ABSTRACT

CHAMBERS, CANDICE LYNN. Working Our Fingers to the Bone: Osteoarthritis in the Hands of a Historic Population. (Under the direction of Dr. D. Troy Case).

This study examines osteoarthritis (OA) progression in the hands of an urban working class population born during the 19^{th} century. The lives of these individuals were marked by the changing atmosphere propagated by the Industrial Revolution. The present study offers important insight into the lives of these individuals through osteological and archival analysis.

A total of 816 hands representing 412 individuals from the Hamann-Todd anatomical collection were macroscopically examined for evidence of OA. Using a nonrandom multi-stage sampling strategy, approximately equal numbers of specimens were selected from each demographic subgroup: 101 African-American males, 102 African-American females, 104 European-American males, and 105 European-American females.

Individuals were grouped into cohorts by age, birth year, sex and ancestry; frequency differences were assessed using multivariate logistic regression, Kruskal Wallis H, Fisher's exact, and Chi Square tests. OA was discovered in 43% of the sample with European-Americans (104/206) having significantly higher rates ($p = 0.0052$) than African-Americans (74/202). Multivariate logistic regression results reveal that the odds of a female developing OA during this time period were nearly 4.0 times that of a male. Also, at any given age, the odds of a female having OA are estimated at 1.9 times greater than for a male at the same age.

Archival research utilizing the Minnesota Population Center's Integrated Public Use Microdata Series (IPUMS) was used to help contextualize these results with regard to occupational stress from the antebellum period to the second industrial revolution in Cleveland, Ohio. As these results demonstrate, industrialism took its toll on the American work force as they toiled in factories and mills in an ever advancing industrial age.

Working Our Fingers to the Bone:
Osteoarthritis in the Hands
of a Historic Population

by
Candice Lynn Chambers

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APPROVED BY:

Dr. D. Troy Case
Committee Chair

Dr. Ann H. Ross

Dr. Scott M. Fitzpatrick

DEDICATION

This thesis is dedicated to my mother in fulfillment of a promise made by a little girl who dreamt of being a writer and scholar and to my grandmother, whose arthritis-ridden hands started it all. Ladies, this one is for you.

BIOGRAPHY

The eldest daughter of Donny and Linda Chambers, Candice and her sister, Amanda, were raised in the small town of Fort Oglethorpe, Georgia, situated on the Chickamauga Battlefield. History was perhaps Candice's first love as she grew up with the local tales and lore of the Civil War. However, she was alternately captivated by the heritage of the region and enticed by the world that existed beyond her hometown. As an undergraduate at the University of Tennessee at Chattanooga, Candice seized the opportunity to travel through a study abroad program in England and the National Student Exchange program in the United States. It was during her time at UTC that she discovered Anthropology. In her first forensic anthropology course, she became intensely curious as she held that first skull in her hands, wondering about the person it had belonged to. It was this experience that propelled events forward as Candice went on to graduate school at North Carolina State University in the hopes of becoming a physical anthropologist and biohistorian.

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Chapter 1

INTRODUCTION

As humans, we are in part products of our environment. The world we live in shapes our lives and our perceptions in ways that are often overlooked. A scholar's voice within a discipline is shaped by innumerable factors. Education, upbringing, innate curiosity, human experience, all these things contribute to who we are as individuals, as social players, and as scholars. These factors that shape our lives also influence our interpretations and potentially bias our research. History is one area where perception plays a key role in interpretation. As de la Cova (2008) notes, "historical events do vary and their interpretations *are* a constantly shifting process." For example, in the years following the American Civil War, the United States experienced significant economic growth. So prosperous were the later years of the 19th century that historians have called this period "The Gilded Age." However, in agreement with de la Cova (2008), the present study demonstrates that this era in history was not gilded for every segment of the population. Rather, the prosperity of this period is only apparent when viewed from a very specific lens. That lens fails to recognize the biological stress that accompanied industrialization and economic growth. The present study explores occupational stress as evident in the presence of osteoarthritis (OA) in the hands of a working class population during the 19th and early 20th century.

The present study employs a biohistorical approach to the study of human skeletal remains. With seven chapters, this thesis aims to provide a historical and osteological context for the study of an urban population of low socioeconomic standing. This chapter serves as a brief introduction to the overall expectations and goals of the present study. Chapter 2 introduces the time period and provides an environmental framework for the population of interest. Chapter 3 summarizes the findings of previous research using musculoskeletal stress markers as evidence for physical activity. Most importantly, the chapter outlines etiological factors related to OA. Chapter 4 describes the methods used for skeletal assessment and analysis, and provides information about the skeletons and archival data used in the sample. Chapter 5 presents the results of statistical analyses, highlighting significant findings. Chapter 6 offers a discussion of the present findings in the context of previous research and significant contributions to the field. Finally, the concluding chapter summarizes the results of this study and offers suggestions for future research.

Overall Goals and Expectations

Osteoarthritis, or OA, is a common biological condition that has affected human and non human joints for millions of years (White 2005, Jurmain 1977). However, despite considerable study of OA, medical researchers and anthropologists alike have struggled to accurately define and identify it. Many scholars have long suggested a link between OA and factors such as sex, age, heredity, trauma, and obesity (Jurmain 1977, Dieppe 1999, Anderson 1971, Brandt 2001, Carr 2003, Hamerman 1997, Jones and Doherty 1995, Kalichman et al. 2005, Kaprio et al. 1996, Kellgren 1961, Rogers and Waldron 1995, Spector et al. 1996, Waldron 1993, Wilder et al. 2006, Jurmain and Kilgore 1995, Rothschild 1997). The present study is an investigation of the relationship between age, sex, and ancestry in the hands of an urban working class

African-American and European-American population born during the 19th century. A total of 816 hands representing 412 individuals from the Hamann-Todd anatomical collection were macroscopically examined for evidence of OA.

During analysis, individuals were classified into cohorts by age, birth year, sex, and ancestry. Multivariate logistic regression, Kruskal-Wallis H, Fisher's Exact, and Chi Square tests were employed to assess OA prevalence rates and trends in the hands. As de la Cova (2008) notes, few studies have compared skeletal data for European-Americans and African-Americans of similar socioeconomic status during the 19th century. Given the harsh conditions of slavery and racist treatment of African-Americans following the American Civil War (de la Cova 2008, Dubofsky 1996), I hypothesized that this group would have higher OA rates than their European-American counterparts. Additionally, I expected that individuals who lived and worked through the latter part of the 19th century would exhibit increased rates of OA in the hands. Archival research utilizing the Minnesota Population Center's Integrated Public Use Microdata Series (IPUMS) (Ruggles et al. 2010) was used to help contextualize osteological findings with regard to occupational stress from the antebellum period to the second industrial revolution in Cleveland, Ohio. In pairing skeletal data, archival data, and historical sources, the present thesis offers a more complete glimpse into the lifestyle of the early American worker, a population often overlooked by historians and anthropologists alike (Dubofsky 1996, de la Cova 2008).

Chapter 2

THE AMERICAN MELTING POT: FARMSTEADS TO FACTORIES, 1830-1930

The period from 1830 to 1930 was tumultuous as the Industrial Revolution took hold in America. Massive waves of immigrants came to the U.S. from all over the world seeking change on a different continent, excited about the world of opportunity that lay ahead. Little did they know that soon, small farmsteads would be abandoned in favor of crowded industrial cities, a civil war would shatter national unity, and that only poor wages and long hours awaited them as they struggled to make their way in the world (Dubofsky 1996). Over several decades, the U.S. became a melting pot of different peoples, all chasing the same dream of economic opportunity and prosperity for themselves and their posterity. However, that dream came at no small cost during the transition to industrialism. This was a stressful time in American history, both in terms of economic and social instability and also with regard to the biohistory of the population.

Before the Industrial Revolution came to America, most people lived in rural areas and survived by farming. Towns were slowly gaining popularity as was commercial farming and cottage industry craftwork (Dubofsky 1996). However, by 1830, industrialism had spread from Great Britain and the rest of Europe and began to supplant the simple agrarian lifestyles known to earlier settlers in North America (Kleinberg 1999). Still, in the 1860s, only about 13% of the population lived in urban areas (Fink 1993). However, nearly 11 million people left farmsteads in the country for hope of work in the cities between 1870 and 1920 (Dubofsky 1996).

Ancestry and Immigration

Thousands of people came to America across four major waves of immigration between the 1830s and the 1920s (Dubofsky 1996). More people entered the country in the period between the American Civil War and World War I than at any other time in history. By 1920, 20 million immigrants had come to America, most of whom took up residence in industrializing cities (Dubofsky 1996). Following the Irish Potato Famine, more than 200,000 unskilled laborers entered the labor market (Kleinberg 1999). However, tensions at the time resulted in poor living conditions for both foreign-born immigrants and non-whites (African-Americans, Asians, and Hispanics) (Dubofsky 1996).

A social hierarchy prevailed during this period and resulted in differential access to essential resources (Dubofsky 1996). Native-born whites and British immigrants frequently held the best jobs—usually as foremen and supervisors. White workers dominated the skilled sector of jobs, while immigrants and non-whites typically only found work in semi-skilled or unskilled occupations. Non-whites and women stood at the bottom of the social hierarchy and always earned less than those at the top. As a consequence, nonwhites and immigrants largely defined the industrial labor force (Dubofsky 1996).

Gender and the Household

As America's commercial ventures changed and industries began to utilize new technologies, social dynamics began to change as well. Industrialism resulted in a marked separation between the laboring world and the household. Until 1865, this "cult of domesticity" segregated the sphere of women from that of men (Kleinberg 1999; Dubofsky 1996). Women were largely restricted to performing tasks at home such as gardening, processing wool, preparing food, quilting, and occasionally gathering hay and slaughtering livestock. Often women attempted to supplement the family income by selling eggs, butter, and cheese produced at home. Enslaved African-American women would grow vegetables, weave baskets, and raise chickens for sale. However, as America moved toward industrialism and mass production, more women began seeking work outside the home (Kleinberg 1999).

The cult of domesticity that had permeated social dynamics in the early 1800s evolved into an institutionalized sexual division of labor following the American Civil War (Dubofsky 1996). Men were awarded skilled jobs while women who sought occupation beyond the household were given semi-skilled or unskilled positions. In 1810, only 10% of all free women held jobs outside the home. Often, women from poorer backgrounds worked part-time outside the home and maintained the household while wealthier women could choose to stay home. Women who sought employment in the early 19th century usually exercised their domestic skill set in the labor market. By 1850, three-fifths of all European-American working women held jobs as domestic servants, though African-American women largely dominated this occupation (Kleinberg 1999). By 1870, most domestic servants in the north were European-American women and their daughters born in the United States. Frequently it was unmarried women who found employment as live-in domestic servants; married women were employed as day laborers, laundresses, or seamstresses.

Across the country, the industrial sector also employed women during this time period. For example, in Massachusetts in 1850, manufacturing ventures employed about one-third of all women between the ages of 10 and 29. Across the nation, Irish women who came to the country following the Irish Potato Famine sought jobs in kitchens and factories. By 1870, 18% of all working women were employed by factories (Kleinberg 1999). Fifty years later, that number had risen to 24%. By 1920, over eight million women were economically active. Those not employed by factories, mills, or shops were employed in sales, service, or clerical occupations during this time period. However, working outside the home was not especially lucrative (Kleinberg 1999; Dubofsky 1996).

Economically active women earned low wages and had to work long hours or bring work home with them to further bolster the family economy. Once their shifts ended, women would spend their evenings rolling cigars, mending garments, or constructing silk flowers between household chores (Dubofsky 1996). The American textile industry was largely dependent on female labor and jobs in this sector were low-paying. In Pittsburgh, seamstresses earned less than 13 cents per shirt in the 1830s. A skilled seamstress would need a full workday to sew a shirt by hand. In 1850, the invention of the McKay stitcher revolutionized the clothing and shoe making industries. Less skill was required to use the machine than to stitch by hand so more workers – mostly women – were hired to manufacture goods. Thirty years later, 60% of all cotton mill workers were women (Kleinberg 1999).

The Working Class

Working conditions during most of the 19th and early 20th century were incredibly burdensome. In 1890, the average workday was 10 hours long (Dubofsky 1996). By 1920, skilled laborers worked an average of 50.4 hours per week and the unskilled worked 53.7 hours per week. Many of these working hours were spent in crowded sweat shops, factories, or mills. Dangerous working conditions became more apparent in the early 20th century when a series of notable industrial accidents resulted in high death rates. For example, in 1909, a coal mine explosion in Cherry, Illinois killed 180 people (Dubofsky 1996). Two years later, the Triangle Shirtwaist Company fire in New York City killed 146 women (Dubofsky 1996; Kleinberg 1999). Women in the factory had complained about locked doors during working hours and the lack of fire escapes to no avail. When the fire started, the women trapped inside were helpless (Kleinberg 1999).

Life was not easy for this segment of the population. This period was particularly difficult as machines began to revolutionize industry (Dubofsky 1996). Seasonal unemployment was often inevitable for the unskilled worker (Higgins et al. 2002). For many, it was difficult to maintain the standard of living (Dubofsky 1996). Women in the sewing industry in 1830s Pennsylvania earned less than $100 annually at a time when an annual income of $600 was necessary to maintain the standard of living (Kleinberg 1999). In the 1880s, a male mule-spinner went to work by the age of 8 or 9 and earned $1.50 per day. Working only 15 weeks of the year, his annual income only amounted to $133 (Fink 1993). By the turn of the century, many American workers were bringing home $10 or less per week when $15 per week would be necessary to maintain household stability and the standard of living. Approximately one-fifth of all Americans lived in poverty (Dubofsky 1996). Increasing populations and limited job availability resulted in thousands living in crowded tenement housing under impoverished or unsanitary conditions. Due in part to these conditions, the lifespan of the working class was reduced (Higgins et al. 2002). The life expectancy at birth in 1850 was only 38.3 years of age (Higgins et al. 2002 *sensu* Haines 1998).

Just as the cost of living was difficult to maintain, so too was the cost of death. Burial could cost nearly as much as a person's annual income at the turn of the century (Fink 1993). In 1903, one out of every ten New Yorkers found their final resting place in Potter's Field, the cemetery for the indigent (Dubofsky 1996). If the local medical schools were not in need of specimens for dissection, the unclaimed or impoverished dead would go to Potter's Field. Humiliated at the prospect, grieving families sometimes crept into upper class cemeteries under the cover of night to bury the deceased. Riis (1901) even noted that a policeman once discovered a woman trying to bury her still living infant in an upper class cemetery. Crowded in death as they were in life, Riis (1901) explained that the dead were lowered in pine boxes down into plots three stories deep, the coffins touching on either side.

The City of Cleveland, Ohio

Cleveland, where the sample in this study originated, has been described as the "quintessential blue-collar, working class American city" (Warf and Holly 1997:208). Its founding and subsequent maturation was not unlike that of many other Midwestern cities. Like other Midwestern cities, it was surveyed after the Indian Removal Act of 1830, when settlers began to push westward and it flourished during the Industrial Revolution (Kleinberg 1999; Warf and Holly 1997; Perry 1995). Cleveland became a home to thousands of foreign immigrants and southern African-Americans before World War I, much like New York, Chicago, and Detroit. At the turn of the century, Cleveland had become the embodiment of the American Melting Pot (Miller and Wheeler 1995).

In 1796, a land speculator named Moses Cleaveland surveyed Ohio's Western Reserve (formerly known as "New Connecticut") with the intention of preparing the territory for sale. Cleaveland saw opportunity hiding at the mouth of the Cuyahoga River much like ancient peoples had found waterways valuable; positioning a city along a river system would enable "communication" and allow for commercial transport. Indeed, this became the city's selling point later in history. Construction of the Erie Canal and a network of roadways had positioned the city as a booming center of commerce by the 1830s (Perry 1995). The Cuyahoga Steam Furnace Company became the first major industry in Cleveland. By the 1840s the company was manufacturing train engines and steam boilers for ships on Lake Erie. This industry paved the way for iron works and shipbuilding in the area (Perry 1995; Miller and Wheeler 1995). By 1850, Cleveland had become a mercantile city much like Chicago or Detroit with gas lights lining paved streets crowded with horse-drawn carriages (Barton 1975; Miller and Wheeler 1995). When the railroad came to Cleveland in 1851, commercial prosperity was certain (Perry 1995). In 1854, the Britt Iron and Steel Company established the first rolling mill. Afterward, hundreds of foundries, furnaces, and mills were built around the city (Barton 1975). Many manufacturing companies produced furniture, clothing, wood products, and farm equipment, though by 1860, only about 10% of all Cleveland workers were employed in factories (Miller and Wheeler 1995).

By 1861, the population of Cleveland had reached 43,000 (Kusmer 1995) and the production of war goods had begun to significantly bolster the city's economy. Under the Anaconda Plan, laid in motion during the American Civil War, commercial ventures on the Mississippi River came to a screeching halt. Just as Moses Cleaveland had suspected more than six decades earlier, the location between the Great Lakes and the Cuyahoga River proved advantageous. Cleveland prospered as a manufacturing and distribution center of wartime goods. Between 1860 and 1866, the number of men employed in the iron industry increased by 600%, from 500 to 3,000. Still, Cleveland had yet to claim its place in the "Manufacturing Belt" (Miller and Wheeler 1995).

In 1870, the post Civil War industrial boom began when John D. Rockefeller opened the headquarters of the Standard Oil Corporation in his native city of Cleveland (Warf and Holly 1997). Manufacturing employed 30% of Cleveland's workforce at the time. Soon, the top industries in the region were oil refining, lumbering, woodworking, railroad machinery and repair, wire, clothing, cooperage, paper, and cigar manufacturing, engine and boiler making and shipbuilding (Miller and Wheeler 1995). The steel industry boomed in the 1870s and 1880s due to the new Bessemer open hearth furnaces. Cleveland quickly became part of the world's largest steel-producing district (Warf and Holly 1997). Soon, Cleveland had become the "premier center of industrialism between Buffalo and Chicago" and a vital part of the Great Lakes Manufacturing Belt (Warf and Holly 1997).

A "second industrial revolution" came through Cleveland between 1880 and 1930, driving the city's manufacturing industry to its peak (Scranton 1999). The gas lamps and horse-drawn carriages of the 1850s were gone, replaced by more advanced technologies that utilized electricity. Electrical devices revolutionized manufacturing at every turn. Sewing machines, updated hardware, stoves and furnaces, foundries, and small items like nuts and bolts changed commercial ventures tremendously. Rockefeller's Standard Oil Corporation allowed the city to become a major refining center in the 1880s (Barton 1975). By the 1890s, Cleveland was a leading shipbuilding city in the nation, second only to Philadelphia (Miller and Wheeler 1995). By the turn of the century, significant numbers of Clevelanders were employed in slaughtering, meat packing, men's clothing, flour mills, malt liquor production, and paint manufacture (Scranton 1999). Industrial employment had increased by 135% between 1900 and 1925 (Scranton 1999). By that time, the largest trades were electrical machinery, motor vehicles and their parts, and metalworking. In 1926, there were 211,000 automobiles in Cleveland and even more were being distributed throughout the country. However, advances in technology did not necessarily improve the quality of life for all segments of the population (Miller and Wheeler 1995).

As with other American cities, Cleveland owed its commercial success to the thousands of workers manufacturing commodities by hand or through the operation of heavy machinery. Many of these workers came from Europe or the southern United

States during two major waves of immigration. Between 1890 and 1920, Southern and Eastern European immigrants came to Cleveland, while African-Americans from the Southern states took up residence during the Great Migration from 1910 to 1950 (Barton 1975; Miller and Wheeler 1995). In the mid 19^{th} century, many Germans entered the city and found semi-skilled jobs in construction or meat processing. African-Americans found similar work. The Irish, in contrast, were not always so lucky; they were often only able to find employment as general laborers that tended to last through only six months of the year (Miller and Wheeler 1995). By 1860, less than 30% of all households in Cleveland were native-born. At that time, African-Americans accounted for only 2% of the city's total population (Perry 1995). Between 1870 and 1930, the population swelled rapidly with an average growth of nearly 50% per decade (Warf and Holly 1997). The African-American population of Cleveland had only grown to 1,300 by 1870. That population gradually increased until 1910 when thousands entered the city (Kusmer 1995). As early as 1880, 160,000 people lived in Cleveland and three-quarters of the population was composed of foreign-born or first-generation Americans (Miller and Wheeler 1995). That proportion remained steady through the turn of the century and, over time, living conditions for these groups became more stressful and crowded (Warf and Holly 1997).

The social hierarchy observed across the country at this time could also be found in Cleveland. Both foreign-born immigrants and African-Americans resided in the poorest and most destitute neighborhoods, plagued by poor wages or unemployment (Kusmer 1995). During this time period, most immigrant workers found jobs as unskilled laborers. However, these jobs were not secure and they were accompanied by low wages and often dangerous working conditions (Barton 1975; Miller and Wheeler 1995). Before the railroad existed, Cleveland lay dormant four months of the year, the landscape blanketed by ice and snow (Miller and Wheeler 1995). One to six months of seasonal unemployment was a risk for all workers. However, the period of unemployment was extended up to 12 months for unskilled workers (Barton 1975). Even more crippling were the periodic depressions that gripped the city. In 1877 and again in 1893, economic downturn resulted in widespread poverty throughout the city. After the stock market crash of 1929, Cleveland felt the same crushing effects experienced by the rest of the nation as the Great Depression resulted in a reduced workforce (Miller and Wheeler 1995). It was during these desperate times that many impoverished families sent the bodies of their loved ones to medical schools for dissection in absence of funerary or burial funding. From there, some came to be a part of the Hamann-Todd Collection. Many of these people had lived and worked for much of their lives in Cleveland's factories and mills, and carried the scars of that labor into the skeletal record in the form of osteoarthritis in the hands.

Chapter 3

ACTIVITY AND THE SKELETON: A REVIEW OF THE LITERATURE

"Manifold is the harvest of diseases reaped by the craftsman … as the … cause I assign certain violent and irregular motions and unnatural postures … by which … the natural structure of the living machine is so impaired that serious diseases gradually develop."
*– 17th century Italian physician Bernardino Rammazzini (*sensu *Tichauer 1978)*

Humans engage in a wide variety of activities during their lifespan. These activities require a broad range of musculoskeletal function and place stress on different regions of the body, leaving behind lasting markers on the skeleton. Leonardo da Vinci was among the first scholars to investigate this relationship between muscle and bone, as he was ever intrigued by the efficiency and grace of the human body (Chaffin et al. 1999). Since da Vinci's time, we have learned a great deal about biomechanics and musculoskeletal stress. With the first sparks of the Industrial Revolution, medical professions began to notice the effect that technological advancement was having on the general population. Literature from that time period began to reflect the growing weight of this stress (Kennedy 1998). Now, equipped with a considerable assemblage of available data and literature, we can explore the complex interaction of various functional and etiological dynamics affecting human existence and the quality of life.

Musculoskeletal Stress Markers

Musculoskeletal Stress Markers (MSMs), also known as Markers of Occupational Stress (MOS) have frequently been used in anthropological studies in efforts to assess activity patterns among past populations (Cashmore and Zakrzewski 2011, Nagy and

Hawkey 1993, Molnar 2006, Cardoso and Henderson 2010, Kennedy 1998, Robb 1998, Stirland 1998, Ubelaker 1979, Agostini 2009). Researchers operate under the assumption that MSM variation is to some extent a product of muscle use resulting in bony response at the muscle attachment site. This is a working manifestation of Wolf's "law" – the notion that bones remodel in response to physical loading (Cashmore and Zakrzewski 2011, Walsh-Haney 2007). Molnar (2006) explained that bone cells have a reactionary response to muscle stress and thus modify attachment sites to better support the body during excess loading. Therefore enthesopathies (muscle origins or insertion points) grow more rugose and robust with increasing activity (Molnar 2006).

Given that the lower limbs function essentially the same in most modern humans due to similarities in the physiological requirements of locomotion and load-bearing, many studies focus on the upper limbs in order to explore activity patterns. Because the upper limbs have a greater range of motion, they are perceived as more readily active in our manipulation of the natural world. Accordingly, the bones of the upper limb are often used in studies of asymmetry and occupation or activity (Cashmore and Zakzrewski 2011).

Scholars have to be cautious not to over-interpret MSM data (Robb 1998, Cardoso and Henderson 2010). According to Cardoso and Henderson (2010:550), activity-related stress refers to "any activity that causes repetitive and regular movements or patterns of movements that exert stress on the musculoskeletal system." However, these authors caution that due to the wide range of activities in which humans engage throughout the lifespan, MSM development may not be specifically isolated to a single activity (Cardoso and Henderson 2010). Rather, Kennedy (1998:308) asserts that we may be restricted to suggesting a range of possible cultural activities based on MSMs or "at best we may be able to isolate markers of habitual stress to certain anatomical regions."

Even when working with identified skeletal collections that include individuals of known occupation, many factors that could influence MSM development remain unknown. For example, we do not always know the age at which an individual began working or whether that individual changed careers during his or her lifetime (Molnar 2006, Cardoso and Henderson 2010). MSM formation can also be a product of human variation or age-related changes (Kennedy 1998, Robb 1998, Stirland 1988). Stirland (1998) notes that some individuals just naturally form more bone than others.

Osteoarthritis

Osteoarthritis (OA) is a condition characterized by inflammation, extra bone formation, joint space narrowing, and morphological changes to joint contours (Jurmain 1977). OA represents not only a failure of integrity in overlying cartilage but of the entire joint (Brandt 2001). Though originally considered a "wear and tear" phenomenon, a growing corpus of research suggests a more complex etiology with multiple factors influencing its onset and progression (Dieppe 1999, Chaffin et al. 1999). Scoring and evidence for OA will be discussed in the following Materials and Methods chapter (Chapter 4).

Brandt (2001) specifies two reasons for the development of OA: 1) normal articular cartilage and subchondral bone succumb to joint failure due to excessive joint loading; and 2) an applied load exerts a reasonable amount of force but the underlying cartilage is inadequate in response to such loading. Once the cartilage is impaired, the bone becomes vulnerable to degradation (Brandt 2001).

A subchondral plate lies just beneath the cartilage and protects the bone metaphysis. This plate is composed of bone ten times harder than cartilage and yet significantly softer than cortical bone (Brandt 2001). Excess loading causes subchondral trabeculae to fracture. These microfractures heal and cause the subchondral bone to stiffen and become more sensitive to future loading. The stiffer the joint becomes, the less it is able to absorb and effectively distribute physical loads. With excess loading, the stiffened joint will fail (Radin 1976, Chaffin et al. 1999, Brandt 2001).

Though researchers commonly use the terms OA and Degenerative Joint Disease (DJD) interchangeably, Kenneth D. Brandt (M.D.) argues that the word “degenerative” inadequately describes the disease process. Though cartilage lacks capillaries and has only limited reparative capabilities, it does undergo hypertrophic repair during the early stages of OA. Though normal adult cartilage cells do not divide, chondrocytes in OA cartilage undergo cellular division. However, these newly formed cells produce excess collagen and other biochemicals compared to the normal cells. Accordingly, differences between remaining normal adult cartilage cells and osteoarthritic cells result in further shortcomings in the cellular matrix and thus in the joint as a whole (Brandt 2001)

According to Kellgren (1961:5243), OA is "an expression of a joint's inadequacy to meet the mechanical stress placed on it." Mechanical factors relate to the development of both primary and secondary OA (Chaffin et al. 1999). Primary or incident OA results when components of the joint surface and shape become altered with age-related changes or in response to habitual loading or strenuous activity. Alternately, secondary OA develops as a result of trauma (Walsh-Haney 2007). The present study focuses on primary OA and, unless otherwise specified, shall be referred to only as "OA" throughout the remainder of this thesis.

Occupational factors have been documented as influencing the development and progression of OA (Chaffin et al. 1999, Wahlstrom 2005, Cardoso and Henderson 2010, Kellgren 1961, Coggon et al. 2000, Anderson 1971, and Fontana et al. 2007). Though age, obesity, heredity and biochemistry have also been identified as etiological factors in OA development, biomechanics is thought to be the primary contributing variable (Chaffin et al. 1999).

Osteoarthritis: Contributing Factors

Several studies have found a strong correlation between OA and age (Walsh-Haney 2007, Dieppe 1999, Cicuttini et al. 1997, Hamerman 1997, Coggon et al. 2000, Anderson 1971, Molnar et al. 2011, Brandt 2001, Buchanan et al. 2003, Jurmain 1977). OA is uncommon in individuals under the age of 45 though it is more frequently found among males at this age. In most individuals, the joints of the hands will be among the first affected (Cicuttini et al. 1997). Premature onset (occurring under the age of 50) is most frequently a product of severe trauma or genetic predisposition (Jones and

Doherty 1995). When females enter menopause around the age of 50, women begin to develop hip and knee OA and hand OA often follows (Brandt 2001). After the age of 55, OA is more common in females and multiple joints will be affected – usually the interphalangeal joints, the first carpometacarpal joint, and the knees (Cicuttini et al. 1997, Jones and Doherty 1995). By the age of 65, about half of the individuals in a modern population will have arthritic characteristics in at least one joint (Jones and Doherty 1995). Unfortunately, OA studies rarely investigate change occurring in individuals over the age of 70 so very little data are available for this latter age group (Cicuttini et al. 1997).

The onset of OA with advancing age is in some respects a product of the changes in body composition that come with age. As we age, our bone density, muscle strength, and lean body mass decrease while our store of fatty adipose tissue increases (Lewis and Bell 1990 *sensu* Hamerman 1997). For women, biochemical changes that occur following menopause can contribute to the development of OA or osteoporosis (OP). In healthy premenopausal women, bone resorption by osteoclasts and formation by osteoblasts maintains equilibrium. However, once a woman encounters menopause and hormone production ceases, this equilibrium can become unbalanced (Hamerman 1997). Excess adipose cells in overweight females can convert to estrogen – an important chemical in bone density maintenance – and contribute to excessive osteoblast function (Boyd 1994 *sensu* Hamerman 1997). Hence, OA is more likely to develop in an obese female than in thinner females.

According to Dieppe (1999), most mild OA fails to progress to its most severe form. Consequently, the risk factors for the progression of arthritis may be different than those related to onset,erhaps with heredity playing a more prominent role in increasing severity (Dieppe 1999). In the 1950s, Kellgren and Lawrence were the first to document a familial relationship between individuals with OA in the hip (Kellgren and Lawrence 1954 *sensu* Carr 2003). Since then, the body of literature relating to the genetic basis for OA has grown immensely. In 1996, a Finnish study found that women had heightened genetic propensity toward OA (Carr 2003). Herberden (1802 *sensu* Kellgren 196) and Brandt (2001) have hypothesized that OA susceptibility is passed on as a single autosomal dominant gene in females and only recessively inherited in males. This might help explain why females are twice as likely as men to develop OA (Brandt 2001). Five regions of the genome have been identified as potentially active players in joint failure of the hip and knee (Carr 2003). Both of these joints are prone to severe and debilitating arthritic change; OA is currently the leading cause of joint replacement surgery and these weight-bearing joints are among those most frequently affected (Carr 2003, Dieppe 1999). Spector et al. (1996) found evidence for a genetic component for radiographic OA in the hand and knee in women. Their results pointed to OA heritability ranging between 39 and 65%, independent of environmental and demographic factors (Spector et al. 1996). Similar findings have been reported by Kaprio et al. (1996).

Jurmain (1977) explains that stress factors such as trauma and occupational activities can lead to the onset of OA. Arthritic change is often discovered among laborers at an earlier age than non-laborers. Terms like “housemaid’s knee”, “policeman’s heel”, “weaver’s bottom”, or “telegraphist’s wrist” originated with the documented discomfort and clinical complaints generated by individuals in these professions (Anderson 1971). Miners are not immune to such occupational ailments; they often exhibit early signs of OA in the joints of the hands, feet, spine, knees, and hips (Jurmain 1977). Intervertebral discs of dock workers, the ankle and knee joints of athletes, and the hands of cotton pickers, diamond cutters, and seamstresses also display evidence of arthritic change in response to occupational stress. Jurmain (1977) also notes that hand or arm dominance can contribute to asymmetrical expression of OA.

Osteoarthritis and Musculoskeletal Stress Markers in the Hand

The hand is a common anatomical region for musculoskeletal pain and discomfort caused by OA among older and elderly adults (Myers et al. 2011). Because OA affects hundreds of thousands of people worldwide, it has been the subject of countless clinical studies in recent decades (Miura et al. 2008, Myers et al. 2011, Chaisson et al. 2000, Chaisson et al. 1999, Hadler et al. 1978, Fontana et al. 2007, Kaprio et al. 1996, Spector et al. 1996, Coggon et al. 2000, Brandt 2001). However, studies using skeletal samples to examine hands in this context are considerably few. Given the problems of preservation, size, difficulty in siding these bones, and difficulty in distinguishing between normal variation and osteoarthritic change, this comes as no surprise (Myers et al. 2011, Cashmore and Zakrzewski 2011). However, the current body of research has shed light on some potential patterns and issues that have helped shape the present study.

Musculoskeletal stress in the hand is a product of the complex interplay of muscle activity and multiple intrinsic biological factors. Just as MSMs can help contextualize the activities of past peoples, so too can OA scores. Nagy and Hawkey (1993) found that bones independently scored for OA and MSMs yielded consistent interpretations with regard to activity patterns. They suggest that combined MSM and OA data should be used in order to generate a more complete analysis of activity patterns. MSMs should be used for studying young and middle age adults while measures of OA would be most useful for studying older individuals (Nagy and Hawkey 1993).

Hand OA, as with that of other anatomical regions, is thought to increase with age and to be influenced by genetics, obesity, sex, and activity (Brandt 2001). The first carpometacarpal joint (CMC1) and the distal interphalangeal joints (DIP) are the most commonly affected joints of the hand (Chaisson et al. 2000, Chaisson et al. 1999, Fontana et al. 2007, Waldron 1993). OA in these joints can sometimes take the form of Herberden's or Bouchard's nodes or erosive interphalangeal OA (Brandt 2001). In a study of 101 skeletons from England, Waldron (1993) found that OA in the CMC1 joint was more frequently apparent in the dominant hand. Involvement of the DIP joints and that of the first metacarpophalangeal (MCP1) joint was observed in one-third of the skeletons examined. (A complete list of joint names and abbreviations can be found in Table 3.1 of this chapter.) In most cases, OA was limited to the first and second rays and it appears to have started with the trapezium and radiated out distally through the other joint surfaces from there (Waldron 1993). Note that a ray refers to each finger or digit from the metacarpal to the distal phalanx. In a 25-year longitudinal radiographic study of the hands of 3,327 Americans over the age of 40, Wilder et al. (2006) found that the DIP joints were those most frequently affected by OA. The proximal interphalangeal (PIP) joints were the least commonly involved. Contrary to the results of Waldron (1993), however, CMC1 OA was more prevalent in the non-dominant hand (Wilder et al. 2006).

Males and females often exhibit different patterns of OA expression. Females tend to have greater overall joint involvement than do males (Waldron 1993, Jones and Doherty 1995). Often multiple joints are affected in females while only a single joint will be affected in males (Waldron 1993). Arthritic changes are frequently observed in the CMC1 joint of both sexes though the DIP and PIP joints are rarely involved in males (Wilder et al. 2006). Wilder et al. (2006) also noted that OA was more prevalent among females in the more distal joints of the dominant hand. Both males and females tended to have involvement of the CMC1 joint in the non-dominant hand (Wilder et al. 2006).

As previously noted, hand dominance may result in asymmetric expression of OA (Waldron 1993, Wilder et al. 2006, Miura et al. 2008). Miura et al. (2008) further investigated hand dominance with regard to the DIP joints. Radiographs of 518 subjects from a rural community were examined for signs of OA. Many individuals in the study exhibited signs of generalized osteoarthritis (GOA), a condition characterized by arthritic change in multiple joints in different anatomical regions of the body. The right hand of subjects with GOA displayed similar rates of DIP involvement (37-40%) regardless of hand dominance. Hand dominance contributed to a much different pattern of involvement in the non-GOA group; right handed individuals had significantly higher frequencies of DIP OA in the right hand than did left handed individuals (Miura et al. 2008). Odds ratios revealed a seven-fold increase for DIP OA in the dominant hand for this group. Consequently, Miura et al. (2008) found evidence for two etiological subtypes of OA in these joints, one being genetic and the other environmental (GOA having the genetic component and incident OA having the environmental component). This may help explain why individuals within the same population exhibit different patterns of OA in the dominant hand (Miura et al. 2008).

Research suggests that biochemical factors may contribute to OA development in the hand (Dieppe 1999, Hamerman 1997, Brandt 2001, Buchanan et al. 2003, Jurmain 1977, Jones and Doherty 1995). Jurmain (1977) found Herberden's nodes in 50% of postmenopausal women studied. These are hard nodes or bone spurs frequently observed in the interphalangeal joints of the hands. Similarly, *nodal generalized osteoarthritis* or *menopausal osteoarthritis* is a condition that is known to have a genetic component, possibly linked to the HLA A1B8 gene. Menopausal osteoarthritis is generally characterized by Herberden's nodes in DIP joints and Bouchard's nodes in PIP joints (Jones and Doherty 1995).

Heredity likely plays a role in the development of Herberden's and Bouchard's nodes and it may also contribute to the overall development of OA (Jurmain 1977, Carr 2003, Kellgren 1961, Kaprio et al. 1996, Brandt 2001). Stecher (1941) found that

Herberden nodes were three times as common among sisters compared to unrelated individuals in the general population (*sensu* Cicuttini et al. 1997). Spector et al. (1996) noted a genetic influence of 50 to 65% for OA in the hands. Obesity is a more complicated factor in OA development in the hand given that hand joints are not weight-bearing (Cicuttini et al. 1997). As noted earlier, obesity shows a clearer pattern among females than males with regard to biochemistry and menopause (Hamerman 1997).

Kalichman et al. (2005) investigated a potential correlation between overall physical characteristics and OA in the hand. Using radiographs of more than 1,100 Russian men and women between the ages of 18 and 90 years old, they calculated an overall physique index including body mass index, stature, and weight and compared each individual's resulting index with corresponding OA scores. Only a slight correlation could be found between hand OA and the physical index factors. These findings suggest that OA in the hand, as in other anatomical regions, has a multi-component etiology (Kalichman et al. 2005).

Age and activity are potential factors in the development of DIP OA, though the mechanism for age-related change has not yet been discovered (Miura et al. 2008, Hadler et al. 1978, Fontana et al. 2007). Lawrence (1961b *sensu* Anderson 1971) found that 38% of male cotton operatives over the age of 45 developed Herberden's nodes

Source: American Society for Surgery of the Hand (2009) *Essentials of Hand Surgery*.

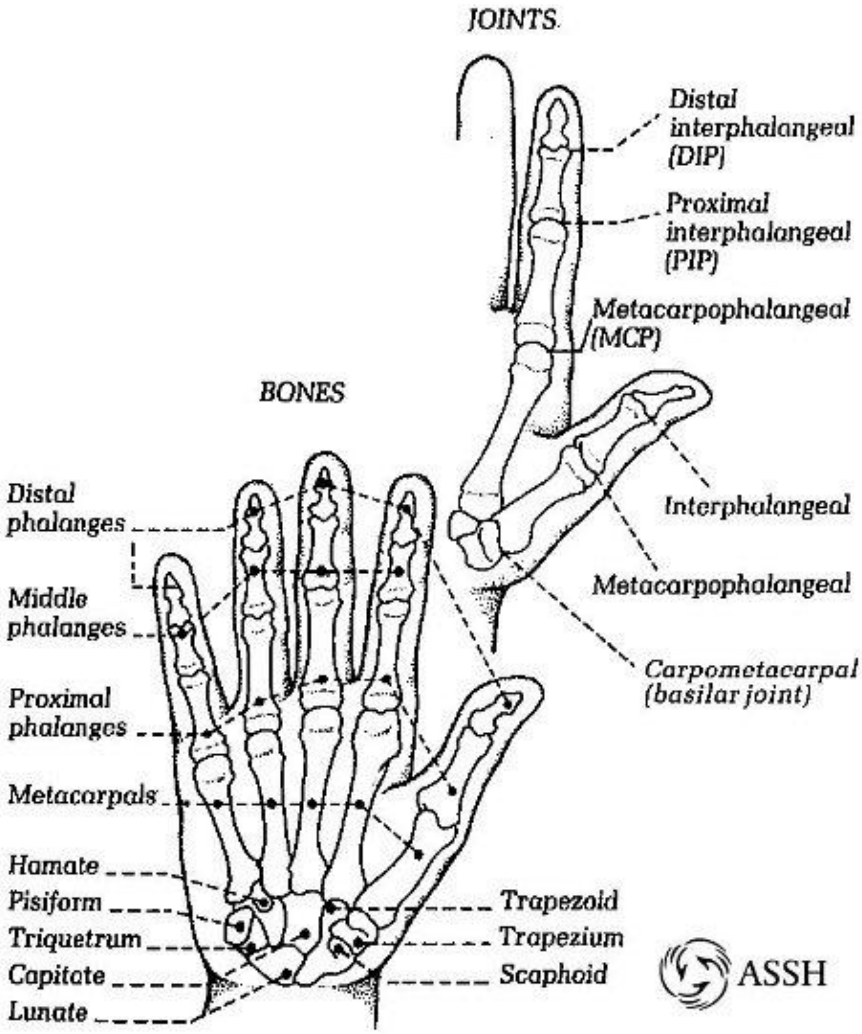


Figure 3.1 Hand Diagram

Table 3.1 Abbreviations Reference Guide

Description	Abbreviation
Osteoarthritis	OA
Generalized Osteoarthritis	GOA
Osteoporosis	OP
Carpo-metacarpal Joint (1-5)	CMC
Metacarpo-phalangeal Joint (1-5)	MCP
Proximal Interphalangeal Joint (2-5)	PIP
Distal Interphalangeal Joint (2-5)	DIP
Interphalangeal Joint 1	IP1

compared to only 12% of males in the general population. Hadler et al. (1978) studied radiographs of a group of female textile workers in Virginia with specific occupational tasks. The textile factory workers held distinctive jobs as winders, burlers, and spinners. Tasks of all workers required repetitive motion and use of both hands. All other age and demographic characteristics of study participants were similar; only specific job functions were the dividing characteristics. In the majority of cases, OA was observed in both hands though it was more prominent in the right regardless of job function (Hadler et al. 1978). Burlers and spinners had more involvement in the finger joints than did winders and only spinners lacked OA in the fifth ray. Winders had less OA involvement of the second and third digits compared to the rest of the individuals in the sample. These patterns are a product of hand usage in that winding tasks require a power grip and significant bilateral use of the wrists (Hadler et al. 1978). Burling and spinning tasks require precision grip and nimble finger movements in comparison. Winders solely had involvement of the wrist joints due to the specific type of required muscle activity (Hadler et al. 1978). Given that many individuals in the present study were performing similar tasks in industrializing Cleveland, I expect to find similar OA patterns.

Wahlstrom (2005) used electromyography (EMG) to assess physical load in a study of computer users with typewriting as the primary job task. Physical load was defined as "factors relating to biomechanical forces generated in the body (Wahlstrom 2005:168)." This study found that repetitive tasks performed over long durations of time can contribute to musculoskeletal stress in the hands. Though computer work only requires minimal muscle activity, Wahlstrom (2005:169) notes that "no safe lower level of muscle activity may exist." Typing places particular stress on the trapezius muscles and requires awkward placement of the wrist. Repetitive movement and extreme or unnatural positioning increases the risk of strain in the wrist and forearm. Working women are found to be at higher risk than working men for musculoskeletal symptoms in the hands and wrist (Wahlstrom 2005). Tittiranonda et al. (1999 *sensu* Wahlstrom 2005) suggest that anthropomorphic differences between the sexes may cause females to work at more extreme or uncomfortable angles than males; most tools and occupational implements are designed to be held or manipulated by larger and more broadly proportioned male hand. This pattern is not restricted to only computer and keyboard users, but can be found in the vast majority of occupational arenas. Chaffin et al. (1999:258) likewise elaborated that individuals with smaller wrists are at a greater risk for injury under occupational circumstances that require "frequent and forceful manual exertions in postures with the wrists deviated."

Grip strength and muscle activity have been shown to correspond with musculoskeletal stress in the hand (Chaisson et al. 2000, Chaisson et al. 1999, Chaffin et al. 1999, Cashmore and Zakrzewski 2011). According to Chaisson et al. (2000:S29), "muscle often serves to attenuate joint load" and muscle activity is the "major determinant of forces at the hand joints." Grip strength is a measure of muscle force generated during specific hand functions (Chaisson et al. 2000). Increasing grip strength was found to raise the risk of developing OA in proximal joints. Males who were found to have greater grip strength were also found to have higher OA rates in the proximal joints such as those of the PIP, MCP, and CMC joints. Similarly, women with higher grip strength were also at a higher risk of CMC and MCP OA. DIP OA, in contrast, failed to demonstrate any association with grip strength in the hands of either sex (Chaisson et al. 2000, Chaisson et al. 1999). These findings are functionally logical in that grasping or gripping objects exerts very little force over DIP joints in comparison to precision grip which requires more force distributed distally (Chaisson et al. 2000). Note that these findings are consistent with those of Hadler et al. (1978), both studies supporting the notion that excessive muscle force contributes to hand OA. However, we must remember that movement of the hand is not restricted to the use of only a single muscle but rather it is the result of the activity of several muscles working in unison (Kennedy 1998, Stirland 1998). See Table 3.2 in the Appendix for a list of selected hand muscles and their function in context.

Based on the available literature, there appears to be a general pattern to the progression and prevalence of OA in the hands. Females are often more affected by the arthritic change than are males (Jones and Doherty 1995; Rogers and Waldron 1995). It appears to manifest initially in the first ray, beginning with the trapezium and spreading out distally to other joints (Waldron 1993; Wilder et al. 2006). The CMC and DIP joints are usually the most involved in OA, regardless of hand dominance (Wilder et al. 2006; Waldron 1993). However, activity patterns and muscle activity appear to play a significant role in musculoskeletal stress including, but not limited to, OA development.

Chapter 4

MATERIALS AND METHODS:

SAMPLING AND SCORING THE HAMANN-TODD OSTEOLOGICAL COLLECTION

As detailed in Chapter 2 of this thesis, the economic shift that transpired during the 19th century changed the circumstances of the American worker. Small farmsteads gradually began to disappear from the landscape to be replaced by bustling mills and factories. Workers went from standing on their feet, toiling away in the fields, to manipulating machinery and precision tools with their hands in cramped spaces. Within the context of this changing occupational climate, the present sample comes from the quintessential American industrial city of Cleveland, Ohio (Warf and Holly 1997). Using a nonrandom multi-stage sampling strategy, this study explores patterns of OA in the hands of a modern documented skeletal collection and a contemporaneous occupational pattern in Cleveland archival records.

The Collection

The Hamann-Todd Human Osteological Collection housed at the Cleveland Museum of Natural History, provides the subjects of this study. The Hamann-Todd collection is one of the largest documented skeletal collections in the world, containing the skeletons of more than 3,000 individuals from the Cleveland area, their births ranging from 1825 to 1910 and deaths ranging from 1910 to1940 (Rankin-Hill and Blakey 1994; de la Cova 2008). The collection was named after the two principal anatomists who initiated it, Dr. Carl Augustus Hamann and Dr. T. Wingate Todd. Hamann began amassing specimens for the collection in 1893 though it wasn't until

1912 when Todd was named Dean of Western Reserve Medical School and took Hamann's spot in the dissecting laboratory, that the rigorous documentation process still evident in the collection archives today began (Todd 1927; de la Cova 2008). Todd's involvement developing the Anatomical Laws of the State of Ohio resulted in the procurement of more than 3,000 unclaimed bodies from local hospitals and morgues (Jones-Kern and Latimer 1999 *sensu* de la Cova 2008). Those bodies were dissected by students and professors of the medical school and then documented and curated by Todd until his death in 1938 (de la Cova 2008). Todd took great care to note age-at-death, sex, ancestry, cause-of-death, anomalies and pathologies, and case history when those records were available. At least two sets of measurements were taken on each specimen, one before dissection and the other following dissection and maceration. By 1939 there were over 3,300 skeletons documented in the collection (Krogman 1989).

Demographic characteristics of the collection have been detailed in Cobb's (1932) Ph.D. dissertation from Western Reserve University (now Case Western Reserve University). By the time of his writing in 1931, there were 2,160 individuals in the collection with European-Americans outnumbering African-Americans by 2 to 1. However, he did note that a significant number of African-American individuals entered the collection after 1915. This finding coincided with a migration trend in which African-American industrial workers came to Cleveland from the southeastern states. Interestingly, birthplace was documented for a little over half of the collection at this time. The collection is largely an amalgamation of foreign-born European-Americans and southern-born African-Americans (Cobb 1935). Many of the foreign-born individuals were born in Germany, Austria, Ireland, Hungary, Czechoslovakia, Russia, Poland, Great Britain, Italy, and Canada. Individuals from these countries account for 86.3 % of the Hamann-Tood collection's foreign-born cadavers. In contrast, only one African-American individual was documented as foreign-born; the majority were born in Georgia, Alabama, South Carolina, Tennessee, Virginia, Kentucky, Mississippi, North Carolina, and Arkansas (Cobb 1935). Cobb also documented a younger median age for African-Americans in the collection as compared to European-Americans (37 years and 45 years, respectively). Additionally, with regard to sex, males outnumber females, making up about 82% of the collection (Cobb 1935).

According to Cobb (1935:157), the collection is comprised of "the least stable elements of marginal economic groups in the living population, chiefly foreign-born [Europeans], their immediate descendants, and [African-Americans], people who with few exceptions were without skilled occupations." Occupational data were available at that time for 858 of the specimens in the collection. Cobb noted that 481 individuals, or 56% of the collection, included general laborers. Only 30 skilled occupations were represented and those were almost entirely allotted to European-American males (Cobb 1932). Cobb's (1932) "Occupations Represented in Cadaver Population" table has been recreated and reproduced in Table 4.1. Given the age distribution, ancestral

Table 4.1 Occupations Represented in Cadaver Population

Occupation	W	B	Sum	Occupation	W	B	Sum
1. Laborer	287	194	481	44. Packer	1	0	1
2. Teamster	19	4	23	45. Bookbinder	0	1	1
3. Cook	9	9	18	46. Cigar Maker	2	0	2
4. Porter	1	15	16	47. Window Washer	1	0	1
5. Peddler	10	0	10	48. Engineer	1	0	1
6. Machinist	8	1	9	49. Accountant	1	0	1
7. Tailor	5	2	7	50. Bricklayer	1	0	1
8. Carpenter	6	2	8	51. Pantryman	0	1	1
9. Salesman	7	0	7	52. Clerk	1	0	1
10. Painter	6	0	6	53. Lather	0	1	1
11. Steel Worker	4	2	6	54. Fisherman	1	0	1
12. Molder	6	0	6	55. Caretaker	1	0	1
13. Sailor	6	0	6	56. Jeweler	1	0	1
14. Barber	2	3	5	57. Ass't. Foreman	0	1	1
15. Farmer	5	0	5	58. Bookkeeper	1	0	1
16. Watchman	4	1	5	59. Handy Man	0	1	1
17. Laundry Worker	3	2	5	60. Bartender	1	0	1
				61. Ice Filler	1	0	1
18. Dish Washer	5	1	6	62. Gardener	1	0	1
19. Plasterer	4	0	4	63. Coal Dealer	1	0	1
20. Butcher	3	1	4	64. Elevator Oper.	1	0	1
21. Driver	2	2	4	65. Cement Worker	1	0	1
22. Wood Worker	3	1	4	66. City Directory Enumerator	1	0	1
23. Hostler	2	2	4	67. White Washer	0	1	1
24. Janitor	2	2	4	68. Bell Hop	1	0	1
25.Polisher	3	0	3	69. Musician	0	1	1
26. Factory	3	0	3	70. Boilermaker	1	0	1
27. Bum	3	0	3	71. Butler	1	0	1
28. Tinner	2	0	2	72. Harness Maker	1	0	1
29. Printer	2	0	2	73. Photographer	1	0	1
30. Oilman	2	0	2	74. Trainman	1	0	1
31. Paperhanger	0	2	2	75. Blacksmith	1	0	1
32. Orderly	2	0	2	76. Carpet Weaver	1	0	1
33. Fireman	2	0	2	77. Wall Washer	1	0	1
34. Shoemaker	2	0	2	78. Pipe Fitter	1	0	1
35. Miner	2	0	2	79. Stone Cutter	1	0	1
36. Rag Picker	1	1	2	80. Doorman	1	0	1
37. Chauffeur	1	1	2	81. Rubber Worker	1	1	1
38. Locksmith	2	0	2	82. Stripper	1	0	1
39. Thief	1	1	2	83. Housewife	44	44	88
40. Boot black	0	1	1	84. Domestic	10	13	23
41. Presser	0	1	1	85. Waitress	2	1	3
42. Amusement Att'd	1	1	2	86. Seamstress	2	0	2
				87. Maid	1	0	1
43. Clothes Cutter	1	0	1	88. Office Girl	1	0	1
				89. Schoolchild	3	6	9
				Total	**535**	**323**	**858**

Source: Human Archives. PhD Dissertation by William Montague Cobb, Dept of Anatomy Western Reserve Univ. May 15, 1932. p.82

composition, and occupational skill level of the individuals present, Cobb (1935) deduces that the collection represents a low socio-economic status population. Todd (1927) agreed on this point and commented that those individuals who came through the dissecting rooms were not the most privileged of society, but rather those "exposed" to the "great hazards of life"…"when not sheltered by specific social legislation." Interestingly, the collection represents a 1% sampling of the population of Cleveland during the years of its assembly (Cobb 1935).

The Osteological Sample

The present study represents an examination of hands from 412 individuals curated in the Hamann-Todd Human Osteological Collection. Using a nonrandom multi-stage sampling strategy, equal numbers of specimens were selected from each demographic subgroup: African American males, African American females, European-American males, and European-American females so that the sample is equally divided

Table 4.2 Osteological Sample Age Range

	African American Sample			European-American Sample		
Sex	**Number of Individuals**	**Age Range**	**Average Age**	**Number of Individuals**	**Age Range**	**Average Age**
Female	102	40 – 89	56	105	40 – 93	65
Male	101	40 – 105	62	104	40 – 96	65
Total	203	40 – 105	59	209	40 – 96	65

Table 4.4 Commonly Documented Birthplaces in the Present Sample

Documented Birthplace					
Outside of the United States					
Country	**Frequency**	**%**	**Region**	**Frequency**	**%**
Germany	17	4.1	Western Europe	33	8.0
Ireland	10	2.4	Eastern Europe	25	6.1
Austria	6	1.5	Canada	5	1.2
Canada	5	1.2			
Hungary	4	1.0			
Within the United States					
State	**Frequency**	**%**	**Region**	**Frequency**	**%**
Ohio	16	3.9	Southeast	47	11.4
Virginia	11	2.7	Unspecified USA	24	5.8
Georgia	9	2.2	Midwest	18	4.4
Tennessee	5	1.2	Northeast	12	2.9

into quarters with at least 100 individuals examined from each category. Arthritic change is infrequently found in individuals under the age of 40 (Jones and Doherty 1995). Accordingly, only subjects age 40 and older at the time of death were selected for study.

Table 4.2 reports the age range of the osteological sample. Also, birthplace is known for approximately 40% of the selected sample and has been graciously provided by Lyman Jellema (Jellema personal communication 2011). Native born United States citizens account for 61.6% of the individuals with documented birthplace while foreign-born citizens account for the remaining 38.4%. Similar to Cobb's (1932) findings for the Hamann-Todd Osteological Collection, foreign-born individuals in the present sample were born in Western Europe (52.4%), Eastern Europe (39.7%), and Canada (7.9%). The majority of native born individuals of documented birthplace were born in the

Southeast (46.5%) and had moved to the Cleveland area sometime prior to death. The top 10% of the most frequently documented countries and states of birth for the sample are listed in Table 4.4 along with frequencies by region. Table 4.5 in the Appendix details the complete birthplace listings for the present sample.

Identifying Osteoarthritis

While there exists a vast body of OA literature, studies of the hand using anatomical collections are limited. Radiographs from living people are the basis of study for much of the current literature. However, radiograph studies have certain shortcomings and limitations. Many studies utilize the Kellgren and Lawrence (1963) criteria for determination of OA in radiographic examination (Cicuttini et al. 1997). Unfortunately, observers frequently fail to agree when assessing individuals using this scale (Cicuttini et al. 1997, Waldron and Rogers 1991). However, Kellgren (1961) notes that early arthritic changes may not be apparent in radiographs; rather they would be more evident in dry bone. Also, radiographic criteria for OA such as joint space narrowing and inflammation are not always present in dry bone, and can be difficult to detect in the hands even in radiographs. According to Rothschild (1997), joint space narrowing is usually a useful criterion for evaluating OA when osteophytes are not visible; but such a criterion is only useful for radiographic studies of the hip joint.

Rothschild (1997) argues that OA must be accurately defined and diagnosed before it can be properly studied. According to Rothschild, OA is commonly misdiagnosed when porosity is used as the sole diagnostic criteria for dry bone. He explains that porosity in bone is a product of discontinuity of subchondral bone as a reaction to bony sclerosis. Additionally, he argues that eburnation—polishing of the joint caused by loss of cartilage—should not be used as a primary indicator of OA, as it represents extreme joint space narrowing and will not be evident in more moderate cases (Rothschild 1997). However, Molnar et al. (2011) used eburnation as the sole indicator of OA in a study of two Neolithic populations. These authors argued that using eburnation as the only defining characteristic of OA yielded conservative assessments of joint impairment. Interestingly, Molnar et al. (2011) discovered that both musculoskeletal stress markers and eburnation were highly correlated with age. Osteophyte formation has also been found to correlate with age (Weiss and Jurmain 2007 *sensu* Molnar et al. 2011). As such, eburnation or osteophytosis alone may not be the best single diagnostic criteria for OA.

Table 4.6 Abbreviations Reference Guide

Description	Abbreviation
Osteoarthritis	OA
American College of Rheumatology	ACR
Carpo-metacarpal Joint (1-5)	CMC
Metacarpo-phalangeal Joint (1-5)	MCP
Proximal Interphalangeal Joint (2-5)	PIP
Distal Interphalangeal Joint (2-5)	DIP
Interphalangeal Joint 1	IP1

Rothschild (1997) suggests that the American College of Rheumatology (ACR) criteria be used in OA diagnosis. ACR criteria for the hand include pain and stiffness, hard tissue inflammation in at least two of ten selected joints—less than three of those including MCP joints and two or more including DIP joints (Altman et al. 1990). In an examination of 400 skeletons from the Hamann-Todd Osteological Collection, Rothschild (1997) investigated the relationship between porosity and osteoarthritis. He found porosity in 17.5% of the sample and osteoarthritis (as determined by ACR criteria) in 29.5% of the sample. Porosity combined with OA was only evident in 5% of the sample. Seventy percent of those exhibiting porosity displayed no signs of OA. Additionally, 82% of the specimens with indications of OA showed no signs of porosity. Using a chi square test, he found no significant correlation between OA and observed porosity. Because the relationship between porosity and OA has not been conclusively proven, researchers should exercise caution when using this characteristic in diagnosis (Rothschild 1997).

Scoring for Osteoarthritis

In the absence of standardized procedures for scoring OA on dry bone (Jurmain and Kilgore 1995), 15 joints of the hand were scored based on the criteria outlined by Rogers and Waldron (1995) which were developed for use on dry bone. Joints scored include all carpo-metacarpal (CMC) joints, metacarpo-phalangeal (MCP) joints, proximal interphalangeal (PIP) joints, distal interphalangeal (DIP) joints, and the first interphalangeal (IP1) joint. See Table 4.3 in the Appendix for a complete list of joints examined. For each hand examined, OA was scored as present if eburnation was apparent or if at least two of the following characteristics were observed: marginal osteophytes, new bone formation on the joint surface, pitting, or contour changes of the joint space. See Figures 4.2 and 4.3 in the Appendix for examples of these characteristics. Both the left and right hand were examined for each individual in the sample unless one of the hands was unavailable for study. The Hamann-Todd collection stores bones of the right and left hand in separate boxes. Each hand was examined independently and siding was verified using methods outlined by Case and Heilman (2006). The number of joints involved in both hands has been used as a measure of severity because many observers fail to agree on its assessment when using an ordinal scale (Waldron and Rogers 1991).

Osteological Analysis

The present study examines the relationship between sex, ancestry, age, historical time period, and the expression of OA in the various joints of the hands. The data has first been validated, resulting in the exclusion of four individuals due to poor preservation and lack of completeness. Individuals were divided into five year age categories so as to document the progression of OA across the lifespan. Eight birth year cohorts were assigned in ten year increments between 1820 and 1899. Those birth year cohorts fall within four broadly defined historical periods distinguished by major American events and eras such as Indian Removal, the Civil War, and the Progressive Era. Figure 4.1 depicts the sample distribution across historical periods. A breakdown of the sample by time period and birth year cohort will be available in Chapter 5.

Statistical analysis, including descriptive statistics, multivariate logistic regression, conditional univariate and multivariate Kruskal-Wallis H Tests, Chi Square and Fisher's exact Tests, were carried out using PASW 18.0 (PASW Statistics 18.0 2009). Multivariate Logistic Regression was used to assess which factors have the greatest effect on the presence of OA in the present sample. Logistic regression was determined to be the most appropriate statistical method for this analysis because it does not assume that the outcome variable has a normal distribution. Rather, it only assumes that the outcome variables are dichotomous and mutually exclusive, outcome scores are independent, and the model is correctly specified to include only relevant predictor variables (Warner 2008, Peng et al. 2002, Tabachnick and Fidell 1989).

OA presence was coded as either 0 for "absent" or 1 for "OA present in at least one joint." Using a Generalized Linear Model (GLN) customized in PASW 18.0, the following predictor variables were selected: Sex, Ancestry, and Historical Period (main factors), Sex and Age, Ancestry and Sex, Sex and Historical Period, Ancestry and Historical Period (interaction variables), and Age (covariate). The entire sample of 412 individuals was included in this part of the analysis and then females and males were analyzed separately in an examination of the effects of age on OA. An Omnibus Test of the full model (after several adjustments and improvements) compared with the null model was statistically significant, χ^2 (4) = 37.894, p < .0001 (Warner 2008). The final model included Sex, Ancestry, and Age as main effect factors with Sex and Age as interacting factors.

Conditional univariate and multivariate Kruskal-Wallis H tests were performed on individuals in the dataset with OA recorded as "present" in at least one hand. Because the datum violated assumptions of normality and homogeneity of variances, a non-parametric test is more appropriate and the Kruskal-Wallis test is used as an alternative (van Emden 2008, Katz and McSweeney 1980, Ruxton and Beauchamp 2008).

The total number of joints involved in both hands has been used as a measure of severity. Asymmetry was assessed with regard to severity by calculating the number of joints involved in each hand and comparing between the hands. Also, OA prevalence in individual joints was analyzed using Chi Square and Fisher's exact tests. Significant results of all comparisons are reported at both the two-tailed alpha level of 0.05. All results are reported in the following chapter.

Archival Analysis

Occupational data for the time period was obtained using the Minnesota Population Center's Integrated Public Use Microdata Series (IPUMS) database, Version 5.0. This database is a compilation of census data for households across the United States (1850-present) and internationally (1960-present) (Ruggles et al. 2010). The primary purpose of this portion of the analysis is to supplement the occupational literature available for the time period during which the osteological sample population lived and worked. The IPUMS sample used in this study includes United States Census records for Cleveland, Ohio for the years between 1850 and 1930 (with the exception of the 1890 census which is not available). The initial sample included all individuals available in the IPUMS dataset for these years. However, in order to generate results most consistent with the osteological sample, only individuals from the two ancestry groups of interest, African-Americans and European-Americans, were selected for analysis. The resulting sample of interest consists of 50,234 individuals from these census years.

PASW 18.0 has been used to generate descriptive and summary statistics about the occupations of individuals from the same demographic subgroups and historic period birth year cohorts as those found in the osteological sample. However, because hundreds of different occupations were provided to census enumerators during data collection, these categories have been collapsed by industry into the typological categories of “Unemployed,” “Manual,” and “Non Manual” for the purpose of the present study. These new categories were assigned based on historic job descriptions and worker classifications by Conk (1980). Only individuals born into the same four historical periods as those of the osteological sample (and thus who could have been curated in the Hamann-Todd collection and potentially incorporated in the present study) were included in the analysis. Results of this analysis can also be found in Chapter 5.

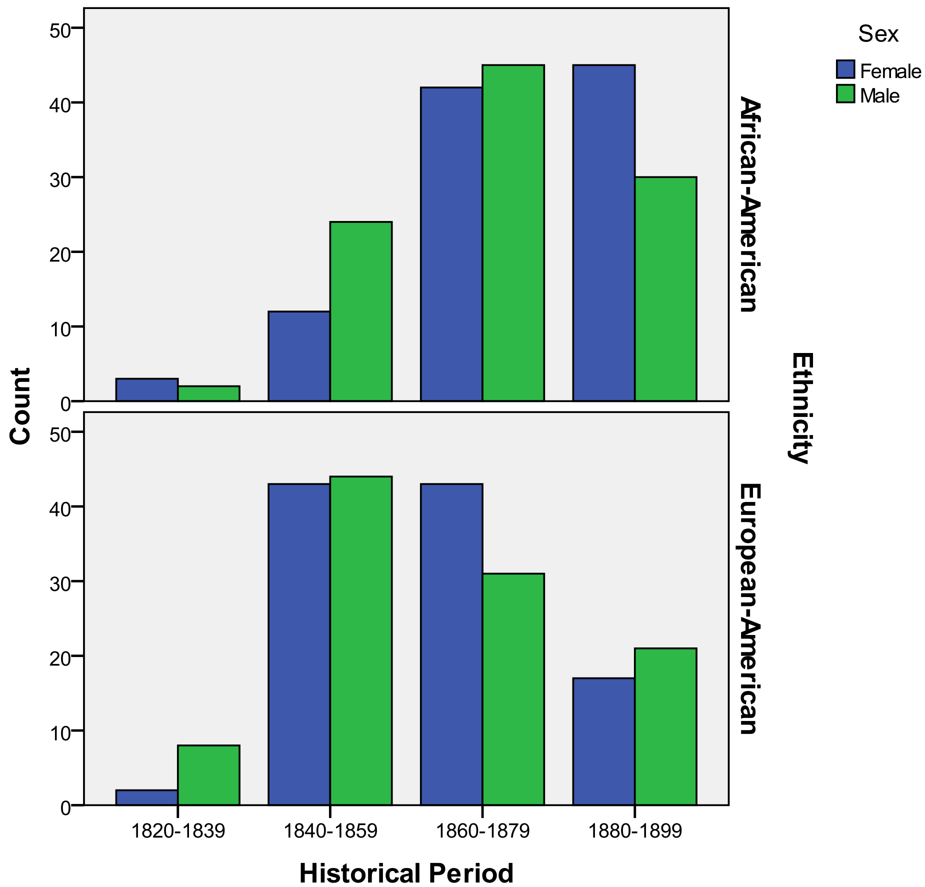


Figure 4.1 Sample Distribution by Historical Period

Chapter 5

RESULTS OF STATISTICAL ANALYSES AND COMPARISONS

I. Results of Osteological Analyses

Three analytical tools were used to assess osteoarthritis frequency and distribution for the present study. A multivariate logistic regression model was generated in order to assess which characteristics might affect OA development. Next, Kruskal-Wallis H tests were employed to compare medians between individuals from various demographic subgroups and time periods with the total number of joints involved in the hands used as an indicator of severity. Finally, Chi Square tests and Fisher's exact tests were used to assess differences between individuals with regard to the specific joint locations affected by OA.

Regression

Multivariate logistic regression was performed to predict the presence of osteoarthritis (OA) in individuals of a given age and with certain documented demographic characteristics who were born between 1820 and 1899. Table 5.2 reports the birth year cohort breakdown by historic period in addition to relevant events occurring in the nation during each cohort's lifetime. Table 5.1a summarizes the binary logistic regression coefficients, Wald statistics, and the estimated change in odds of OA presence for the entire sample. Not surprisingly, age was found to be a significant factor in the presence of OA (p-value =.015). Table 5.3 reports frequencies and proportions of individuals with OA in each age group. The results of this analysis reveal that the odds of a female developing OA are estimated as nearly 4.0 times that of males (Warner

2008). Also, at a given age, the odds of a female having OA are estimated as 1.9 times greater than for a male at the same age. In other words, males are at an overall lower risk of developing OA than are females in this sample from the Hamann-Todd Anatomical Collection.

Multivariate logistic regression results for analysis by sex and age group are provided in Tables 5.1b and 5.1c. An Omnibus Test of the model compared with the null model was statistically significant for both females (χ^2 (9) = 40.272, p < .0001) and males (χ^2 (9) = 21.392, p = .011) (Warner 2008). Among females, two statistically significant results emerged. OA rates are significantly different among females in the age range of 40-44 (p =.012), 45-49 (p=.006) Similarly, among males, significant differences are found in the same age groups (40-44, p=.024; 45-49, p=.001). However, one additional significant results emerge in the age group of 70-74 (p=.028) among males.

Table 5.1a Multivariate Logistic Regression Analysis

Predictor Variable	*B*	Wald Chi-Square Test	p	exp (*B*)	95 % Confidence Interval For exp (*B*) Lower	Upper
Intercept	1.959	7.313	.007	7.092	1.715	29.332
Sex	1.355	1.736	.188	3.879	.516	29.139
Ancestry	.293	1.869	.172	1.341	.881	2.042
Age	-.026	5.916	.015**	.974	.954	.995
Sex*Age	-.029	3.130	.077	.972	.941	1.003

** significance with α = .05

Kruskal-Wallis H Test

A conditional univariate Kruskal-Wallis H test was performed to compare the total number of hand joints affected for individuals with OA documented in at least one joint (n=177). Variables selected for comparison included Sex, Ancestry, Age group, and Historical Period as well as combinations of these variables to account for interaction. Kruskal-Wallis tests yielded several statistically significant results, at a confidence interval of 95%. As would be expected, comparisons of the number of joints involved between individuals of different age groups yielded a highly significant result ($p =.005$). Individuals between the ages of 50 and 64 commonly had as many as twice the number of joints affected than those of other age groups. When further analyzed by ancestry, European-Americans had significantly different numbers of joints involved between the age groups ($p =.016$). Overall, individuals between the ages of 50 and 64 had the most joint involvement. When compared without regard to age group, European-Americans again had significantly higher joint involvement than did African-Americans ($p =.017$). Males had significantly different involvement between historic birth year time periods ($p =.015$). In addition, the interaction between sex and ancestry was significant. The effect of sex on OA varies as a function of ancestry. European-American males had significantly higher joint involvement across the different periods ($p =.046$). The mean number of joints affected by historical birth year period has been provided in Tables 5.4 and 5.5. Results of these statistical tests are provided in Table 5.6.

Table 5.1b Multivariate Logistic Regression For Each Age Group, Analyzed by Sex: Females

Predictor Variable	*B*	Wald Chi-Square Test	p	exp (*B*)	95 % Confidence Interval For exp (*B*) Lower	Upper
Intercept	-.693	.961	.327	.500	.125	1.999
1. 40-44	2.251	6.315	.012**	9.500	1.641	54.994
2. 45-49	2.442	7.518	.006**	11.500	2.007	65.906
3. 50-54	1.344	2.881	.090	3.833	.812	18.092
4. 55-59	.375	.196	.658	1.455	.277	7.637
5. 60-64	-.223	.068	.794	.800	.149	4.286
6. 65-69	.894	1.138	.286	2.444	.473	12.629
7. 70-74	.357	.189	.663	1.429	.287	7.118
8. 75-79	-.336	.147	.702	.714	.128	3.995
9. 80-84	-.154	.024	.876	.857	.124	5.944
10. 85 and older	NA	NA	NA	1	NA	NA

** significance with α = .05

Table 5.1c Multivariate Logistic Regression For Each Age Group, Analyzed by Sex: Males

Predictor Variable	*B*	Wald Chi-Square Test	p	exp (*B*)	95 % Confidence Interval For exp (*B*) Lower	Upper
Intercept	-.693	1.602	.206	.500	.171	1.463
1. 40-44	1.792	5.069	.024**	6.000	1.261	28.547
2. 45-49	2.944	10.168	.001**	19.000	3.110	116.074
3. 50-54	1.099	2.586	.108	3.000	.786	11.445
4. 55-59	.981	2.158	.142	2.667	.720	9.870
5. 60-64	.375	.272	.602	1.455	.356	5.945
6. 65-69	1.135	2.670	.102	3.111	.797	12.140
7. 70-74	1.609	4.857	.028**	5.000	1.195	20.922
8. 75-79	.470	.421	.517	1.600	.387	6.620
9. 80-84	1.232	2.885	.089	3.421	.827	14.209
10. 85 and older	NA	NA	NA	1	NA	NA

** significance with α = .05

Table 5.2 Historic Periods and Events

Historic Period	Historical Events During the Lifetime	Birth year Cohort
1	Industrial Revolution begins (1830) Irish Potato Famine/Immigration (1830-1865) Trail of Tears (1838) Beginning of labor and wages Cuyahoga Steam Furnace Company opens (1830)	1. 1820-1839
2	Mexican War (1846-1848) Western Expansion Antebellum (1840-1860) Britt Iron and Steel Company opens (1854)	2. 1840-1859
3	American Civil War (1861-1865) Reconstruction Standard Oil Corporation opens (1870) Urbanization (1870-1920)	3. 1860-1879
4	Second Industrial Revolution (1880-1930) Building of the first Skyscraper (1885) The Progressive Era (1897-1914) Completion of the Transcontinental Railroad (1900) Panama Canal completed (1914) WWI (1914-1918)	4. 1880-1899

To explore asymmetrical patterns of OA joint involvement between the hands, conditional multivariate Kruskal-Wallis tests were carried out, again only including individuals in the analysis with at least one joint affected (n=177). This analysis compared the number of joints involved in the right hand and those in the left while controlling for other factors. Overall, European-Americans had significant involvement in the right hands (p=.005) compared to African-Americans. Comparisons of the

Table 5.3 OA Presence by Age Group

	OA Present in at least 1 joint					
	Females		Males		Overall	
Age Group	N	%	N	%	N	%
40-44	4	4.2	4	4.9	8	4.5
45-49	4	4.2	2	2.5	6	3.4
50-54	12	12.5	10	12.3	22	12.4
55-59	11	11.5	12	14.8	23	13.0
60-64	15	15.6	11	13.6	26	14.7
65-69	9	9.4	9	11.1	18	10.2
70-74	14	14.6	6	7.4	20	11.3
75-79	14	14.6	10	12.3	24	13.6
80-84	7	7.3	7	8.6	14	7.9
85 and older	6	6.3	10	12.3	16	9.0
Total	96	100	81	100	177	100

Table 5.4 Mean Number of Joints Involved for each Sex by Birth Cohort

Historical Period	Sex: Female	Sex: Male
1. 1820-1839	8.5	1.9
2. 1840-1859	4.3	6.7
3. 1860-1879	5.4	4.7
4. 1880-1899	4.7	3.2

Table 5.5 Mean Number of Joints Involved for each Ancestry by Historical Period

	Ancestry	
Historical Period	AA	EA
1. 1820-1839	4.5	5.9
2. 1840-1859	3.4	7.7
3. 1860-1879	4.9	5.2
4. 1880-1899	3.6	4.3

Table 5.6 Results of Kruskal-Wallis H Tests between individuals

Kruskal-Wallis Mean Rank with Independent Interacting Variables								
	Sex		Ancestry		Sex and Ancestry			
	F 90.16	**M** 87.63	**AA** 78.11	**EA** 96.64	**(F) AA** 42.47	**(F) EA** 52.28	**(M) AA** 36.25	**(M) EA** 44.80
Median joints involved	4.0		4.0		3.5		4.0	
p-value	**.741**		**.017****		**.090**		**.099**	

	Overall	Ancestry		Ancestry and Sex			
Age Group		**AA**	**EA**	**AA (F)**	**AA (M)**	**EA (F)**	**EA (M)**
40-44	43.31	19.50	24.33	11.25	5.00		12.00
45-49	56.58	29.90	12.00	15.38	15.00		6.00
50-54	65.32	36.36	28.77	20.50	17.14	16.25	12.67
55-59	80.13	37.63	43.73	19.13	18.94	23.50	21.50
60-64	91.92	44.32	48.33	23.21	21.00	26.19	22.50
65-69	112.44	46.50	63.29	23.17	23.83	33.42	29.17
70-74	97.00	23.86	68.58	13.40	10.00	40.50	28.38
75-79	108.15	49.58	59.00	21.50	27.25	33.75	25.42
80-84	103.86	32.33	63.18	16.50	17.00	27.83	34.70
85 and older	86.47	39.21	49.39	26.50	14.00	43.00	16.17
Median joints involved	4.0	2.0	5.0	2.0	2.0	5.0	5.0
p-value	**.005****	**.210**	**.016****	**.599**	**.527**	**.080**	**.131**

	Overall	Sex		Ancestry		Ancestry and Sex			
Historic Period		**F**	**M**	**AA**	**EA**	**AA (F)**	**AA (M)**	**EA (F)**	**EA (M)**
1. 1820-1839	83.78	70.88	21.90	38.75	46.60	28.00	10.00	45.50	11.67
2. 1840-1859	98.17	49.27	49.25	33.56	59.36	15.00	18.90	31.38	28.30
3. 1860-1879	87.26	47.27	40.38	40.97	47.01	20.18	21.56	27.84	19.32
4. 1880-1899	70.72	42.68	30.29	31.75	40.67	17.94	14.00	24.33	17.83
Median joints involved	4.0	3.5	4.0	2.0	5.0	2.0	2.0	5.0	5.0
p-value	**.127**	**.356**	**.015****	**.417**	**.133**	**.405**	**.228**	**.462**	**.046****

Note: The p-value listed at the base of each column represents differences between all age groups and historical period cohorts.
** significance with α = .05

number of joints involved in each hand between individuals of different age groups showed that males had significantly different frequencies in the left hand (p =.039). Interestingly, males in their 70s had the greatest joint involvement. Among individuals of different ancestry, European-Americans were found to have significant involvement in the left hands (p =.008) between age groups. The interaction between ancestry and sex revealed a significant difference between European-American males in the left hand (p =.008), indicating that the effect of sex on OA varies as a function of ancestry Sex was significant across historical periods for the left hand (p =.002) among males. Once ancestry and sex were selected as interacting variables between time periods, four significant results emerged. During the third historical period (1860-1879), males of the African ancestry had significant levels of joint involvement in the left hand (p =.027). Among European-American males, significant levels of joint involvement were evident in both the left (p =.043) and right hands (p =.036) during the second historical period. Results of each of these tests are recorded in Table 5.7 and 5.8.

Chi Square and Fisher's Exact Tests

Following the Kruskal-Wallis H Tests, OA presence in specific joints was compared between individuals and between the hands using Fisher's Exact and Chi Square in PASW 18.0. Variables selected for comparison included age group, ancestry, and historical period. Using Chi-Square, when OA prevalence by joint was compared by age group, several statistically significant differences emerged. In the left hand, the expression of OA in the DIP2 (p =.016) joint was more affected by age than were other joints. In these joints, OA tends to be absent or minimal until the age of 55 or older.

Similarly, in the right hand the DIP3 (p =.025) and DIP4 (p =.017) joints were more affected by age. However, OA in these joints becomes apparent in individuals as early as the age of 50. Results of these comparisons are presented in Table 5.9 (a and b) for joints in which more than 8 individuals were affected.

Results of Fisher's Exact tests comparing joints by ancestry revealed greater frequency of OA in all except for two European-American hand joints as compared to African-Americans. However, only 11 of these findings were statistically significant. In the left hand, findings were significant for the second proximal interphalangeal (LPIP2) joint (p=.005), second distal interphalangeal (LDIP2) joint (p=.010), and fifth distal interphalangeal (LDIP5) joint (p=.031). Similarly, in the right hand findings were significant for the second, third, and fourth distal interphalangeal (RDIP2, RDIP3, and RDIP4) joints (p=.018, .002, and .014, respectively). On average, European- Americans experience 12.3% greater prevalence of OA in the left hand and 7.7% in the right compared to African-Americans. The left and right carpo-metacarpal (LCMC1 and RCMC1) joints are the only joints in which African-Americans had higher proportions of OA; in the left hand prevalence was 2.1% higher in African-Americans as compared to European-Americans. This finding was more pronounced in the same joint of the right hand where the proportion was 9.7% higher African-Americans. However, this result is not statistically significant. Results from this test are reported in Table 5.10. When groups were compared by historical period, four statistically significant differences

Table 5.7 Results of Kruskal-Wallis H Tests –Number of Joints Involved in the Left Hand

Kruskal-Wallis Mean Rank with Independent Interacting Variables								
	Sex		Ancestry		Sex and Ancestry			
	F	**M**	**AA**	**EA**	**(F) AA**	**(F) EA**	**(M) AA**	**(M) EA**
	92.41	84.96	76.38	97.86	44.27	51.15	33.42	47.07
Median joints involved	1.0		1.0		1.5		1.0	
p-value	**.322**		**.005****		**.226**		**.008****	

Age Group	Overall	Sex		Ancestry		Ancestry and Sex			
		F	**M**	**AA**	**EA**	**AA (F)**	**AA (M)**	**EA (F)**	**EA (M)**
Group	48.13	29.13	21.00	24.30	22.00	12.88	6.00		10.33
40-44	63.50	32.75	32.50	31.30	29.50	14.50	19.50		13.50
45-49	60.07	32.21	28.25	35.68	25.18	20.75	17.57	13.38	12.33
50-54	89.17	47.86	41.63	36.00	54.91	17.50	19.06	30.07	25.88
55-59	93.44	47.43	46.55	44.14	49.57	22.07	21.88	24.56	25.50
60-64	113.06	59.50	53.39	48.08	63.25	24.83	24.33	34.83	28.08
65-69	105.03	56.29	48.42	32.07	71.38	14.80	17.00	42.28	29.13
70-74	95.02	50.71	44.60	42.58	51.78	19.00	23.50	30.42	21.92
75-79	104.61	47.43	56.29	34.50	64.09	15.50	19.50	29.50	33.90
80-84	81.53	69.75	26.70	34.43	46.22	28.00	9.38	41.50	15.42
84 and older									
Median joints involved	1.0	1.5	1.0	1.0	2.0	1.0	1.0	2.0	2.0
p-value	**.007****	**.117**	**.039****	**.676**	**.008****	**.639**	**.567**	**.031****	**.153**

Historic Period	Over all	Sex		Ancestry		Ancestry and Sex			
		F	**M**	**AA**	**EA**	**AA (F)**	**AA (M)**	**EA (F)**	**EA (M)**
1. 1820-1839	74.89	73.13	14.10	35.75	37.80	29.50	6.00	43.00	7.17
2. 1840-1859	98.80	51.50	47.64	36.42	58.39	18.50	18.40	32.02	27.25
3. 1860-1879	88.41	44.63	44.72	39.43	49.54	17.50	23.00	27.68	22.21
4. 1880-1899	68.80	44.95	27.46	32.66	38.44	20.44	12.75	21.17	17.17
Median joints involved	1.0	1.5	1.0	1.0	2.0	1.0	1.0	2.0	2.0
p-value	**.058**	**.184**	**.002****	**.737**	**.118**	**.461**	**.027****	**.402**	**.043****

Note: The p-value listed at the base of each column represents differences between all age groups and historical period cohorts.

** significance with $\alpha = .05$

Table 5.8 Results of Kruskal-Wallis H Tests –Number of Joints Involved in the Right Hand

Kruskal-Wallis Mean Rank with Independent Interacting Variables								
	Sex		Ancestry		Sex and Ancestry			
	F	**M**	**AA**	**EA**	**(F) AA**	**(F) EA**	**(M) AA**	**(M) EA**
	88.61	89.46	80.84	94.73	42.57	52.22	38.49	43.01
Median joints involved	2.0		1.0		2.0		2.0	
p-value	**.911**		**.070**		**.092**		**.379**	

	Overall	Sex		Ancestry		Ancestry and Sex			
Age		**F**	**M**	**AA**	**EA**	**AA (F)**	**AA (M)**	**EA (F)**	**EA (M)**
Group	58.50	32.13	26.88	26.80	31.83	14.88	12.50		14.83
40-44	64.00	41.88	18.00	33.80	12.00	19.00	12.50		6.00
45-49	75.16	40.42	35.20	37.36	37.45	20.75	17.07	20.75	18.17
50-54	75.02	40.27	35.08	37.38	38.18	21.50	17.38	21.00	17.63
55-59	89.06	50.13	39.00	43.68	47.33	23.00	21.00	27.75	19.79
60-64	103.00	52.61	50.06	45.00	58.17	21.00	24.83	31.42	26.42
65-69	89.38	50.50	38.17	18.50	63.62	11.00	7.50	38.17	25.63
70-74	116.15	62.32	54.45	52.58	64.50	26.25	26.38	36.04	29.08
75-79	99.61	41.57	57.07	32.00	60.00	15.50	16.75	24.25	35.20
80-84	86.44	56.00	35.20	35.29	51.61	17.17	17.50	41.67	18.25
84 and older									
Median joints involved	2.0	2.0	2.0	1.0	2.0	1.0	1.0	2.0	2.0
p-value	**.049****	**.481**	**.124**	**.153**	**.091**	**.704**	**.595**	**.174**	**.236**

	Overall	Sex		Ancestry		Ancestry and Sex			
Historic Period		**F**	**M**	**AA**	**EA**	**AA (F)**	**AA (M)**	**EA (F)**	**EA (M)**
1. 1820-1839	89.28	59.75	33.60	35.38	54.40	18.00	17.00	45.25	17.33
2. 1840-1859	95.80	47.07	49.20	30.58	58.86	11.19	19.00	30.57	28.68
3. 1860-1879	86.29	50.14	35.87	41.44	45.90	22.63	19.38	28.72	16.64
4. 1880-1899	78.14	42.68	35.89	34.91	44.00	18.44	16.50	25.00	19.83
Median joints involved	2.0	2.0	2.0	1.0	2.0	1.0	1.0	2.0	2.0
p-value	**.448**	**.697**	**.080**	**.295**	**.171**	**.073**	**.916**	**.561**	**.036****

Note: The p-value listed at the base of each column represents differences between all age groups and historical period cohorts.

** significance with $\alpha = .05$

Table 5.9a OA Present by Joint in the Left Hand for Each Age Group

Age Group	LCMC1	LIP1	LPIP2	LPIP3	LPIP4	LPIP5	LDIP1	LDIP2	LDIP3	LDIP4	LDIP5
40-44	1/8	2/8	0/8	0/8	0/8	0/8	1/8	0/8	1/8	1/8	1/8
45-49	3/6	1/6	0/6	0/6	0/6	0/6	1/6	1/6	1/6	1/6	1/6
50-54	10/22	3/22	2/22	1/22	0/22	0/22	2/22	2/22	2/22	2/22	2/22
55-59	8/23	6/23	2/23	2/23	1/23	1/23	5/23	7/23	7/23	5/23	5/23
60-64	16/26	2/26	3/26	1/26	2/26	2/26	8/26	8/26	9/26	8/26	7/26
65-69	5/17	5/17	2/17	4/17	4/17	3/17	8/17	9/17	9/17	9/17	9/17
70-74	8/20	1/20	4/20	3/20	1/20	2/20	10/20	10/20	9/20	8/20	9/20
75-79	12/24	4/24	0/24	0/24	0/24	2/24	10/24	12/24	12/24	9/24	10/24
80-84	7/14	2/14	2/14	2/14	1/14	2/14	7/14	7/14	6/14	6/14	6/14
85+	7/15	1/15	0/15	0/15	0/15	1/15	5/15	5/15	5/15	5/15	5/15
Total	77/ 175	27/ 175	15/ 175	13/ 175	9/ 175	13/ 175	57/ 175	61/ 175	61/ 175	54/ 175	55/ 175
p-val	**.387**	**.441**	**.401**	**.119**	**.060**	**.639**	**.063**	**.016****	**.079**	**.131**	**.074**

Table 5.9b OA Present by Joint in the Right Hand for Each Age Group

Age Group	RCMC1	RIP1	RMCP2	RPIP2	RPIP3	RPIP4	RPIP5	RDIP1	RDIP2	RDIP3	RDIP4	RDIP5
40-44	1/8	0/8	0/8	0/8	0/8	0/8	0/8	2/8	2/8	1/8	0/8	2/8
45-49	0/6	0/6	0/6	1/6	0/6	0/6	0/6	1/6	1/6	1/6	2/6	3/6
50-54	8/22	5/22	1/22	1/22	0/22	0/22	1/22	6/22	7/22	5/22	3/22	5/22
55-59	8/22	5/22	2/22	1/22	1/22	2/22	1/22	5/22	6/22	4/22	4/22	6/22
60-64	15/26	5/26	2/26	3/26	3/26	1/26	3/26	10/26	9/26	7/26	7/26	8/26
65-69	6/17	2/17	0/17	2/17	4/17	2/17	3/17	9/17	10/17	8/17	8/17	7/17
70-74	6/19	3/19	1/19	2/19	2/19	3/19	2/19	9/19	9/19	9/19	9/19	9/19
75-79	11/24	3/24	2/24	3/24	4/24	1/24	4/24	13/24	16/24	15/24	13/24	14/24
80-84	5/14	2/14	2/14	1/14	1/14	1/14	1/14	8/14	6/14	7/14	7/14	6/14
85+	6/16	4/16	1/16	1/16	0/16	0/16	0/16	7/16	5/16	6/16	5/16	6/15
Total	66/174	28/174	11/174	15/174	16/174	10/174	15/174	70/174	71/174	63/174	58/174	66/173
p-val	**.258**	**.844**	**.892**	**.948**	**.472**	**.545**	**.545**	**.227**	**.091**	**.025****	**.017****	**.358**

Table 5.10 Joint-by-Joint Results between Ancestry Groups

	Overall		Ancestry AA		EA		
Joint	**N/Total**	**%**	**N/Total**	**%**	**N/Total**	**%**	**p-value**
LCMC1	77/175	44.00	33/73	45.21	44/102	43.14	.877
LIP1	99/175	56.57	12/73	16.44	87/102	85.30	.833
LMCP2	7/175	3.93	2/73	2.74	5/105	4.76	.701
LMCP3	5/175	2.86	2/73	2.74	3/102	2.94	1.00
LMCP4	3/175	1.71	0/73	0	3/102	2.94	.266
LMCP5	4/175	2.29	1/73	1.37	3/102	2.94	.641
LPIP2	15/175	8.57	1/73	1.37	14/102	13.73	.005**
LPIP3	14/175	8.00	3/73	4.11	11/102	10.78	.076
LPIP4	9/175	5.14	1/73	1.37	8/102	7.84	.082
LPIP5	13/175	7.43	2/73	2.74	11/102	10.78	.076
LDIP1	57/175	32.02	19/73	26.03	38/102	37.26	.142
LDIP2	61/175	34.86	17/73	23.29	44/102	43.14	.010**
LDIP3	61/175	34.86	19/73	26.03	42/102	41.18	.053
LDIP4	54/175	30.86	18/73	24.65	36/102	35.30	.140
LDIP5	55/175	31.43	16/73	21.92	39/102	38.24	.031**
RCMC1	66/174	37.93	31/71	43.66	35/103	33.98	.207
RIP1	28/174	16.09	11/71	15.49	17/103	16.50	1.00
RMCP2	11/174	6.32	4/71	5.63	7/103	6.80	1.00
RMCP3	5/174	2.87	1/71	1.41	4/103	3.88	.650
RMCP4	1/174	.57	0/71	0	1/103	0.97	1.00
RMCP5	8/174	4.60	2/71	2.82	6/103	5.83	.475
RPIP2	15/174	8.62	5/71	7.04	10/103	9.71	.595
RPIP3	16/174	9.20	3/71	4.23	13/103	12.62	.067
RPIP4	10/174	5.75	3/71	4.23	7/103	7.00	.530
RPIP5	15/174	8.62	6/71	8.45	9/103	8.74	1.00
RDIP1	70/174	40.21	24/71	33.80	46/103	44.66	.161
RDIP2	71/174	40.80	21/71	29.58	50/103	48.54	.018**
RDIP3	63/174	36.21	16/71	22.54	47/103	45.63	.002**
RDIP4	57/174	32.76	16/71	22.54	41/103	40.78	.014**
RDIP5	66/173	38.15	22/70	31.43	44/103	42.72	.153

** significance with $\alpha = .05$

were observed. All of these differences were found among the European-Americans in the sample. In the left hand, OA in the DIP1 (p =.047) and DIP3 (p =.043) joints was most influenced by historical period of birth. In the right hand, only the CMC1 joint was significantly affected (p =.042). Interestingly, all of these results reflect a rise in OA for European-Americans born during historical period two which lasted from 1840-1859. Notable results from these tests have been recorded in Table 5.11 (a and b).

II. Results of Archival Analyses

The archival analysis portion of the present study was carried out using descriptive statistics, Chi Square tests, and Fisher's exact tests. Descriptive statistics were generated for African-Americans (AA) and European-Americans (EA), males and females, and each demographic subgroup in the sample. There are 50,234 individuals in the IPUMS sample with ages ranging from infants under the age of 1 year to adults 95 years of age (Ruggles et al. 2010). Age ranges for each demographic group have been provided in Table 5.12 (a and b). The average age of this sample is 26 years. There are 24,083 females and 24,827 males in the dataset, representing an approximately equal sex distribution (49% female, 51% male). Distribution of individuals by ancestry, however, is unequal. There are 47,586 European-Americans and 1,324 African-Americans in the sample (97% European-American, 3% African-American).

Approximately 60% of the individuals in the sample held jobs. Individuals between the ages of 8 and 93 are documented in the workforce. However, the youngest documented worker in the historical period birth cohorts of interest was 10 years

Table 5.11a Joint-by-Joint Results between Historical Periods among African-Americans

	Historical Period of Birth				
	1820-1839	1840-1859	1860-1879	1880-1899	
Joint	**N/Total**	**N/Total**	**N/Total**	**N/Total**	**p-value**
LCMC1	0/4	9/18	16/35	8/16	.306
LDIP1	2/4	5/18	9/35	3/16	.645
LDIP2	2/4	4/18	9/35	2/16	.429
LDIP3	2/4	4/18	10/35	3/16	.596
LDIP4	2/4	3/18	10/35	3/16	.459
LDIP5	2/4	3/18	8/35	3/16	.523
RCMC1	1/4	6/16	20/35	4/16	.129
RDIP1	1/4	6/16	11/35	6/16	.936
RDIP2	1/4	4/16	11/35	5/16	.964
RDIP3	1/4	4/16	9/35	2/16	.754
RDIP4	1/4	4/16	9/35	2/16	.754
RDIP5	1/3	4/16	11/35	6/16	.900

Table 5.11b Joint-by-Joint Results between Historical Periods among European-Americans

	Historical Period of Birth				
	1820-1839	1840-1859	1860-1879	1880-1899	
Joint	**N/Total**	**N/Total**	**N/Total**	**N/Total**	**p-value**
LCMC1	2/4	26/50	13/39	3/9	.313
LDIP1	2/4	25/50	9/39	2/9	.047**
LDIP2	2/4	28/50	12/39	2/9	.058
LDIP3	1/4	27/50	13/39	1/9	.043**
LDIP4	1/4	23/50	11/39	1/9	.119
LDIP5	1/4	24/50	12/39	2/9	.239
RCMC1	1/5	24/51	9/38	1/9	.042**
RDIP1	3/5	27/51	13/38	3/9	.257
RDIP2	3/5	28/51	15/38	4/9	.494
RDIP3	3/5	28/51	13/38	3/9	.193
RDIP4	3/5	25/51	12/38	2/9	.186
RDIP5	3/5	25/51	13/38	3/9	.410

** significance with $\alpha = .05$

Table 5.12a IPUMS Sample Age Range

Worker Type	Overall			Ancestry						Sex					
				AA			EA			Male			Female		
	Min	Max	μ	Min	Max	μ	Min	Max	μ	Min	Max	μ	Min	Max	μ
Overall	0	95	26	0	95	28	0	95	27	0	95	26	0	95	26
Unemployed	0	95	22	0	95	22	0	95	22	0	95	14	0	95	25
Non Manual	8	93	34	13	76	35	8	93	34	8	93	36	12	79	28
Manual	8	86	33	8	82	34	10	86	33	8	86	35	8	86	27
Employed Individuals	8	93	33	13	82	36	10	93	34	8	93	35	8	86	27

Table 5.12b IPUMS Sample Age Range by Demographic Subgroup

Worker Type	AA (M)			AA (F)			EA (M)			EA (F)		
	Min	Max	μ	Min	Max	μ	Min	Max	μ	Min	Max	μ
Overall	0	95	28	0	95	27	0	93	26	0	95	26
Unemployed	0	95	16	0	95	25	0	93	14	0	95	25
Non Manual	13	76	35	17	66	31	8	93	36	12	79	28
Manual	8	82	35	8	73	32	10	86	35	10	86	27
Employed Individuals	8	82	35	8	73	32	8	93	35	10	86	27

of age. Individuals between the ages of 10 and 14 account for just over 1% of the workforce with just 6.3% of individuals in the age group employed. The greatest number of individuals in the workforce are between the ages of 20 and 39. After the age of 69, very few individuals remain employed; individuals in these older age groups account for less than 1% of the working population. Only about 17% of all individuals 70 and older continue to maintain employment. Workforce totals for each age group are provided in Table 5.13.

The majority of the working population was European-American (97%) or male (80%) with manual jobs (64%). Fisher's exact tests revealed statistically significant differences between European-Americans and African-Americans with regard to worker type ($p<.0001$); more African-Americans (71%) held manual jobs than did European-Americans (64%). Comparison between the sexes yielded no significant differences ($p=.406$). When compared within ancestry groups, worker type by sex was significantly different among African-Americans ($p<.0001$). In this group, a greater percentage of females held manual jobs (88%) compared to males (64%). Between European-American and African-American females, a greater percentage of African-American women (88%) held manual jobs compared to European-American women (64%) and these findings were also statistically significant ($\alpha=.05$, $p<.0001$). Results of these tests are provided in Table 5.14 (a-c). The top employing industries for each ancestry group and sex are provided in Table 5.15 (a and b).

Chi-Square tests were used to assess trends in employment across historic birth periods. The number of manual laborers was compared across each demographic group and subgroups with statistically significant results were found among all except for one group, European-American females. Overall, the greatest number of manual laborers was found in the later historic periods between 1860 and 1899. The greatest peak was observed among African-American females, 45.3% of whom were born between 1880 and 1899 and worked as manual laborers. The fewest manual workers were reported with birth years occurring during the first historic period (1820-1839). These results are reported in Table 5.16 (a and b). All results reported here will be further discussed in the following chapter.

Table 5.13 IPUMS Worker Type by Age Group
(Among Individuals Eligible for Curation in Hamann-Todd Collection)

Age Group	Unemployed	Worker Type		% Workforce Total	Totals
		Non Manual	Manual		
10-14	3,790	73	181	1	4,044
15-19	1,925	734	1,520	11	4,179
20-24	2,003	1,033	1,961	15	4,997
25-29	2,142	971	1,752	14	4,865
30-34	2,219	1,037	1,722	14	4,978
35-39	2,107	885	1,657	13	4,559
40-44	1,659	742	1,329	10	3,730
45-49	1,362	550	1,064	8	2,976
50-54	1,072	472	756	6	2,300
55-59	776	280	448	4	1,504
60-64	597	160	264	2	1,021
65-69	360	91	133	1	584
70-74	295	50	35	<1	380
75-79	207	7	16	<1	230
80-84	69	3	3	<1	75
85-89	16	1	1	<1	18
90 and older	5	1	0	<1	6
Total	**20,514**	**7,090**	**12,842**	**100%**	**40,446**

Table 5.14a IPUMS Fisher's Exact Results for Cleveland Workers

	Ancestry		Sex	
Worker Type	AA	EA	Male	Female
Non Manual	204/702	6,886/19,230	5,688/15,926	1,402/4,006
Manual	498/702	12,344/19,230	10,238/15,926	2,604/4,006
p-value	<.0001**		.406	

Table 5.14b IPUMS Fisher's Exact Results between the Sexes by Ancestry

	African-American		European-American	
Worker Type	Male	Female	Male	Female
Non Manual	180/501	24/201	5,508/15,425	1,378/3,805
Manual	321/501	177/201	9,917/15,425	2,427/3,805
p-value	<.0001**		.559	

Table 5.14c IPUMS Fisher's Exact Results between Ancestry Groups by Sex

	Males		Females	
Worker Type	AA	EA	AA	EA
Non Manual	180/501	5,508/15,425	24/201	1,378/3,805
Manual	321/501	9,917/15,425	177/201	2,427/3,805
p-value	.926		<.0001**	

Table 5.15a Top Employing Industries in the IPUMS Sample by Ancestry

Overall		African-Americans		European-Americans	
8.7%	Construction	10.8%	Construction	8.6%	Construction
6.7%	Private Households	7.4%	Other primary iron and steel industries	6.2%	Private Households
4.3%	Blast furnaces, steel works, and rolling mills	3.4%	Eating and Drinking Places	4.4%	Blast furnaces, steel works, and rolling mills
4.2%	Misc. machinery	2.9%	Blast furnaces, steel works, and rolling mills	4.3%	Misc. machinery
4.2%	Railroads and Railways	2.6%	Not specified manufacturing industries	4.3%	Railroads and Railways

Table 5.15b Top Employing Industries in the IPUMS Sample by Sex

Males		Females	
10.6%	Construction	27.0%	Private Households
5.2%	Blast furnaces, steel works, and rolling mills	9.8%	Dressmaking Shops
5.2%	Misc. machinery	6.0%	Educational Services
5.0%	Railroads and Railways	5.8%	Apparel and accessories stores (excluding shoes)
4.0%	Fabricated steel products	4.2%	General merchandise

Table 5.16a Chi-Square Results for Manual Workers in the IPUMS Sample by Sex and Ancestry

	Overall	Sex		Ancestry	
Historic Period		**F**	**M**	**AA**	**EA**
1	932 (4.7%)	80 (2.0%)	852 (5.3%)	30 (4.3%)	902 (4.7%)
2	3,115(15.6%)	542 (13.5%)	2,573 (16.2%)	76 (10.8%)	3,039 (15.8%)
3	4,475 (22.5%)	940 (23.5%)	3,535(22.2%)	112(16.0%)	4,363(22.7%)
4	4,320 (21.7%)	1,042(26.0%)	3,278 (20.6%)	280 (39.9%)	4,040 (21.0%)
p-value	**<.0001****	**<.0001****	**<.0001****	**.013****	**<.0001****

Table 5.16b Chi-Square Results for Manual Workers in the IPUMS Sample by Ancestry

	African-American		European-American	
Historic Period	**F**	**M**	**F**	**M**
1. 1820-1839	8 (4.0%)	22 (4.4%)	72 (1.9%)	830 (5.4%)
2. 1840-1859	32 (15.9%)	44 (8.8%)	510 (13.4%)	2,529 (16.4%)
3. 1860-1879	46 (22.9%)	66 (13.2%)	894 (23.5%)	3,469 (22.5%)
4. 1880-1899	91 (45.3%)	189 (37.7%)	951 (25.0%)	3,089 (20.0%)
p-value	**<.0001****	**<.0001****	**.314**	**.001****

Chapter 6

DISCUSSION: WEIGHING IN ON THE PRESENT FINDINGS

Many scholars have argued that our bodies are a reflection of the way we move them (Cashmore and Zakrzewski 2011, Walsh-Haney 2007, Molnar 2006, Cardoso and Henderson 2010, Nagy and Hawkey 1993, Kennedy 1998, Robb 1998, Chaffin et al. 1999). In effect, the body is a manifest mirror of the life we have led. Regular or strenuous movement can wreak havoc on an aging musculoskeletal system and this finding remains valid across time and space. Archaeological populations as well as those of modern times bear evidence of past activity on their bones. The hand bones of individuals from early industrial Cleveland, Ohio represent one such sample in which activity and hand use becomes apparent in the skeleton.

Osteoarthritis and Age

Of the 412 individuals examined in the present study, osteoarthritis (OA) was discovered in approximately 43% (N=177) of the sample. As previous authors have suggested (Dieppe 1999, Hamerman 1997, Cicuttini and Spector 1997, Coggon et al. 2000, Anderson 1971, Molnar et al. 2011, Brandt 2001, Buchanan et al. 2003, Miura et al. 2008, Myers et al. 2011, Walsh-Haney 2007, Jurmain 1977), age was found to be a significant factor in OA development. As had been suggested by Cicuttini and Spector (1997), the present study found arthritis in one or two joints in the hands of individuals beginning in their early and mid-40s. In the present study, consistent with the observations of Cicuttini and Spector (1997) and Waldron (1993), arthritic change was most prevalent in the hands of individuals over the age of 55 and it frequently affected multiple joints in females. In the present study, females and males both had lower rates of OA in the younger age groups, though after the age of 50, females exhibited increasing prevalence with age until about the age of 65. Between the ages of 65 and 69, OA rates decrease slightly and then rise again once a female reaches the age of 70. In contrast, males experience less OA between the ages of 65-74 with otherwise steady prevalence rates after the age of 50. These findings suggest that while males and females of advanced age both experience OA, arthritic change becomes apparent in females at a younger age compared to males, while many males maintain normal hand joints until old age. See Figure 6.1 and 6.2 for a visualization of these trends.

Similarly, Jones and Doherty (1995) noted that nearly half of the individuals in a modern population will exhibit OA by the age of 65. More than 60% of individuals in the present study in each of the following age categories exhibited evidence of OA: 60-64, 75-79, and over the age of 85. As previously mentioned, very few studies are available documenting the progression of OA after the age of 70. However, Cicuttini and Spector (1997) reference a 1978 study in which OA prevalence rates were documented for nursing home residents over the age of 65. In their report, the DHEW National Center for Health Statistics (1978 *sensu* Cicuttini and Spector 1997) reported OA rates of 23.2% for individuals age 65-74, 36.2% for age 75-84, and 68% for those over the age of 85.

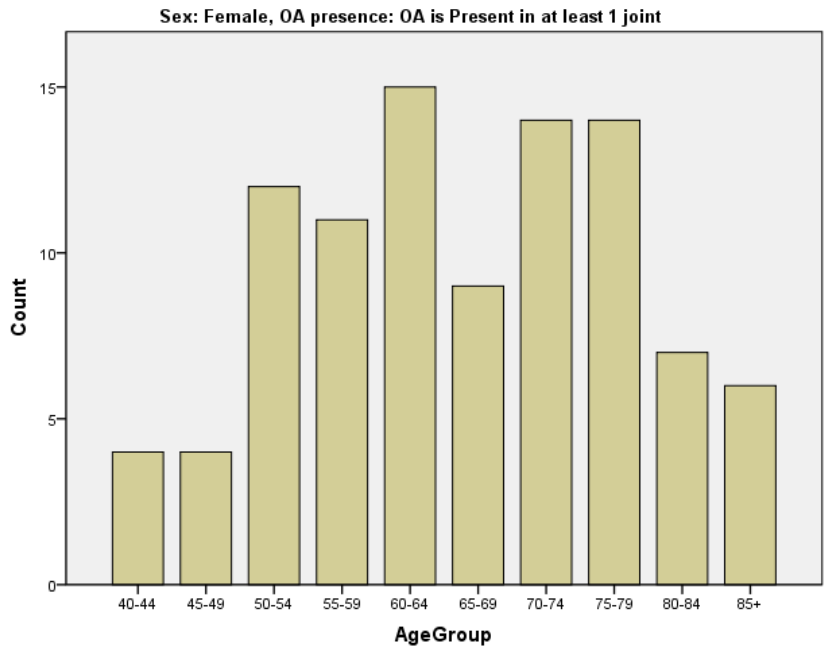


Figure 6.1 Female OA Prevalence by Age

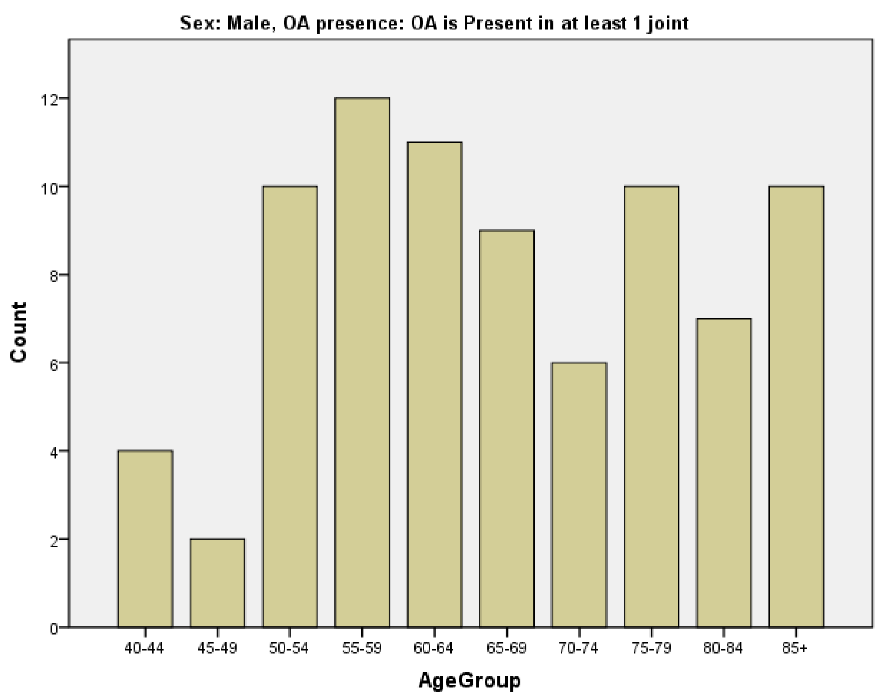


Figure 6.2 Male OA Prevalence by Age

Results between the DHEW study and the present one were only consistent in the eldest group of individuals. However, differences in OA rates between studies will likely reflect variation in lifestyle and activity between cohorts from different time periods.

Osteoarthritis and Sex

Females in the present study were four times more likely to develop OA compared to males. However, individuals in the female sample were also older, inflating the apparent difference. Among males and females of the same age, females are only 1.9 times as likely to develop OA. This comes as no surprise as several scholars have observed heightened risk in addition to greater arthritic involvement and severity in the joints of females (Brandt 2001, Molnar et al. 2011, Waldron 1993, Jones and Doherty 1995, Hamerman 1997). Brandt (2001) notes that females generally have twice the risk of developing OA compared to males. The results of the present study add further support to the growing body of literature regarding differences in OA expression by sex.

In agreement with earlier research, the present study demonstrates that males and females exhibit different patterns of OA expression. Consistent with Waldron (1993), multiple joints were affected in females while generally only a single joint was affected in males. Just as Wilder et al. (2006) observed, arthritic changes were frequently observed in the CMC1 joint of both sexes though, the DIP and PIP joints were only occasionally involved in the hands of males.

Wahlstrom (2005) reported that working women have a greater risk for musculoskeletal symptoms in the hands and wrist compared to working men. As previously mentioned in Chapter 4, Tittiranonda et al. (1999 *sensu* Wahlstrom 2005) suggest that anthropomorphic differences between the sexes may cause females to work at more extreme or uncomfortable angles than males due to problematic designs in tool implements not suited to the size and shape constraints of the female hand. This pattern is not restricted to only computer and keyboard users, but can be found in the vast majority of occupational arenas. Chaffin et al. (1999:258) likewise elaborated that individuals with smaller wrists are at a greater risk for injury under occupational circumstances that require "frequent and forceful manual exertions in postures with the wrists deviated." Perhaps these size and shape limitations help explain why women frequently experience higher rates of OA.

Joints, Hand Dominance, and Function

As previously noted, hand OA appears to increase with age and is influenced by genetics, obesity, sex, and activity (Brandt 2001). Consistent with the current body of literature, the present study found that the first CMC1 joint and the DIP joints were those most frequently affected by OA. In the present study, OA prevalence in the DIP joints ranged from 30-40% and in the CMC1 joints 37-44%. Interestingly, OA rates in the left CMC1 joints were nearly 7% higher than in the right hand. This finding is consistent with that of Wilder et al. (2006), though it contrasts with Waldron (1993). However, just as Waldron (1993) discovered, OA was largely concentrated in the first ray of individuals from the present sample.

In most cases, upon osteological examination, the base of the first metacarpal or the adjacent articular surface of the trapezium was the first joint surfaces to display signs of arthritic change or remodeling. In the present study, OA is found with relative consistency in this joint of both the left and right hand. Given that the CMC1 joint is the hand joint most consistently faced with failure and cartilage loss (as evident from the presence of eburnation), this saddle joint may just be functionally inadequate in the face of rigorous or strenuous hand use.

Hand dominance may contribute to asymmetric expression of OA (Waldron 1993, Wilder et al. 2006, Miura et al. 2008). In the present study, there is some evidence for asymmetrical hand use and OA, though, overall, it is not significantly pronounced. In general, individuals experienced OA in the joints of the right hand with greater frequency than in the left. The greatest difference between the hands was observed in the DIP joints. However, even in these joints there was only 7% more OA in the right hands compared to the left. These findings suggest individuals were either using their hands approximately equally while performing various tasks or that hand dominance makes little difference in the development of OA in the Hamann-Todd sample. Given that Miura et al.'s (2008) study reported a seven-fold increase in OA in the dominant hand, the present findings seem incongruous. However, the difference between their results and the results reported here may reflect different scoring methods; Miura and colleagues utilized self-administered questionnaires paired with radiographs scored on the Kellgren and Lawrence scale while the present study involved osteological examination and identified OA based on the criteria developed by Waldron and Rogers (1991). This begs the question of whether radiographic or osteological examination is more accurate in identifying OA.

Osteoarthritis, Ancestry and Occupation

Across this period of Cleveland history, African-Americans accounted for only 3% of the city's total population. Of that 3%, the results of the present study reveal that 71% of all African-Americans were employed as manual workers compared to 64% of the European-American majority. Eighty percent of males and 20% of women were employed as manual workers at this time. Differences between these groups (noted as statistically significant in the previous chapter), validate the notion of an ethnic and gendered occupational hierarchy (Dubofsky 1996). Before the Civil War, African-Americans had no more difficulty finding jobs than did European-Americans. However, following the Civil War, African-Americans encountered indifference or animosity in cities across the nation. As a result, it became considerably more difficult for these individuals to find work. As such, both foreign-born immigrants and African-Americans would have held the most labor-intensive jobs as general laborers, construction or foundry workers (Dubofsky 1996). These individuals would have held low socio-economic status and some would be among the specimens curated in the Hamann-Todd Osteological Collection (Cobb 1935 and Todd 1927).

Dividing the sample into birth year cohorts by historical period yielded some interesting results. OA was notably pronounced in the hands of individuals who would have lived and worked during the latter half of the 19th century. Severity peaked among European-Americans who were born between 1840 and 1859. People born during this Antebellum period and working during the post-Civil War economic boom in Cleveland were suddenly thrust into industry. With oil refining, steel production, and lumbering employing ever more people, workers were exposed to new conditions during Cleveland's "second industrial revolution" (Miller and Wheeler 1995, Warf and Holly 1997, Scranton 1999).

Interestingly, a peak in severity was also observed for males born during the latter years of the Antebellum period, though the peak for females occurred among those born in the earlier years, between 1820 and 1839. In context, women born in this twenty year time frame would have lived through the early waves of the Industrial Revolution in the nation (Dubofsky 1996). Working from the Antebellum period through the so-called Gilded Age, a growing number of women would have been employed outside the home during these years (Kleinberg 1999, Dubofsky 1996). As the archival analysis component of this study reveals, fewer women were staying home to raise children and perform functions in the household and more were beginning to seek work beyond the household, finding jobs as domestic servants in private households and dressmaking shops (Ruggles et al. 2010).

As noted in Chapter 4 of this thesis, occupation was known for approximately 40% of the individuals found in the Hamann-Todd collection when Cobb completed his dissertation in 1932. Unfortunately, these records are currently unavailable and therefore individual specimens do not have occupational data to supplement osteological examination. However, specimens only entered the collection for another four years following Cobb's (1932) examination. Accordingly, we can deduce that occupational trends for new specimens curated in those years followed those of previous years with some similarity. Thus, using Cobb's (1932) Table XX (reproduced in this thesis as Table 4.1) and occupational descriptions provided in Conk (1980), it is possible to estimate the number of manual and non-manual workers in the collection and—by extension—in the sample analyzed in the present study. These estimates are provided in Figure 6.1 and suggest that as many as 88% of the individuals in the sample were employed as manual workers. Given the high level of strenuous and repetitive tasks associated with some of these occupations (for example, foundry and metal working) and the hardships associated with low socioeconomic status at this time in history, the moderate level of OA discovered in the present study (43%) comes as no surprise.

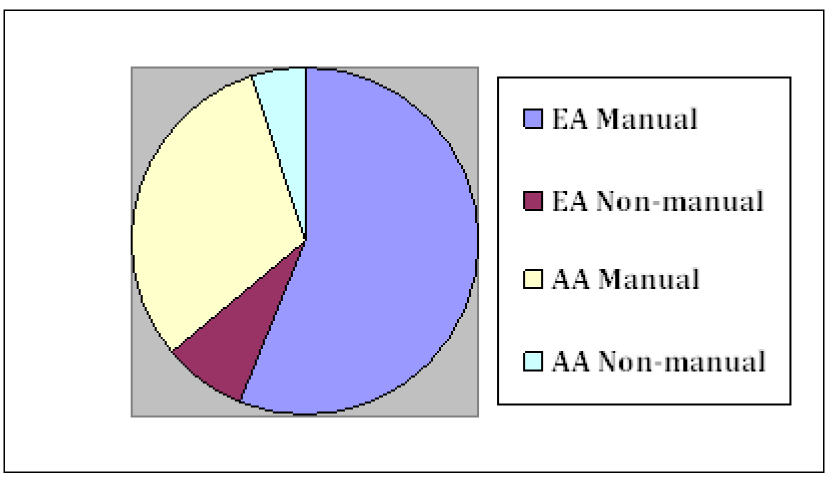


Figure 6.3 Worker Types in the Hamann-Todd Collection

In the present study, European-Americans were found with significantly higher rates of hand OA than their African-American counterparts. Though both groups were exposed to similar environmental conditions in terms of socioeconomic stress, evidence of occupational stress is more pronounced among European-Americans. However, de la Cova (2008) suggests that African-Americans may naturally be more resilient to skeletal stress than European-Americans due to overall greater skeletal robusticity. Disparities in OA prevalence between individuals of different ancestry have variously been reported in the literature (Davies 1988, Moskowitz 1996, Wright et al. 2008, Caspi et al. 2001, Arden and Nevitt 2006, Brandt 2001, Buchanan et al. 2003, Fontana et al. 2007, Cardoso and Henderson 2010). Gordon (1986 *sensu* Buchanan et al. 2003) found no difference in prevalence rates between European-Americans and African-Americans. Davies (1988) and Moskowitz (1996) report that European-Americans tend to have higher OA rates compared to individuals of African, Asian, and Hispanic ancestry. Alternately, Wright et al. (2008) discovered that African-American women had greater odds of developing OA compared to non-Hispanic European-American women. Women of Asian ancestry, however, had significantly lower odds of developing OA compared to the latter group (Wright et al. 2008). This finding is supported by Nevitt et al. (2002) and Zhang et al. (2006) (*sensu* Arden and Nevitt 2006). Interestingly, Caspi et al. (2001) examined the hand joints of Jewish individuals from Western and Eastern Europe and found that Ashkenazi Jews had significantly higher OA scores compared to Sephardic Jews. The differential severity and prevalence of OA between ancestry groups, such as that reported by Caspi et al. (2001), Davies (1988), Moskowitz (1996), and the present study may be attributed to differential susceptibility to joint malformation, different patterns of joint use, or genetic factors (Moskowitz 1996, Davies 1988 sensu Caspi et al.

2001, Spector et al. 1996, Kaprio et al. 1996, Dieppe 1999, Kellgren and Lawrence 1954 *sensu* Carr 2003).

Chapter 7

CONCLUSION

The present study pairs osteological analysis with historical inquiry and archival analysis in a biohistorical examination of a sample from urban 19th and 20th century Cleveland, Ohio. Many of the individuals included in this study had lived with low socioeconomic status, maintaining low-paid, labor-intensive jobs at the turn of the 20th century. Some battled unemployment or engaged in a variety of cottage industies, ever striving to supplement family income and survive in an industrializing city. Frequently overlooked in historiographical inquiry, analysis of the urban worker in the wake of the Industrial Revolution can help contribute to a more acute understanding of social, economic, and biological conditions of a tumultuous era in American history (Dubofsky 1996).

The present study draws conclusions similar to those of de la Cova (2008). I expected to find disparities in the prevalence of OA between individuals of different ancestry. However, African-Americans were anticipated to have higher prevalence rates than European-American and, in fact, the reverse was true. This finding holds true for individuals born across all four birth cohorts. Though both groups were exposed to similar environmental conditions in terms of socioeconomic stress, evidence of occupational stress is more pronounced among European-Americans. However, de la Cova (2008) found that African-Americans were more skeletally robust than European-Americans. This suggests that African-Americans may naturally be more resilient to skeletal stress than their European-American counterparts.

Dividing the sample into birth year cohorts by historical period yielded some interesting results. Consistent with my initial expectations, OA was notably pronounced in some of the individuals who would have lived and worked during the latter half of the 19th century. OA severity peaked among European-Americans who were born between 1840 and 1859. People born during the Antebellum period and working during the post-Civil War economic boom in Cleveland were suddenly thrust into industry. With oil refining, steel production, and lumbering employing ever more people, workers rode on the waves of Cleveland's "second industrial revolution" (Miller and Wheeler 1995, Warf and Holly 1997, Scranton 1999).

Interestingly, a peak in severity was observed for males born during the same period. However, the peak for females occurred among those born between 1820 and 1839. In context, women born in this early Antebellum era would have lived through the early waves of the Industrial Revolution in the nation (Dubofsky 1996). As industrialism created new jobs outside the household, a growing number of women would have been employed outside the home during these years (Kleinberg 1999, Dubofsky 1996). As the archival analysis component of this study reveals, fewer women were staying home to raise children and perform functions in the household and more were beginning to seek jobs as domestic servants in private households and dressmaking shops (Ruggles et al. 2010). No doubt, as the world was innovating, people stood behind those innovations and propelled the industrial culture forward.

As the present study emphasizes, the so-called "Gilded Age" was not a time of prosperity and opportunity for all segments of the population. Many people living during the 19th and early 20th century led difficult lives. The present study adds to the growing body of anthropological and medical literature that can be used to supplement historical literature and vice versa. Just as osteoarthritis is a multifactorial condition, so too is human history. As such, skeletal biology and paleopathology have much to offer the student of history (Perry 2007).

Considerations for Future Research

In the present study, OA was scored as present or absent for each joint in the hand as opposed to scoring on an ordinal severity scale for each joint. This scoring method was employed in an effort to minimize potential error and offer a conservative prevalence rate for the population (Waldron and Rogers 1991). Using these dichotomous scores to calculate the number of joints involved (in each hand and on an individual basis) offers a more objective measure of severity that may be of use to future researchers examining dry bone.

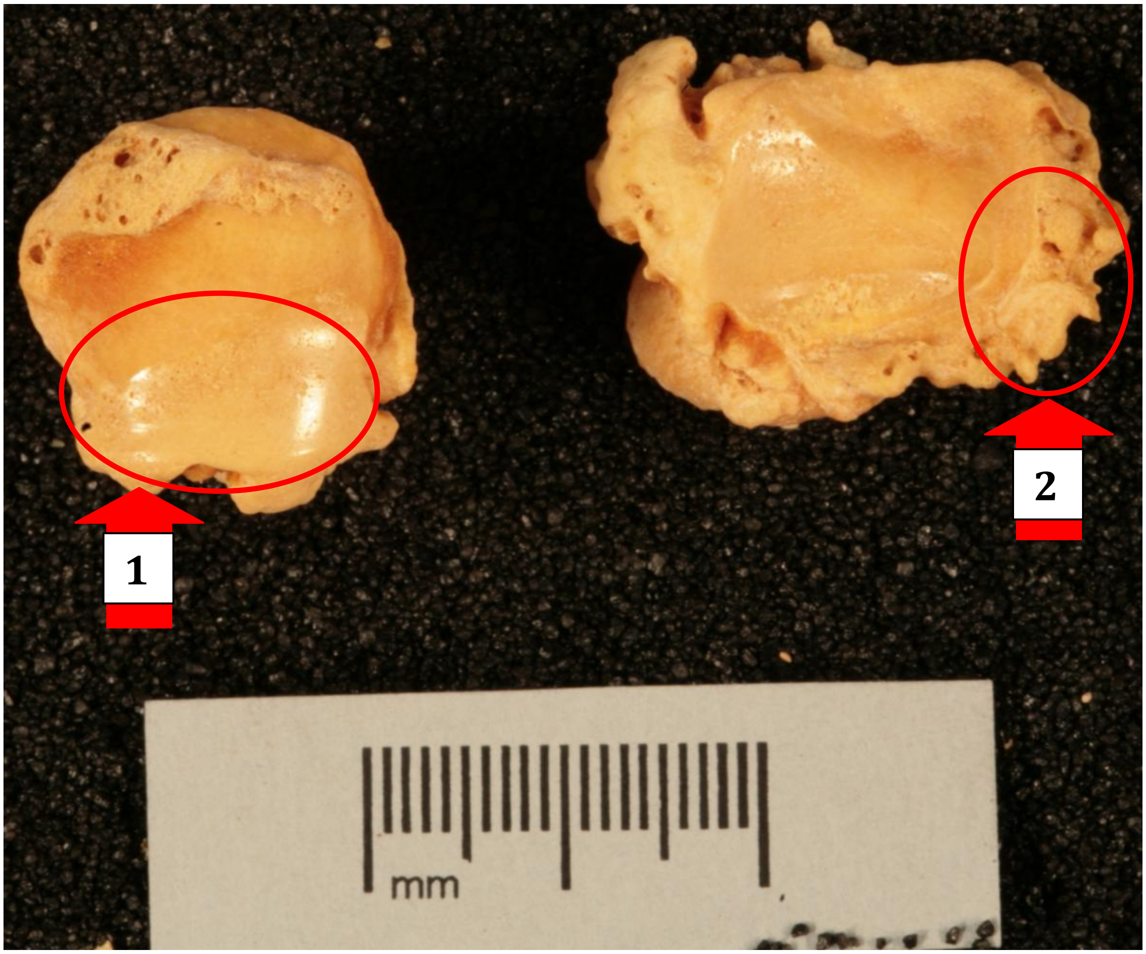
Future studies of activity patterns may also benefit from pairing enthesopathies or musculoskeletal stress markers (MSM) and OA scores in osteological analysis of the hands (Nagy and Hawkey 1993). Additionally, as the present study demonstrates, studies focusing on occupational stress or activity patterns would be more valuable to the discipline if performed on osteological assemblages with documented occupation for each individual in the skeletal sample. Without such information, researchers are limited to only generalized interpretations or conclusions that stretch the data beyond its means (Jurmain and Kilgore 1995, Robb 1998, Cardoso and Henderson 2010).

Appendix

Table 3.2 Muscle function in the hand

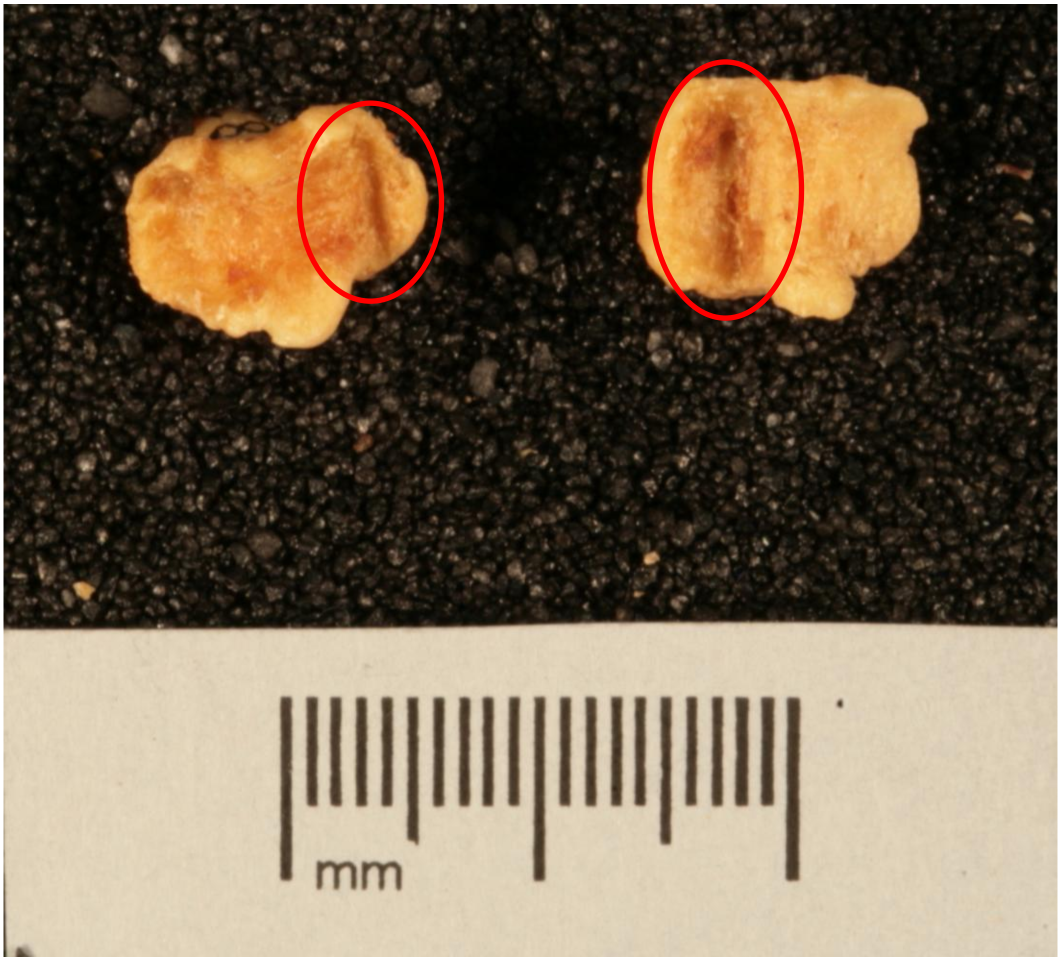
Muscle	Abbreviation	Location and Function
Flexor pollicis longus	FPL	Attaches to the palmar surface of the base of PP1 and is responsible for the flexion of the thumb
Adductor pollicis (transverse)	APT	Attaches to the palmar surface of MC3 and allows for adduction and flexion of the thumb
Oppenens digiti minimi	ODM	Attaches to the medial edge of MC5 and is responsible for the rotation of MC5 into opposition with the thumb so that the bone can be drawn forward to assist in the flexion of the fifth metacarpal joint
Flexor digitorum profundus 2,3,4,5	FDP	Attaches to the palmar surface of the base of distal phalanges 2-5 and is responsible for flexion of DIP joints in these digits. It also assists in the adduction of the second, fourth, and fifth digits in flexion of the wrist
Flexor digitorum superficialis 2,3,4,5	FDS	Attaches to both sides of the palmar surface of intermediate phalanges 2-5 and is responsible for flexion of these bones and also for flexion of the wrist

Source: Cashmore and Zakrzewski (2011)



1. Eburnation (on base of CMC1)
2. Extra bone formation (on joint surface of trapezium)

Figure 4.2 Some Visual Characteristics of Osteoarthritis



Bases of distal phalanges

Figure 4.3 Some Visual Characteristics of Osteoarthritis—
Changes to joint contour

Table 4.3 Joints Scored in the Present Study

Joint Coding	Description	Abbreviation
1	Interphalangeal Joint 1	IP1
2	Distal Interphalangeal Joint 2	DIP2 *
3	Distal Interphalangeal Joint 3	DIP3*
4	Distal Interphalangeal Joint 4	DIP4*
5	Distal Interphalangeal Joint 5	DIP5*
6	Proximal Interphalangeal Joint 2	PIP2
7	Proximal Interphalangeal Joint 3	PIP3
8	Proximal Interphalangeal Joint 4	PIP4
9	Proximal Interphalangeal Joint 5	PIP5
10	Metacarpo-phalangeal Joint 1	MCP1
11	Metacarpo-phalangeal Joint 2	MCP2
12	Metacarpo-phalangeal Joint 3	MCP3
13	Metacarpo-phalangeal Joint 4	MCP4
14	Metacarpo-phalangeal Joint 5	MCP5
15	Carpo-metacarpal Joint 1	CMC1

* Due to the difficulty in siding DP2-5, they were often scored by category so that the resulting database entry would reflect the presence of OA in a DP2-5.

Table 4.5 Documented Birthplace

USA Birthplace	N	%	Foreign Birthplace	N	%
ALABAMA	11	2.7	AUSTRIA	6	1.5
CINCINNATI, OH	2	.5	BOHEMIA	2	.5
CLEVELAND, OH	2	.5	CANADA	5	1.2
GEORGIA	9	2.2	CROATIA	1	.2
KENTUCKY	1	.2	DENMARK	1	.2
LEXINGTON, KY	1	.2	ENGLAND	4	1.0
MARYLAND	1	.2	GERMANY	17	4.1
MISSISSIPPI	4	1.0	HUNGARY	4	1.0
MISSOURI	1	.2	IRELAND	10	2.4
N. ROYALTON, OHIO	1	.2	ITALY LATVIA	1 1	.2 .2
NASHVILLE, TENN.	1	.2	RUSSIA	3	.7
NEBRASKA	1	.2	SCOTLAND	3	.7
NEW JERSEY	1	.2	SLOVAKIA	2	.5
NEW YORK	3	.7	SWEDEN	1	.2
NORTH CAROLINA	1	.2	SWITZERLAND	2	.5
OHIO	9	2.2			
PARKERTOWN, OH	1	.2			
PENNSYLVANIA	1	.2			
SOUTH CAROLINA	4	1.0			
TENNESSEE	4	1.0			
Unspecified USA	24	5.8			
VIRGINIA	11	2.7			
WASHINGTON, DC	2	.5			
WEST VIRGINIA	4	1.0			
YOUNGSTOWN, OHIO	1	.2	**UNKNOWN	248	60.2

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