. (2002) suggest that Love and Müller have the best approach by starting with an estimate of Pr $(c_j|a)$ which they call the "weight functions". The correct value of Pr $(a|c_j)$ is acquired from an estimate of Pr $(c_j|a)$ using Bayes' theorem:

$$\Pr\left(a\middle|c_j\right) = \frac{\Pr\left(c_j\middle|a\right) f(a)}{\int_0^{\infty} \Pr\left(c_j\middle|x\right) f(x)dx}$$

$f(a)$ is the age-at-death distribution of the ancient population of study, is used as the prior distribution, and comes before the estimation of Pr $(a|c_j)$. After $f(a)$ is estimated for the whole sample, you can apply Bayes' theorem. Therefore, age estimates are a product of the population-level analysis, which is an accurate way to produce age estimates, but requires a large sample size. Instead, TA uses a prior distribution for $f(a)$ that is independent of the skeletal material.

There is always a risk of imposing a prior distribution onto an archaeological sample with an unknown distribution. It has been suggested that the uniform distribution may be best, but that makes the assumption that a skeleton has an equal chance of being from any age, which is untrue of human mortality when there are greater chances of being very young or old. The TA software allows the selection of a prior distribution of either an archaeological (17th century rural Danish population) or forensic (late 20th century homicides in the US) distribution. When comparing age estimates of known-age modern skeletons using the uniform vs the archaeological prior distribution, as done by Milner and Boldsen (2012), there is no meaningful difference in the age estimates produced until age 50. From age 50 until the mid 70s, the archaeological prior slightly overestimates age compared with the uniform prior but after the mid 70s, the archaeological prior underestimates age compared with the uniform prior. The forensic prior distribution is only appropriate in forensic cases as it has a disproportionate number of younger individuals.

The third goal of TA is to effectively combine different skeletal traits which they do through age-at-transition curves. TA age estimates are based on multiple age-progressive changes in the pubic symphysis, iliac auricular surface, and cranial sutures (Boldsen et al., 2002; Milner and Boldsen, 2012). These anatomical structures have been used in prior age estimation methods and have been shown to provide valuable age estimation data. To extract the most information from these skeletal parts, and since the entire surface of these traits may not advance at the same rate, multiple traits are scored for each skeletal element – 33 in total: 5 cranial suture segments, 5 observations from each the left and right pubic symphysis, and 9 for the left and right auricular surface. For the 33 observations, there are multiple categories to which they can be assigned. These categories are unidirectional and ordinal, and it is the transitions between each of these categories that are of value. The age-at-transition curves are then combined to yield an overall age estimate. When applied to a skeleton of unknown age, the conditional probabilities of a suite of characteristics are combined to determine the likelihood that a skeleton died at a certain age.

To evaluate the accuracy of TA, Milner and Boldsen (2012) used known-age, modern skeletons from the Bass Donated Collection and the Mercyhurst forensic skeletons. None of these skeletons were used in developing the method. They concluded that the method allowed for estimates throughout the lifespan but that the three skeletal elements used (pubic symphysis, auricular surface, and cranial sutures) had different success in age estimation. The pubic symphysis performed better than the auricular surface, and cranial sutures provided little additional information.

Bullock et al. (2013) tested the method against two different prehistoric (unknown age), Mexican skeletal populations and came to the conclusion that the TA method has a better tradeoff of accuracy and precision over other age-estimation techniques. It further showed that while traditional age estimation showed few to no individuals living beyond 50, TA demonstrated that most individuals who lived into adulthood would survive past 50, with females experiencing menopause long before modern medicine.

TA provides better age estimates throughout the lifespan than other methods but the method is undergoing further refinement and a new version will be available by the end of 2020. Preliminary results (*Milner personal conversation*) suggest that the new version performs far better than the older version used in this research.

Grandmother Hypothesis

Since menopause is unique to humans among primates, it has drawn much attention. Early attempts to explain why females experience menopause focus on the early termination of fertility (Medawar, 1952; Williams, 1957; Hamilton, 1966). Pregnancies later in life are riskier and more likely to lead to maternal death and there is a well-established link between increases in childhood mortality after the death of a mother (Sear et al., 2002). Mothers that ceased to be fertile could focus their efforts on raising their current children, thereby increasing the likelihood of survival for those children, which in turn leaves more descendants from the mother. Even though these women who are no longer reproductively capable are not directly passing their genes onto new offspring, they are ensuring the survival of their current offspring. Building upon this concept, researchers such as Kristen Hawkes proposed that grandmothers, even more so than mothers, contribute to their inclusive fitness by aiding their adult daughters, nieces, and grandchildren (Hawkes et al., 1989; O'Connell et al., 1999; Hawkes, 2003; Hawkes and Coxworth, 2013; Hawkes and Finlay, 2018).

Grandmothers are primarily argued to contribute to their daughters by providing additional calories (Hawkes et al., 1989), which has two potential benefits. First, it can reduce the interbirth interval by providing calories to grandchildren allowing them to wean at a younger age. Second, it can provide more nutrition for the grandchildren and increase their likelihood of surviving to adulthood. When working with the Hadza from Tanzania, Kristen Hawkes and her colleagues (1989) studied the caloric contributions made by grandmothers when harvesting tubers. Tubers are deeply buried and cannot be collected by children. The time investment is often too great for women with children; however, older, post-reproductive women will dig these tubers. They frequently dig far more than their caloric needs and will share the tubers with their family, particularly their grown daughters and nieces.

These studies and the Grandmother Hypothesis have provided a framework in which other ethnographic researchers have been able to look at the inclusive fitness benefits that grandmothers had. Some researchers (Gibson and Mace, 2005) found that maternal grandmothers did have a positive impact on their grandchildren in rural Ethiopia. Others (Hill and Hurtado, 1991), among the Ache, have found mild support for grandmothering, but not enough to explain the evolution of longevity. Finally, one researcher (Sear, 2008) found that grandmothers actually have a negative impact on the survival of their grandchildren in Malawi.

Support for grandmothering leading to increased PRLSs is not unique to humans but has been found in the two other species that experience extended, natural PRLSs: the killer whale and short-finned pilot whale (Brent et al. 2015; Marsh and Kasuya, 1986; Olesiuk et al. 1990; Foster et al., 2012.). Killer whales reproduce between age 12-40 but females can live into their 90s (Foster et al., 2012), and a surviving grandmother can increase the survival of their grandchildren (Nattrass et al., 2019). It is theorized that females boost the fitness of kin through the transfer of ecological knowledge, particularly in periods of scarcity. It is often post-reproductive females that lead collective movement in salmon foraging grounds (Brent et al., 2015). It is argued that, similar to humans, killer whales can increase their inclusive fitness by providing calories for their offspring and their grand offspring.

Examining social status from a cemetery sample

Unlike ethnographic work, archaeology cannot directly observe the behavior of past peoples. In order to infer someone's societal position in life, we must rely on their treatment in death. The primary way this has been done in archaeology is through burial goods, sometimes called funerary objects. These objects are placed with the dead by mourners and have been recognized by scholars (*see* Bendann, 1930; Hertz, 1960; Goodenough, 1965; Binford, 1971; Peebles, 1971) as representing three things. First is the social status (or persona) of the deceased (Goodenough, 1965). This is a culmination of the social identities an individual maintained in life that were recognized as appropriate for consideration at death. This may include age, sex, position in the social organization, or relationship to others. Each individual has a social persona which is a combination of the personalities and roles. For example, a single individual can simultaneously be a parent, a sibling, and a friend. In burial, all, some, or none of these identities will be reflected in burial goods. Secondly, burial goods may reflect the situation surrounding the death of the individual. A warrior or soldier killed in battle or a sacrificial victim may receive a specific burial that reflects the circumstances of their death. Thirdly, burial goods may be a summation of the activities and statuses of the group of people who constitute the mourners. Of these three categories, it is the first – social status or persona – that is of interest here.

There is a strong correlation between how an individual was treated in life and the way he or she was treated at death. Bendann (1930) completed a survey of ethnographic literature on burial customs and concluded that burial goods will depend on the individual's sex, age, and status, as well as factors such as social organization, environment, morality, religion, myth conception, and belief in the afterlife. Much subsequent work (Hertz, 1960; Binford, 1971; O'Shea, 1984) supports the idea that the signal of an individual's status will be detectable with a sufficiently large sample.

Case study: Carrier Mills

Materials

Carrier Mills, also sometimes referred to as Black Earth, is an archaeological site in southern Illinois used for thousands of years by Native Americans. The earliest use of the site dates to the Paleoindian period but these peoples were highly mobile and left little trace of their occupation. By the Early Archaic, Carrier Mills had a climate, rainfall, and temperature similar to what we see today in southern Illinois. Early Archaic artifacts are mixed in with later artifacts making it difficult to determine the extent of habitation during the Early Archaic. The projectile points dating to the Early Archaic come from a wide geographic area, spanning southern Illinois into adjacent states.

By the latter half of the Middle Archaic there was a shift from seasonal to longer, multi-seasonal occupation. Larger groups were using the area as indicated by more complex, multi-seasonal sites and large cemeteries. This time period is characterized by a one-meter thick band filled with burnt plant materials and other organic matter creating the very dark soils. For this study, the skeletons analyzed (n=165) were from this layer and all date to 4000-3000 BC. The backfill used for the graves is full of the chert flakes and animal bones that mark this layer. When looking at the burial goods for this analysis, only the artifacts that were clearly and intentionally buried with an individual are studied.

An osteological analysis (Bassett, 1982) of the Archaic skeletons suggested that there was high infant mortality and the oldest individual was aged at 58±4 years. In adults, males outnumbered females 1.5:1. Age estimates of juveniles were based on dental calcifications (following Morees et al., 1963), occipital development (Redfield, 1970), long bone length (Sundick, 1978; Ubelacker, 1978), dental eruption (Garn et al., 1960), and union of epiphyses (Krogman, 1962; Stewart 1957). The aging method for the adults is described as loosely being based on the "forensic method"[1] of Meindl et al. (1980) originally presented at the 48th annual meeting of the American Association of Physical Anthropology and subsequently published by Lovejoy et al. (1985). Five age indicators

[1] "All adults are sequenced from the youngest to the oldest on the basis of a single indicator of age. Biological variation within the indicator is constantly reassessed as each individual's position relative to others is assigned. To accomplish this it is necessary to arrange that indicator (the pubic symphysis, for example) for all individuals on a table. Those symphyses that are morphologically similar to the standardized 25-year-olds are assigned that age. Those falling between the standardized 25 and the standardized 30 are assigned the ages of 26, 27, 28, or 29 depending on position and morphology." (Bassett, 1982:1036)

were used: auricular surface, pubic symphysis, cranial suture closure, functional dental wear, and involution of the cortical and trabecular bone of the proximal femur. A summary age is the product of a weighted average of the five traits based on the results of a double-blind study of the Todd collection**.** The auricular surface received the strongest weight followed by the pubic symphysis, and the least weight was given to the x-rays of the proximal femur. A subsequent test of this method by Bedford et al. (1993) demonstrated that this method performed better than any method that relies on only one age indicator, but its accuracy is better in a younger population. Its application to the Grant Skeletal Collection underestimated individuals over age 60 by 10.4 years on average.

Methods

Age estimation

In the present study, juveniles were aged by dental eruption and epiphyseal fusion following Buikstra and Ubelaker (1994). Adult ages were estimated using the TA method discussed above (Boldsen et al., 2002; Milner and Boldsen, 2012; Bullock et al., 2013). TA age estimates produce age-at-transition curves for features in the pubic symphysis, auricular surface, and cranial sutures. The transition curves are then combined and generate a maximum likelihood age estimate (MLE) and a confidence interval tailored to each skeletal individual. When none of the features in the pubic symphysis, auricular surface, or skull were present, the age was recorded as “adult”.

Measures of social status

Burial goods were analyzed as both a total count and as counts within three categories: decorative items, tools, and unmodified animal bones/parts (Table 3.2). Decorative items include worked bone and shell, ochre, pendants, beads, and bone pins. Tools are worked stone tools and bone awls. Unmodified bones are any animal bone or shell that has not been altered.

Results

Age estimation

While the original analysis of the skeletal remains using the Meindl et al. (1980) method produced age estimates that showed a maximum lifespan of 58 years, the TA procedure shows that some people were living into their 80s. Figure 3.1 plots the TA maximum likelihood estimates against the age estimates of Bassett (1982). Before age 30-35 the two methods produce similar age estimates. But after age 35 the method of Bassett systematically underestimates, sometimes by decades, the skeletal individuals. Using TA, this sample has a large portion of individuals at older ages: 23% of the adult skeletons were estimated to be over 45 and 14% over 70 years of age.

Burial	Sex	Age	Fos	Total	Tool	Unmod	Deco
1	F	78.8	mussel shell; two modified deer bone fragments	3	0	1	2
3	M	26.7	Canada goose (*Branta canadensis*) wings; mussel shell; red ochre; chert core; deer bone awl; decorated antler tube; deer metatarsals; fox; squirrel (*Sciurus niger*) bone	9	2	5	2
4	F	87.5	modified deer bone (tube) fragment	1	0	0	1
19A	F	29.6	red ocher; two worked antler tines; chert biface; bone needle or pin; two bone awls fragment of worked turtle shell; mandible of a large wetland bird	8	4	1	3
25	M	29.2	two side-notched projectile points; chert drill; two woodchuck (*Marmota monax*) mandibles	5	3	2	0
33	M	33.3	grooved axe fragments, fossil (blastoid), two fluorspar crystals, utilized chert flake, deer bone awl, and worked shale fragment.	7	3	0	4
35	M	26.5	bone awl; red ocher; two deer metatarsi; two worked antler tines; bone pin fragment	7	2	0	5
50	M	35.4	red ocher	1	0	0	1
72A	M	37.1	red ocher	1	0	0	1
82	M	32.6	two fragments of worked antler; drilled shell (*Amblema plicata)* pendant	3	0	0	3
84	M	29.2	bone awl	1	1	0	0
86	M	35.5	antler cup; three shell (*Amblema plicata*) pendants; antler bead; turkey-bone awl.	6	1	0	5
99	F	55.8	shell (*Amblema plicata*) pendant; chert biface	2	1	1	0
103	F	40	mussel shell; bone awl	2	1	1	0
106	F	46.6	mussel shell	1	0	1	0
121	M	77.2	mussel shell; chert scraper	2	1	1	0
124	M	75.1	possible stone axe fragments; side-notched projectile point; mussel shell; bone awl	4	3	1	0
137	M	37.2	two mammal phalanges; modified turtle (*Trionyx spiniferus*) costal bone; marsupialis bones (two individuals); modified canid canine; five phalanges from a large bird; deer-bone pin and awl; premaxilla of a large wetland bird; polished radius of large mammal; fragment of turtle plastron; five side-notched projectile points; utilized chert flake; stone net weight; worked limestone tool and fragment; three fragments of hematite; grooved stone axe; two quartzite pebbles; fragment of banded slate; seven pebbles; hafted chert endscraper; two shale bar gorgets; tip from a large chert projectile point; incised cylindrical stone; fossil crinoid stem.	45	12	12	21
178	F	33.9	two mussel shell valves; deer bone awl	3	1	2	0
180	F	84.4	mussel shell; hafted chert scraper; worked fragment of turtle shell	3	1	1	1
188A	F	48.3	three deer-bone awls	3	3	0	0

Table 3.2 Adults buried with grave goods are listed with sex, a list of funerary objects (FOs), total count, count of tools, unmodified bone and shell, and decorative object.

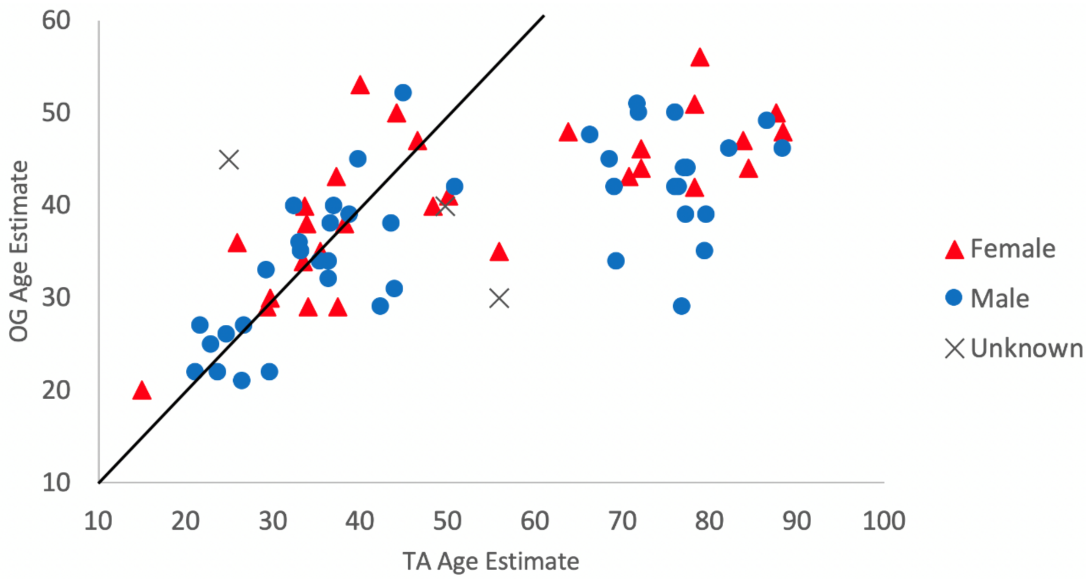

Figure 3.1 Age estimates from the Transition Analysis method plotted against the age estimates of Bassett (1982).

Funerary objects

Funerary objects are displayed two ways, the first is the percentage of individuals with grave goods by sex and age group (Figure 3.2). The second is the count of burial goods with each individual possessing goods (Figure 3.3). Figure 3.2 demonstrates different trends between males and females across the lifespan. Nineteen percent of juveniles (sex unknown) are buried with grave goods. Of reproductive aged females (15-45), 43% (n=14) are buried with grave goods. Males of the same age (n=28) also have 43% buried with grave goods. Forty percent of post-reproductive aged females (45+) (n=15) have grave goods while only 10% of males over age 45 (n=20) have grave goods.

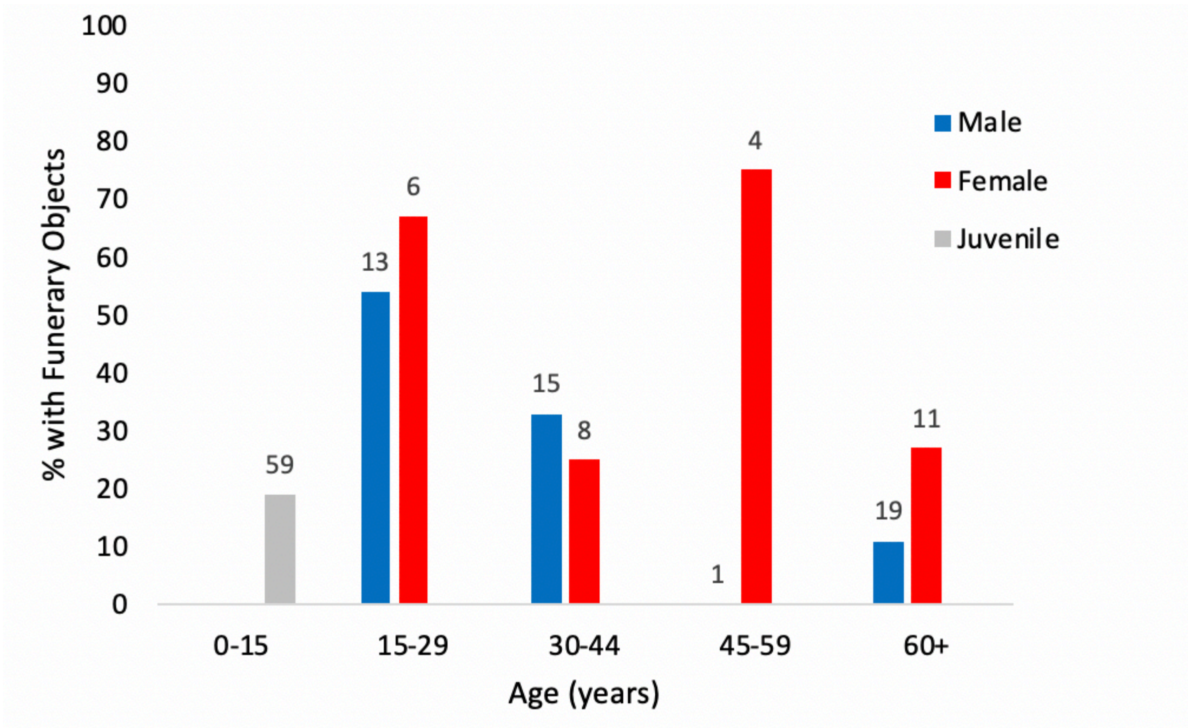

Figure 3.2 shows the percent of individuals in each age and sex category with funerary objects. The count of individuals in each category is listed above the bar. Of the 165 total individuals, 136 are shown here. 8 individuals could be sexed but not aged, 5 could be aged but not sexed, and 16 could be neither sexed nor aged.

Figure 3.3A shows known-sex individuals over the age of 15 that had burial goods (n=21). The group with the most funerary objects is young men between 20 and 40. Among females, we see that women have roughly the same quantity of grave goods across their lifespans. Of post-menopausal aged individuals, we see that more women than men have burial goods.

To further explore the sex difference in grave goods Figures 3.3B-D show the count of grave goods with an individual with when categorized as decorative (Figure 3.3B), tool (Figure 3.3C), or unworked (Figure 3.3D). Young men of reproductive age are primarily buried with decorative goods. Older women also have decorative items but relatively few

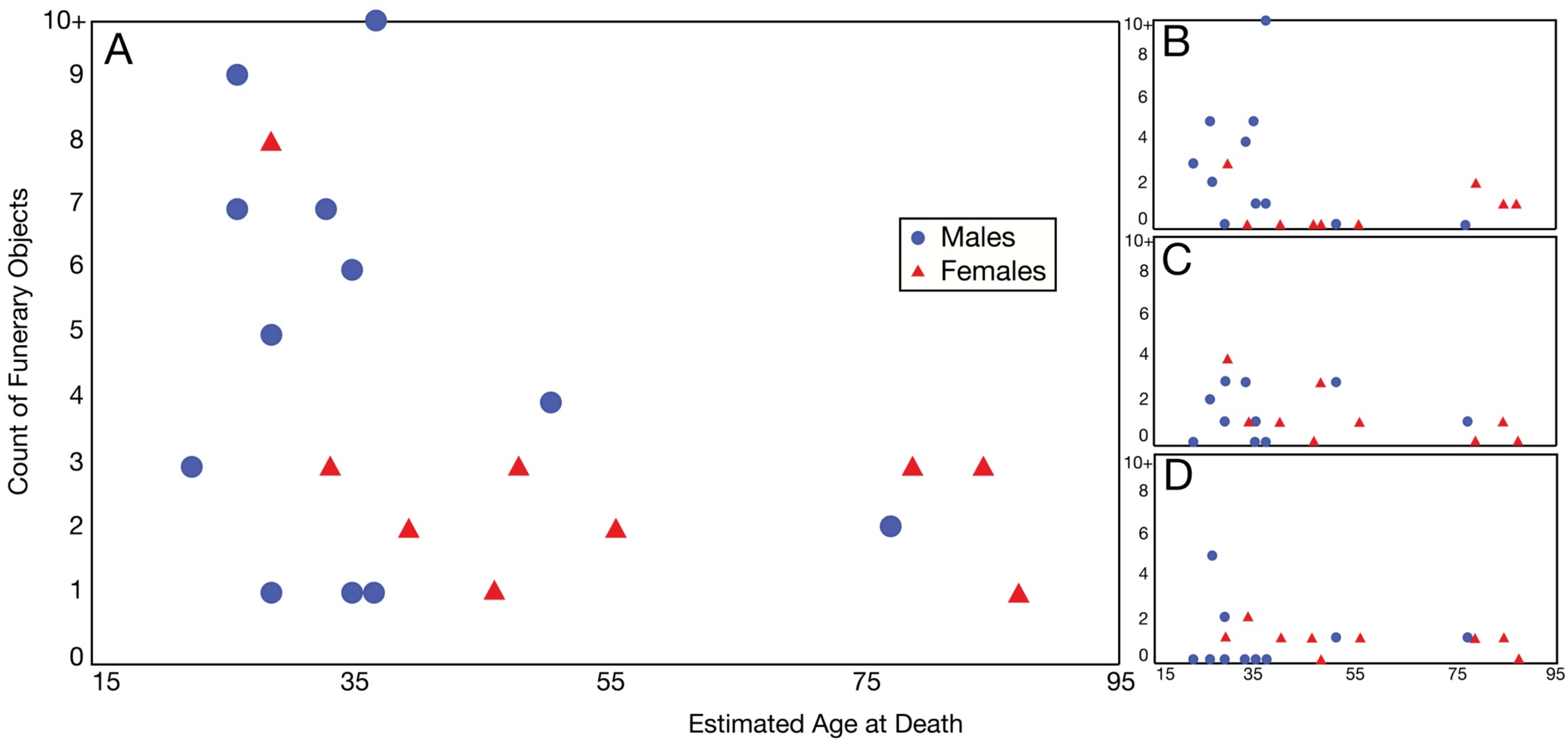

Figure 3.3 All individuals buried with funerary objects (n=21) are shown with A. A total count of funerary objects per individual, B. Decorative items per individual, C. Tools per individual, D. Unmodified items per individual.

of them. However, older women have more decorative items than younger women. Tools are found more among younger individuals, both males and females. Women mostly have bone awls, while men have a mixture of stone tools and bone awls. Unmodified animal bone and shell items take the least time investment to make and are found with women of all ages. A few men were found to have these items, but those men are also buried with other items. Most of the women buried with unmodified animal bone and shells had no other burial goods.

Discussion

Menopause has been argued to be a product of recent increases in life expectancy due to medical advancements. This research shows that post-menopausal women were present in the Middle Archaic, demonstrating that menopause is in need of an evolutionary explanation. The argument that post-menopausal women are a product of modernization relies on studies that show that premodern societies have few, if any individuals living long enough to experience menopause. This has been critiqued as being flawed on two levels: one looking at ethnographic data and the other at paleodemographic data.

The first is a claim that ethnographic hunter gatherer societies have relatively short life expectancies (*summarized by* Hawkes and Coxworth, 2013; Oeppen and Vaupel, 2002). The argument is that short life expectancy exists in all hunter gatherer populations, based on ethnographic and skeletal data, which encompasses most of human history. However, the short life expectancy in ethnographic hunter gatherers that they report is life expectancy at birth and is a reflection of high infant mortality as opposed to a truncated potential lifespan. In fact, we see in many hunter gatherer (as well as pastoral and traditional agricultural) societies, that many people do in fact survive beyond menopause. One example is from the Gainj of Papua New Guinea, a group of traditional agriculturalists where 31% of females and 36% of males survive to age 45 (Wood, 1987). Additionally, individuals who reach age 45 (age of menopause) have an additional life expectancy of 14.4 years.

The second argument is that paleodemographic studies have demonstrated few people living beyond 50 (Lovejoy et al., 1977; Weiss, 1973; Willey & Mann, 1986; Trinkhaus & Thompson, 1987; Austad, 1994). However, these studies are often believed to be based on problematic age estimation techniques (Milner and Boldsen, 2012; Bocquet-Appel and Masset, 1982; Bocquet-Appel and Masset, 1985; Aiello and Molleson, 1993; Jackes, 1992), which have plagued the field of paleodemography. In the 1980s, Bocquet-Appel and Masset (1982) declared the death of the field as there was no use in its application without more reliable age-estimation methods. Also in the 1980s was the creation of the age-at-death estimation technique of Meindl et al. (1980) used by Bassett (1982) in the analysis of the skeletal material from Carrier Mills. While this technique takes a step forward from earlier age-at-death estimation methods, it did not benefit from the full extent of the publications that followed the Bocquet-Appel and Masset (1982) publication and the method was still flawed in its systematic underestimation of individuals past middle age.

This study used a different age-at-death estimation technique, TA, which, unlike other age-at-death estimation methods, does not have a terminal open-ended category but produces age estimates into old age (Milner and Boldsen, 2012; Bullock et al., 2013). The application of this age estimation technique provided more accurate age estimates through the entire lifespan when tested by Milner and Boldsen (2012) and Bullock et al. (2013). When applied to the Middle Archaic skeletons from Carrier Mills, we see that individuals are living well beyond their 50s (the maximum lifespan from previous analysis of the site) and some individuals were even living into their 80s. The age estimation method used by Bassett (1982) works similarly to the TA method until the age of 35 at which point individuals are being underestimated, sometimes by decades.

In Figure 3.1, there is a gap in the age estimates produced by TA between (approximately) 50 and 65. TA is less accurate in middle age because of the skeletal features selected for the method. Also the use of the archaeological prior distribution in the TA software, when tested by Milner and Boldsen (2012), overestimated the age of individuals between age 50-70, but underestimated individuals over age 70. The "gap" in ate age estimates produced by TA in the study likely reflect a combination of these two flaws in the method. In the new version of TA, different skeletal traits are used which will lessen the problem of aging individuals in middle age. Although flaws in the method impact individual age estimates, the sample is sufficiently large to preserve the overall age-at-death structure.

The TA method addresses many concerns about accuracy, precision, and inability to age the elderly, but it is dependent on only three skeletal elements, the auricular surface, pubic symphysis, and cranial sutures. The Meindl et al. (1980) procedure was based on those three features as well as tooth wear and the proximal femur. The additional features in the analysis conducted by Bassett (1982) meant that fewer skeletons were classified simply as “adult” and ages were estimated for most of the population. TA age estimates were produced for all of the individuals who had FOs so this did not impact the conclusions about social status. It did however exclude some individuals from the overall age-at-death distribution.

Since the research on Carrier Mills confirms what researchers have long suspected, that a significant proportion of the population does reach the age of menopause, and the fact that humans are alone among primates that experience menopause, we need to look at an evolutionary explanation for the unique phenomenon. The existence of post-menopausal women supports all of the theories that are shown in Table 3.1. An archaeological sample cannot test any of these theories directly, but it can look at how post-menopausal individuals are treated in death, the difference in treatment of males and females, and the difference in treatment across the lifespan. Since the Grandmother Hypothesis is the only hypothesis that discusses the role of post-reproductive individuals, it is the only one that we can look at with the skeletal assemblage from Carrier Milles. In this sample, the grave goods suggest that men have a peak in status during their most productive years (15-45) while women maintain their status throughout their lives demonstrating the merit in the proposition that women contribute to society in old age, perhaps through childcare or caloric provisioning.

The sample, while small, shows an age-dependent difference in grave good quantities between the sexes. Reproductive and post-reproductive aged females have both similar proportions of women with grave goods and similar counts of grave goods among these women. Alternatively, reproductive aged males have a high percentage of individuals with high counts of grave goods, but few post-reproductive men have grave goods and those that do, have very few. This suggests that there is a correlation between males and their ability to reproduce/produce. Women are not valued simply for their ability to reproduce but maintain their value throughout their lives. What they are valued for is unknowable but it may be something that increases the inclusive fitness for their kin, such as food gathering or childcare. This is consistent with the Grandmother Hypothesis and provides sufficient reason to look for this trend in other archaeological samples.

When looking at grave goods there are two outliers. The first is a juvenile with 177 shell beads (*Anculosa* sp.) who was not included in this analysis. The second outlier is unique in both the quantity and range of grave goods. This individual (Burial #137) is a 43-year-old male buried with a variety of objects including animal remains from mammals (bear, opossum, canid), birds (loon, eagle), reptiles (turtle), and tools made of bone and stone (Table 3.2). The objects were in a bundle above the right shoulder and were likely in a bag or other container. It has been reasonably suggested that it is a medicine bundle along the lines of those known from the historic period (Jefferies, 2013). This burial, like the above-mentioned juvenile, does not differ in the treatment of the body. Even though this male has more burial goods than other individuals in this cemetery, it seems that this is based on a different role in society, not evidence of a hierarchical society.

Apart from the two outliers most individuals have no grave goods and those that do have grave goods have between one and ten objects. The grave goods quantities suggest that there is an age and sex patterning where females, unlike males, maintain their status beyond their prime reproductive years. This suggests that post-menopausal women and grandmothering may play a role in past societies. There are many Archaic-grade societies in the world and this research only examined one. In order to say something meaningful about grandmothering, more work and investigation are needed.

The data from Carrier Mills suggest that as far back as the Archaic, we have substantial proportions of the population living to old age (post-reproductive state in females). The application of TA to additional populations could provide additional support for the enduring nature of menopause in the human species. The Grandmother Hypothesis is based on evolutionary principles that have a far greater time depth than the skeletons available here. TA is only designed to be applied to anatomically modern humans (AMH) but earlier AMH populations are limited in number, small in population size, and suffer from poor preservation. Carrier Mills cannot address the evolutionary aspect of the Grandmother Hypothesis but rather provides an argument for further investigation into the topic and an argument against menopause as a result of recent expanded lifespans.

Furthermore, the role of grandmothers – for example, the actual day to day activities and benefits of their presence – is impossible to learn from the archaeological record. Carrier Mills shows a patterning to the funerary objects that are left with the deceased. The patterning is statistically different between males and females, but more work would be required to learn if the pattern is more widespread geographically and temporally.

Additional work on this topic may also provide a sample with larger variation in grave goods to conduct an analysis than is more complex than types of artifacts by sex.

Conclusion

The skeletal and archaeological analysis of Carrier Mills demonstrates that prehistoric individuals as far back as the Archaic are living sufficiently long to experience menopause. The presence of post-menopausal women in prehistory, and the uniqueness of menopause among primates, necessitates an evolutionary explanation. The evolution of menopause has been widely studied (Table 3.1), and one of the more popular evolutionary scenarios is the Grandmother Hypothesis. The hypothesis suggests that post-reproductive females provide calories for their daughters and nieces, thereby increasing their inclusive fitness.

The funerary objects with the individuals at Carrier Milles show a patterning where males have a decrease in the number of funerary objects after their productive and reproductive prime whereas women maintain their status through old age, as evidenced by quantity of grave goods. This patterning suggests that more archaeological work needs to be done to understand the social status of post-reproductive women and men of the same age in the distant past.

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Chapter 4

Extracting social organization principles from prehistoric Native American cemetery structure

Introduction

The third feature of mortuary archaeology addressed in this dissertation is the cemetery. To look at the use of space within a cemetery, we must combine important variables from the skeleton like age and sex (as done in Chapter 2 and 3) and from the grave goods (as in Chapter 3) and body treatment. The types of data collected in the earlier chapters will be repeated with the Kane Mounds cemetery (11Ms104) and will be used for a more comprehensive look at how social organizational principles can be studied from cemetery structure.

For decades archaeologists have recognized the importance of burials as a reflection of an individual (Bendann, 1930; Binford, 1971; Saxe, 1971) and the cemetery as a characterization of an ancient society (Goldstein, 1977; Saxe, 1971). Furthermore, the spatial layout of cemeteries, and archaeological sites more generally, can be very informative (Hodder, 1978; Kidder, 2002). Researchers of mortuary archaeology have relied on visual clues in their interpretations of funerary spaces (Goldstein, 1977; 1981; Hodder, 1978; Melbye, 1963).

While visual analysis can provide insights into the use of space, more recently developed, spatial statistical analyses hold the potential to confirm long-standing interpretations. These newer techniques provide an ideal complement to human interpretations because of the susceptibility of researchers to identifying nonexistent patterns. This tendency, called pareidolia, is a psychological phenomenon where random stimuli are perceived as having meaningful patterning (Moyano, 2011). Some examples include seeing the man in the moon (Brueton, 1991), or identifiable shapes in clouds (Lee, 2016). Today we have software designed for investigating spatial patterns, including clusters (e.g., GeoDa or QGIS) that are not susceptible to the same shortcomings as the human brain, therefore, naturally complementing visual analysis. We can use the tools available in these software to build on our visual interpretations of mortuary contexts.

Kane Mounds (AD 1200-1275) is an ideal case study by which the utility of revisiting classic interpretations with modern techniques can be explored. It is archaeologically well understood in its relationship to the Mississippian site of Cahokia, the largest settlement in prehistoric eastern North America. The excavators of Kane noted spatial characteristics that they believed to be related to the use of the site by different descent groups. We can take their interpretations as baseline visual analyses of the cemetery space and then use an exploratory spatial data analysis (ESDA) and statistical but aspatial cluster analysis to add new perspectives to what we know about the site.

Background

Use of Landscape

Individuals across societies experience the world through viewpoints that are culturally rooted in their understandings of the landscape. Following the work of Heiddeger (2005), Iwaniszewski (2007) discusses the concept of living in the world as a result of being there. He further defines it as the subjective relationship between humans and the world around them. When humans live in a space, they make decision about where to build structures based on their world view or practical constraints (e.g., large rocks, waterways, etc.). Although they may be aware that the human use of space is conscious, archaeologists are challenged by not knowing how the landscape looked when in use, what the emotional ties to its features were, or what other, practical explanations may have dictated the use of space.

There are a series of recognized psychological phenomenon that explain how humans tend to see patterns: apophenia, pareidolia, patternicity, and agenticity. Apophenia was defined by Klaus Conrad (1958) as the tendency to mistakenly perceive connections and meaning between unrelated things. While once thought to be a symptom of schizophrenia, it is now recognized as a human norm. Apophenia is a broad category which includes pareidolia, patternicity, and agenticity. Pareidolia is when people see or hear patterns in random data (Sagan, 1995); patternicity is the tendency to find patterns in meaningless noise (Shermer, 2008); and agenticity is the human tendency to infuse patterns with meaning, intention, and agency (Shermer, 2011). These conditions all serve to cast doubt on past visual analyses.

We know that these psychological experiences have led pseudoscientists astray in misidentifications such as the face in central Australia (Gojak, 2016) or finding the lost city of Atlantis (Puiu, 2019). Both of these claims were based on the examination of satellite imagery in Google Earth and manually searching for patterns. Those found – a face in central Australia and a pattern of rings off the coast of Spain – were shown to not be archaeologically pertinent (Gojak, 2016). These studies do not necessarily mean that we cannot rely on our visual senses in identifying patterns, but we must avoid describing a spatial organization that is not significant. With digital mapping and an ESDA, we can explore the visually detected patterns and search for additional information that may lead to a more complex view of the site.

Mortuary Archaeology

Kane Mounds offers a rare analytical opportunity because the original burial patterns identified by the excavators are perfect candidates for confirmation with newer methods. These burial patterns were identified in conjunction with anthropological theory that contextualized how importance and meaning can be inferred from material remains.

In the early twentieth century, archaeologists such as Kroeber (1919; 1927) reported that mortuary patterns did not reflect the beliefs of a society but rather varied unsystematically. In his 1919 paper he went as far as to liken variation in mortuary practices to dress styles with hem lines that go up and down unpredictably, but it is now widely believed that mortuary patterning does not vary randomly. Instead it is a combination of both the simple concept that burials are a direct reflection of the deceased, and more complex views that burial patterns are indicative of social organization, social obligation of the living to the deceased and each other, and concepts of the afterlife and belief system.

Shortly after Kroeber's work, Bendann (1930), based on a combination of ethnographic literature, asserted that the burial goods in a grave are dependent on a number of factors like social status, sex, age, as well as the society's social organization, environment, moral and religious beliefs, and view of the afterlife. Decades later, Goodenough (1965) defined the concept of "social persona", the idea that each person is an agglomeration of the different social identities and relationships that are called forth in different occasions. That is, anyone's role in a specific situation can be different from their role in another situation (i.e., parent, sibling, or friend) and any number of these identities may be reflected in a person's treatment at death.

A shift in mortuary archaeology came in the early 1970s with the works of Lewis Binford (1971) and Arthur Saxe (1971). Unlike the previous cultural-historical practitioners, Saxe and Binford examined the social source for patterned variability in mortuary treatment that might be associated with differences in an individual's role in society or their circumstance of death. All of these works combine to the overarching conclusion that given a sufficient sample size, the treatment at death can be used to identify social roles and status in life, hence social organization.

In a formal cemetery, it has been suggested that mortuary patterning reflects social organization. Saxe's dissertation (1971:119) was presented as a series of hypotheses. The final hypothesis stated that “to the degree that corporate group rights to use and/or control crucial but restricted resources are attained and/or legitimized by means of lineal descent from the dead (i.e., lineal ties to ancestors), such groups will maintain formal disposal areas for the exclusive disposal of their dead and conversely.” Saxe did not have the materials in his dissertation to address this hypothesis but Lynne Goldstein, in her 1976 dissertation, put this hypothesis to the test with ethnographic and archaeological samples. She surveyed over 100 groups, but only 30 had sufficient data to use in her final analysis. She drew many conclusions, such as burials near or in the house are always from communities with strong ancestor worship and the investment required to prepare a body for secondary burial means that there was a great respect for the dead. Perhaps the most important conclusion in her writing was that a bounded, organized cemetery was a mark of control of the land and its resources by a group of people.

In addition to her ethnographic work, Goldstein (1977; 1981) also examined the use of cemetery space in the Schild and Moss sites in the lower Illinois River valley. Using simple visual analysis, Goldstein was able to identify burials that seemed to be organized in rows. There is a likelihood that the cemetery was truly organized by rows, but the only evidence was the visual patterning and a scatterplot that put a best fit line to the burial coordinates that she identified as more of less lining up in a row.

Materials

The Kane Mound skeletons are from a ranked society based in large part on maize agriculture. Kane, excavated during interstate highway construction in the early 1960s, was located on a bluff consisting of deep loess overlooking a segment of the Mississippi River floodplain in Illinois known as the American Bottom (Figure 4.1). The site is geographically, culturally, and temporally associated with the Cahokia chiefdom. In this area about 800 years ago, there was a select group of elite individuals who occupied the main mound centers, but most people, regardless of where they lived, never held positions of any great influence (Milner, 1982; Milner, 1998; Pauketat, 1997; Pauketat et al. 2013). Many of them lived in outlying settlements and were buried in cemeteries like Kane.

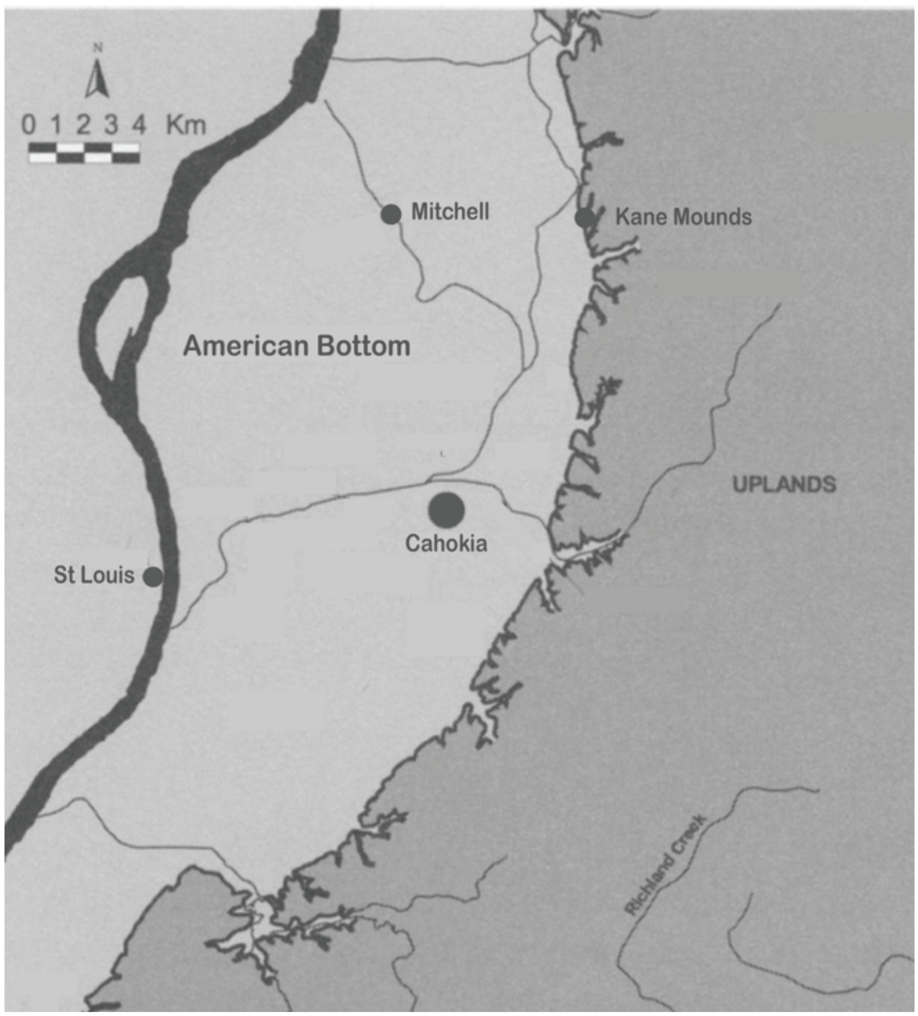

Figure 3.1 Map of the Cahokia region showing Kane Mounds, Mitchell Site, Cahokia, and modern-day St. Louis. To the east of the river, dark gray marks the uplands while light gray marks the lowlands. Adapted from Emerson (2002).

Kane Mounds is a series of four mounds that varied in size, with the largest being three meters high. Of the four mounds, only the two southernmost were excavated as they were within the right of way for the construction of Interstate 270. The excavators noted that the burials had two orientations that, when mapped, were in line with two archaeological landmarks: Monks Mound, the largest mound at Cahokia, and the Mitchell site, a cluster of mounds that were part of a major settlement. Monks Mound is 12 kilometers away and 18.5° west of magnetic south. Mitchell is 6.5 kilometers away and due west (Figure 4.1). The burials were oriented towards Monks Mound and Mitchell with a reported discrepancy of fewer than five degrees (Melbye, 1963). The other most notable feature of the burials at Kane Mounds is a clustering of bodies at the north side of the cemetery. The excavators noted that there are at least 22 individuals described as a “continuous amorphous mass of bones” but further analysis identified at least 109 individuals. One of these individuals is in an extended position oriented towards Mitchell Mound but the other bodies were in a disarticulated state.

The excavator’s preliminary analysis (Melbye, 1963) suggested that burial goods are associated with age and sex. Goods are mostly everyday pottery and tools, but some individuals were interred with valued goods such as marine shell beads. The collection contains 165 individuals who were contemporaneous with Cahokia and Mitchell but are believed to be drawn from small outlying communities (Milner, 1984). The people buried at Kane may not be in positions of great power but based on Melbye’s work there is expected variation in social status as well as identifiable differences between subpopulations, perhaps different descent groups, within the cemetery.

Methods

Burials were analyzed by the variables of sex, age, grave good quantity, body treatment, and grave orientation. Sex was scored using standard procedures (Buikstra and Ubelaker, 1994) as male, female, or unknown. Juvenile ages were also collected using standard procedures – dental development and epiphyseal fusion (Buikstra and Ubelaker, 1994), and adult ages were collected using Transition Analysis (TA). TA age estimates are based on age-progressive changes in the pubic symphysis, iliac auricular surface, and cranial sutures (Boldsen et al., 2002; Milner and Boldsen, 2012). In this procedure, age-at-transition curves for a number of features are combined to create a maximum likelihood age estimate and confidence interval tailored for the observable skeletal structures in each individual. Consequently, the age estimates are continuous, not categorical like many methods. Grave goods were assessed both as counts and presence/absence. Body treatment is classified as a primary burial, a secondary or bundled burial, or commingled. Orientation was the direction the burial faced either towards Monks Mound at Cahokia, the Mitchell site, or neither.

A map of Kane Mounds by Milner (1982) (Figure 4.2) was digitized in QGIS (https://www.qgis.org/en/site/) to complete these analyses (Figure 4.3). The original map was based off excavation notes and photographs. In the laboratory analysis of the skeletal remains, some burials consisted of more bodies than were recognized during excavation. Burials with multiple skeletons are digitized as sharing identical burial space. For all burials, the decision was made to digitize the burials, instead of skeletal elements, and spatial analyses are based on the central point of the burial.

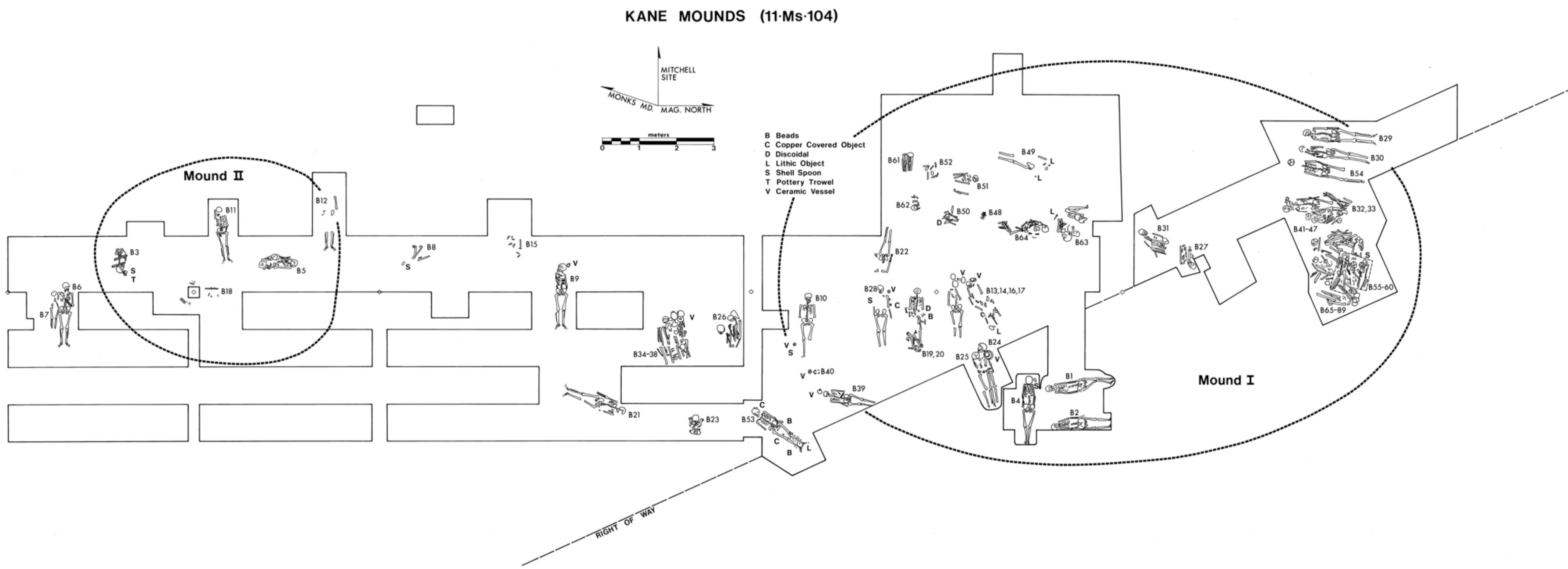

Figure 4.2 Map of Kane Mounds from Milner (1982).

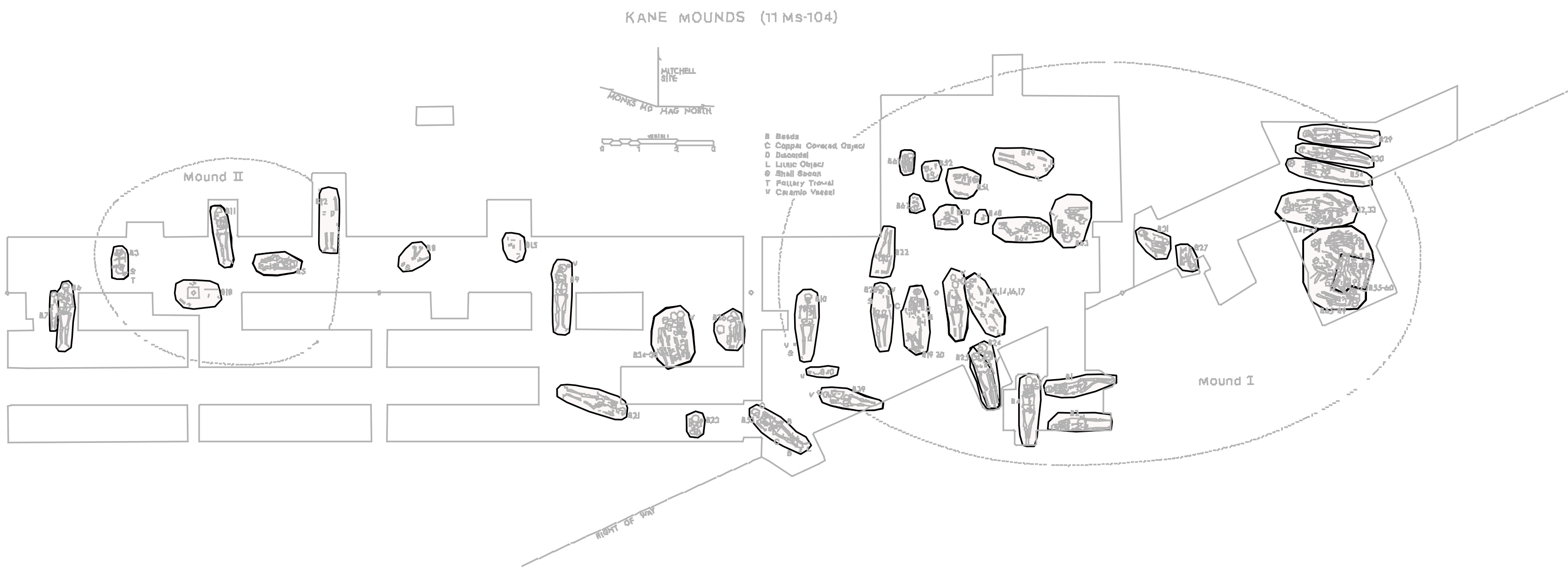

Figure 4.3 Map of Kane Mounds showing the digitized burial.

The group of burials on the northern side of the cemetery was excavated as one feature. The disarticulated bones were not mapped and labeled separately, so they all share the same location in all spatial analyses. It was not possible to re-associate the skeletal elements from this feature in the lab, so the skeletal data were collected from the individual pelves. The nature of these data points separates them from the other burials. To control for possible influence these points may have on the overall project, each analysis will be conducted on the entire site and on the cemetery without this feature.

First, simple descriptive statistics were summarized for the cemetery as a whole. To see if there is a spatially discernible relationship between the burials based on the variables defined above, an exploratory spatial data analysis (ESDA) was conducted in GeoDa (https://spatial.uchicago.edu/geoda). A spatial weights matrix of k-nearest neighbors was used where k=4 (multiple k values were tested and made little impact on the outcome). To test if there was any signature of spatial autocorrelation, a Moran's I statistic was used for the continuous variables of age and burial good count for the 56 burials not in the commingled feature. The remaining 109 burials share the same location. For the categorical data, a join count statistic was applied and the percent of individuals in the sample that were significantly clustered is presented for both all burials (n=165), and just the burials not in the commingled mass (n=56). Join count statistics work on a binary variable so the categorical data were converted into the following binary categories: male, female; primary burial, secondary burial; Monks Mound orientation, Mitchell site orientation; and presence or absence of funerary objects.

Next a cluster analysis was run on a combination of the variables to see if there is a natural, non-spatial division in the data that is more complex than what can be seen and accounted for visually. A cluster analysis was conducted that accommodated categorial and continuous data. The FAMD (factor analysis of mixed data) treats the categorical data as a multiple correspondence analysis (MCA) and the continuous data as a principle component analysis (PCA). The clusters were then mapped and a join count statistic was applied to determine if the clusters were spatially grouped.

Finally, descriptive statistics of the skeletons are sectioned on burial orientation, as suggested by Melbye (1963), and by body treatment, as the cluster and ESDA analyses suggest here. This will lend to a discussion of what these divisions might tell us about the societies of individuals buried at Kane Mounds.

Results

There are 165 individuals identified in the Kane Mounds sample. The age and sex distributions are shown in Table 4.1 with similar numbers of men (n=36) and women (n=32) with 97 individuals of unknown sex. Thirty-three individuals (20%) are buried with funerary objects (FO). Of the 33 individuals with burial goods, 29 individuals had fewer than five items while four individuals had more: 7, 16, 47, and 137 respectively. The percentage of individuals in each age and sex group with burial goods is shown in Figure 4.4. A larger proportion of males have burial goods in all age categories compared to females, but the percentage of males with FO decreases with age while the proportion of females with grave goods increases. Of the 56 individuals not in the commingled feature, 22 were oriented towards Monks Mound, 27 toward Mitchell, and 7 were too fragmentary to determine orientation. For body treatment, 30 individuals had a primary interment, 21 were in secondary/bundled burials, 109 were commingled, 1 was a cremation, and 4 were too fragmentary to determine body treatment.

	Male	Female	Unknown
0-14	0	1*	46
15-29	8	13	12
30-44	9	4	5
45+	17	8	10
Unknown	2	6	24

* This individual was estimated to be aged 12-15 years but had sufficient female markers to estimate sex

Table 4.1 Distribution of individuals by age and sex.

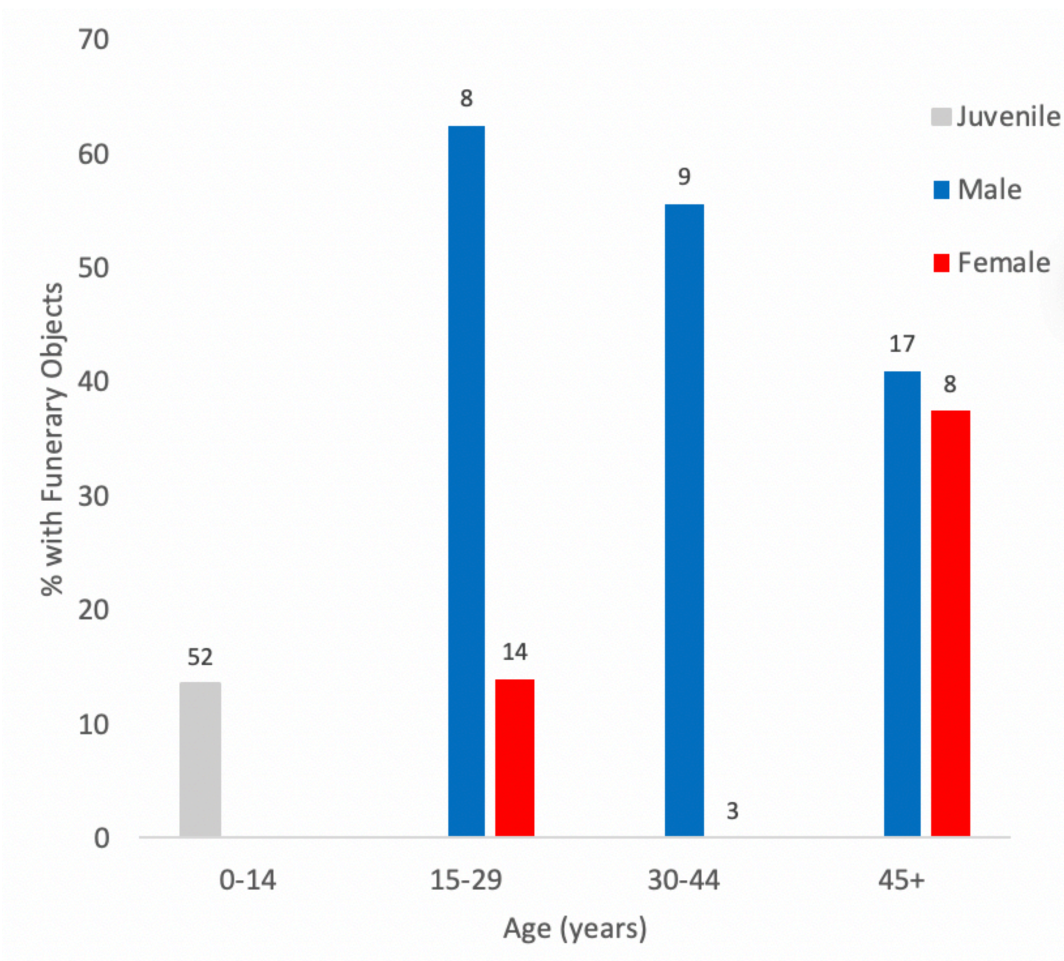

Figure 4.4 Shows the percent of individuals in each age and sex category with funerary objects. The count of individuals (n) in each category is listed above the bar. Of the 165 total individuals, 111 are shown here. 8 individuals could be sexed but not aged, 22 could be aged but not sexed, and 24 could be neither aged nor sexed.

When looking at the spatial layout, the Moran's I for age is -0.028 and for the continuous count of grave goods is 0.002. A value of 1 is a map in which data points are clustered; -1 is evenly spaced in a non-random pattern; and 0 is no spatial organization. The values for these two variables show that they are randomly dispersed across the cemetery. The join count shows what percentage of burials are statistically spatially grouped (Table 4.2). Burials are somewhat grouped by presence/absence of burial goods, but more so by body treatment (i.e., primary, secondary/bundled, commingled). While sex was not shown statistically to have any clustering, it is worth noting that there are no males in Mound 2 (Figure 4.5). The mound has 13 individuals: 4 females, 5 juveniles, and 4 unknowns. Mound 2 was the smallest of the four mounds at Kane cemetery, and it had a fewer burials than the other excavated mound with 129.

	W/ Commingled	W/O Commingled
Male	1.2%	2.2%
Female	1.8%	0.0%
FO presence	8.5%	10.8%
Primary Burials	12.8%	7.5%
Secondary Burials	17.7%	22.6%
Mitchell Mound	1.8%	0.0%
Monks Mound	3.7%	2.2%

Table 4.2 The percent of burials that are spatially clustered for each variable using a join count statistic. The spatial data are shown with (n=165) and without the comingled burials (n=56) at the northern end of site.

The cluster analysis used did not include a spatial factor to see if there is a natural, aspatial division of the data. The data cluster into four groups defined in Table 4.3, and they are primarily dictated by body treatment. All burials in Cluster 1 (n=29) are primary

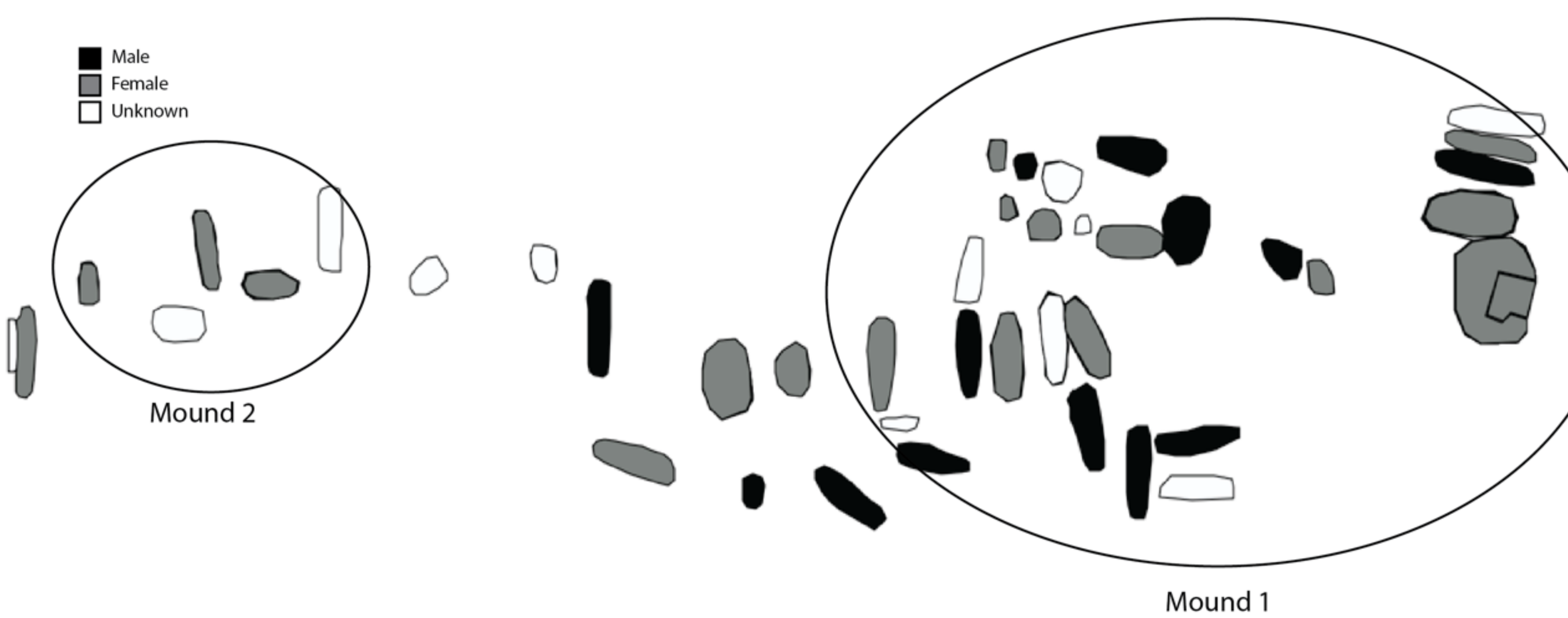

Figure 4.5 The cemetery is shown with males, females, and individuals of unknown sex. There are no males in Mound 2

	n	Sex			FOs	Orientation			Burial Type		
		M	F	U		Monk	Mitchell	Neither	Primary	Secondary	Commingled
Cluster 1	29	48.3	31	20.7	55.2	44.8	51.2	3.4	96.6	0	3.4
Cluster 2	81	18.5	14.8	66.7	4.9	7.4	1.2	91	0	3.7	96.3
Cluster 3	25	12	16	72	12	4	12	84	4	8	88
Cluster 4	30	13.3	23	63	33.3	6.7	26.7	66.7	0	43.3	56.7

Table 4.3 Summaries for the four clusters designated in the cluster analysis.

burials. There is a larger representation of adults and burial goods than in the other clusters. Cluster 2 is the largest (n=81) with most of the commingled burials and the one cremation. These individuals have fewer grave goods on average than the other clusters. Individuals in Cluster 3 and Cluster 4 tend to be younger than those in the first two clusters. Cluster 3 is the smallest cluster (n=25) and is mostly commingled burials. Cluster 4 (n=30) is an almost even mixture of secondary and commingled burials. The clusters are mapped in Figure 4.6 and a join count statistic showed that the clusters were minimally grouped spatially. The percentage of each cluster that was significantly grouped was 6%, 16%, 4%, and 12% respectively.

If there are groups distinguishable by body treatment as suggested by the spatial and cluster analysis, or by burial orientation as suggested by Melbye (1963), there is no statistical difference in the breakdown of the sample by age or sex. Looking only at the 68 known-sex individuals, if we divide them by body treatments (primary, secondary, commingled), males make up 62% (n=16), 41% (n=7), and 37% (n=7) respectively. While females make up 38% (n=10), 59% (n=10), and 63% (n=12). When divided into two samples differentiated by orientation (Monks, Mitchell), males make up 82% (n=11), and 52% (n=11) respectively. While females make up 18% (n=3), and 48% (n=10). Slightly more males than females face Monks Mound, but equal proportions of males and females face Mitchell. A one-way ANOVA by body treatment of the ages for the 133 individuals for whom age could be estimated has a p-value of .491, indicating that there is not a statistical difference in the age distributions between the three samples. By burial orientation, a one-way ANOVA of the age distributions had a p-value of .116.

Figure 4.6 The cemetery is shown with Clusters that correspond to Table 4.3.

Discussion

The statistical analyses and the visual analysis of Melbye (1963) demonstrated two potential interpretations. If there are multiple groups using the site that can be marked by the features tested here, then the visual analysis suggested that there was orientation of the burials was an important division while the ESDA and the cluster analysis suggested that body treatment (primary, secondary, commingled) is a factor of importance. Age, sex, and funerary objects cannot be used as a means of differentiating the use of space at Kane Mounds. They are instead spread evenly across site. Funerary objects are argued here to be a reflection of the individual's status, not spatially clustered or linked to body treatment or orientation. A larger percentage of males have FOs than females in any age category (Figure 4.4), but fewer males have FOs in older age categories than in younger ones. Fewer females have FOs, but their social status, as represented here by percentage of the population with FOs, does not decrease with age and rather increases. This is similar to what was found at the Archaic Carrier Mills site in southern Illinois (Tremblay, 2020).

The orientation of the burials towards Monks and Mitchell Mounds was seen and documented by Melbye in his 1963 report, and that rather clear patterning can be seen in the digitized map of the burials (Figure 4.7). Despite the seemingly obvious nature of the burial orientation, Melbye (1963) commented that the link between the individual and these two sites was unclear. Individuals with these two orientations are spread evenly across the cemetery and across the four clusters suggesting that orientation is not linked to age, sex, funerary object count, or body treatment. The burials of individuals oriented towards

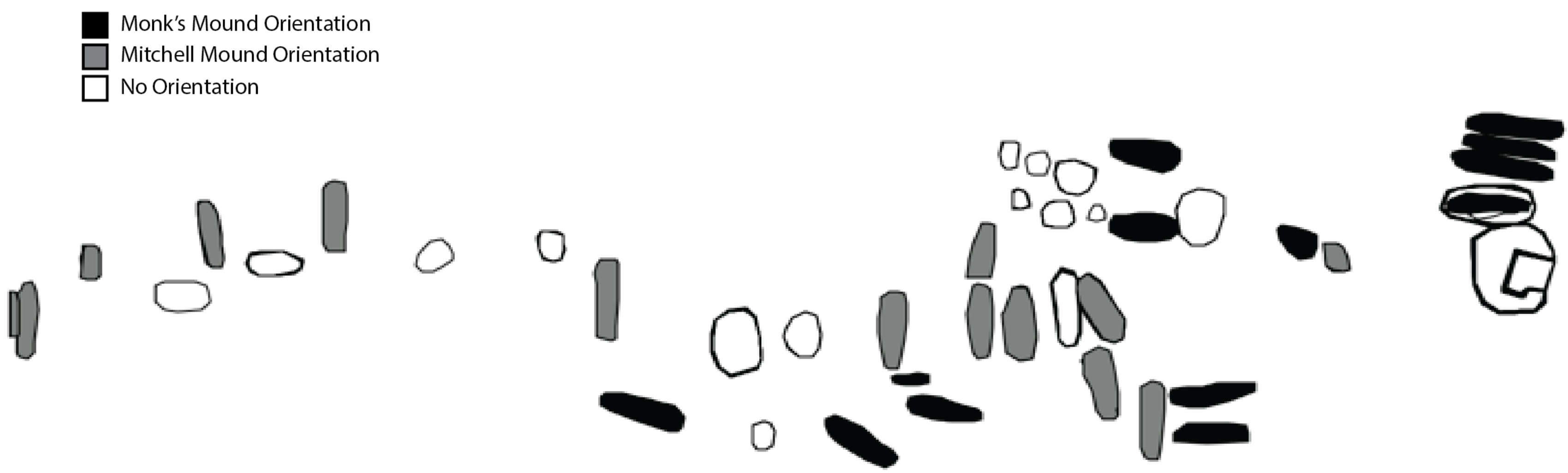

Figure 4.7 The cemetery is shown with the orientation of the burials toward Monks Mound and Mitchell Site.

Mitchell and those oriented towards Monks Mound have similar proportions of males and females (although slightly more males are facing Monk's Mound than females) and similar distribution by age. Given this, it seems that the orientation of the grave was unlikely to have been determined by social status or social persona as identifiable by material or skeletal remains. It is possible that what determined the orientation of a grave could have been the use of the cemetery by different descent groups or some other factor that cannot be seen archaeologically.

When the variables associated with the skeleton and burial are used in a cluster analysis or an ESDA of the distribution of burials, we see that body treatment is the primary factor that drives spatial and statistical clustering. While the burial types are minimally spatially grouped, the clusters developed in the cluster analysis – which are primarily clustered around body treatment – are less so. At Kane Mounds, we see three different body treatments: primary burials, secondary interments referred to as bundled burials, and the feature of commingled bones at the northern edge of the site (Figure 4.8). The archaeological literature suggests that the difference in body treatment is not cultural but might be a factor of seasonality (Albrecht, 2013), mobility/distance from the village at the time of death (Miller and Gill, 1980; Milner et al., 1991), or a signal of status (Goldstein, 1977).

A thesis by Albrecht (2013) suggests that bundle versus primary burials are indicative of the season of death. She hypothesized that individuals who die in winter months may not be interred until the ground thaws and a grave can be dug. These bodies may instead be left on the surface to partially decompose and be buried at a later date.

Figure 4.8 The cemetery is shown with body treatment - primary, secondary/bundled, and commingled

Similar to what Albrecht (2013) found at Dickson, Kuhlman, and Albany Mounds, we see that the demographic differences between primary and bundled burials are minimal.

Secondary interment may also be necessary for individuals who died far from home or died under circumstances where their bodies could not be recovered immediately. From the site of Stone Fence (south-central Wyoming), Miller and Gill (1980) concluded that secondary interments were the result of highly mobile individuals. Another example comes from the site of Norris Farms (Illinois) (Milner et al., 1991) where individuals who were killed as a result of warfare have evidence of animal scavenging before being interred. It is suggested that their bodies were not recovered immediately after death because of their distance from home leaving their bodies exposed to animal activity before the body was found.

Deviating from these hypotheses about the practical nature of bundled burials, Lynne Goldstein (1976), among others suggested that there may be a link between this body treatment and social status. She stated that the work required to prepare a body for secondary burial means that there was a greater investment in time, and therefore respect for the dead. However, the link at Kane Mounds between body treatment and funerary objects – which are a widely used marker of social status in funerary archaeology – suggest that there are slightly fewer secondary burials with FO (28%) than with primary burials (44%).

The final feature of the cemetery to be discussed is the “continuous amorphous mass of bones” as described by Melbye (1963). Of the 165 individuals at Kane Mounds, 109 were buried in this feature. Based on information from geographically and temporally similar sites, both non-elite and elite, it is possible that this feature is a charnel structure despite the lack of post holes found nearby. Schild Cemetery was the first cemetery in the area with a recognized charnel structure. The site was thought to have a charnel-type structure filled with partial and disturbed burials (Goldstein, 1977). The area was surrounded by large limestone pieces that may have been part of the structure and the fill layer above the burials contained burnt bone, corn, and artifacts.

The East St. Louis Stone Quarry site, also excavated as a part of the Interstate 270 project (but decades later), had a charnel structure located in the center of the site characterized by limestone slabs (Milner, 1983). Four post holes were excavated that must have supported a structure. The disarticulated bones of several people were documented from this area.

Some cemeteries use charnel structures as an "elite" burial area such as at The East St. Louis Mound Group (Milner, 1984). The charnel structure was described by John Francis Snyder in 1909 (cited by Kelly, 1994 and Pauketat, 2005):

> *"[It was] built, twelve feet square and seven feet high. The corner posts, of cedar, were still in place; the other uprights and roof timbers, of softer wood, were reduced to dust. The side walls of the house, constructed of poles planted perpendicularly and interlaced with long slender willow sprouts, or reeds, had disappeared, leaving only here and there their impression in the adjacent dry clay… When all had been cleared away, the bottom of the space bounded by the four cedar posts defining the area of the buried bone-house was found to be covered, to a depth of eighteen or twenty inches, with a mass of mingled human bones so far decayed – with the exception of the teeth – that their separation and removal for careful inspection and preservation was utterly impracticable."*

The feature at Kane Mounds lacks some of the distinctive characteristics of the charnel structures at the other sites like the limestone or, more notably, the postholes indicating a structure. However, post holes can be difficult to identify in loess soil, like that found at Kane. They may have been missed by the excavators, have disappeared in the prior to excavtion, or have never existed, but the quantity of disarticulated bones and the square nature of the feature are in line with a charnel structure.

Conclusion

Pareidolia can lead to researchers over-identifying patterns in spatial information. This paper aimed to confirm the visually identified patterns at Kane Mounds of burials oriented towards Monk's and Mitchell Mound. The ESDA and the cluster analysis did not confirm that patterning but found that body treatment (primary, secondary, and commingled) is a potentially important variable. As archaeologists, we cannot recreate the worldview of the individuals that constructed the cemetery, but we can use the visual analysis, the ESDA, and the cluster analysis to support a discussion about the use of space. The two orientations of the burials might be a reflection of two different subpopulations using the same space. The different body treatments might also reflect different groups but are more likely reflections of seasonality, mobility, or circumstance of death. Instead of confirming the visually identified patterns, we have added an additional line of evidence to discuss the use of cemetery space at Kane Mounds.

Acknowledgements
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Chapter 5

Conclusion

This dissertation looks at three different types of mortuary archaeological evidence – the skeleton, grave goods, and the layout of the cemetery – to see what information can be extracted from each. Each of the previous three chapters focused on one of these types of evidence, but the methods in each chapter build upon each other. Chapter 2 looks at skeletal morphology to assess how individuals of different ages and sexes sit. The skeletal analysis used in Chapter 2 is built upon in Chapter 3 where demographic information is combined with counts of funerary objects – used as a proxy for social status – to look at age-dependent status and how it differs between males and females. Finally, Chapter 4 examines the spatial distribution of graves based on the demographic traits of age and sex (the same methods as in Chapters 2 and 3) and combines it with traits of the grave such as grave goods (the same method as in Chapter 3), body treatment, and burial orientation to investigate social organization. All of the chapters look at separate populations in the same region and regional contextualizing is of key importance in order to extract as much information as possible from these studies.

Chapter 2

The Norris Farms cemetery (AD 1300) in central Illinois is associated with tribal, subsistence-level agriculturalists and comprises 164 burials. Femoral torsion was measured and degree of asymmetry analyzed for the 83 adult skeletons that had both femora present and no pathological involvement of the proximal femur. Degree of asymmetry was defined as the absolute difference of angles of femoral torsion in the left and right femora. Females in this population had higher degrees of asymmetry than the males, proposed to be a result of side sitting for long periods of the day starting at a young age. Side sitting is sitting with the knees positioned in front of the body and bent such that both feet lie together and outside of the hips. This posture is also found in archaeological figurines from the region dated to the Woodland period. Additional skeletal material, photographs, and written documentation from European explorers suggests that side sitting was pervasive among Native American females geographically and temporally. Geographically, the posture is documented as far north as Minnesota, south as New Mexico, east as Illinois, and west as Oregon, while temporally it dates from the Archaic to the early 20th century.

There are three main flaws with the study that can be addressed by future work: 1) the sample size, 2) the existing literature on “normal” versus “abnormal” measures of femoral torsion, and 3) individuals excluded from this study because of pathological conditions.

The first flaw in research of asymmetric femoral torsion and side sitting in archaeology is the small number of studies devoted to the topic. The Chapter 2 sample includes 83 individuals who met the criteria (both left and right femora and no pathological involvement of the proximal femur). The other two researchers who have published on its presence in the archaeological record, Westcott et al. (2014) and Basgall (2008), were fairly limited in their geographic and temporal scope. Westcott et al. examined two populations (n=273), both from South Dakota, while Basgall only looked at 13 skeletons, all from Wyoming. Added to the sample from Norris Farms makes only 369 skeletons that have been measured for asymmetric femoral torsion and published. Not all geographic and temporal periods are equally represented which partially reflects preservation bias but expanding studies of this nature is key to understanding the range of side sitting.

One of the ways to increase the sample of observable populations is to reevaluate the methods and measurements of femoral torsion. The literature for "normal" femoral torsion is weak in a few areas. Measurements of femoral torsion are taken predominately from living individuals, the documentation of what is "normal" has not been reexamined in many years, and the studies that record these data – and have been used by medical doctors and physical therapists since – do not state which populations were analyzed to determine average femoral torsion. These flaws necessitated that in Chapter 2 femoral torsion was compared between the sexes using a t-test, as did Westcott et al. (2014). An alternative method was used by Basgall (2008) who used a sectioning point of an asymmetry greater than five degrees as abnormal, as suggested by Alvik (1962) and Anderson and Trinkhaus (1998).

By more widely studying femoral torsion in skeletal populations we can examine if small degrees of asymmetry are more common that thought or if people do typically adhere to a less than five-degree difference between femora. A better understanding of what is and is not normal would allow for studies of smaller populations. If you must rely of a comparison between the sexes, only large sample sizes will have robust statistical significance, but with better guidelines of what ranges are or are not "normal", we can apply this study to smaller samples as done by Basgall (2008).

In Chapter 2, individuals were not measured for femoral torsion if they had a pathological condition that impacted the femoral head or neck. This included five individuals who suffered from congenital hip dislocation in one or both femora. Increased bilateral femoral torsion is known to be related to hip dislocation (Cibulka, 2004; LeVeau and Bernhardt, 1984; Gulan, 2000; Getz, 1955; Jani, 1979; Staheli, 1985; Shefelbine and Carter, 2004) so it is possible that this study has missed important information. A fuller look at the hip morphology like the one undertaken by Getz (1955) of the Lapps (from Finnmark County, Norway) might provide a means of collecting data from the skeletons with congenital hip dislocation that the method in Chapter 2 could not accommodate, and to explore the relationship between increased femoral torsion and hip dislocation. Getz (1955) set out to explain the high rate of congenital dislocation in the Lapp population. They did this by taking measurements of femoral antetorsion (this has the same definition as the femoral torsion measure in Chapter 2), femoral neck shaft angle also called the collo-diaphyseal angle, depth of acetabulum, inclination angle of the acetabulum to the sagittal plane. The dislocation rate in the historic skeletal population was 0.24 while other populations in Norway averaged 0.10. There was also a large disparity between the sexes in all populations studied with a larger portion of females experiencing dislocation than males (Loder and Skopelja, 2011).

Finally, while not a shortcoming of the study, another avenue of potential information into the functional deficits caused by asymmetric femoral torsion would be to look into historic medical literature from reservations to see if there is a trend of complaints in regard to hip or knee pain or difficulty with walking. Photographic evidence shows that females were side sitting into the 20th century and this is an avenue that should be explored.

Chapter 3

The Carrier Mills population from southern Illinois is an Archaic period, semi-sedentary, hunter-gatherer population used to examine the post-reproductive individuals of this society. Humans are unique among primates in that they experience menopause (Kirkwood and Shanley, 2010; Kim et al., 2014; Mattern, 2019), but menopause has been argued to be a recent phenomenon by researchers who believed that prehistoric peoples did not live long enough to experience it (Austad, 1994; Lovejoy et al., 1977; Trinkhaus & Thompson, 1987; Weiss, 1973; Willey & Mann, 1986). Most age-at-death estimation methods have a terminal open-ended age category (i.e., 45+) but Transition Analysis (TA) provides estimates throughout the lifespan. Its application tests if an appreciable portion of the individuals at Carrier Mills survived past the age of 45. Many individuals from Carrier Mills did live past their reproductive prime so funerary objects (as a proxy of social status) were used to further investigate age-dependent social status of males and females. It was demonstrated that males had higher status at all ages but had a decrease in status after their productive prime while females maintained their status through old age.

The TA method is being improved upon and a new version of the method should be available by the end of 2020. While the version applied in Chapter 3 is sufficiently accurate when looking at population level patterns, it is far less accurate for aging a single skeleton. The Carrier Mills population is sufficiently large that the overall age-at-death pattern should be maintained and the conclusions about many individuals surviving into old age should be true no matter which version of TA is applied. Chapter 3 also examined the social status at time of death using burial goods as a proxy for social status. Of the 165 individuals at Carrier Mills, only 21 of them had burial goods. With the much smaller sample size, the age-at-death pattern is more susceptible to error. By placing skeletal individuals into age groups (e.g., 15-29, 30-44, etc.), we have preserved most of the overall pattern, but a more accurate age-at-death estimation (the new version of TA) would allow for a more precise look at burial goods.

An additional problem with looking at burial goods from the Carrier Mills population is the quantity of grave goods with each individual. There was very little that could be done with social status aside from a count of funerary objects, very generalized categories including decorative, tools, and unmodified, and the association of a few individuals with funerary objects thought to represent a specific role in society such as shaman. The application of the same methods to additional populations would confirm the age-at-death pattern seen here, which is particularly important in other Archaic (or Neolithic) grade societies globally to see how long in prehistory people have routinely survived beyond age 45. It would also provide different grave goods to expand the simple count and categories of funerary objects used in Chapter 3.

Chapter 4

A map of the Kane Mounds burials was digitized to look at the spatial distribution of skeletal and grave data to examine the social organization of the society, using the same methods for age and sex as Chapters 2 and 3, and the same methods of analyzing grave goods as Chapter 3. When excavated in the early 1960s Melbye (1963) noted that the burials were oriented towards two mounds that, when the cemetery was in use, would have been visible from the bluff where the cemetery was located. The two mounds were Monks Mound at Cahokia and the mounds at the Mitchell site. Based on the archaeological literature, one explanation of the orientation might be related to different sub-groups (otherwise hidden archaeologically) using the cemetery.

To test if the orientation of the burials were spatially grouped in a statistically significant way, or to see what other factors might be important for spatial clusters, an exploratory spatial data analysis (ESDA) was undertaken. An ESDA provides the benefits of examining the spatial data, to see how the spatial layout is of burials is affected by individual traits. One of its primary benefits is that it eliminates the susceptibility of the human mind in seeing patterns that are not statistically valid. An ESDA has no inherent means of explaining why a cemetery is laid out in that particular fashion but knowing something about the site and regional context will help situate the results. In addition to the ESDA, a non-spatial cluster analysis was conducted. The results of the ESDA and the cluster analysis suggested that body treatment (primary, secondary, or commingled) was an important variable around which groups of burials were clustered spatially and non-spatially. The body treatment may have reflected the seasonality (Albrecht, 2013), mobility/distance from the village at the time of death (Miller and Gill, 1980; Milner et al., 1991), or a signal of status (Goldstein, 1977) as suggested by archaeological research at other sites

The methods that were utilized in Chapter 4 are demonstrated to be a useful way of examining the arrangement of space of an archaeological cemetery, but the Kane Mounds cemetery is not an ideal data set for their application. The sample size of the Kane Mounds skeletal collection is sufficiently large for a study of this nature, but since 109 of the 164 burials are in the same commingled location, many of the analyses had a much smaller sample size. The methods used in Chapter 4 are a starting place for similar studies of the use of space in cemetery samples. The contextualization and interpretation of the analysis will vary depending on the location of the study but the methods provide a template to look at any cemetery samples.

Conclusion

Like many archaeological studies, the work conducted here represents a small snapshot of prehistoric life. It utilized different types of archaeological evidence to answer questions about the day-to-day lives of three populations but the work needs to be greatly expanded to make broader claims about the human condition in this region. Skeletal morphology was used to determine seated posture that would have been assumed daily. Grave goods demonstrated that post-reproductive women maintain status, unlike males, suggesting that they play an important role in society. Finally, the cemetery was used to investigate how social organization is reflected in the use of space. By using any of the three elements discussed here – skeletal morphology, grave goods, and the spatial organization of a cemetery – we can say something meaningful about the daily lives of individuals living in the past, and each chapter here provided information that can be used to launch additional work in the field of mortuary analysis.

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Appendix A

Figure A.1 Photograph of Wichita Indians c. 1892. BAE GN 1338 B, National Anthropological Archives, Smithsonian Institution.

Figure A.2 Photograph, Warm Spring Apache Indians, demonstrates side sitting. BAE GN 2899 B12, National Anthropological Archives, Smithsonian Institution.

Figure A.3 Photograph of Cayuse Indians c. 1900. BAE GN 03073B73 06501400, National Anthropological Archives, Smithsonian Institution.

Figure A.4 Photograph of Cayuse Indians c. 1900.by Lee Major Moorehouse BAE GN 03073B81 06502200, National Anthropological Archives, Smithsonian Institution.

Figure A.5 Photograph of Dakota Brule Indians c. 1872 by Alexander Gardner. BAE GN 03121 06515300, National Anthropological Archives, Smithsonian Institution.

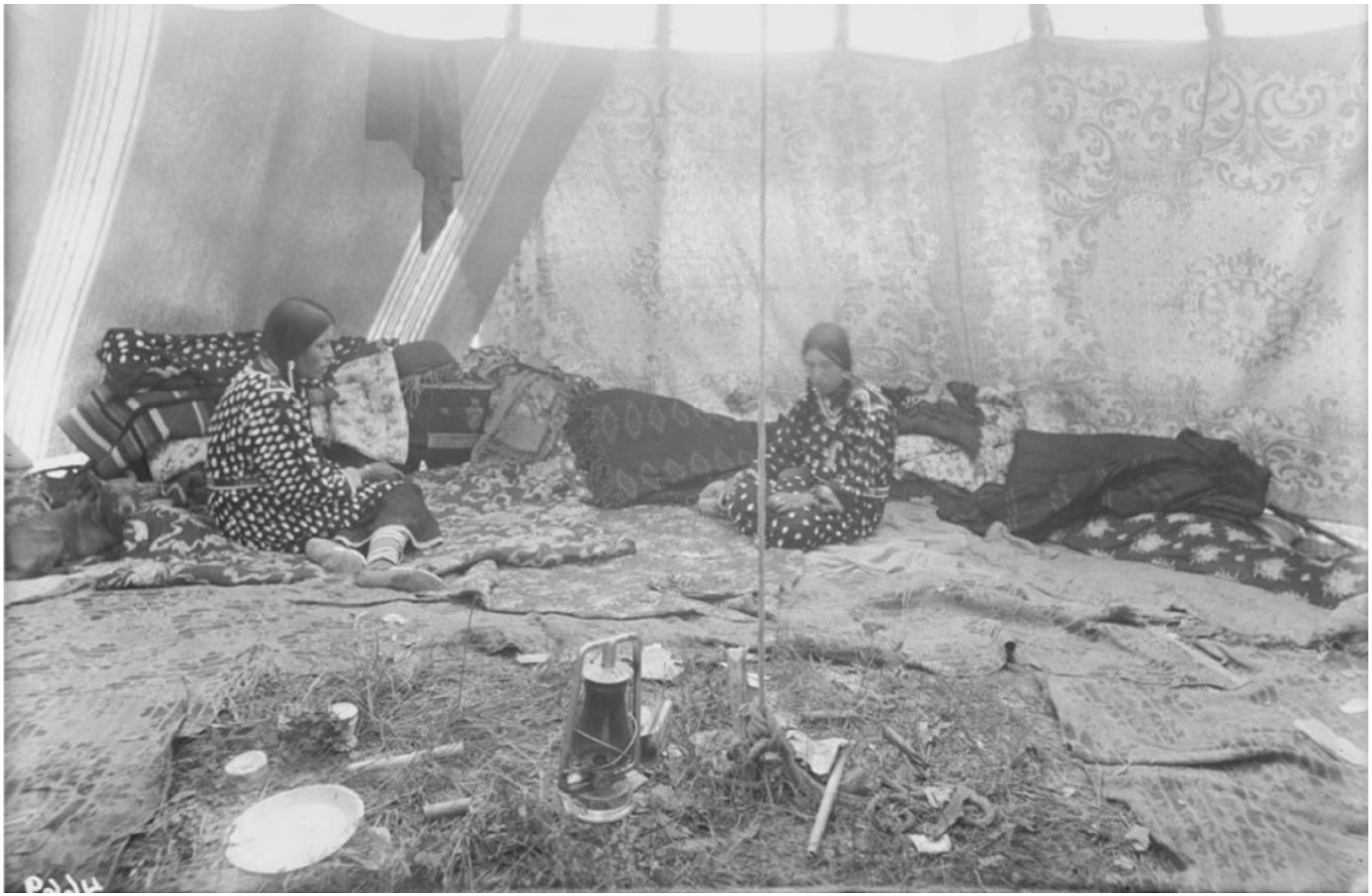

Figure A.6 Photograph of Crow Indians. BAE GN 4669, National Anthropological Archives, Smithsonian Institution.

Figure A.7 Photograph of Assiniboine Indians c. 1898 by Frank Albert Rinehart. Photo Lot 60: BAE Ref Album 7: Assinibion/Blackfoot 0290262, National Anthropological Archives, Smithsonian Institution.

Figure A.8 Photograph of Assiniboine Indians c. 1898 by Frank Albert Rinehart. Photo Lot 60: BAE Ref Album 7: Assiniboin/Blackfoot 02902701, National Anthropological Archives, Smithsonian Institution.

Figure A.9 Photograph of Winnebago Indians c. 1898 by Frank Albert Rinehart. Photo Lot 60: BAE Ref Album 15: Omaha/Winnebago 02919902, National Anthropological Archives, Smithsonian Institution.

Figure A.10 Photo from Richard Throssel, 1902-1933. University of Wyoming American Heritage Center, Richard Throssel Papers, Accession Number 02394, Box 8, TP11, Throssel #14.

Figure A.11 Photo from Richard Throssel, 1902-1933. University of Wyoming American Heritage Center, Richard Throssel Papers, Accession Number 02394, Box 12, TP77, Throssel #187.

Figure A.12 Crow man and woman inside tipi by Richard Throssel, 1902-1933. University of Wyoming American Heritage Center, Richard Throssel Papers, Accession Number 02394, Box 31, TP473, Throssel #715.

Figure A.13 Crow woman braiding hair by Richard Throssel 1902-1933. University of Wyoming American Heritage Center, Richard Throssel Papers, Accession Number 02394, Box 31, TP482, Throssel #733.

Figure A.14 Photo by Richard Throssel, 1902-1933, University of Wyoming American Heritage Center, Richard Throssel Papers, Accession Number 02394, Box 48.

Site	County	State	Culture	Sex	Posture	Material	H (cm)	W (cm)	L (cm)	Catalog Number	CITATION
Knight Mound, Mound 9	Calhoun	IL	W	F	seated	Ceramic	7.5-11			MPM, A50673A-E/17563	
Knight Mound, Mound 10	Calhoun	IL	W	F	seated	Ceramic	7.5-11			MPM, A50673A-E/17564	
Twenhofel site	Jackson	IL	W	F	seated	Ceramic	8.3	3.3		ISM, 803630	Smail (1954); Griffin et al. (1970)
Arkansas River Valley	Muskogee	OK	M	M	kneeling	Stone	20.9	10.5	12.8	SLM, 12X83	
BBB Motor site	Madison	IL	M	F	kneeling	Stone	20	14			Emerson (1982); Emerson and Jackson (1984)
BBB Motor site	Madison	IL	M	M	kneeling	Stone	13	7	9.7		Emerson (1982); Emerson and Jackson (1984)
Bell Field Site	Murray	GA	M	M	kneeling	Stone	9	15			
Cahokia made/found AR	Desha	AR	M	F	kneeling	Stone	18	18	14		
Emerald Site (?)	Clairborne	MS	M	M	kneeling	Stone	12.2	17	8.5	BM, 37.2802	Squier and Davis (1848); Schoolcraft (1855)
Guy Smith Village site	Jackson	IL	M	M	kneeling	Stone	9.3	12.7		UI MNH, A3419	West (1932); Emerson (1982)
Guy Smith Village Site	Jackson	IL	M	M	kneeling	Stone	9.5				
Hayes Farm	Davidson	TN	M	F?	kneeling	Stone	46.2				
Knight Mound, Mound 8	Calhoun	IL	W	M	kneeling	Ceramic	7.5-11			MPM, A50673A-E/17562	
Mound 4 Turner Site	Hamilton	OH	W	M	kneeling	Ceramic	8.3	3.7		PM, 82-35-10/29687	Willoughby and Hooton (1922); Griffin et al. (1970)
unknown	unknown	AR	M	F	kneeling	unknown					
unknown	unknown	MO or AR	M	M	kneeling	Ceramic	16	13.8		GIAHA, 5425.1517	Phillips (1970)
unknown	unknown	MO	M	M	kneeling	Stone	17.8				
unknown	unknown	MS	M	M	kneeling	Stone	12.2	17			
unknown	unknown	AR	M	M	kneeling	Stone	19.1	22.9			
Piasa Creek mound	Madison	IL	M	M	kneeling	Stone	19.3	18		GIAHA, 6124.18.913	MacAdams (1887); Perino (1971); Emerson (1982)
Rock Shelter	Smith	TN	U	F	kneeling	Ceramic	22.9				
Shiloh Indian Mounds	Hardin	TN	M	M	kneeling	Stone	20.3				
Sponemann	Desha	AR	U	F	kneeling	unknown					
Twin Mounds Site	Ballard	KY	M	M	kneeling	Stone	17.8				
Angel Site	Warrick	IN	M	M	sitting	Stone	22				Black (1967)
Bell Site	Roane	TN	M	M	sitting	Stone	7.9			FMM, 13/51REI	Lewis (1937) Chapman (1982)
Bottom Land of the Ohio River	unknown	KY	U	M	sitting	Stone	25	18			
Carrier Mills	Saline	IL	W	M	sitting	Ceramic	8.3	3.5			Jeffries and Butler (1982)
Charleston area	Mississippian	MO	M	M	sitting	Ceramic	22	14			
Craig Mound, Spiro Site	LeFlore	OK	M	M	sitting	Wood	18.7	7.7		GIAHA, 7325.3	Brown (1976)
Craig Mound, Spiro Site	LeFlore	OK	M	M	sitting	Wood	32.5	16.8		NMNH 448892	Hamilton (1952)
Etowah site, Mound C	Bartow	GA	M	F	sitting	Stone	61				Kelly and Larson (1957); Larson (1971)
Etowah site, Mound C	Bartow	GA	M	M	sitting	Stone	61				Kelly and Larson (1957); Larson (1971)
Francis Simonim Farm	St Clair	IL	M	F	sitting	Ceramic	14.9	9.7		SLM 8X65	Blke and House (1978)
Jackson township	Wells	IN	M	M	sitting	Stone	9.3	3.6	4.6		
Kentucky Lake	none	TN	U	F	sitting	Stone	35				
Kentucky Lake	none	TN	U	M	sitting	Stone	17.5				
Lake Okeechobee	none	FL	U	M	sitting	Wood	18.75			NMNH, 316,254	
Mound C Etowah Site	Bartow	GA	M	M	sitting	Stone	44.6				Moorehead (1932)

Site	County	State	Culture	Sex	Posture	Material	H (cm)	W (cm)	L (cm)	Catalog Number	CITATION
unknown	none	AR	M	F	sitting	Ceramic	23.2				
unknown	Rhea	TN	U	F	sitting	Stone	34.5			MAI, 21-965	
unknown	Rhea	TN	U	M	sitting	Stone	33			MAI, 7277	
unknown	Lincoln	TN	U	M	sitting	Stone	43.75	12.5	8	NMNH, 388049	
unknown	Knox	TN	U	M	sitting?	Stone	51.25	15.5	9.5	NMNH, 6462	
unknown	Knox	TN	U	M	sitting?	Stone	51.25	15.5	9.5	NMNH, 6462	
Poverty Point	W Carroll Parish	LA	A	F	sitting	Ceramic	4.8	2.65		GIAHA 6123.5424.5739	Webb (1968)
Racoon Creek	Bartow	GA	U	M	sitting	Stone	53.75				
Seller Farm site	Wilson	TN	M	M	sitting	Stone	46.2			FMM 1/1W11	Lewis (1948); Kneberg (1952); Chapman (1982)
Smiling Dan Site	Scott	IL	W	M	sitting	Ceramic	2.5	1.5		CAA, SMD SQ. 52-24D-7	Stafford and Sant (1983)
Spiro	LeFlore	OK	M	M	sitting	Stone	27.5	23		UAM, 47-2-1	Hamilton (1952); Brown (1976)
Ware Site	Union	IL	M	M	sitting	Stone	33	23			
unknown	none	AR	U	M	sitting	Stone	8.75	12.5	5	RPM, 32-395-1	
unknown	Bartow	GA	U	M	sitting	Stone	15	10.5		RPM, 32-391-1	
Adena Mound	Ross	OH	W	M	squatting	Stone	20				Willoughby and Hooton (1922); Griffin et al. (1970)
Lookout Mountain	none	TN	M	F	squatting	Stone	15.5		5	RPM, 32-390-1	
Lookout Mountain	none	TN	M	M	squatting	Stone	12	17.5		RPM, 32-394-1	
Moundville	Hale	AL	M	M	squatting	Stone	21.25			MAI, 17-2810	
unknown	none	TN	U	M	squatting	Stone	20				
Spiro, Craig Burial Mound	LeFlore	OK	M	M	squatting	Stone	20.5			SM, B 99-2	
Spiro, Craig Burial Mound	LeFlore	OK	M	M	squatting	Stone	23.4				
Spiro, Craig Burial Mound	LeFlore	OK	M	M	squatting	Stone	22.4	22	9.3		
Baehr Mounds	Brown	IL	W	M	standing	Ceramic	ca. 8				Griffin et al. (1970)
Baehr Mounds	Brown	IL	W	M	standing	Ceramic	ca. 13				Griffin et al. (1970)
Buck Mound	Okaloosa	FL	W	?	standing?	Ceramic	36.4	22.9		TMM 1197	Brose (1979); Lazarus (1979)
Knight Mound, Mound 11	Calhoun	IL	W	F	standing	Ceramic	7.5-11			MPM, A50673A-E/17565	
Knight Mound, Mound 12	Calhoun	IL	W	F	standing	Ceramic	7.5-11			MPM, A50673A-E/17566	
Spiro	LeFlore	OK	M	M	standing	Stone	24.8				
Sponemann	Desha	AR	U	F	unknown	unknown					
Twenhofel site	Jackson	IL	W	?	unknown	Ceramic	4.7	3.2		ISM, 803631	

Table A.1 List of archaeological figures with site name, county, state, culture (A=Archaic, W=Woodland, M=Mississippian, U=Unknown), sex (M=Male, F=Female, ?=Unknown), posture, material, height, width, length in centimeters, catalog number as assigned by the museum (BM=Brooklyn Museum, CAA=Center for American Archaeology, FMM=Frank H. McClung Museum, GIAHA=Gilcrease Institute of American History and Art, ISM=Illinois State Museum, MAI=Museum of the American Indian, MPM=Milwaukee Public Museum, NMNH=Smithsonian Institute National Museum of Natural History, PM=Peabody Museum, RPM=Reading Pubic Museum and Art Gallery, SLM=St. Louis Museum of Science and Natural History, SM=University of Oklahoma Stovall Museum, TMM=Temple Mound Museum, UAM=University of Arkansas Museum, UI MNH=University of Illinois Museum of Natural History), and citation.

SK #	Sex	Age	R FNA	L FNA	Asymmetry	Legs To:	R Width	R Depth	L Width	L Depth
5	M	45-50	32	27	5	Right	27	28	29	28
10	M	45-50	48	42	6	Right	24	30	24.5	29
15	F	40-50	47	19	28	Right	23.5	23.5	31	25
19	M	50+	58	41.5	16.5	Right	25	30.5	26	32
20	F	17-19	46	45	1	Right	20.6	24.2	20.8	23.7
21	F	45+	49	35	14	Right	22	26	23	26
22	F	50+	49	32	17	Right	23.5	26	26	26.5
24	F	50+	38	31	7	Right	26	26	27	25
26	M	30-35	38	37	1	Right	33.5	29	31.5	28
27	F	30-35	51	36	15	Right	22.5	24.5	23.5	25
28	f	50+	39	26	13	Right	24	24	24	23
31	F	50+	32	30	2	Right	26	27.5	26	27.5
33	F	30-35	32	34	-2	Left	25	26	23.5	24.5
34	F	50+	36	37	-1	Left	24	26	25	25.5
35	F	45-50	36	39	-3	Left	24.5	27	24.5	27.5
36	F	50+	52	28	24	Right	23	23	26.5	25
37	F	18-21	39	47	-8	Left	21	23	22.5	23
40	F	50+	49	32	17	Right	23	26	25.5	27
41	F	30-35	36	40	-4	Left	21	27	21.5	26.5
44	M	20-23	40	34	6	Right	23.5	25.5	23	25.5
45	M	35-40	38	32	6	Right	27.5	29	29.5	28
47	F	45-50	49	34	15	Right	23.5	25.5	25	26
49	M	20-25	30	32	-2	Left	27	27.5	26	28.5
50	M	30-35	38	34	4	Right	22	27.5	24.5	28
51	F	50+	37	31	6	Right	24.5	24.5	26	25
55	M	50+	50	44	6	Right	25	24.5	25	26
60	M	50+	43	33	10	Right	26.5	33.5	28	31
61	M	45-50	36	30	6	Right	26	32	26	32
62	M	30-35	41	34	7	Right	27	30.5	27	29.5
66	F	18-21	44	35	9	Right	20.5	21.5	22	22
67	M	40-50	44	39	5	Right	25	28.5	25	29
69	F	18-21	46	42	4	Right	21	24	22	25
72	F	18-21	57	41	16	Right	21	25	23	25
80	F	30-35	50	17	33	Right	23.5	26.5	25	28
82	F	35-45	44	41	3	Right	20.5	24	21.5	23.5
83	F	50+	49	31	18	Right	24	30	25	27.5
86	F	50+	45	27	18	Right	25	28	27.5	27

SK #	Sex	Age	R FNA	L FNA	Asymmetry	Legs To:	R Width	R Depth	L Width	L Depth
91	F	35-40	44	16	28	Right	24.5	24.5	25	24
92	F	45-50	46	29	17	Right	22	24	23.5	23.5
94	F	35-40	46	38	8	Right	21	26	22.5	25
96	F	50+	30	41	-11	Left	26	26	23	26
100	M	30-35	43	32	11	Right	25	29	26	29
105	M	25-28	38	35	3	Right	24	20.5	24.5	20.5
106	M	35-40	31	33	-2	Left	27	29.5	26	30.5
107	M	35-40	35	40	-5	Left	21	22	22	22
108	M	50+	30	29	1	Right	27	26	26	27
132	F	25-30	39	28	11	Right	23.5	26	24	25
174	F	18-21	41	30	11	Right	21	24.5	22	25
185	M	45-50	46	27	19	Right	28.5	26	27	27
188	F	18-21	51	32	19	Right	20	22.5	21	23.5
191	F	50+	46	24	22	Right	23	25	26	28
203	F	18-21	36	32	4	Right	22	23	23	21
205	F	25-35	50	31	19	Right	21.5	23.5	23	24
208	F	50+	25	36	-11	Left	25	27	24	25
213	M	35-40	31	36	-5	Right	27.5	28.5	26.5	28
214	M	45-50	40	34	6	Right	25	33	26	33.5
215	F	25-29	37	34	3	Right	24	26	25	26
216	M	30-35	24	45	-21	Left	28	28	26.5	26.5
217	M	30-35	42	40	2	Right	25	29	26	30
223	F	30-35	51	41	10	Right	22	25	22.5	25
224	F	50+	51	40	11	Right	21.5	24	23	24
225	M	40-45	40	30	10	Right	29	29	26.5	26
229	F	25-35	52.5	39.5	13	Right	23	24.5	24	24
231	F	18-21	41	24	17	Right	23	26.5	24	26
233	F	50+	45	34	11	Right	26	28	28	29
234	F	45-50	46	28	18	Right	22.5	24	26	24
236	M	35-40	45	40	5	Right	25	28	27	27.5
237	F	50+	56	39	17	Right	22.5	27	23.5	28
243	M	35-40	35	30	5	Right	28	26.5	27	27.5
245	M	30-35	47	51	-4	Left	28	26.5	25.5	27
249	F	50+	45	31	14	Right	23.5	25	24.5	25.5
251	F	30-35	54	32	22	Right	22	26	24	26.5
252	F	50+	52	21	31	Right	21	26	26	26
254	M	35-40	38	25	13	Right	28	27	30	28

SK #	Sex	Age	R FNA	L FNA	Asymmetry	Legs To:	R Width	R Depth	L Width	L Depth
255	F	30-35	43	36	7	Right	25.5	23	25.5	24
259	M	50+	30	29	1	Right	29.5	32.5	29.5	30.5
262	M	45-50	46	49	-3	Left	25.5	29	25.5	28.5
263	F	27-30	40	36	4	Right	24.5	25	25.5	25
264	F	50+	52	31	21	Right	22	27	25	27.5
274	F	40-45	40	35	5	Right	21.5	24	24	25
282	F	40-50	62	59	3	Right	19	23.5	19	22
287	M	40-45	34	34	0	Right	28	27.5	28	27.5
288	M	40-45	37	30	7	Right	25	26	26	26

Table A.2 Skeletons listed with SK# (assigned by excavators), Sex (M=Male, F=Female), Age, R FNA (femoral neck anteversion angle of the right femur), L FNA (femoral neck anteversion angle of the left femur), Asymmetry (the difference between FNA angle of left and right femur, Legs to is the side of the body the ankles sit to the hips, R width (measure of right femur mid shaft medial/lateral), R Depth (measure of right femur mid anterior/posterior), L width (measure of left femur mid shaft medial/lateral), L Depth (measure of left femur mid anterior/posterior).

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Appendix B

Burial	Sex	OG Age	Method	PE	Min	Max
1	F	56	TA	78.8	57.4	92
3	M	27	TA	26.7	26.7	39.9
4A	F	50	TA	87.5	75.6	110
4B	-	12	S	12	12	12
5	-	0.08	S	0	0	0
7	F	47	TA	83.8	68	94.6
8	F	45	TA	ADULT	ADULT	ADULT
11	-	0.08	S	0	0	0
13	-	0.08	S	0	0	0
14	F	42	TA	ADULT	ADULT	ADULT
17	F	50	TA	76.1	55.3	89.8
18	-	0.08	S	0	0	0
19A	F	30	TA	29.6	23	39.4
19B	-	0	S	0	0	0
21	-	2	S	3	2	4
22	M	22	TA	21.1	16.6	26.1
23	-	0.08	S	0	0	0
24	-	0.25	S	0	0	0
25	M	33	TA	29.2	23.9	36.6
26	F	26.5	TA	ADULT	ADULT	ADULT
28	M	41	TA	ADULT	ADULT	ADULT
29	M	44	TA	ADULT	ADULT	ADULT
30	-	0.16	S	0	0	0
32	-	0.67	S	0.75	0.5	1
33	M	35	TA	33.3	27	41.7
35	M	21	TA	26.5	26.5	40.1
38	M	40	TA	32.5	25.8	42.4
39	M	22	TA	29.6	22.8	40.1
40	-	0.5	S	0.75	0.5	1
41	F	26.5	TA	ADULT	ADULT	ADULT
43	M	26.5	TA	ADULT	ADULT	ADULT
45	M	45	TA	68.5	43.3	85.8
46	-	0.08	S	0.25	0.5	0.75
48	M	26.5	TA	ADULT	ADULT	ADULT
49	M	46	TA	88.3	76.2	110
50	M	34	TA	35.4	27.1	48.5
51	M	50	TA	71.9	36.3	89
55	-	0.08	S	0	0	0
60A	-	11	S	12	9	15
60B	-	3	S	3	2	4
62	-	0.33	S	0.25	0	0.5
63	-	0.33	S	0.75	0.5	1
64	-	0.08	S	0.5	0.25	0.75
65	M	49	TA	86.7	74.3	110
66	M	21	TA	21	21	21
67	-	0.08	S	1.5	1	2
69	M	29	TA	42.4	30.7	64.5
72A	M	40	TA	37.1	27.6	53.6
77	-	1	S	0	0	0
80	-	0.08	S	0	0	0
81	-	0.08	S	0	0	0
82	-	25	TA	32.6	32.6	69.6
83A	F	20	TA	15	15	20.3
84	M	29	TA	29.2	23	38.4
85	F	40	TA	33.7	15.3	81.4
86	M	35	TA	35.5	27.2	48.9
87	-	0.67	S	1	0.67	1.33
88	M	26.5	TA	ADULT	ADULT	ADULT
89	M	16	TA	15	15	19.5
90	-	0.08	S	0	0	0
91	M	42	TA	76	34.1	91.6
92A	-	12	TA	ADULT	ADULT	ADULT
92B	M	39	TA	38.9	20	71.2
93	M	42	TA	76.4	56.6	89.9
94	-	44	TA	ADULT	ADULT	ADULT

Burial	Sex	OG Age	Method	PE	Min	Max
95	M	34	TA	33.5	24.7	49.1
96	-	0.08	S	0.00	0.00	0.00
99	F	35	TA	55.8	37	76.7
100	M	18	TA	ADULT	ADULT	ADULT
101	-	0.16	S	0	0	0
103	F	53	TA	40	20.1	82
104	M	46	TA	82.3	64.2	93.9
105	M	27	TA	21.7	21.7	68.7
106	F	47	TA	46.6	31.8	68.5
109	F	21	TA	18	17	19
110	M	36	TA	33	27.3	40.6
111	F	22	TA	18	17	19
113	M	26	TA	24.7	20.3	30.1
114	M	20	TA	18	17	19
115	M	42	TA	78.2	38.7	110
116A	M	18	TA	18	17	19
121	M	39	TA	77.2	55.8	90.7
123	M	41	TA	ADULT	ADULT	ADULT
124	M	42	TA	75.1	40.8	90.6
125	-	0.42	S	0.75	0.5	1
126	-	0.08	S	0	0	0
127	F	26.5	TA	ADULT	ADULT	ADULT
128	-	0	S	0	0	0
129	M	51	TA	71.8	25.8	90.5
130	M	52	TA	45	25.3	80.6
132	-	0.42	S	1	0.5	1.5
133	M	19	TA	17	16	18
134	-	26.5	TA	ADULT	ADULT	ADULT
135	-	0.42	S	0.75	0.5	1
136	-	0.08	S	0	0	0
137	M	43	TA	37.2	23	59.6
138	M	29	TA	34	26.1	46.7
139	-	0.08	S	0	0	0
140	M	44	TA	77.4	55.8	91.1
141A	M	32	TA	36.5	28.5	48.9
141B	-	0	S	0.5	0.25	0.75
142	M	34	TA	3.4	28.6	48
143	M	38	TA	36.7	29	48.9
144	-	26.5	TA	ADULT	ADULT	ADULT
145	F	38	TA	38.2	27.8	55.4
146	F	41	TA	59.2	39.4	79.8
147	M	44	TA	77.1	52.7	91.1
148	-	0.42	S	0	0	0
154	-	0.08	S	0	0	0.25
156A	M	47.5	TA	66.4	42.6	84.3
156B	-	0	S	0	0	0
160	-	0.58	S	1.5	1	2
162A	M	15.5	S	12	9	15
164	F	47	TA	85	71.5	95
166	-	0.08	S	0	0	0.25
167A	M	26.5	TA	ADULT	ADULT	ADULT
168	-	0.17	S	0	0	0
171	-	0.08	S	0	0	0
172	-	0	S	0	0	0
173	M	22	TA	23.8	19.5	29.8
174	-	26.5	TA	ADULT	ADULT	ADULT
175A	F	48	TA	88.3	75.9	110
175B	M	39	TA	79.6	61.2	91.9
176	M	31	TA	43.9	31.3	68.7
177A	-	0	S	0	0	0
177B	-	0.08	S	0	0	0
178	F	38	TA	33.9	19.8	57.4
179	-	11	S	11	11	11
180	F	44	TA	84.4	68.7	110
181	F	48	TA	ADULT	ADULT	ADULT

Burial	Sex	OG Age	Method	PE	Min	Max
182	M	38	TA	43.6	33.4	62.3
183	M	42	TA	69.2	31.6	88.8
184	-	0.08	S	0.75	0.5	1
185	F	35	TA	79.4	60.2	92
186	F	43	TA	70.8	45.9	87.6
187	F	46	TA	72.1	50.2	87.9
188A	F	40	TA	48.3	31.9	73.1
188B	F	51	TA	78.2	61.5	90.6
189	-	0.75	S	0.5	0.25	0.75
191	M	29	TA	76.8	58.8	89.8
192	-	0.58	S	8	6	10
193	F	44	TA	72.2	49	87.7
194	M	45	TA	39.7	31.5	53.1
196A	F	45	TA	25	21	30
196B	F	48	TA	63.8	33.3	85.7
196C	M	34	TA	69.3	37.8	87.5
200	F	50	TA	44.2	29.6	69.3
201	M	29	TA	37.4	27.9	52.4
202	-	0.08	S	0.5	0.25	0.75
207	F	36	TA	26	26	48.2
209	-	0.75	S	0.75	0.5	1
216	F	17	S	15	12	18
217	-	0.08	S	0.5	0.25	0.75
219	F	44	TA	ADULT	ADULT	ADULT
221	F	28	TA	ADULT	ADULT	ADULT
222	M	32	TA	ADULT	ADULT	ADULT
224A	F	30	TA	55.8	23.1	85.8
224B	F	16	S	15	12	18
224C	F	16	S	10	7	13
225A	F	23	TA	23	21	25
225B	-	0.75	S	9	7	11
225C	F	40	TA	49.7	22.3	81.8
225D	-	0.08	S	0	0	0

Table B.1 All 165 individuals are listed with their Burial Number (assigned by the excavator), Sex, and Age. OG age is the age estimate recorded by Bassett (1982). Method is the method used in this study – TA is Transition Analysis for adults and S is Standards (Buikstra and Ubelaker, 1994) for juveniles. PE is the point estimate. With Transition Analysis this is the maximum likelihood estimate and for juveniles it is the average age. Min and Max are the 95% confidence interval for TA.

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2017 Tremblay, Anna, and Daniel E Ehrlich. "$7x10^5$ Dimensions of Pottery: Multivariate Analyses of Pottery Assemblages from the Lower Town site of Mycenae, Greece." Poster presented at the 82nd annual meeting of the Society for American Archaeologists, Vancouver, British Columbia.
2016 Tremblay, Anna, and Matthew Veres. "Asymmetric Femoral Torsion among the Oneota of Illinois" Poster presented at the 85th annual meeting of the American Association of Physical Anthropologists, Atlanta, GA.
2015 Tremblay, Anna. "Skeletal Age Estimations: A Comparison of Four Techniques" Poster presented at the 84th annual meeting of the American Association of Physical Anthropologists, St Louis, MO.