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WORKING WOMEN: AGRICULTURAL INTENSIFICATION, OSTEOARTHRITIS IN
FEMALES, AND SUBADULT HEALTH IN ILLINOIS WOODLAND
AND MISSISSIPPIAN MORTUARY CONTEXTS

Paige M. Dobbins

56 Pages

Temporal variation was examined in female labor associated with subsistence modifications in pre-Columbian human osteological samples from the Mississippi River valley of west-central Illinois related to weaning patterns, diet, and overall health status of subadults. This study was performed on a sample of 173 burials constituting 98 subadults and 75 adult females from temporally sequential Illinois mortuary contexts (Albany [11WT1], Kuhlman [11A163], Schroeder [11HE177], and Dickson [11F10] Mounds) that represent the transition from Middle Woodland hunter gatherers to Mississippian maize agriculturalists. This was accomplished by (1) scoring pattern and degree of dental attrition and dental caries in subadults, (2) identification of porotic hyperostosis and cribra orbitalia in subadults as reflective of iron-deficient and megaloblastic anemia and (3) analysis of frequency and severity of osteoarthritis (OA) on the joint surfaces of the humerus, radius, and ulna in multiple age cohorts of adult females. Subadults of Kuhlman (AD 600-1050) and Dickson Mounds (AD 800- ~1250) shared patterns of higher frequencies of porotic hyperostosis, cribra orbitalia, and osteoarthritis when compared to the Albany (BC ~200-AD 300) and Schroeder Mounds (AD 900-1150) samples. Results also show evidence of labor and settlement modifications in within Kuhlman and

Dickson Mounds possibly related to intensive processing. In all, this research gives further insight into the relationship between intensive female labor and subadult health status in Illinois.

KEYWORDS: Bioarchaeology, Gender, Illinois, Paleopathology, Late Woodland, Mississippian

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FEMALES, AND SUBADULT HEALTH IN ILLINOIS WOODLAND
AND MISSISSIPPIAN MORTUARY CONTEXTS

PAIGE M. DOBBINS

A Thesis Submitted in Partial
Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

Department of Sociology and Anthropology

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2018

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WORKING WOMEN: AGRICULTURAL INTENSIFICATION, OSTEOARTHRITIS IN
FEMALES, AND SUBADULT HEALTH IN ILLINOIS WOODLAND
AND MISSISSIPPIAN MORTUARY CONTEXTS

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P.M.D

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CHAPTER I: INTRODUCTION

This study focuses on four sites in the North-West and West-central region of Illinois located within the Upper Mississippi River Valley (UMVI) and the middle and lower Illinois River Valley (LIRV). This region is home to culturally diverse groups spanning multiple time periods (McElrath et al., 2000). This region of Illinois shows great variability in climate, landscape, and availability of food sources resulting in a large amount cultural diversity evident within the archaeological record including variation in plant use, material culture, and subsistence (Esarey, 2000; Green, 2000; Simon, 2000; Simon, 2017).

TIME PERIOD	DATES
ARCHAIC	8,000-1,000 BC
EARLY WOODLAND	600 - 150 BC
MIDDLE WOODLAND	150 BC – AD 250
EARLY LATE WOODLAND	AD 400 – 700
TERMINAL LATE WOODLAND	AD 800 – 1300
MISSISSIPPIAN	AD 800 - 1650

Table 1. Pre-Columbian Time Periods in Illinois

Relative to the Central Illinois River valley (CIRV) and the Lower Illinois River valley (LIRV), the Mississippi River Valley (MVI) of Illinois lacks a large breadth of archaeological research resulting in limited contexts by which to analyze the human paleopathological (i.e., Asch, 1976; Buikstra 1976; Cook 1984; Esarey, 2000; Goodman et al. 1984; Milner 1991; Rose, 2003; Schober 1998; Van der Merwe 1978). While West-central Illinois has been studied extensively, the clear majority of bioarchaeological analyses assess Lower Illinois River Valley and American Bottom sites with little focus on the upper Mississippi River valley.

Figure 1. Research Region

Archaeobotanical and isotopic evidence suggests the Illinois region exhibits an increase in cultivation of local plants during the early Late Woodland period (Table 1) followed by the eventual inclusion, and then reliance upon, maize during the terminal Late Woodland and Mississippian periods (Table 1) respectively (Rose, 2003; Simon, 2000, 2008, 2017). From a broader geographic context, labor practices during the Middle and Late Woodland period also show evidence of variation during these transition periods. Most relevant to this study is evidence of increased mechanical stress on females (i.e., injury, skeletal robusticity) relative to males that is likely due to increasing labor demands of cultivation (Bridges, 1989, 2000; Buikstra, 1986; Claassen, 2001; Pickering, 1984). This possible sex-based division of labor is also seen in historic Native American groups in the Southeast and in many modern agriculturist groups where women are responsible for most cultivation and processing labor (e.g., Hudson 1976; Ember, 1983; Bridges, 1989). An intensification of female labor would have likely resulted in more energy and time being spent on crops which meant that new foods and

technologies had to be adopted resulting in many changes both physically and culturally including thinner pottery for cooking, increases in starchy foods as a dietary staple, and changes in food processing (Kelly and Cross, 1984; Van Der Merwe and Vogel, 1978; Hedman et al., 2002 Gallagher, 1989; Smith and Cowan, 2003). These changes to diet and labor also have been hypothesized to have had effects on population size, sedentism, weaning practices, and subadult diets (e.g., Buikstra et al. 1986; Claassen, 1998, Schurr and Powell, 2005).

To explore this period of subsistence-settlement change in the UMRI, four sites accounting for three temporally sequential time periods were analyzed. These sites were Albany Mounds (11WT1), Kuhlman Mounds (11A163), Schroeder Mounds (11HE177), Dickson Mounds (11F10) which are dated Middle Woodland, the Late Woodland, Terminal Late Woodland, and the Mississippian respectively (Figure 1) (Bridges, 2000; Kolb, 1973; Jeske, 1987). The time periods employed seek to explore changes in pathology over the subsistence transitions in Illinois from hunter gatherers, to horticulturalists focused on local plants (Middle Woodland to Early Late Woodland) and, from local plants horticulture to a more intensive maize based agriculture (Late Woodland to Mississippian) (Simon, 2000, 2006, 2017). These time periods represent a gradual increase in fertility, population size, sedentism, cultural complexity, and disease frequency all of which have posited links to agriculture (Simon, 2000; Rose, 2002, 2008). Schroeder Mounds specifically is a mortuary context in West-Central Illinois which lacks cultural information other than a tentative date range. As the cultural landscape of the Illinois is entirely variable, the possibilities for Schroeder's culture are also variable (Esarey, 2000; Kolb, 1973). The pathological analyses in the following chapters also seek to frame Schroeder within the surrounding cultures of the region and within the subsistence changes of the region.

Figure 2. Site Map

As change is reportedly visible in females (via bone diaphyseal strength) between middle and early Late Woodland populations, this research will seek to see if variation in osteoarthritis is also prevalent in females during these subsistence periods (Bridges, 1989, 2000; Pickering, 1984). This could further support a narrative of female focused labor. There is also evidence that these transitional periods effected weaning foods and, in this way, subadult health which is evident in other studies of dental attrition, caries, porotic hyperostosis, and cribra orbitalia (Cohen and Armelagos, 1984; Walker, 1985; Walker, 1986, 2009; Mittler and Gerven, 1994; Pechenkina et al., 2002; Steckel and Rose, 2002; Larsen, 1997; Rose et al., 1985; Schmidt, 2001; Lallo and Rose, 1978). Utilizing the three aforementioned sites, this study will seek to identify these pathologies in subadult samples and determine any meaningful relationships therein.

With the goal being to answer three research question:

- Can osteoarthritis aid in our understanding of female labor during the Late Woodland and Mississippian period?
- Can subadult pathology and dental data be used as evidence of dietary change, weaning, sedentism at the sampled sites?
- Do the pathological findings of this study support current understandings of Illinois subsistence periods?

CHAPTER II: THE ARCHAEOLOGY OF SUBSISTENCE IN ILLINOIS

Within the Upper Mississippi River Valley and the Illinois River Valley region, it is possible to say that Middle Woodland, Late Woodland, and Mississippian periods all practiced some level of horticulture which focused on the cultivation of local native seeds. Beginning around 900 AD, maize was introduced and eventually replaced most local seeds as the primary crop for the region (Asch and Asch, 1985a; Asch et al., 1979; Bridges, 2000; Cook, 1979; Simon, 2000, 2006, 2017). It is yet unclear why by the Mississippian period, maize so completely replaced local seeds as many of local cultigens had similar yields and were more nutritionally balanced than maize (Smith, 1984; Gremillion, 1996, 2004). Transitional periods are difficult to study archaeologically as they represent relatively short time-periods and often do not leave behind clear material culture evidence. In this way, the transition between local seed horticulture and agriculture is somewhat difficult to study, but through a combination of isotopic analyses, archaeobotanical assemblages, and skeletal remains, a clearer picture of this transitional period in Illinois is anticipated (Simon 2017, VanDerwarker et al., 2013).

Isotopic analyses are intrinsic to the analysis of maize and are done through use of the carbon and nitrogen isotope ratios. Maize is a non-native (Central America) C₄ plant; most of the indigenous plants of Illinois and animals that consumed them are C₃ (Kelly and Cross, 1984; Van Der Merwe and Vogel, 1978; Hedman et al., 2002). This change from C₃ to C₄ in chemically processed bone samples results in a change in carbon isotope ratios resulting in less negative ratios which gives researchers the ability to track maize consumption compared to local seeds and nitrogen based foods like fish (Johannessen, 1984; Schoeninger 1985). Buikstra et al.'s (1989) carbon isotopic analysis of skeletal samples within the Midwest was the one of the first studies to identify isotopic evidence of maize reliance in the Mississippian period. The study also

acknowledged that use of maize cultivation and consumption varied along regional, sexed, and status based fault lines. Hedman et al.'s (2002) study into the Mississippian Moorehead phase (AD 1150-1250) in the American Bottom also supported the existing literature that maize reliance was evident but regional variation was significant at all levels.

Although there is no question that maize was a common, and in many cases, pervasive food source during the Mississippian period in Illinois, the question of its earliest uses and spread throughout Illinois is still one being examined. Maize has been identified in small quantities in the early Late Woodland within the Upper Mississippi River Valley though it was rarely eaten (e.g., Schroeder, 1994; Simon, 2000; Parker, 1989; Rose, 2008). Previous research has proposed maize's presence as early as the Middle Woodland Period at the Holding site in the American Bottom though Simon's (2017) reanalysis of the botanical assemblage identified that several of the sample identified as maize were incorrect and that all confirmed maize dated to post AD 900. Earlier studies postulated that during the Middle Woodland, maize was mainly used for ritualistic purposes as the earliest discoveries of the cultigen have been within ceremonial contexts (Hastorf and Johannessen, 1994; Johannessen, 1993; Scarry, 1993; Rogers, 2011; VanDerwarker et al., 2013; Wymer, 1994) or consumed relative to rank or privilege (Rose, 2002, 2008).

The introduction of maize in Illinois is especially difficult to identify from material culture as indigenous people in this region were practicing horticulture long before maize was introduced (Chapman and Watson, 1993; Rose, 2003; Rose, 2008, Simon, 2000). In Illinois, sites adjacent to the Illinois, Mississippi, Kaskaskia Rivers share patterns of cultivation and domestication of complex starchy seeds hundreds of years prior to the emergence of maize agriculture (Simon, 2000). Starchy seeds including *Chenopodium bushianum* (goosefoot), *Polygonum erectum* (knotweed), *Hordeum pusillum* (little barley) and *Phalaris caroliniana*

(maygrass) were a major part of cultivation as early as the Late Archaic period (BC 2500-1000) (Simon, 2000; Smith and Yarnell, 2009; Yarnell, 1994). This is evident due to large pieces of land cleared for crops, greater amounts of complex villages, and evidence of population growth which is closely associated with sedentism and agriculture (Asch and Asch, 1985, Smith, 1985;).

This known as the Eastern Agricultural Complex, meaning that even prior to maize, societies were structured around the planting, processing, and use of domesticated plant species (Delcourt et al. 1998; Yarnell, 1993; Zeanah, 2017). Maize was merely integrated with, and eventually replaced, local cultigens. Several studies provide skeletal evidence that indigenous people were already adapted to the labor practices of planted, harvesting, and processing prior to maize adoption. For example, Bridges et al. (2000) utilized skeletal samples from sites adjacent to the LIRV (and a sample from Kuhlman Mounds in the MVI) to study on long bone diaphyseal strength in the Middle Woodland through Mississippian Period in West-central Illinois. The study found that the adaptation of maize specifically did not dramatically increase the intensity of labor practiced. However, the earlier adaptation of seed based horticulture during the Middle and Late Woodland did lead to an increase in diaphyseal strength which is evident in the Kuhlman Mounds sample.

Buikstra et al. (1986:531) reported “It is clear that female pathology changed significantly in a way that would be consistent with a model of increased labor for women with the acquisition of a maize agriculture.” Though peoples were adapted to cultivation of indigenous plants, maize requires specific cultivation techniques including intensive weeding, sowing, and preparation of corn hills (Gallagher, 1989; Smith and Cowan, 2003). If women were primarily responsible for this level of intensive agriculture, it is likely to have had large effects

physically and culturally. Included changes are ceramics (e.g., thin-walled pottery), population growth, and earlier weaning (Buikstra et al. 1986; Claassen, 1998; Schurr and Powell, 2005).

Fertility, Weaning, and Subadult Survival

As Thomas Holland (1989) purported in his work, success of agriculture is not judged by a society's ability to produce food but rather by a society's ability to produce future generations of agriculturalist at a constantly increasing rate. With this orientation, childhood survival, health, and dietary practices become especially important to the examination of subsistence in the Eastern Woodlands region. Though populations were slowly increasing during the Middle Woodland, Late Woodland, and Mississippian periods, DeRousseau (1973), in a mortuary survey performed on the LIRV, found marked population growth between the early (AD 600–1050) and terminal portions (AD ~900-1150) of the Late Woodland period. These dates closely match the onset of local seed based horticulture and intensive maize agriculture making many researchers believe a causality exists (Buikstra et al. 1986; Claassen, 1998, 2001; Weitzel and Coddling 2016).

In Illinois, thin walled pottery developed during the Late Woodland period and enabled foods to be cooked over a fire (Briggs, 2016). This includes mashed foods and gruels which are common weaning food cross culturally (Dettwyer, 1995; Katzenberg et al., 1996; Sellen and Smay, 2001). Early weaning could have been inspired by a number of variables, but it is believed to have had an immediate effect on population size due to the more rapid return of maternal fecundity (Buikstra et al. 1986). Post-partum infertility is caused due to increased levels of the pituitary hormone prolactin which is triggered by frequent and extended stimulation of the breasts during breastfeeding (Cregan et al., 2002; Crosignani and Robyn, 1977; Dennis, 2002; Tyson and Perez, 1978). If pre-Columbian women in Illinois were weaning with seed based

gruels these prolactin levels could have lowered and allowed for shorter intervals between pregnancies and contributed to population growth.

Weaning is a process highly dictated by culture, making it conceivable that the subsistence culture at the time greatly affected this (Sellen and Smay, 2001; Schurr, 1996, 1998). Weaning is defined as the process of slow discontinuation of breastfeeding and replacement with solid external foods while “complete weaning” refers to the end of all breastfeeding (Dettwyler and Fishman, 1992; Stuart-Macadam 2017). In contemporary human’s, this ranges from 2-4 years of age. In contemporary Western societies, this can often occur at less than 1 year of age. Dettwyler (1995) uses variation to illustrate the wide range of cultural variability. In this way, it is plausible that such cultural variation was readily present in prehistory as well (Sellen and Smay, 2001).

Age of complete weaning is estimated archaeologically in several ways. In rare cases, historic records are available on the topic, but in most situations, it must be deduced through chemical analyses (Dupras and Tocheri, 2007; Richards et al., 2002; Schurr, 1998; Wright and Schwarcs, 1998). Chemical analysis is done through analysis of carbon to nitrogen ratios found in collagen preserved in bones (Ambrose, 1990; Lee-Thorp et al., 1989; Schurr, 1996). As infants receives a large amount of nitrogen through breast milk relative to the amounts received through normal diet, this analysis looks for a gradual decrease in nitrogen within age groups to determine weaning age. However, as this is process is cost prohibitive and destructive making it difficult to perform on indigenous human skeletons (Dupras and Tocheri, 2007; Richards et al., 2002; Schurr, 1998; Wright and Schwarcs, 1998).

In a stable isotope study performed by Schurr and Powell (2005) a sample of Archaic and Middle Mississippian sites in the Lower Ohio Valley were analyzed to test the possibility of

early weaning in the region. The study found no meaningful variation between the Archaic and Middle Mississippian sample in regards to weaning age. Furthermore, the study found that an increase of population growth could not have resulted from early weaning as weaning with local seed and maize based gruels would have resulted in high levels of infant mortality. Though no isotopic studies exist for the sites used in this study there is pathological data that could give further insight into dietary practices in subadults. Regarding Dickson Mounds specifically, a study performed by Lallo (1979) non-specific stress related hypoplasias found that within the terminal Late Woodland component of the site (a maize transitional period) the highest instances of stress related hypoplasia at 2.25 years while within the Middle Mississippian component (post maize transition) showed a bimodal pattern with peak incidence at 1.75 years and 3.25 years. Implying dietary or health related stress variation between the two time periods.

CHAPTER III: PATHOLOGIES CO-OCCURRING WITH AGRICULTURALIZATION

Though many early models of humanity's transition from hunter gatherers to agriculturalists framed the transition as beneficial due to a supposed reduction in stressors related to hunting and mobility and presence of food surplus (Braidwood, 1960; Lee, 1972), modern literature now reveals that the shift has associated with a decrease in health status in many contexts (e.g., Bridges, 1991, 1994; Jurmain 1975, 1977, 1990; Lallo and Rose, 1979; Larsen, 1995, 1997; Walker et al., 2009; Watson et al., 2010). These changes in health status were caused by a number factors including reduced mobility, narrowing range of foods, population growth and aggregated settlement, technological innovations, intensification of labor practices, and (most relevant to this study) the advent of maize (Cook, 1979). Among the most easily noticeable hallmarks of maize agriculture is degeneration of teeth.

Dental Wear and Pathologies

As dentition preserves well, dental analysis is a common area of study within bioarchaeology for obtaining information about archaeological populations (Molnar, 1971a; Smith, 1983; Turner, 1979; Larsen, 1983; Bullington, 1991; Schmidt, 2001; Eshed et al., 2006 Forsythe, 2009). This data can consist of dental caries, periodontal disease, tooth loss, linear enamel hypoplasia, and micro and macro wear on the tooth surface. All of which give pertinent information about behavior, diet, and in some cases culture of individuals.

Dental wear consists of attrition, abrasion, and erosion of the enamel resulting in exposure of the primary dentin. Primary dentin is softer than the thick, hard enamel surface so the rate of wear increases when the primary dentin is exposed. Archaeologically, patterns and severity of wear can be dependent on texture of the masticated material (Smith, 1983; Turner et al, 1993; Deter, 2009; Eshed et al, 2006). Agricultural societies specifically can show variable

patterns of wear depending on their food production (Molnar, 1971a, Eshed et al, 2006; Deter, 2009). In general, microwear, which uses data gained from scanning electron microscopy of pitting and scratches on the tooth surface enamel, indicates the Middle Woodland diet in the LIRV was overall coarser and plagued with grit while agriculturalists showed fewer pits and scratches implying a less gritty diet overall (Bullington, 1991; Rose et al., 1985; Schmidt, 2001). Smith (1984) also found that hunter gatherers generally show relatively flat wear while agriculturalists tend to show highly angled wear patterns which were interpreted as indicative of a reduction in coarse materials being chewed by agriculturalists.

This decrease in dental wear is matched with an increase in other oral pathologies (Lukacs, 1996; Cook, D.C. and J.E. Buikstra. 1973; Eshed et al., 2006). Dental caries are diagnosed by cavities in the tooth enamel (Standards, 1994). They form due to demineralization of the enamel of teeth due to bacterial fermentation of starchy foods, carbohydrates, and sugars (Larsen, 1995). Because of this, dental caries prevalence in North America is highly co-associated with the adoption of the cariogenic carbohydrate, maize. Caries tend to appear in teeth that are more complex in shape (i.e., premolars and molars) (Larsen, 1997; Eshed, 2006). Incisors and canines for instance rarely present with cavities. In subadults circular caries *can* form in the incisors due to hypoplasia and the composition of food ingested as mashes and gruels are more likely to stick to teeth (Cook and Buikstra, 1973; Larsen, 1995).

Subadult Health Status

Subadult skeletal material holds a large amount of possible subsistence and sociocultural data due to their innate plasticity as well as pathology-related osseous reactive changes (Baxter, 2008). Agricultural communities, both historically and prehistorically, tend to consume a narrower variety of foods (Walimbe and Lukacs, 1992, Larsen, 1995; Hedman and Ambrose,

2002; Rose, 2008; Forsythe, 2009; Keegan, 2010) which of itself, can lead to nutritional stress and illness (Cohen and Armelagos, 1984; Walker, 1986; Steckel and Rose, 2002). Maize specifically lacks the essential amino acids lysine, isoleucine, and tryptophan and has extremely low iron absorption (Tchang, 1988; Ashworth et al. 1973; Young and Pellett, 1994; Walker et al. 2009). Because of this, children specifically, solely eating a maize based diet would have increased instances of infectious diseases, growth stunting, and iron-deficient or megaloblastic anemia (Lozoff, 1988; Cohen and Armelagos, 1984; Walker, 1986; Steckel and Rose, 2002).

Anemia is a symptom of deficiencies in various minerals necessary to the production and homeostasis of red blood cells (Burkhardt et al., 1987; Sharourou, 2018). As such, dietary deficiencies, illness, or parasites could all lead to anemic symptoms and appear on the skeleton in many cases as cribra orbitalia and porotic hyperostosis (Sullivan, 2005; Blom et al., 2005; Walker et al., 2009). These skeletal pathologies are the result of marrow hypertrophy caused by the oxygen-starved body trying to create more red blood cells by expanding the diploë resulting in macroscopically visible porosity of the cranium and eye orbits (Ortner, 2003). Due to this relationship, these pathologies are routinely used by bioarchaeologists to determine times of dietary stress and study sedentism, urbanism, subsistence, and/or culture change in the archaeological record (Cohen and Armelagos, 1984; Walker, 1985; Walker, 1986; Mensforth, 1991; Mittler and Gerven, 1994; Pechenkina et al., 2002; Steckel and Rose, 2002).

Blom et al. (2005) in a study of Andean coastal samples found high occurrence of childhood anemia despite a variable diet. Groups predicted to have low frequencies due to a nutritionally diverse fish based diet had near equal occurrences as groups that at a nutritional deprived maize based diet. Leading researchers to believe that instances of anemia were most likely caused by environmental stressors or parasites rather than diet. However, as active porotic

lesions is only present in subadults due to their skeletal plasticity allowing for expansion the diploë, presence of anemia in adults does not have the same connotations. In one study, Mittler and Van Gerven (1994) found that individuals with cribra orbitalia lived an average of 15.5 years longer than those without active or healed lesions. Meaning adults with healed lesions were likely stronger individuals able to withstand diseases (i.e., osteological paradox).

In Illinois, Lallo et al. (1977) reported that the earlier component of Dickson Mounds (Late Woodland during the maize transitional period) had an overall frequency for porotic hyperostosis was 25.5% while the later post maize transition Middle Woodland component had a frequency of 51.5%. This coupled with evidence of stunted growth in the sample (Lallo, 1972) lead to a presumption that porotic hyperostosis was a result of a nutritionally deficient diet and infectious disease.

Females and Osteoarthritis

Beyond disease, cultivation of crops also had more direct effects on the human skeleton by way of labor related trauma and pathologies (e.g., Bridges, 1991; Jurmain, 1999; Larsen, 1984, 1995; Weiss 2015; Welzein, 2007). The most ubiquitous in the archaeological record is osteoarthritis. The American Rheumatism Association defines osteoarthritis as multiple ailments that lead to articular cartilage loss, synovial inflammation, and changes to the subchondral bone (Anjum and Abbas, 2016; Felson et al., 2000; Glyn-Jones et al., 2015; Johnson and Hunter, 2014; Mobasheri, 2016; Palazzo et al., 2016). The causes of OA include aging, injury, and overuse of the joint surfaces leading to degeneration (Anjum and Abbas, 2016; Corti and Rigon, 2003; Glyn-Jones et al., 2015; Johnson and Hunter, 2014; Jurmain, 1999). Archaeologically, OA is a commonly researched pathology due to its pervasive nature in the human body, its relative

ease to diagnose (if not quantify), and due to the potential to extrapolate activity patterns based on its pattern presence and/or severity (Bridges 1992; Sofaer-Derevenski, 2000; Welzein, 2007).

The connection between OA and behavior is tenuous and often difficult to identify confidently (Jurmain, 1999; Kahl and Smith, 2000; Welzein, 2007). This is especially true as it relates to occurrences and causes of osteoarthritis due to subsistence. Results of a pre-Columbian Alabama samples indicate a similar vulnerability of joints between hunter-gathers and agriculturalists: higher OA in the elbow, shoulder and knee joint than the wrist, ankle, and hip joints (Bridges, 1991). Larsen (1984, 1995) found there was a decrease in OA among pre-Columbian Georgia hunter gatherers when compared to agriculturalist while Bridges (1991) found that OA prevalence is consistent between the same subsistence comparison. Overall, activities practiced by prehistoric groups in the Southeastern United States stress the elbow more than any other joint which is thought to be caused by intensive activity practiced in short spurts.

Studies on OA in Illinois are relatively limited (e.g., Lallo 1973; Goodman et al. 1984; Pickering 1984; Welzein, 2007). Welzein's (2007) study performed on OA in Orendorf Mounds, a LIRV mortuary context, found that the skeletal sample from Orendorf as a whole match the patterns of prehistoric OA proposed by Bridges with a Elbow>Shoulder>Wrist and Knee>Hip>Ankle pattern. Leading the researcher to believe that the adaptation of maize did not result in any change in OA unique to the region. In Lallo's (1973) study of Dickson Mounds in the LIRV he found a significant increase in frequency of OA in the Middle Mississippian component (65.8%) when compared to the Late Woodland component (39.7%) which could imply there is some level of variation in OA associated with maize in this region.

CHAPTER IV: MATERIALS AND METHODS

Materials

This research utilized samples from the Albany (11WT1), Kuhlman (11AD28), and Dickson (11F10) Mounds skeletal collections housed at the Illinois State Museum and the Schroeder Mounds (11HE177) collection housed at Illinois State University on loan from the Illinois State Museum.

Albany Mounds

Albany Mounds is a mortuary site located in Whiteside county, Illinois on the east bank of the Mississippi river (Nickerson et al., 1971). Dated to the Middle Woodland period (BC ~200-AD 300), the mound group constitutes 81 mounds spread out over a rolling bluff area and 3 possible village locations. Nickerson (1971) interpreted as semi-sedentary with groups of individuals traveling seasonally. Initial analysis of the remains revealed that preservation of the remains was low with many of the remains being fragmentary and comingled. As such, though all female and subadult skeletons were considered for the study only a sample of 32 skeletons (16 subadults and 12 adult females) were used from the Albany Mounds collection. Selection criteria were based on preservation and presence of areas of interest, and is discussed further in the methods section.

Kuhlman Mounds

The Kuhlman Mound group is located in Adams County, Illinois in the Mississippi river valley (Atwell and Connor, 1991). This Late Woodland period (AD 600-1050) mortuary context has an MNI of 260 burials. The mounds used for this study were mound 1 and 3. Mound 1 is a conical mound which contained 185 individuals. Mound 1 represents over 50% of the sample population and 37% of the sample has an age-at-death of <5 years of age and 46% has an age-at-

death of < 15 years. Mound 3 is one part of a larger accreted mound also contained mound 4, it produced 10 burials. A sample of 46 burials (29 subadults and 17 adult females) from the Kuhlman Mounds sample was used for this study.

Schroeder Mounds

Schroeder Mounds (11HE177) is a Late Woodland period (AD ~900-1150) mortuary site located in Henderson County in West-Central Illinois (Kolb, 1982). The site is located ~5km east of the Mississippi river on the west facing hillside of a Pleistocene sand dune dissected by a system of small Mississippi river tributaries. There is little material culture context for the site. Kolb (1982) reported two possible cultural origins for the site; the Illinois River Valley's Maples Mills culture and the Effigy Mound culture based on preliminary analysis of fabric pressed and cord marked pottery and white chert side notched Madison points. The site sample consists of circa 124 human skeletal remains. A sample of 45 (25 subadults and 20 adult females) burials was used for this study.

Dickson Mounds

The Dickson Mound (11F10) group is located in Fulton County in the central Illinois River valley (CIRV) within a cluster of prehistoric mortuary and village sites (Harn, 1980). Dated to AD 800- ~1250, Dickson represents a Middle Mississippian site representative of a complex culture of aggregated (often palisaded) mound centers flanking central village plazas that was engaged in maize-intensive agriculture (Harn, 1980; Rothschild, 1979; Lallo, 1973). 60 Middle Mississippian individuals were examined for this study; 30 adult females and 30 subadults. 28 Subadults and 29 adult females were used in this study.

Methods

Aging and Sexing Illinois State Museum Material

For all four collections, only adult females and all subadults (neonates-plus) were analyzed for inclusion in the study. The collections housed at the Illinois State Museum have been previously aged and sexed by the researchers at the museum (i.e., Ms. Dawn Cobb) and those designations were relied on during data collection. Age cohorts employed by the Illinois State Museum consist of 0-3, 3-12, 12-20, 20-35, 35-50, and >50. Due to time constraints, re-aging into more precise age cohorts was not possible, limiting the possible analysis between age cohorts.

Aging and Sexing Schroeder Mounds Material

The Schroeder Mounds collection was re-evaluated for age and sex during data collection. For identifying females, analysis scored robusticity of the cranium including pronounced glabella, robust nuchal crest, square orbits, and mastoid processes. Post-cranial sex classification was limited to the pelvis and scored variation based on the Phenice method (1969) which scores sex differences visible in the ventral arch, subpubic concavity, and the medial aspect of the ischiopubic ramus. Aging Schroeder included dental eruption, epiphyseal fusion, cranial suture fusion depending on the preservation of the individual. All age estimations were then translated into the age cohorts designated by ISM for comparison between sites.

Inclusion Criteria

Subadults were defined as lacking in the eruption of the 3rd molar and lack of fusion of the clavicle (individuals with un-erupted third molars and fused clavicles [i.e., adults] were excluded from the subadult sample). All subadults (including neonates) retaining cranial elements were examined for porotic hyperostosis and cribra orbitalia. Subadults with greater than

75% antemortem tooth loss were not used in the dental portion of the study (neonates were not used in the dental study). As only half of each dental arcade was recorded for dental wear, in most cases individual retaining at least 3 teeth were used. Total sample size for the subadults was calculated by accounting for every individual with analyzed teeth or crania. Sample sizes were also calculated for half dental arcades, full dental arcades, and cranium.

Adults were similarly identified by presence of the 3rd molar and, where that was not available, the fusion of the proximal humerus and clavicle. Due to low preservation of some samples all individuals were scored as long as they preserved at least 25% of a joint surface. As such, total sample size for the adult females was calculated by accounting all individuals retaining at least one usable joint in the arm (right or left), then joint sample size was determined by the amount of each joint present.

General Methods

Photographs were taken of all skeletal elements utilized and all scoring was done on *Standards* (1994) score sheets. Initial macroscopic analysis was undertaken at the time of research. Parameters scored were: presence of joint surfaces, presence or absence of porotic hyperostosis and cribra orbitalia, antemortem presence or absence of teeth, and presence of caries. Photos were used to later score severity of dental wear, severity of OA, and confirm presence of porotic hyperostosis and cribra orbitalia. Photos were also used to maintain consistency in scoring.

Scoring Methods

Dental Wear

For the purposes of this research, dental wear is defined as **(1)** attrition: wear from tooth-to-tooth contact **(2)** abrasion: wear from tooth-to-foreign object contact and **(3)** erosion: loss of

enamel from acid (Larsen, 1997; Kaidonis, 2008). These wear patterns result mostly from the ingestion of coarse, edible materials (e.g., seeds or nuts), the unintentional ingestion of debris materials (e.g., sand), or from non-masticatory tooth use (e.g., leather softening, pipestem wear, 'tooth pick' wear). The quantification of dental wear was undertaken using methods outlined in *Standards* (1994). This is an ordinal scale which measures total flat wear of individual teeth on a scale of increasing severity wherein 0 accounts for the loss of the tooth (either pre, pari, or post-mortem), 1 is no visible wear (Figure 3), and 8 accounts for complete loss of enamel and exposure of the pulp cavity. As this study was concerned with dental wear in subadults, wear rarely surpassed a 6 (Figure 4). Unless there was a noted asymmetry in the dental arcade (due to use of teeth as tools, side favoring, or other frequent uses) only the left upper and lower portions of the full dental arcade were recorded for dental wear. In cases of missing, damaged, or congenitally absent teeth the right side was measured.

Figure 3. Dental Wear Score of 1
from Dickson Mounds Subadult
Aged 3-12

Figure 4. Dental Wear Score of 6
from Kuhlman Mounds Subadult
Aged 3-12

Caries

Teeth were examined macroscopically and with a hand lens for additional clarity and to differentiate caries from congenital buccal pits based on visible signs of decay resulting from a carious lesion. Dental caries were scored based on presence or absence per tooth (Figures 5 and 6). As such for this, analysis was *not* limited to a half arcade.

Figure 5. Circular Caries from
Dickson Mounds Aged 0-3

Figure 6. Occlusal Caries from
Dickson Mounds Aged 3-12

Subadult Pathology

Sub-adult crania were examined macroscopically and with a hand lens for additional clarity to identify presence of porotic lesions in the superior orbit (Figure 8) and/or the mid parietal or the parieto-occipital margins (Figure 7) (i.e., straddling the lambdoidal suture). Lesions were scored nominally for presence (1) or absence (0) of either pathology. A score of 1 was given to both active and healed lesions. Active lesions were identified by porosity coupled

with bone bridges while healing lesions were identified by a smooth but bumpy texture characteristic of new bone healing over the previously visible porosity (Standards, 1994).

Figure 7. Porotic Hyperostosis from Schroeder Mounds Aged 0-3

Figure 8. Cribra Orbitalia from Dickson Mounds Aged 0-3

Osteoarthritis

For the purposes of this research only the articular surfaces of the proximal and distal humerus, radius, and ulna were scored. The multiple locations serve to illuminate specific joints (i.e., shoulder and elbow) locations of activity related injury as well as provide multiple areas to record when preservation is low. This was recorded through a modified scoring methodology utilizing Bridges (1990, 1994) and Jurmain (1975, 1990) scoring methodology used by Welzein (2003) in a study on Orendorf Mounds. There are many scoring methods used for osteoarthritis that could have produced similar results, however it is difficult to compare results from different methods. This method was chosen due to its existing region used and therefore potential for comparison between sites. This is an ordinal scale that scores severity of eburnation (Figure 9),

porosity (Figure 10), and lipping (osteophytosis) (Figure 11) from 0-4 wherein 0 represents no presence of the pathology and 4 represents extreme severity (ie. ankylosis or polished eburnation). Scoring of OA was done conservatively so as to avoid misidentifying normal changes to the joint surface as reactive change. Joints displaying OA thought to be the result of traumatic injury were also removed from the study.

Severity Scale (Bridges, 1990, 1994; Jurmain, 1975, 1990; Welzein, 2003)

0- Arthritis not present

1- Lipping barely present and/or surface osteophytes barely present and/or surface porosity and < 10% of surface

2- Lipping creates sharp ridge and/or small surface osteophytes and/or surface porosity pinpoint or coalesced and < 50% of surface

3- Lipping has sharp ridge with extensive spicules and/or very large surface osteophytes and/or surface porosity is pinpoint and coalesced and > 50% of surface, and any evidence of eburnation

4- Ankylosis

Figure 9. Eburnation of a Distal Ulna from Albany Mounds Aged 35-50

Figure 10. Porosity of a Proximal Radius from Albany Mounds Aged 35-50

Figure 11. Lipping of a Distal Humerus from Dickson Mounds Aged >50

Analysis

A Fisher's exact test was used to examine statistical significance due to the small sample size. Fisher's exact tests determine p-values based on a 2x2 contingency table to determine statistical variation at a .05 confidence. Beyond this, analyses were made based on comparison of frequencies and mean scores between the sites.

CHAPTER V: RESULTS

Evidence of Osteoarthritis

This study sought to determine if OA could be used as an indicator of changes to female labor. Predictions were made based on previous research that suggested intensive agriculturalists would exhibit higher frequency and severity of OA. In this way, Kuhlman, Schroeder, and Dickson Mounds were expected to show progressive increases in prevalence or severity of OA while Albany mounds acted as a control sample. As OA is also a natural part of aging, comparing the same age-at-death cohort across the samples allowed for differences in frequency and severity of OA to be interpreted as indicative of level of intensive labor. As the samples used represented varying levels of preservation, sample size of recorded data varied. Albany Mounds, specifically, was a small sample (Table 2) with poor preservation which limited the analyses.

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
12-20	0	0	3	7
20-35	5	10	10	14
35-50	7	6	3	4
>50	0	1	4	4
TOTAL	12	17	20	29

Table 2. Total Adult Female Individuals Sampled

Table 2 shows that the >50 and 12-20 age cohorts are small in the Kuhlman and Albany Mounds samples. In Kuhlman, the >50 age cohort is only represented by one individual with evidence of minor OA in all 3 usable joint surfaces from the left and right elbow (Table 3). Albany has one individual with a traumatic injury on the left ulna and radius which resulted in modifications causing eventual degeneration and eburnation on the distal radius and porosity and osteophytosis on the proximal ulna (Figure 12). This individual was removed from the aggregate data seen in Tables 3-7.

Figure 12. Healed Fracture of the Left Radius from Albany Mounds Aged 35-50

As all four samples were relatively small, one “individual” was often represented by a single articular surface. To combat this, data in this section was analyzed by mean scores for the entire joint. That is, the shoulder consisted of the left and right proximal humerus; the elbow consisted of the left and right distal humerus, proximal ulna, and proximal radius; and the wrist consisted of the left and right distal ulna and distal radius. This allowed for more accurate means as well as identification of more severely affected joints (Figures 6 and 7). However, this method does allow for the possibility that well preserved individuals with more usable joint surfaces were overrepresented in the sample. In future studies, comparison between individual case studies could be done to counteract this.

Frequency

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
12-20	0/0	0/0	1/35	11/58
20-35	7/24	29/80	25/107	30/120
35-50	3/16	6/16	3/28	10/45
>50	0/0	3/3	6/42	10/19
TOTAL	10/40	38/99	35/212	61/242

Table 3. Total Joint Surfaces with Evidence of OA

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
12-20	x	x	2.86%	18.97%
20-35	29.17%	36.25%	23.36%	25.00%
35-50	18.75%	37.50%	10.71%	22.22%
>50	x	100.00%	14.29%	52.63%
TOTAL	25%	38.38%	16.51%	25.21%

Table 4. Frequency of OA by Age

For age cohort comparisons a Fisher's exact test was employed to determine if significant variation existed between OA presence between the 20-35 and 35-50 age cohort (Table 4). No statistical significance was found for any specific joint or for the OA presence. This is likely due to the small sample size, it is possible with a larger sample significance would be found.

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
SHOULDER	0.4444	x	1	1
ELBOW	x	0.5578	0.5133	1
WRIST	1	1	1	0.581
TOTAL	0.3451	0.438	0.6233	1

Table 5. Statistical Significance of OA Between 20-35 and 35-50 Age Cohorts

Several intergroup patterns were noted by joint. Kuhlman has an Elbow>Shoulder>Wrist pattern of declining frequency of OA (Table 6). Albany's pattern is Elbow>Shoulder>Wrist. Within Schroeder we see a pattern of Shoulder>Elbow>Wrist though the variation between the elbow and shoulder is not significant ($p = 0.0962$). Within Dickson Mounds, the presence of OA is nearly equal to the shoulder and elbow (Shoulder=Elbow>Wrist) with no statistical difference between the elbow and shoulder ($p = 0.8454$).

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
SHOULDER	2/8	5/15	16/34	13/41
ELBOW	7/25	29/55	33/111	39/134
WRIST	2/7	4/29	9/67	9/67

Table 6. Total Joint Surfaces with OA by Joint

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
SHOULDER	25%	33.33%	47.05%	31.71%
ELBOW	28%	52.27%	29.72%	29.11%
WRIST	28.57%	13.79%	13.43%	13.43%

Table 7. Frequency of OA Per Joint

There was no statistically significant variation present in the shoulder between any site (Table 8). Statistical variation was identified in the elbow between Albany and Kuhlman and Kuhlman and Schroeder (Table 9). The lack of significance in the shoulder is likely because more joint surfaces were considered in the sample size for the elbow making statistical significance more possible.

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
ALBANY				
KUHLMAN	1			
SCHROEDER	0.4307	0.3152		
DICKSON	1	1	0.1584	

Table 8. Statistical Significance of OA Presence in the Shoulder

COLUMN1	ALBANY	KUHLMAN	SCHROEDER	DICKSON
ALBANY				
KUHLMAN	0.053			
SCHROEDER	1	0.0014		
DICKSON	1	0.001	0.8601	

Table 9. Statistical Significance of OA Presence in the Elbow (Significant Variation in Bold)

Concerning total frequencies of OA at the site's, no statistical significance was found for Albany Mounds comparisons, likely due to the small site sample (Table 10). A statistically significant increase in OA was found in Kuhlman Mounds when compared to Schroeder Mounds and Dickson Mounds. And a significant increase in Dickson was found when compared to Schroeder Mounds.

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
ALBANY				
KUHLMAN	0.1687			
SCHROEDER	0.2583	0.0001		
DICKSON	1	0.018	0.0284	

Table 10. Statistical Significance of Total OA Presence Between Sites (Significant variation in bold)

Severity

Mean severity scores were also analyzed for further nuance. A pattern of declining severity of OA (Elbow>Shoulder>Wrist) was also predicted within the severity data (Table 11). Schroeder again shows an overall decrease in elbow severity and an increase in shoulder OA resulting Shoulder>Elbow>Wrist, while Dickson has Shoulder=Elbow>Wrist.

Intergroup variation is minimal with some exceptions. Schroeder shows higher severity of OA in the Shoulder when compared to all other sites and Kuhlman shows a high severity in the elbow compared to all other sites (Table 11). Albany overall shows the lowest OA in all joints except the wrist.

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
SHOULDER	0.27	0.33	0.53	0.32
ELBOW	0.3	0.65	0.32	0.34
WRIST	0.25	0.13	0.13	0.15
TOTAL	0.27	0.3	0.33	0.35

Table 11. Mean Severity Per Joint

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
12-20	x	x	0.02	0.2
20-35	0.35	0.38	0.3	0.25
35-50	0.18	0.19	0.36	0.24
>50	x	0.33	0.67	0.74

Table 12. Mean Severity by Age

Subadult Results

The health status information collected from the subadult remains sought to examine pathologies associated with dietary changes that could be co-occurring with modifications to female labor. It was predicted that between Kuhlman and Dickson Mounds there would be increasing evidence of sedentism and aggregate living when compared to Albany mounds with the worst health conditions being within Schroeder and Dickson mounds.

Dental Wear

Among the dental markers recorded, dental wear was predicted to show decreases overall due to processing of foods. As with the adult data, the subadult sample from Albany mounds was the smallest and therefore lacks reliability as to its ability to represent the full population accurately. Means were calculated per tooth seen in Tables 13-18 show the means for Albany mounds were often based on only 1-3 teeth.

		m2	m1	c1	i2	i1
ALBANY	Mean wear	1	1	1	3	x
	N=	1	1	1	1	0
KUHLMAN	Mean wear	2	1.75	1.44	1.86	3
	N=	4	8	9	7	8
SCHROEDER	Mean wear	1.50	1.56	1.86	2.60	3.67
	N=	4	9	7	10	9
DICKSON	Mean wear	1.50	1.36	1.50	1.70	2
	N=	5	8	7	9	8

Table 13. Mean Mandibular Dental Wear Ages 0-3

		m2	m1	c1	i2	i1
ALBANY	Mean wear	1	2	2.50	2.50	3.50
	N=	1	2	2	2	2
KUHLMAN	Mean wear	1.60	5	1.86	2	2.25
	N=	5	7	7	7	8
SCHROEDER	Mean wear	1.67	1.86	2.71	2.57	2.17
	N=	3	7	7	7	6
DICKSON	Mean wear	1.40	1.77	1.56	1.89	1.75
	N=	5	5	9	7	5

Table 14. Mean Maxillary Dental Wear Ages 0-3

		m2	m1	c1	i2	il	M2	M1	PM4	PM3	C1	I2	I1
ALBANY	Mean wear	2.80	3.75	4	3	3.60	2	2.50	0	x	0	x	2
	N=	5	4	1	1	1	1	1	1	0	1	0	1
KUHLMAN	Mean wear	4	3.71	4.63	4	3.60	2	1.75	1	1	1	1.50	1.50
	N=	8	7	8	6	5	2	4	2	2	2	4	4
SCHROEDER	Mean wear	3.38	4.50	4	4.20	4.50	x	1.80	x	x	1	1.33	1.50
	N=	8	8	7	5	4	0	5	0	0	1	3	4
DICKSON	Mean wear	2.9	3.16	3.16	3.50	2.50	1.5	3	1.50	1.50	1.50	1.50	2
	N=	8	5	5	4	1	1	2	2	2	2	2	2

Table 15. Mean Mandibular Dental Wear Ages 3-12

		m2	m1	c1	i2	il	M2	M1	PM4	PM3	C1	I2	I1
ALBANY	Mean wear	3.70	4.50	4	x	x	2	2.83	1	1	1	1.50	1.50
	N=	5	4	1	0	0	3	3	1	1	2	2	2
KUHLMAN	Mean wear	3.78	3.50	3.71	4	4.25	3	1.60	1	1	1	2	1.33
	N=	9	8	7	5	4	1	5	2	1	3	3	3
SCHROEDER	Mean wear	3	2.75	4.13	3.50	4.75	x	1.50	x	x	x	1.50	1.50
	N=	9	8	8	4	4	0	4	0	0	0	4	4
DICKSON	Mean wear	2.45	2.65	3.67	3.5	3.80	1.67	2	2	1.50	1.75	2	2
	N=	10	7	5	3	5	1	4	3	2	2	4	4

Table 16. Mean Maxillary Dental Wear Ages 3-12

		m2	m1	c1	i2	il	M2	M1	PM4	PM3	C1	I2	I1
ALBANY	Mean wear	x	x	x	x	x	2	3	2	2	2	x	x
	N=	0	0	0	0	0	2	2	2	2	2	0	0
KUHLMAN	Mean wear	x	x	x	x	x	x	x	x	x	x	x	x
	N=	0	0	0	0	0	0	0	0	0	0	0	0
SCHROEDER	Mean wear	x	x	x	x	x	1.67	2.50	1	1	1.50	2.40	2.20
	N=	0	0	0	0	0	6	6	4	6	6	5	5
DICKSON	Mean wear	x	x	x	x	x	x	x	x	x	x	x	x
	N=	0	0	0	0	0	0	0	0	0	0	0	0

Table 17. Mean Mandibular Wear Ages 12-20

		m2	m1	c1	i2	il	M2	M1	PM4	PM3	C1	I2	I1
ALBANY	Mean wear	3	3	x	x	3	x	x	x	x	x	x	x
	N=	1	1	0	0	1	0	0	0	0	0	0	0
KUHLMAN	Mean wear	x	x	x	x	x	x	x	x	x	x	x	x
	N=	0	0	0	0	0	0	0	0	0	0	0	0
SCHROEDER	Mean wear	6	x	5	x	x	1.50	2.17	1.40	1.25	1.67	2	2.60
	N=	1	0	1	0	0	6	6	5	4	3	5	5
DICKSON	Mean wear	x	x	x	x	x	x	x	x	x	x	x	x
	N=	0	0	0	0	0	0	0	0	0	0	0	0

Table 18. Mean Maxillary Dental Wear Ages 12-20

The most variation between sites was observed in the 0-3 age cohort which showed Dickson had a trend of lower dental wear (Figure 13). However, no significant variation was found between deciduous m1 when teeth with wear of 2 or below were compared to teeth with wear of 3 (Figure 14).

Figure 13. Mean Dental Wear Severity Ages 0-3

Figure 14. Wear Means for m1

Caries

Caries presence and location was also recorded for further insight into dietary habits. It was predicted that caries presence would be greatest in Dickson mounds. This was expected due to the site's heavy reliance on maize. 34 out of the 196 teeth examined in the Dickson Mounds sample had at least one carious lesion present with a 17.36% frequency (Table 19). 3 out of the 233 teeth examined within the Schroeder Mounds sample had one carious lesion present which is a 1.28% frequency. The increase in caries frequency in Dickson Mounds is significant when compared to Schroeder Mounds ($P=0.00001$).

	m2	m1	c1	i2	i1	M2	M1	PM4	PM3	C1	I2	I1
ALBANY	0	0	0	0	0	0	0	0	0	0	0	0
KUHLMAN	0	0	0	0	0	0	0	0	0	0	0	0
SCHROEDER	0	0	0	1	0	1	0	0	0	0	0	1
DICKSON	4	10	3	4	3	3	7	0	0	0	0	0

Table 19. Total Caries Per Tooth

The frequency of caries in the 0-3 age cohort is 21.42% at Dickson Mounds and 22.09% in the 3-12 age cohort (Table 20). There was no statistically significant variation between the two age cohorts with $P=1$.

	m2	m1	c1	i2	i1	M2	M1	PM4	PM3	C1	I2	I1
0-3	1	7	1	3	3	0	x	x	x	x	x	x
3-12	3	3	2	1	0	3	7	0	0	0	0	0

Table 20. Caries by Age Cohort for Dickson Mounds

Porotic Hyperostosis and Cribra Orbitalia

Porotic hyperostosis (PH) and cribra orbitalia (CO) were used to determine general health status and evidence of sedentism and disease at the sites. It was expected that Albany would have a relatively smaller frequency of the two pathologies, with frequencies gradually

increasing from Kuhlman to Schroeder. Dickson was predicted to show the greatest frequencies of both pathologies. Overall, presence of both CO and PH had highest frequencies in Kuhlman and Dickson (Tables 21-24). With CO having a higher frequency in Kuhlman Mounds than within Dickson Mounds (Table 24). Kuhlman Mounds had a significant increase in CO when compared to Albany and Schroeder Mounds had a statistically significant decrease in PH presence when compared to Dickson Mounds (Tables 22 and 25).

Within the age cohorts in Kuhlman and Dickson also shows an increase in PH and CO in the 0-3 cohort compared to the 3-12 cohort. However, this was not significant.

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
0-3	0/2	7/17	0/9	9/14
3-12	4/11	4/10	1/9	4/14
12-20	0/3	0/0	3/6	0/0
TOTAL	4/16	11/27	4/24	13/28

Table 21. Individual with Porotic Hyperostosis

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
0-3	0%	41.18%	0%	64.29%
3-12	36.36%	40%	11.11%	28.57%
12-20	0%	x	50%	x
TOTAL	25%	40.74%	16.67%	46.43%

Table 22. Frequency of Porotic Hyperostosis

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
ALBANY				
KUHLMAN	0.3415			
SCHROEDER	0.6905	0.0729		
DICKSON	0.2076	0.7875	0.0371	

Table 23. Statistical Significance of PH Presence (Significant Variation in Bold)

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
0-3	0/2	8/12	5/10	8/11
3-12	3/9	4/7	3/9	3/9
12-20	0/2	0/0	1/6	0/0
TOTAL	3/13	12/19	9/25	11/20

Table 24. Individuals with Cribra Orbitalia

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
0-3	0%	66.67%	50%	72.72%
3-12	33.33%	57.14%	33.33%	33.33%
12-20	0%	x	16.67%	x
TOTAL	23.07%	63.15%	36%	55%

Table 25. Frequency of Cribra Orbitalia

	ALBANY	KUHLMAN	SCHROEDER	DICKSON
ALBANY				
KUHLMAN	0.0359			
SCHROEDER	0.4859	0.1271		
DICKSON	0.0873	0.7475	0.2395	

Table 26. Statistical Significance of CO Presence (Significant Variation in Bold)

CHAPTER VI: DISCUSSION AND CONCLUSION

Osteoarthritis

To return to the research questions presented in Chapter 1: Can osteoarthritis aid in our understanding of female labor during the Late Woodland and Mississippian period? The osteoarthritis frequency and severity scores do imply variation in osteoarthritis that could be associated with variations in female labor between subsistence methods, with Kuhlman being the most notable example. Kuhlman showed a statistically significant increase in overall OA and specifically an increase in OA localized to the elbow when compared to Schroeder ($P=0.0014$) and Dickson Mounds ($P=0.001$). Kuhlman also had the highest mean severity of the elbow when compared to all three other sites. Bridges (2000) identified increases in diaphyseal strength in females at Kuhlman relative to earlier sites at the region, making it is possible this statistically significant increase in OA is due to an increase in (likely) subsistence-linked labor resulting from particular processing techniques or level of intensity. However, future research further exploring sexual dimorphism within the site would be necessary to definitively identify a sex-based division of labor.

The Dickson Mounds female sample also showed a significant increase in OA when compared to Schroeder Mounds ($P=0.0284$). As intensive cultivation was being undertaken at Dickson, this increase could be evidence of an increase in female labor compared to Schroeder Mounds. An analysis of OA within the male sample would be needed to confirm a change that affected both sexes equally.

Schroeder's Statistically significant decrease in OA when compared to Kuhlman ($P=0.0001$) and Dickson ($P=0.0284$) suggests a decrease in female labor overall. As there is limited contextual information on Schroeder, it is difficult to predict why this is. Possibilities

include a younger age-at-death sampling bias in Schroeder, and/or a different suite of repetitive arm/shoulder movements relative to the Kuhlman and Dickson samples.

Albany Mounds had low scores of severity per joint when compared to the other three site and the lowest overall frequencies per joint for every joint but the wrist, though none of the decreases were statistically significant. Overall, though the sample size was small, based on this analysis, females at Albany Mounds likely had less intensive mechanical stress relative to Kuhlman, Schroeder, and Dickson. This could support the presumption that Albany was likely not practicing an intensive level of processing.

Subadult Dentition

The next research question examined is whether subadult pathology and dental data can be used as evidence of dietary change and/or sedentism at the sampled sites. The results of the caries study within the sample population supported earlier predictions, with Dickson Mounds having caries present in 39.38% of individual and 17.36% of teeth sampled having at least one carious lesion; Schroeder had presence of caries in 12% of individuals and 1.28% of teeth, Albany and Kuhlman had no evidence of carious lesions. The lack of caries at Albany and Kuhlman supports the archaeological data that maize was not present in Illinois prior to 1000 AD.

Within the Dickson Mounds sample, there was no significant differences between the 0-3 age cohort and 3-12 age cohort to support the hypothesis that maize consumption began at a relatively young age. Dickson also had a lower mean dental wear scores which is consistent with lower amounts of grit in the Mississippian, though this was not significant. The significantly decreased amount of caries present in Schroeder Mounds ($P=0.00001$) made it impossible to compare dental wear scores by age cohort to Dickson as there were only three individuals with

caries. In a future study encompassing further sites and the adult sample, a study analyzing dental wear based on caries presence of absence should be undertaken to further explore this.

Subadult Health

It was predicted that Schroeder and Dickson Mounds would have the highest instances of porotic hyperostosis and cribra orbitalia. This was because there is a consistent subsistence-settlement co-association of chronic poor health in sedentary and aggregated communities. The findings of this study show the highest frequencies of the pathologies to be within Dickson and Kuhlman Mounds (Figure 15). With Kuhlman actually showing a higher percentage of cribra orbitalia overall when compared to Dickson, though it was not statistically significant (Figure 16). Barring sampling error, Dickson and Kuhlman may share a similar aggregated settlement pattern despite variation in time-period and location.

Figure 15. Frequency of Porotic Hyperostosis

Figure 16. Frequency of Cribra Orbitalia

Albany had lower frequencies of PH when compared to Dickson and Kuhlman and lower frequencies of CO when compared to all three sites (significant in CO when compared to Kuhlman at $P=0.0359$). A significant decrease in PH in Schroeder was also found when compared to Dickson ($P=0.0371$). Schroeder had the overall lowest frequency of PH and lower scores of CO when compared to Kuhlman and Dickson implying less non-specific stress on subadults at the Schroeder site. Schroeder's lower frequencies of subadult pathology was an unexpected result. However, acute illness mortality may obscure quality of life correlates (i.e., osteological paradox).

Conclusions and Future Research

Overall, the findings of this study are most relevant to analysis of variations in sedentism in the Upper Mississippi River Valley of Illinois. The results showed females at the Middle Woodland site of Albany Mounds had minimal mechanical stress and lower frequencies of PH and CO compared to Kuhlman and Dickson, meaning the site was likely not sedentary (e.g., better community hygiene) or practicing any intensive horticulture. The Early Late Woodland site Kuhlman Mounds showed increases in OA compared to the three other sites and increases in

CO (compared to Dickson, Schroeder and Albany) and PH (compared to Schroeder and Albany). These results imply intensive cultivation and some level of sedentism which would have resulted in increases in infectious diseases and parasites. The Middle Mississippian site Dickson Mounds showed a significant increase in OA when compared to Schroeder and a decrease in OA when compared to Kuhlman. The site also had higher frequencies of PH when compared to all three sites and higher frequencies of CO when compared to Schroeder and Albany. This, coupled with the statistically significant increase in caries, supports intensive cultivation of maize and likely sedentary living in a village. As Dickson represents a decrease in OA compared to Kuhlman it could be evidence that Kuhlman was practicing more intensive labor or that local seed horticulture was more mechanically stressful than maize agriculture in this region. However, a larger study on mechanical injuries would be required to substantiate this.

The terminal Late Woodland site Schroeder presents an interesting regional variant, with caries present implying maize ingestion but lower levels of OA compared to Kuhlman and Dickson. Schroeder also had lower levels of CO compared to all three sites and lower levels of PH compared to Dickson and Kuhlman. Though the presence of maize at the site implies a more sedentary settlement pattern allowing for intensive cultivation, the pathology pattern does not support the presence of aggregate village living. So, it is difficult to determine the settlement and dietary pattern at Schroeder. It is possible that though maize was present at the site that it was not being widely cultivated or eaten, it is also possible they were only receiving maize through trade from the nearby Mississippi River and were not cultivating crops at all. Overall future research into Schroeder Mounds and other terminal Late Woodland sites from the region is necessary to fully comprehend this site.

A larger project encompassing further sites would be beneficial to the identification of a true regional pattern and for comparison between sites in similar time periods. Generally, it is the belief of this researcher that due to the massive regional variation present in Illinois, subsistence patterns should be more thoroughly analyzed especially within the Upper Mississippi River Valley wherein analyses are minimal. Further research needs to be done to explore the relationship between cultivation of crops and female labor to expand the data available, and subadult health.

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