6-2017

Biological Stress Indicators among Historically Documented Populations (1913-1935): An Analysis of Labor through Entheses and Joint Disease

Anna Paraskevi Alioto
Western Michigan University

BIOLOGICAL STRESS INDICATORS AMONG HISTORICALLY DOCUMENTED POPULATIONS (1913-1935): AN ANALYSIS OF LABOR THROUGH ENTHESES AND JOINT DISEASE

by

Anna Paraskevi Alioto

A thesis submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Masters of Arts
Anthropology
Western Michigan University
June 2017

Thesis Committee:

Jacqueline Eng, Ph.D., Chair
Michelle Machicek, Ph.D.
LouAnn Wurst, Ph.D.

BIOLOGICAL STRESS INDICATORS AMONG HISTORICALLY DOCUMENTED POPULATIONS (1913-1935): AN ANALYSIS OF LABOR THROUGH ENTHESES AND JOINT DISEASE

Anna Paraskevi Alioto, M.A.

Western Michigan University, 2017

Recent studies about the American past have aimed to examine multiple lines of evidence to reanalyze the American lived experience. Despite this, there has been limited research conducted using methods from biological anthropology. Skeletal analysis of a sample from the Hamann-Todd Osteological Collection, consisting of individuals (n=118) who lived in Cleveland, Ohio was utilized to understand how the American lived experience impacted the biological stresses of these individuals. The objective was to investigate entheseal changes and degenerative joint disease on the upper limb to reconstruct activity patterns and to test for possible disparities which may represent differing biological stress experiences. The prevalence and distribution (patterning) among site locations was scored and interpreted as evidence of biological stress variability and changes over time or different types of activity patterns. Results indicate that most locations among entheseal changes and degenerative joint disease were similar. However, there were some instances which demonstrate statistically significant differences and patterning between among all the variables which is indicative of different life experiences and stresses.

For my grandmother, Κυριακή, who shared her own experiences and struggles as an immigrant in America and who taught me that you can lose everything in this world except your education. Your stories and wisdom are a continuous inspiration to me and will never be forgotten.

ACKNOWLEDGEMENTS

Foremost, I would like to express my sincerest thanks to the members of my thesis committee, Dr. Jacqueline Eng, Dr. Michelle Machicek and Dr. LouAnn Wurst, for their continuous support and guidance throughout the duration of this study. Their suggestions and expertise were essential in the creation of this work and my current progress as a researcher.

Lyman Jellema, collections manager of the Hamann-Todd Osteological Collection at the Cleveland Museum of Natural History, who granted me access to the collection, challenged me to think about the collection from different contexts, and would stay past normal hours in the lab so that I could collect the data. I am extremely grateful and appreciative for all that you did. In addition, I want to thank Maria Escobedo, who opened her home to me while I collected the data in Cleveland, Ohio. Your hospitality and friendliness helped make the trip a success.

I would also like to thank my parents, Katherine and Michael Alioto, for being my constant supporters and keeping me sane throughout the entire process. My siblings, Alexandra and Antonio Alioto and my grandfather, George Chucales who in addition to being supportive, asked me to approach and think about this research and its significance on a broader scale.

Anna Paraskevi Alioto

TABLE OF CONTENTS

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

LIST OF TABLES

List of Tables—Continued

List of Tables—Continued

List of Tables—Continued

List of Tables—Continued

LIST OF FIGURES

List of Figures—Continued

List of Figures—Continued

CHAPTER I

INTRODUCTION

Understanding the American past is a recurring question within American society and culture. Recent studies have begun to examine multiple lines of evidence from different disciplines in conjunction with the historical records to reanalyze lived experiences. In the past few decades alone, there has been a surge of studies including relationships with Native Americans and understanding the hidden histories of marginalized groups (Barber and Berdan, 1998). Ultimately, these studies center around the incorporation of new research techniques in order create a clearer picture of past individuals and cultures. While such studies have integrated different lines of evidence from disciplines such as history, cultural anthropology and sociology, there has been limited research conducted using techniques and methods in biological anthropology in conjunction with historical analysis to reconstruct the past (Foster et al., 2012).

The purpose of this research is twofold. First, it seeks to expand current methods concerning skeletal activity markers to examine the relationship between intrinsic and extrinsic factors that may affect formation of these markers. Specifically, I explore entheseal changes and osteoarthritis including improving the current understanding of interrelated variables age, sex, bilateral and directional asymmetry, and biological affinity (‘race’)—while testing others such as sudden/acute and chronic causes of death and disease that may impact entheseal formation and osteoarthritis variation. Second, by expanding the methods and exploring frequencies of entheseal changes and osteoarthritis among the skeletal population, this study will also reinterpret the American past in the industrial Midwest by applying those bioarchaeological techniques to the historical narratives of Cleveland during the beginning of the twentieth century.

Entheseal changes (also known as musculo-skeletal markers or MSM) refers to the sites on the bone where muscles or ligament attach and osteoarthritis denotes a joint disease which reduces the cartilage and allows bones to rub together (Larsen, 1997). A sample of individuals from the Hamann-Todd Osteological Collection at the Cleveland Museum of Natural History was analyzed to examine and interpret potential changes in physical activity and labor patterns in lower socio-economic individuals across different time periods, biological and cultural attributes during the beginning of the twentieth century in Cleveland. Utilizing these multiple lines of evidence provide a new understanding of the American past.

Study Objectives

A few previous studies have sought to understand the biological and cultural contexts of the lower socio-economic classes of the early twentieth century United States. De la Cova (2010, 2011) used osteological methods and the historical records to examine cultural and biological patterns of violence through the examination of unhealed and healed trauma, pathology, and its associated cultural and biological repercussions. While these studies by De la Cova examined trauma and pathology in the Hamann-Todd Collection, there are no current studies which examine entheseal changes and joint disease in this particular collection. Therefore, the question remains whether the study of entheseal stress and osteoarthritis complements previous understandings about activity patterns and labor stresses in turn of the century America, especially in one of the largest industrial cities of the time, Cleveland. Given the amount of historical documentation referring to industry and labor, I hypothesize that osteological material would concur with the previous stated literature however only on a general population level. To test this question, data were collected from a sample of the Hamann-Todd Osteological

Collection which consists of lower class and status individuals from Cleveland, Ohio. It is currently held at the Cleveland Museum of Natural History.

I begin with a list of hypotheses, expectations and justifications regarding the research focuses of this study (Table 1). Based on historical documents about early 20th century Cleveland as well as previous bioarchaeological studies using entheseal changes and osteoarthritis, I predict the following hypotheses. First, the overall population will have similar instances of entheseal stress because of their low socio-economic status compared to other samples of early 20th century American industrial population such as the Almshouse in Albany, New York. Second, chronically ill individuals will have lower frequencies of entheseal and osteoarthritic stress because of decreased muscle mass. Third, the population will be right side biased because most individuals are right handed and that labor tend to favor one side of the body over the other. Fourth, there are indications of a sexual division of labor in which males and females will have different locations and frequencies of entheseal and osteoarthritic stress. Fifth, older individuals will have higher instances of stress than other adult age groups due to stress build-up over time. Lastly, African Americans will have higher instances of stress than Caucasian individuals.

Table 1. Central hypotheses, expectations, and justifications

EXPECTATIONS FOR EACH VARIABLE/FACTOR	
Location	A correlation exists among locations of entheseal changes and osteoarthritis because of similar movements in skilled and unskilled labor Examining locations of entheseal changes on the individual and population levels will infer types of movements during the Industrial Revolution

Table 1—Continued

Frequency	Frequencies of entheseal changes will be in similar locations as movements and actions are performed together over long period of time (repetitive motions) Examining frequencies of entheseal changes would demonstrate the possibility of a uniform/repetitive work force or a diverse one
Correlation between Entheseal changes and osteoarthritis	Following previous studies, there will be a correlation between entheseal changes and osteoarthritis due to resulting wear and tear on the body. Those individuals with higher degrees of entheseal changes should have higher degrees of associated osteoarthritis

VARIABLE	**HYPO-THESIS**	**EXPECT-ATION**	**IF EXPECTATIONS ARE NOT MET**	**JUSTIFICATION**
Overall Population (based on sample size)	Based on rigor and stress of 20th century industry, individuals in the population will have similar rates of entheseal and osteoarthritic stress compared to other industrial populations of the time such as the Almshouse in Albany, New York	Individuals from this collection should have the same indicators of stress compared to the Albany Almshouse	Individuals have the same or lower rates of entheseal and osteoarthritic stress	Examining entheseal changes and osteoarthritis in a lower socio-economic population will help understand if there are instances of manual labor and how much of the population is impacted
Cause of Death (sudden/acute vs. chronic disease)	Higher degree of stress in individuals with sudden/acute conditions due to chronic diseases often lead to the wasting of the muscles	Chronic conditions should have lower entheseal and osteoarthritic stress	Sudden/acute conditions have higher instances of entheseal and osteoarthritic stress or both groups are relatively even	Minimal studies have addressed the possibility of chronic vs sudden/acute conditions as the record is unclear yet literature states that pathology impacts entheseal formation

Table 1—Continued

Bilateral/ Directional Asymmetry	Higher degree of asymmetry (right side bias) because American factories tended to be assembly lines with piece work and repetitive motions	Most individuals should demonstrate asymmetry but lean towards a right side bias	There is complete symmetry between the left and right sides or higher instances of left side biases	Examining bilateral symmetry can demonstrate whether or not stress occurred evenly between the limbs or if occupations/work favored one side of the body
Sex	There will be differences in male and female entheseal stress indicative of a sexual division of labor	Frequencies and locations of entheseal and osteoarthritis will differ between males and females	Males and females will have similar frequencies of stress and at similar locations on the upper limb	Sex is found to be a correlated variable based on previous studies, it would indicate a possible sexual division of labor in this population
Age	Older individuals will exhibit higher amount and degree of entheseal changes and osteoarthritis	Frequencies of entheseal changes and osteoarthritis will be higher in old adults versus middle and young adults	All age groups will either have similar frequencies of stress or middle or young adults will have higher frequencies than older adults	Previous studies have indicated a correlation between entheseal changes and osteoarthritis due to aging
Biological Affinity	African Americans will have higher amounts of stress than Caucasians due to possible stresses of institutionalized racism and movement from Great Migration	Frequencies of entheseal changes and osteoarthritis will be higher in African American individuals	Both African Americans and Caucasians will have similar stress or Caucasians will have higher amounts of stress	Previous studies on the Hamann-Todd Collection have demonstrated differences in some life experiences i.e. trauma (De la Cova). As a result, entheseal changes should also be tested

Study Outline

I begin this study by examining the historical context of early 20th century Cleveland with specific focus on labor, class, and racial relations along with access to healthcare and medicine. I then explore the background of entheseal changes and osteoarthritis and how they are used to understand activity patterns and stresses including critiques and discussions of biological and cultural variables. Next, I offer a modification of the standard methods used to identify entheseal stress and osteoarthritis which is tailored to skeletal collections that have historical documentation like the Hamann-Todd. Lastly, I present and interpret the results of the data analysis and explain the significance of this study and how future studies could further clarify the American experience.

CHAPTER II

REVIEW OF RELEVANT CONCEPTS AND LITERATURE

Activity Reconstruction

Studies of activity reconstruction methods have taken on many forms over the past few decades. These include analyzing the development of entheseal changes (Hawkey and Merbs, 1995), cross-sectional bone geometry (Ruff, 1984), osteometry (Wanner et al., 2007), patterns of degenerative joint disease such as osteoarthritis (Deverenski, 2000) and other diverse ways such as stress lesions (Knüsel et al., 1996) or forms of activity-related dental wear (Alt and Pichler, 1998). This literature review will examine two of these forms in conjunction, the development of entheseal changes and patterns of degenerative joint disease because they usually are dependent on one another in which one impacts the other (Meyer et al., 2011).

These types of studies are carried out based on a modified form of Wolff's Law, called "bone functional adaptation" (Pearson and Lieberman, 2004; Ruff et al., 2006). This premise states that bone may be altered physically due to the stresses applied to it through (environmental or cultural) processes such as activity. A bone would become stronger due to increased muscle tension placed on it which would then alter the physical appearance of the bone. The bone would adapt in a way that would minimalize any possible harmful strain or stress on it (Meyer et al., 2011). Thus, increasing or decreasing amounts of strenuous bone activity would not only alter the cortical bone but may cause an increase or reduction in bone strength. This has been addressed through analyses of bone cross-sections (Ruff et al., 2006).

Despite this adaptation, activity reconstruction from skeletal remains is more complex than just analyzing certain areas of cortical or cross-sections of bone. Many activity patterns or motion sequences are made up of several different muscles (Meyer et al., 2011). As a result, it is not possible to simply correlate one type of movement with a single area of the skeleton and a specific movement (Stirland, 1998). Instead, the researcher must look at how activity patterns collectively are imprinted on the skeleton since similar movements will activate similar muscle groups (Meyer et al., 2011).

Entheseal Changes

Entheseal changes, also known as musculo-skeletal stress markers, refer to sites on the bone where muscles and ligaments attach (Hawkey and Merbs, 1995; Larsen, 1997). The examination of entheseal changes involves a macroscopic examination of certain muscle and ligament attachment sites. These then can be used to reconstruct habitual anatomical movements based on the particular morphological expressions at these sites (Machieck, 2011). Although previous studies have attempted to determine specific occupations using entheseal changes, different types of occupations tend to utilize similar muscle movement and patterns, making specific occupation reconstruction nearly impossible (Stirland, 1998; Meyer et al., 2011). Despite these limitations, bioarchaeologists still used entheseal changes to understand or answer other questions about activity and labor within a population. Recent studies in activity reconstruction have focused on examining and determining generalized motion patterns which may then be used to narrow down the range of possible occupations. One example are studies that examine entheseal stress that results from horseback riding or spear throwing (Larsen, 1997;

Villotte et al., 2009). Larsen (1995, 1997), among others, has looked at such generalized activity as possibly ways to reconstruct culture.

Early Studies

Studies about activity reconstruction from skeletal material began to gain popularity in the early 1980s with work like Ruff et al. (1984) research regarding structural changes in the femur with the transition to agriculture on the Georgian coast. This work is one of the first that recognized patterns within the skeletal record that could be used to reconstruct patterns of physical activity among individuals. The study also examined cross-sectional analysis and attempts to standardize its methods and decrease margin of error by looking at two different human population lifestyles, pre-agricultural, and post-agricultural (Ruff et al., 1984). Since these beginning steps, the development of this topic has taken a drastic step towards trying to reconstruct specific activity patterns and subsequent occupations.

Because of early studies on the differences between skeletal populations in pre- and post-agricultural communities, skeletal biologists have noticed that the amount of physical activity as well as activity patterns can leave stress markers on the bone (Ruff et al., 1984). As a result, skeletal biologists among others have turned their attention to what could possibly be another way to try to reconstruct past human biology and culture.

Methods

In the past decades, several methods have been developed to reconstruct activity patterns from human skeletal remains. Most methods, which analyze the development of musculo-skeletal markers (MSM) and entheseal changes (EC), have been created which allow comparative and standardized evaluation of the markers (Meyer et al., 2011). The method described by Hawkey and Merbs (1995) became one of the most utilized methods in scoring MSMs and determining biological stresses from activity (Meyer et al., 2011). Hawkey and Merbs (1995) analyzed bone stress from MSMs by examining and standardizing their methods by utilizing three different categories of stress lesions: robusticity, cortical defeat and ossification exostosis. Their conclusions demonstrated the relationship between biological stresses on bone and activity and has since been expanded upon by other researchers (Hawkey and Merbs, 1995; Meyer et al., 2011).

Other methods have been recently developed and employed in other studies (e.g. Mariotti et al., 2004, 2007; Villotte et al., 2010). Older studies which utilize Hawkey and Merbs (1995) have treated attachment sites similarly, and have a standard system to score the expressions of musculo-skeletal markers or enthesopathies in the skeleton (e.g. Meyer et al., 2011). The evaluation scale begins with non-pathological robusticity transitions to cortical defect and ends in osteolytic pathological stress lesions or even exostoses (Meyer et al., 2011). Instead, the new method presented by Villotte et al. (2010) uses only fibrocartilaginous entheses which are believed to be more vulnerable to physical stress and thus suited for population activity reconstruction (Meyer et al., 2011). Older studies did not distinguish and specify these certain types of entheses which have been criticized by recent methods (Henderson et al., 2015). The comparative accuracy between these two methods and the validity of fibrocartilaginous methods only has yet to be determined (Cardoso and Henderson, 2010). However, relatively recently, a new method called the Coimbra Method has standardized scoring of fibrocartilaginous entheseal changes (Henderson et al., 2015). This method divides the enthesis into two zones and scores the relevant features in each zone. These features represent either bone formation or bone destruction and include lesions, porosity and cavitations (Henderson et al., 2015). The zones are then averaged and analyzed per each enthesis.[1]

Another type of method involves cross-section analysis of long bones in which the biomechanical strength of the bone is measured and examined based on Wolff's law (Meyer et al., 2011). CT scans and other non-invasive techniques are often utilized to access the necessary information; however, direct sectioning of the bone (often with a saw) has also been used in the past but is not common today due to its destructive methods (Meyer et all., 2011). The cross-sections of bones are thought to reflect mechanical forces that have been subjected to the bone and can be influenced by factors such as body mass but most importantly activity over the lifetime of an individual (Ruff, 1992).

Alternative approaches include methods such as pure osteometry which concentrated on the external dimensions of the bone and dental modifications on the teeth. Osteometic analysis has often been employed in the field when conducting archaeological excavations as quick evidence of activity patterns and stress (Meyer et al., 2011). Skeletal modifications especially on the teeth have also been used to reconstruct activity patterns. One of the most prominent of these modifications are those in the teeth which demonstrate clay pipe smoking (Alt and Pichler, 1998). Continued years of clenching the pipe produces circular patterns in the teeth which vary in size. These alterations are restricted to certain archaeological deposits of the 17^{th}-19^{th} centuries and very few other activities produce such specific marks (Goyenchea et al., 2001).

[1] Recently, this study has been recommended for widespread use when reconstructing activity. However, the Hawkey and Merbs, (1995) methods were utilized for this study as a future goal of this study is to use the Hamann-Todd Collection as a proxy to understand undocumented bioarchaeological samples. Many of these samples either have used the Hawkey and Merbs, (1995) methods in the past and have not rescored the markers with the new methods or cannot use the new methods due to the lack of preservation in the skeletal material.

Population and Individual Studies

Meyer et al. (2011) has divided activity markers analyses mentioned above into two groups. The first includes the study of entheses which can only be analyzed in a skeletal assemblage as they require an understanding of the prevalence within a population (population level). The second group are those studies that focus on features which can demonstrate information about the activities of an individual without requiring a population context. Musculoskeletal markers and cross-section analysis typically belong in the first group while skeletal modifications belong to the second group. Patterns of degenerative joint disease are often attributed as an intermediate level between both groups since they offer information on both a population and individual level.

Critiques

While biological anthropologists who examine entheses and osteoarthritis agree that there is a correlation between the skeletal system, stress and physical activity, there is much debate on how to standardize methods, establish definitive markers and relate these biological aspects to specific cultural traits (Buikstra and Pearson, 2006; Meyer et al., 2011). As a result, studies on this topic have brought to light questions about the practicality and accuracy of such an examination (Jurmain et al., 2011), especially when reconstructing specific occupations from entheses.

There are many different reasons why the reconstruction of activity patterns based on osteological and pathological markers is controversial in the biological anthropological community. Most of the major critiques can be narrowed down into two different arguments;

one, the issue with samples and two, incomplete or inaccurate methods (Meyer et al., 2011). Most of the critiques revolve around the lack of strong sample sizes within a population. Since most bioarchaeological sample sizes are small to begin with because of preservation, legal issues etc., this critique is discussed as an issue in almost every method on the analysis of human skeletal material (Buikstra and Beck, 2006). Despite this, activity patterns can use these small sample sizes to make broad assumptions not only about that particular population, but also across different populations (Meyer et al., 2011). In this study, a sample of the Hamann-Todd Collection will be examined to understand the possible overarching social and demographic complexities surrounding early 20th century Cleveland.

The other major critique of activity reconstruction concerns incomplete or dysfunctional methods. In some ways, this critique connects to the previous ones as oftentimes small sample sizes are to blame for some of the reasons why the methods are lacking (Meyer et al., 2011). Regarding the specific methods used for the reconstruction of activity patterns, the major critique argues that most methods created in reconstructing activity patterns do not 'truly conform' to the standards of the field. Meyer et al. (2011) examines these specific examples of this non-conformist approach which include the neglect of other possible explanations for data results such as disregarding other variables as things that affect or even are a cause of data results. An illustration of this critique, they note is the issue of sexual dimorphism regarding reconstructing physical activity. The authors argue that in some instances the differences seen in bone markers between the sexes could in fact be sexual dimorphism within the *Homo sapiens* species rather than between cultural populations. As a result, many authors argue that much of the methods that has been created needs to be evaluated and standardized before research is continued and that activity pattern reconstruction should be undertaken cautiously to make sure it fits the data without overreaching conclusions (Weiss et al., 2011; Meyer et al., 2011; Jurmain et al., 2012; Henderson and Cardoso, 2013).

Because of these issues, reconstructions of activity patterns based on human skeletal remains have been called into question. At the same time, this research has become increasingly important to other fields outside of anthropology such as the medical or forensic fields. Godde and Taylor's (2011) article looks at the question of obesity and what kind of stress that puts on the skeletal material. This article has been used in current population studies to combat what are huge issues within society such as the obesity epidemic. Villotte and Knüsel, (2012) article specifically critiqued Godde and Taylor (2011) research arguing that they did not consider other variables such as age at death and that their conclusions are too far-reaching for the science that is currently developed on this issue.

To address these problems concerning reconstructing activity patterns, many researchers have suggested some criteria that should be observed when conducting research (e.g. Hawkey and Merbs, 1995). Table 2 below lists the suggested criteria and sources proposed when constructing activity patterns through observation of entheseal changes from human skeletal remains. It is necessary to point out that some criteria can be applied to any type of skeletal analysis, not just activity reconstruction.

Table 2. Critiques of current entheseal changes methods

CRITIQUES OF CURRENT ENTHESEAL CHANGES METHODS	**JUSTIFICATION**	**SOURCE**
Sufficient number of remains	A Small sample size cannot adequately demonstrate entheseal changes about a particular group or population	Hawkey and Merbs, 1995; Meyer et al., 2011

Table 2—Continued

Adequate preservation	Examine entheses, cross sections etc./ prevent missing data	Hawkey and Merbs, 1995; Meyer et al., 2011
Samples should be chronologically sound	Smaller collections should not span hundreds or thousands of years	Meyer et al., 2011
Population should be genetically homogenous	Avoid bias due to underlying hereditary differences	Meyer et al., 2011
Background information about types of activities (historical records, archaeological artifacts)	Available as written or archaeological material	Meyer et al., 2011; Baker et al., 2012

Despite these recommended criteria, they are not always utilized due to the limits of skeletal materials. Many samples do not have good preservation and are limited even further by the division of adults and subadults, sex and age which could lead to single digit sample sizes for each variable (Marchi et al., 2006; Rhodes and Churchill, 2009; Jurmain, 1999). To increase sample sizes, many researchers pool smaller cemeteries together, but the results in the sample may potentially span thousands of years (Churchill and Morris, 2009) or different geographic areas (Eshed et al., 2004), limiting the utility of these results (Trinkaus, 1997; Trinkaus and Churchill, 1999; Holt 2003). This study, which uses a historical cadaver collection, does not have these concerns, and could be used as a proxy for other archaeological studies especially when new techniques and methods need to be examined further.

Ethnographic and Osteobiographic Parallels

Another concern in activity reconstruction is the correlation of activity patterns or variables such as sex or age from (pre)historic populations to what may be considered their contemporary close equivalents (Churchill and Morris, 1998; Meyer et al., 2011). Behaviors in one population, such as those that are sex-linked, may not be reflected in other communities the same way. The association of activities with a sub-group of individuals such as those based on age or sex may also change in that population over time (Meyer et al., 2011). This can cause problems in the interpretation of activity patterns, especially if changes over time are unrecognizable. Therefore, the ethnographic record, when consulted, is only utilized for a small part of the cultural heritage (Jurmain, 1999). For example, researchers should consult the ethnographic record (if available) to understand information about sex-specific activities. For this study, the historical record was utilized to understand what types of occupations individuals were completing around the time of the collection's curation.

More recently, skeletal biologists and especially bioarchaeologists have tried to push the boundaries even further by reconstructing specific physical activities from bone in conjunction with other methods of data collecting such as archaeology (Baker et al., 2012). In many instances, material evidence from the archaeological record forms important studies with the reconstruction of activity patterns in undocumented and/or ancient populations (Meyer et al., 2011). However, usually only well-preserved materials such as stone, bone or metal survive long enough to be examined and therefore will limit the researcher's reconstruction of activity patterns (Meyer et al., 2011). However, if the material is collected and interpreted, there is an opportunity to dissect specific activity patterns and occupations for an individual or population.

One of the best examples of this type of reconstruction is Baker et al. (2002) work on a woman from the medieval city of Polis in Cyprus. Through both the bioarchaeological as well as archaeological data, they could pinpoint her specific occupation as being that of a seamstress.

Biological Variables

Literature in activity reconstruction has determined certain variables which impact the ability to interpret and understand labor and activity in the past. The following section highlights some of these variables for entheseal changes.

The effect of age on the skeletal system is known in most cases to create increased levels of entheseal and osteoarthritic stress due to age-related effects such as degeneration (Henderson, 2015). In other words, the older an individual is, the more likely their bones lose density and strength (Larsen, 1997). This impacts activity reconstruction because earlier occupation and activity stresses may be hidden and combined with later life stresses especially if individuals drastically changed their occupations over their lifetime as well as degenerative impacts. Researchers such as Villotte and Knüsel (2013) have understood the importance that the determination of age plays regarding the reconstruction of activity patterns.

Many researchers have also looked at osteological/pathological markers between the sexes and have often attributed differences to the social differences between the sexes. An example is Havelkova et al. (2011) who examines enthesopathies and bone remodeling between the sexes from two different sites and lifestyle patterns between two different social groups, those from the castle and the hinterlands. This type of activity reconstruction has been used mostly by bioarchaeologists and osteologists to reconstruct aspects of culture from past societies especially gendered labor patterns. However, it is also one of the main reasons why such markers have been called into question recently. The scoring of the markers can be subjective and based on amount of experience and judgment calls of the osteologists as well as the biological difference between males and females which may impact their response to entheseal and osteoarthritis stress. (Havelkova et al, 2011). However, if the skeletal sample is large enough (e.g. a sizable cadaver collection), these differences could be determined and then proper techniques could be applied in order to understand gendered labor in the past.

Additional studies recognized and researched other attributes which may affect activity patterns on the skeletal system. One of these approaches examined the differences in mechanical stress and subsequent activity patterns in the right and left sides of the skeleton. (Steele, 2000; Auerbach and Raxter, 2008). These methods focused on calculating the percentage directional (%DA) and absolute (%AA) asymmetries using both the maximum length of bones and the diaphyseal breadths (Steele, 2000; Auerbach and Raxter, 2008). Based on Steele's (2000) %DA and %AA calculations of the humerus, radius, ulna, and metacarpals, he demonstrated that humans predominantly have the same side directional bias in the upper limb which can indicate activity patterns through the mechanical stress on the bones. In addition to this work on upper limb asymmetry, Auerbach and Raxter (2008) demonstrated that the clavicle is an important factor in determining upper limb asymmetry yet develops differently than other bones of the upper limb when mechanically stressed. Their research concluded that the while the clavicle mimics the same right side biased in diaphyseal length as other bones of the upper limb, the maximum length demonstrates left side bias. Despite this difference, the clavicle remains an integral part of upper limb support system and furthermore demonstrates that different bones of the upper limb react to mechanical stress differently (Auerbach and Raxter, 2008). This work on patterns of bilateral asymmetry on the clavicle demonstrates how it is possible that there could be the wear on the bones, in their case the clavicle, that does not match on both sides of the body. In other words, through their study, it was found that in the analysis of activity patterns among populations, there is often a difference in osteological/pathological markers, which is attributed to a favoring of one side of the body over the other (Auerbach and Raxter, 2008). This is especially important for activity reconstruction to determine if activity stresses only rely on an individual's preferred left/right bias or if they create stress on both sides leading to relatively symmetrical entheseal and osteoarthritis scores.

Osteoarthritis

Osteoarthritis, a type of degenerative joint disease, consists of a macroscopic examination of degenerative changes on the skeletal material at particular joints. It has been suggested that the patterning and frequency of osteoarthritis may be the result of long term habitual movements which impact certain joint locations (Larsen, 1997). Waldron (1994) has also stated that because the conditions is usually not found at immovable joints, such as cranial sutures, then it is more likely that anatomical movements in conjunction with age are the primary causes of osteoarthritis. Pathological processes associated with joint disease generally occur two different ways. Either there is new bone formation at the joint site or the bone will deteriorate. Despite this, a great amount of variation exists in determining and scoring osteoarthritis and has not been fully standardized (Bridges, 1994; Rogers and Waldron, 1991). For example, pitting/porosity at a joint site is commonly used to determine osteoarthritis however, it is not accepted as an indicator by all researchers (Rothschild, 1997).

Because the skeleton uses bony responses for a variety of different causes such as entheseal stress, pathology, and trauma, there is a debate among researchers about the validity of scoring osteoarthritis using only one indicator of osteoarthritis. As a result, Rogers and Waldron (1995) proposed to the need to examine and score multiple indicators of bony responses in order to be considered osteoarthritis. These are lipping, joint contour, porosity/pitting, and new bone growth. Their exception to this rule was eburnation which represents a smoothing reaction to loss of cartilage and is considered a positive indicator of osteoarthritis by itself.

Therefore, several studies have examined both entheseal changes and degenerative joint disease together (e.g. Schrader, 2012; Palmer et al., 2014). In some instances, though, researchers have been skeptical of examining both entheseal changes and joint disease to determine specific physical activities (Waldron, 1994; Jurmain, 1999). However, other researchers argue that there is value in these studies if researchers proceed with caution (Stirland, 1998; Lieverse et al., 1997). Because entheseal changes create wear patterns on bone over time which can results in degenerative affects such as osteoarthritis, this study has included both entheseal changes and osteoarthritis to understand how these biological indictors point to activity stresses in a population.

Biological Variables

Literature in activity reconstruction has determined certain variables which impact the ability to interpret and understand labor and activity in the past. The following section highlights some of these variables for osteoarthritis.

One of the main concerns in reconstructing occupational and activity patterns from osteoarthritis is the role of anatomical and genetic differences between males and females. Females have different types of hormones and anatomical features such as smaller joint surfaces than males which may impact activity stress (Weiss and Jurmain, 2007). For example, the smaller size would impact the amount of osteoarthritic distribution which may be incorrectly interpreted as cultural differences rather than biological ones (Weiss and Jurmain, 2007).

Therefore, researchers should exercise extreme caution when comparing male and female osteoarthritis distributions and patterns.

Because the human body, including the skeletal system degenerates with age, one of the problems in determining activity patterns and its relationship to age has been accounting for those individuals in different age groups. By using age-adjustment as logistic regression applications to skeletal material, it was demonstrated that activity and osteoarthritis patterns can be compared with better accuracy (Baker and Pearson, 2006).

While body size is more difficult to ascertain in past populations since all that is left is the skeleton, if other factors including stature are considered, it is possible to get a better understanding of these activity patterns in individuals (Buikstra and Beck, 2006). Body type and stature could affect the development and growth of the bones in which people with a bigger body type and bigger bones could handle more stress than those who could not (Knüsel, 2000). If so, researchers should control for differences in body size or physique, otherwise it could lead to a biased data set (Meyer et al., 2011). Body proportion differs greatly among populations, even more so if taken out of context (Mays, 1999). For example, Allen and Bergmann's rules on the relationship between climate, limb size and body mass are applied to human populations. These rules demonstrate that individuals from the tropics versus those from the subarctic should not be directly compared unless acknowledging the importance of climate variation which may be derived using date from the populations studies, not other selected groups (e.g. Weiss, 2003).

Historical Reconstruction of Cleveland

In order to reconstruct activity and labor patterns in early 20th century Cleveland, it is crucial to understand the labor and manufacturing companies there as well as population movements and their corresponding social and cultural spheres.

Industry and Labor

At the turn of the twentieth century, Cleveland like other northern cities was enjoying a period of industry and expansion. Prior to this time, Cleveland had already started and expanded industries such as the creation of highways, railroads, and canals to connect the Great Lakes and iron to use in manufacturing. By 1860, Cleveland was a predominantly heavy industry city with little to no commerce in agricultural products (Van Tassel and Grabowski, 1996). The Civil War increased Cleveland's iron industry and by 1880, iron accounted for about 20% of Cleveland's manufacturers. Another contribution to Cleveland's industrial growth came in the 1880s with new industries such as petroleum, chemicals for refineries, and automobiles in which Cleveland boasted three of the earliest manufactures of gasoline, electric or steam-powered cars (Van Tassel and Grabowski, 1996). Cleveland's age of rapid growth industry peaked around 1930 in which it was second only to Detroit among American cities in the number of workers employed in industry (Van Tassel and Grabowski, 1996).

Since Cleveland had one of the highest percentage of industrial works around the turn of the twentieth century, different labor forces (contingent on skill sets) developed throughout the city. Cleveland's early laborers can be traced to the construction of the Ohio and Erie Canal, which began construction in 1825 and demanded a lot of unskilled labor. As Cleveland's industries began to grow, labor unions were formed among the skilled laborers as they had the economic advantage to do so while the city's unskilled laborers did not (Van Tassel and Grabowski, 1996). In the 1870s and 1880s, there were at least ten different types of industrial unions in the city. When the economic recession of 1873-1878 deepened, the amount of union activities and labor strikes increased in the city due to the economic pressure (Van Tassel and Grabowski, 1996). Some of these were successful, such as the major strike that occurred at the Cleveland Rolling Mills in 1882, which resulted in 80% of the workforce organized and higher wages for the workers (Van Tassel and Grabowski, 1996). By the end of the 1880s, life improved for Cleveland's workers however the tension between the unions and the corporations never completely went away. The most important trend that occurred out of these labor movements was the development of the working class which shared similar goals and values. This would even transcend the ethnic and religious barriers between different groups of people as America fell into the Great Depression (Van Tassel and Grabowski, 1996).

The Great Migration and African Americans

As industry expanded in America towards the end of the 19th and the beginning of the 20th centuries, there was an abundance of lower skilled labor in America's cities. Soon after, America's rural poor along with formally enslaved African Americans who engaged in seasonal agricultural work began to move to the Northern cities, a shift known as the Great Migration (Van Tassel and Grabowski, 1996). One of these Northern American cities was Cleveland in Cuyahoga County, Ohio. Despite the new labor opportunities, discrimination and segregation to a certain extent followed African Americans northwards. In Cleveland, the most serious discrimination occurred as very few African Americans were permitted to work in industry, even though Cleveland was a heavily industrialized city (Van Tassel and Grabowski, 1996). African Americans were not hired in the steel mills and foundries that becomes some of the most important industries in Cleveland. This prejudice was often found in labor unions which usually excluded African American workers. As a result, by 1910 only ten percent of Cleveland's African Americans were skilled laborers (Van Tassel and Grabowski, 1996).

The period of 1915-1930 was an era of both progress and difficulties for African Americans. The industrial demands and the decline in immigration due to the war created an opportunity for African American labor which prompted more individuals to head north looking for jobs (Van Tassel and Grabowski, 1996). Opportunities for African Americans increased generally such as the development of an African American middle class however discrimination and segregation still existed. For example, African Americans were still sequestered in the Central Avenue ghetto despite differing economic statuses (Van Tassel and Grabowski, 1996).

Second and Third Waves of European Immigration

While African Americans and rural Americans shifted from the South to North to take advantage of the unskilled and skilled labor available in Cleveland, Europeans from southern and eastern Europe also migrated to America's industrial cities due to poverty and political unrest within home countries. Early immigration waves to Cleveland during the mid-19th century originated in countries such as Ireland, Britain, and Germany. These groups were utilized to help construct the Ohio and Erie Canal near Cleveland which allowed Cleveland's economic potential, especially in mercantile endeavors, to grow and make it more attractive to other groups of immigrants (Van Tassel and Grabowski, 1996).

By the 1870s, European migration continued to be from the Germanic states, Great Britain and even more so Ireland. However, the most diverse and substantial European immigration to Cleveland occurred from around 1870-1914 and was coined the ‘new migration’ in which many Southern and Eastern European groups settled in Cleveland. This large movement was the result of land shortages in home countries, liberal emigration policies, increased military conscription, poverty, and even persecution (Van Tassel and Grabowski, 1996). Some of these groups included Italians, Austro-Hungarians, and Greeks. The influx was so great that the city used some of its police officers, stationed around the city, to count and assist new arrivals in the city. Because Cleveland was one of the later northern cities to industrialize, following Chicago and Detroit, the city received more ‘new immigrants’ somewhat later than the others. Therefore, immigrant communities and institutions to help immigrants such as churches and benefit organizations arose in Cleveland later than in cities such as Chicago or Detroit (Van Tassel and Grabowski, 1996). The impacts of this can be seen when examining entheseal stress in relation to activity patterns and workload as early immigrants would not have had the resources to find higher levels of occupations such as white-collar cleric positions and would have to rely on the menial labor jobs that offered work on a sporadic schedule such as day laborers.

During World War I, ‘new immigration’ came to a standstill in Cleveland because the war involved many of the immigrants’ home countries such as Austria-Hungary. In addition, the federal government passed restrictive legislation such as the National Origins Act of 1921 (1924) which prohibited large scale immigration from Southern and Eastern Europe, among other “undesirable” populations such as East Asians, Arabs and Africans and provided restriction quotas for different ethnic groups (Van Tassel and Grabowski, 1996). After that, very little immigration took place in Cleveland until after World War II.

Women and Industry

At the turn of the 20th century, Cleveland began to expand its manufacturing into a variety of different industries. While African Americans migrated north and European immigrants came to Cleveland and other U.S. cities looking for work and opportunity, changes in labor patterns occurred for women as well. During the Civil War, women had easier access to the workforce as men were away at war. Once the men came back, opportunities for women dwindled but did not completely disappear as by 1880, 10,000 women were employed in Cleveland with over 75% of them working as domestic servants, laundresses, dressmakers, and milliners (Van Tassel and Grabowski, 1996). By the turn of the 20th century, women gained more opportunities through the creation of light industries such as paper box factories, bakeries, cigar plants, laundries and the garment industry and made up 20% of Cleveland's workforce (Van Tassel and Grabowski, 1996). Working women in Cleveland were mostly young and single but came from different ethnicities. Ethnicity helped determine what type of work women sought after but once employed, most women endured long hours (60-hour week) and low wages (about $5 per week) (Van Tassel and Grabowski, 1996). Another drawback for women was that most the light industries were seasonal and workers experienced times where there were no jobs available. However, the wages were crucial to the family economy, no matter how small or sporadic.

After World War I, females' experiences in Cleveland's workforce were varied. Immigrant women of the 1920s often were separated from their families because of restrictive legislation, however, many of them began to join other native-born women in white collar jobs such as sales, clerical work, and communication-related employment (Van Tassel and

Grabowski, 1996). By 1930, 40% of Cleveland's working women were engaged in white collar jobs (Van Tassel and Grabowski, 1996). Despite these advancements, working conditions were still poor for African American women who replaced immigrants at the bottom of the employment ladder. They began to complete the heavy industrial occupations but ultimately all cultural groups suffered under the Great Depression (Van Tassel and Grabowski, 1996).

Cleveland and Cuyahoga County Occupations circa 1900

In order to understand and discern possible activity stresses and patterns from the Hamann-Todd, it is crucial to understand Cleveland's geographic and economic landscape. By 1900, the city of Cleveland was well on its way to becoming one of the top industrial cities in the United States. The development of new industries along with the increasing population from the south and Europe created a perfect blend of occupations at all social and economic levels. At the beginning of the 20th century, Cleveland had a population of 876,050 and Cuyahoga County (where Cleveland is situated) had a population of 1,412,140 (Van Tassel and Grabowski, 1996). Cuyahoga Cleveland was divided into several townships and the city of Cleveland was comprised of 42 wards. Similar to other urban centers in the north, the outlying townships had different occupations than those who lived in Cleveland and even different wards housed different occupations and groups of people.

Since the occupations for each person within the Hamann-Todd Collection are unknown as of now, the following section details some of the occupations individuals had in Cuyahoga County based on the 1900 Federal Census in order to understand the possible occupations individuals in the sample could have had. Beginning with townships outside of Cleveland, a sample of at least 50 occupations per each was collected for East Cleveland township (east of the city). The results of the entire sample can be found in the appendix which lists each occupation, the number of individuals, the sex of the individuals and the amount of skill and force that went into the job based on Villotte et al. 2010.

Table 3 below lists the top five occupations for both males and females based on that list. The sample demonstrates that most of the work for males dealt with farm labor in some form in addition to other skilled manual labor such as carpentry. For females, the top ranked occupations were more domestic work such as house servants and skilled trades such as dress makers. Based on Villotte et al., (2010), the top occupations for both males indicate both skilled and unskilled labor with high workloads and force which would subsequently create higher stress at enthesis attachment sites. For females, the pattern is a little different in which females are engaged more in unskilled and skilled non-forceful labor which would create less stress on entheses compared to males.

Villotte et al., (2010) created four occupation groups based on the type of labor (manual versus nonmanual) and the amount of force applied. Group A included non-manual workers who do not engage in forceful activities such as storekeepers, policeman and landowners. Group B included individuals who participated in manual but nonforceful occupations such as shoemakers, tailor, weavers, and home servants. Group C included manual workers who carried heavy loads or were involved in forceful tasks. Example are carpenters, masons, rural workers, butchers, and steelworkers. Lastly, Group D were manual, unskilled, and forceful laborers such as foot soldiers, day laborers and unskilled workers. These groups were utilized in this study to understand the types of entheseal and occupational stresses individuals may have experienced based on their occupations.

Table 3. Top ranked male and female occupations from East Cleveland Township

TOP 5 MALE AND FEMALE SAMPLED OCCUPATIONS CIRCA 1900 FROM EAST CLEVELAND TOWNSHIP						
OCCUPATION	**RANK**	**TALLY**	**SEX**	**RACE**	**IMMIGRANT?**	**PLACE OF BIRTH**
FARMER	1	25	M	CAU.	YES/NO	HUNGARY, GERMANY, ENGLAND, OHIO, NEW YORK, SWITZERLAND, CONNECTICUT
FARM LABORER	2	13	M	CAU.	YES/NO	ENGLAND, GERMANY, OHIO, IOWA, NORTH CAROLINA
LABORER	3	10	M	CAU.	YES/NO	OHIO, GERMANY, NORWAY, HUNGARY, PENNSYLVANIA, ILLINOIS, CANADA
CARPENTER	4	9	M	CAU.	YES/NO	OHIO, NEW YORK, GERMANY, SCOTLAND, AND VIRGINIA
MILK PEDDLAR	5	8	M	CAU.	YES/NO	KANSAS, OHIO, ENGLAND, VERMONT
HOUSE SERVANT	1	7	F	CAU.	YES/NO	OHIO, IRELAND, GERMANY, INDIANA, MICHIGAN, BOHEMIA, CANADA
DRESS MAKER	2	4	F	CAU.	NO	OHIO
GUM MAKER	3	2	F	CAU.	YES/NO	DENMARK, OHIO
MILLINER	3	2	F	CAU.	NO	OHIO, MINNESOTA

Table 3—Continued

BASKET BRAIDER	5	1	F	CAU.	YES	GERMANY

U.S. Census Bureau, 1900

A sample was also collected from Newburgh Township which is located south of Cleveland and the results are similar to the sample from East Cleveland Township (Table 4). Top occupations for males were either farm or heavy labor related with only one non-manual skilled occupation, the clerk. For females, the pattern is a little different because while the top occupation, a teacher, is considered non-manual but skilled, the other top occupations demonstrate that women in this township were working with the men in the fields and at the labor mills. Therefore, these women would most likely have higher stressed entheses like the males if they are completing similar work.

Table 4. Top ranked male and female occupations from Newburgh Township

TOP 5 MALE AND FEMALE SAMPLED OCCUPATIONS CIRCA 1900 FROM NEWBURGH TOWNSHIP						
OCCUPATION	**RANK**	**TALLY**	**SEX**	**RACE**	**IMMIGRANT?**	**PLACE OF BIRTH**
FARMER	1	48	M	CAU.	YES/NO	NEW YORK, OHIO, ENGLAND, GERMANY POLAND, IRELAND, VERMONT, SWITZERLAND, FRANCE, BOHEMIA, PENNSYLVANIA
FARM LABORER	2	26	M	CAU.	YES/NO	OHIO, POLAND, GERMANY, GREECE, MICHIGAN

Table 4—Continued

LABORER	3	18	M	CAU.	YES/NO	OHIO, POLAND, ENGLAND, MICHIGAN, WALES
CLERK	4	11	M	CAU.	YES/NO	GERMANY, OHIO, POLAND
LABOR MILLS	5	5	M	CAU.	YES/NO	GERMANY, OHIO, POLAND
CARPENTER	5	7	M	CAU.	YES/NO	OHIO, NEW YORK, ENGLAND
TEACHER	1	3	F	CAU.	NO	OHIO, KANSAS
FARMER	2	2	F	CAU.	YES	ENGLAND, GERMANY
FARM LABORER	2	2	F	CAU.	YES/NO	GERMANY, OHIO
LABOR MILLS	2	2	F	CAU.	YES	ENGLAND
DRESSMAKER	5	1	F	CAU.	NO	OHIO
BOOK KEEPER	5	1	F	CAU.	NO	OHIO
SERVANT	5	1	F	CAU.	YES	GERMANY

U.S. Census Bureau, 1900

Samples of different occupations were also taken from three different wards in the city of Cleveland, Ward I (east and west sides, center of the city), Ward IX (northeast) and Ward XLI (northwest). Ward I was split into east and west sides as it had a lot of industrial activity in addition to being hotspots for both immigrant and African American communities. Unlike East Cleveland and Newburgh Townships which featured some industrial work but mostly farm labor, Ward I (east side) has more of a variety of different types of industrial labor and trades (Table 5). For males, the top occupations were both industrial in the form of day laborers (both African American and Caucasian) and service industry jobs which were all African America. This complements the historical literature which mentioned that African Americans were on a large scale banned from industrial jobs and rather worked service jobs such as waiters or hotel personnel. The top occupations for females were more domestic and service industry rather than industrial demonstrating that they would most likely have lower entheseal stress marker scores than males.

Table 5. Top ranked male and female occupations from Cleveland City Ward 1 (East Side)

TOP 5 MALE AND FEMALE SAMPLED OCCUPATIONS CIRCA 1900 FROM CLEVELAND CITY WARD I (EAST SIDE)						
OCCUPATION	**RANK**	**TALLY**	**SEX**	**RACE**	**IMMIGRANT?**	**PLACE OF BIRTH**
DAY LABORER	1	43	M	AFR./ CAU.	YES/NO	INDIANA, OHIO, HAYTI, ITALY, CAROLINAS, VIRGINIA, NEW YORK, PENNSYLVANIA, ALABAMA, ILLINOIS, IRELAND, ENGLAND, SYRIA
HOTEL WAITER	2	18	M	AFR.	NO	VIRGINIA, KENTUCKY, TENNESSEE, OHIO, NORTH CAROLINA, ALABAMA, MARYLAND
LABORER	3	5	M	AFR./ CAU.	YES/NO	OHIO, VIRGINIA, PENNSYLVANIA, GERMANY
CARPENTER	3	5	M	CAU.	NO	NEW YORK, OHIO, PENNSYLVANIA
SALESMAN	3	5	M	CAU.	YES/NO	OHIO, NEW YORK, HUNGRY
PAINTER	3	5	M	CAU.	NO	NEW YORK, OHIO, MICHIGAN

Table 5—Continued

HOUSEKEEPER	1	12	F	AFR./ CAU.	YES/NO	VIRGINIA, OHIO, CANADA, NEW YORK, MARYLAND, OHIO, MISSOURI, MISSISSIPPI, PENNSYLVANIA, ENGLAND
SERVANT	2	7	F	AFR./ CAU.	YES/NO	NORTH CAROLINA, OHIO, INDIANA, CANADA, HUNGRY
COOK	3	4	F	AFR./ CAU.	NO	OHIO, MARYLAND
DRESS MAKER	4	3	F	AFR./ CAU.	NO	MICHIGAN, OHIO
FACTORY WRAPPING	5	2	F	CAU.	NO	OHIO
WASHER WOMAN	5	2	F	CAU.	NO	OHIO

U.S. Census Bureau, 1900

On the west side of Ward I in Cleveland, there are both similar and different patterns regarding types of occupations (Table 6). While day laborer is still the highest ranked occupation, instead of the service industry, the next ranked occupations are more skilled trades such as tailors and candy makers both of which seem to be ethnically run businesses based on the few types of geographic birth places. It is also important to note that on the west side there are few, if any, African Americans living there demonstrating that sections of Cleveland were ethnically divided. For females, the highest ranked occupations were similar to males in that it was a combination of industrial or factory jobs as well as skilled trades.

Table 6. Top ranked male and female occupations from Cleveland City Ward 1 (West Side)

TOP 5 MALE AND FEMALE SAMPLED OCCUPATIONS CIRCA 1900 FROM CLEVELAND CITY WARD I (WEST SIDE)						
OCCUPATION	**RANK**	**TALLY**	**SEX**	**RACE**	**IMMIGRANT?**	**PLACE OF BIRTH**
DAY LABORER	1	77	M	CAU.	YES	IRELAND, ITALY, RUSSIA, POLAND, AUSTRIA, HUNGARY, ASSYRIA
TAILOR	2	9	M	CAU.	YES	ITALY, BOHEMIA
CANDY MAKER	3	7	M	CAU.	YES	GREECE, ROMANIA
CLERK	4	6	M	CAU.	YES/NO	OHIO, GERMANY, IRELAND
TEAMSTER	5	5	M	CAU.	NO	OHIO, WISCONSIN
WAITER	5	5	M	4CAU/ 1AFR.	YES/NO	ITALY, VIRGINIA, GERMANY, NEW YORK
SEWER (FACTORY)	1	3	F	CAU.	YES/NO	OHIO, RUSSIA
TAILOR	1	3	F	CAU.	YES	ITALY, BOHEMIA
WASHWOMAN	3	2	F	CAU.	YES/NO	MICHIGAN, IRELAND
BOOK KEEPER	4	1	F	CAU.	NO	NEW YORK
COOK	4	1	F	AFR.	NO	OHIO

U.S. Census Bureau, 1900

In Ward IX, the sexual division of labor is more noticeable (Table 7). For males, all five of the highest ranked occupations were heavy industrial labor either done in factories or in workshops. These individuals would have high amount of entheseal and osteoarthritis based on their heavy, repetitive workload. For females, there is more of a mix of non-manual and manual labor. Some females ran a boarding house while others worked as servants with minimal stress or as laborers will heavy stress. Despite the heavy male dominated workforce, females in Ward IX had a variety of different labors. Perhaps this demonstrates more freedom in their choice of occupation which is plausible considering those who are immigrants are from Western Europe rather than the 3rd and 4th wave immigrants who came from South and Eastern Europe.

Table 7. Top ranked male and female occupations from Cleveland City Ward 9

TOP 5 MALE AND FEMALE SAMPLED OCCUPATIONS CIRCA 1900 FROM CLEVELAND CITY WARD IX						
OCCUPATION	**RANK**	**TALLY**	**SEX**	**RACE**	**IMMIGRANT?**	**PLACE OF BIRTH**
STEEL LABORER	1	15	M	CAU.	YES/NO	ENGLAND, PENNA, IRELAND, OHIO, AUSTRIA, WALES
MACHINIST	1	15	M	CAU.	YES/NO	GERMANY, OHIO, ENGLAND, IRELAND, PENNA, WALES
DAY LABORER	3	6	M	CAU.	YES/NO	ENGLAND, IRELAND, OHIO
BLACKSMITH	4	5	M	CAU.	YES/NO	SCOTLAND, ENGLAND, ISLE OF MAN, OHIO
IRON MOULDER	4	5	M	CAU.	YES/NO	ENGLAND, OHIO, IRELAND, MICHIGAN
BOARDING HOUSE	1	2	F	CAU.	YES/NO	IRELAND, OHIO
SERVANT	1	2	F	CAU.	NO	OHIO, NEW JERSEY
SALOON KEEPER	3	1	F	CAU.	NO	MICHIGAN
DAY LABORER	3	1	F	CAU.	YES	IRELAND
MACHINIST	3	1	F	CAU.	YES	WALES

Table 7—Continued

STORE KEEPER	3	1	F	CAU.	NO	OHIO

U.S. Census Bureau, 1900

Lastly, Ward XLI was also sampled and showed a completely different pattern than any of the previous wards (Table 8). In this case, both male and female occupations were less labor intensive and higher economic status jobs. For example, the highest ranked job in this ward was a police officer which is known as a low intensity non-repetitious job. For females, running a boarding house and being a dressmaker were highly ranked demonstrating economic choice in their occupations.

Table 8. Top ranked male and female occupations from Cleveland City Ward 41

TOP 5 MALE AND FEMALE SAMPLED OCCUPATIONS CIRCA 1900 FROM CLEVELAND CITY WARD XLI						
OCCUPATION	**RANK**	**TALLY**	**SEX**	**RACE**	**IMMIGRANT?**	**PLACE OF BIRTH**
POLICE	1	4	M	CAU.	YES/NO	PENNSYLVANIA, OHIO, IRELAND
DRAUGHTSMAN IRON	2	3	M	CAU.	NO	INDIANA, OHIO
MACHINIST	2	3	M	CAU.	YES/NO	CANADA, OHIO, AUSTRALIA
LETTER CARRIER	2	3	M	CAU.	YES/NO	WISCONSIN, CANADA, OHIO
BARBER	5	2	M	CAU.	NO	NEW YORK, OHIO
HOUSEKEEPER	1	4	F	CAU.	YES/NO	OHIO, ENGLAND, NEW YORK
DRESSMAKER	2	3	F	CAU.	YES/NO	OHIO, ENGLAND
BOOKKEEPER	2	3	F	CAU.	NO	OHIO, MICHIGAN
TEACHER	4	2	F	CAU.	YES/NO	CANADA, OHIO

Table 8—Continued

SERVANT	4	2	F	CAU.	NO	MICHIGAN, OHIO

U.S. Census Bureau, 1900

Ultimately, while specific occupations of each individual within the Hamann-Todd Collection are unknown, there is ample documentation about the types of occupations available at the time. Moreover, analysis of activity markers from these samples give us an understanding of the effects of different forms of occupations in both rural and urban settings.

CHAPTER III

MATERIALS AND METHODS

Skeletal Sample

The Hamann-Todd Collection

The Hamann-Todd Collection is one of the few cadaver collections in the United States that offers a glimpse of late 19^{th} and early 20^{th} century urban life. It is comprised of 2,139 individuals who died from 1911-1938 and represents some of the marginalized groups of Cleveland and the surrounding Cuyahoga County, Ohio (Cobb, 1935). Individuals from this collection are mostly Caucasian-Americans along with African Americans and smaller samples of other groups such as Asian-Americans and Hispanic-Americans. The individuals who became a part of this collection either donated their bodies, could not afford burial, or were found on the streets (Cobb, 1935). Therefore, many individuals were picked up from hospitals, asylums, and poorhouses and represent the lower classes. Most Caucasian Americans are foreign born immigrants and their immediate first-generation descendants while most of the African Americans migrated to the North from the South as a part of the Great Migration (Cobb, 1935). The following tables below list general demographic information from the Hamann-Todd collection as related to social and economic trends in Cleveland. The sample size, n=1,177 represents those individuals that have a place of birth, age, and cause of death in associated documentation (Cobb, 1935).

Table 9. Demographic composition of the Hamann-Todd Collection based on birthplace and age

Birthplace	**Foreign-Born Caucasian-Americans**	**Native-Born Caucasian-Americans**		**Native-Born African Americans**	**Misc. (Foreign-Born African Americans, Asian-Americans)**
Number of Individuals	431	292		447	7
Percentage of Collection (n=1,177)	≈36.9%	≈25.0%		≈38.0%	<1%
Age	Total Population	Native Caucasian Americans	"Old" Immigrant Caucasians	"New" Immigrant Caucasians	Native African Americans
Median Age	≈ 45 years	≈ 45 years	≈ 58 years	≈ 42 years	≈ 37 years

(Cobb, 1935)

Table 10. Demographic composition of the Hamann-Todd Collection based on cause of death

Top Causes of Death	**Respiratory Tuberculosis**		**Heart Disease**		**Pneumonia**		**Alcoholism**		**Apop-lexy**		**Other types**	
Percentage of "racial" group (Caucasian and African) (n=1,177)	Cau ≈17%	Afr ≈28%	Cau ≈15%	Afr ≈13%	Cau ≈10%	Afr ≈19%	Cau ≈9%	Afr ≈2%	Cau ≈6%	Afr ≈3%	Cau ≈43%	Afr ≈35%

(Cobb, 1935)

Table 11. Demographic composition of the Hamann-Todd Collection based on immigration patterns *

Migrations	**"Old" Immigrant Caucasians**	**"New" Immigrant Caucasians**	**Great Migration Africans**	**Native Born Individuals and Others**
Countries/States of Origin (most popular)	Germany, Ireland, Great Britain	Austria, Hungary, Czechoslovakia	Georgia, Alabama, South Carolina	Ohio, New York, Pennsylvania
Number of Individuals	≈ 172	≈ 247	≈ 284	≈ 474
Percentage of Collection (n=1,177)	≈ 14.6%	≈ 20.9%	≈ 24.1%	≈ 40.3%

*percentages based those 1,177 individuals who were documented for place of birth (Cobb, 1935)

Because the Hamann-Todd Collection is representative of a collection of lower class and marginalized individuals who often worked in unskilled occupations, the collection can be used to loosely trace economic and social trends in Cleveland at the beginning of the 20th century (Cobb, 1935). For example, at the beginning of the collection in 1911, there was a significantly higher percentage of Caucasian-Americans than African Americans. Yet, starting at 1915 to the end of the collection, there was a steady rise in percentage of African Americans in the collection and in 1931, there were more African-Americans added to the collection than Caucasian-Americans (Cobb, 1935). These data align with the one of the waves of the Great Migration as the demand for unskilled labor in the North outweighed the economic opportunities for African Americans in the South (Cobb, 1935).

Similar trends also exist for the Caucasian-American immigrant population which demonstrate the two waves of European immigrant to the United States, the first from Northern Europe and the second from Central, Eastern and Southern Europe (Cobb, 1935). Because these developments are represented in this collection, there have also been studies examining these and other trends through an osteological lens. One of these studies examined trauma patterns in both Caucasian and African American males from the collection to understand possible tension between the two groups based largely on similar economic opportunities and somewhat similar social stigma against immigrant groups (De la Cova, 2010).

Sampling Methods

The sample observed for this study from the Hamann-Todd Collection was limited to 118 adult individuals. Sub-adults and infants were excluded from this research as they would have either a limited amount or no entheseal stress nor degenerative joint disease on their skeletons. I limited the sample to individuals who died between the ages of 25 and 75. While this is a larger age range, it was chosen to examine the impacts of age on entheseal formation and osteoarthritis and to ascertain if older individuals were still performing high levels of muscle stress up until death. This concept assumes that entheses can, to a certain extent, decrease over time once the bone is no longer stressed. However, the entheses still retain bony repairing and remodeling such as osteoarthritis. If correct, the entheses can possibly demonstrate that for some individuals in this collection, labor continued until death or that labor occurred early in life shown by degenerative joint disease but did not occur recently.

Furthermore, the sample was also limited by weight as individuals were selected from a weight category of 115 to 200 pounds at time of death. This was to account for differences and body mass and size among different geographic populations as well as the sexes. The category was also created to prevent the inclusion of individuals with extreme lower weights due to pathological conditions. For example, individuals who had been emaciated by the effects of tuberculosis, who weighed at times 70 pounds at time of death, were found in the collection. But they were not used in this study as these individuals most likely did not engage in strenuous activities that resulted in entheseal stress prior to death, or their conditions impacted the formation of entheseal stress. Severe pathological conditions were also excluded to prevent the examination of pseudoarthritis which occurs because of pathology rather than activity stress.

Once the criteria were set, there were still many individuals who met the conditions. Therefore, I took a random sample from those individuals by running the sub-set through a Microsoft Excel sampling technique which randomly coded and mixed up the individuals. Despite choosing from a large sample that fit the criteria and every effort to include an equal number of males, females, Caucasians, African Americans and age groups, there were some categories such as Old Adult African American males and females in which the sample size (n=3 per each) was small. Because this study examines entheseal stress and activity patterns over twenty-year period, labor may have been different for those individuals who died in the older adult category versus the middle and younger categories (Table 12).

Table 12. Sample size and demographic composition for the research study

	FEMALES	**MALES**	**TOTAL**
Total Sample	46	72	**118**
African American (AF)	29	16	45
Caucasian (CA)	16	56	73
Young Adult (YA)	15	15	30
Middle Adult (MA)	25	34	59
Old Adult (OA)	6	23	29
AF/YA	12	2	14
AF/MA	14	11	25
AF/OA	3	3	6
CA/YA	3	13	16
CA/MA	11	23	34
CA/OA	3	20	23

Assessing Musculo-Skeletal Stress

Entheseal Changes

This study examined entheseal changes for 118 individuals. To be included in the study, the skeletal material must be complete in the upper limb to score at least 75% of the proposed entheseal markers and instances of osteoarthritis each. The upper limb was targeted as an area of study because previous research (Weiss, 2004; Niinimaki and Sotos, 2013) demonstrated that age and body size impact the lower limb more than physical activity patterns and those activity patterns are difficult to ascertain on the lower limb in post agricultural societies. Thus, the research focused on the upper limb because habitual anatomical movements that are more apparent there rather than the lower limb was not accessed in this project.

Twenty-three entheseal markers were scored on the clavicle, scapula, humerus, radius and ulna (Table 13). These attachment sites were chosen for this study because they incorporate a range of possible movements on the upper limb and they have also been used in previous studies that examined entheseal changes (Hawkey and Merbs, 1995; Lieverse et al., 2009; Machicek, 2011).

Table 13. Upper limb entheseal attachment sites

BONE	MUSCLE/LIGAMENT	LOCATION OF ATTACHMENT SITE	ACTIONS PERFORMED
CLAVICLE	COSTOCLAVICULAR LIGAMENT	Inferior sternal end of clavicle, costal tuberosity	Anchors the clavicle, prevents medial displacement and elevation

Table 13—Continued

CLAVICLE	SUBCLAVIUS	Subclavian Groove	Anchors and depresses the clavicle
CLAVICLE	TRAPEZOID LIGAMENT	Trapezoid Line	Reinforces the joint between scapula and clavicle
CLAVICLE	CONOID LIGAMENT	Conoid Tubercle	Reinforces the joint between scapula and clavicle
SCAPULA	TRAPEZIUS	Acromion and spine of the scapula	Retracts and rotates the scapula
SCAPULA	PECTORALIS MINOR	Coracoid Process	Protraction and rotation of scapula
HUMERUS	SUPRASPINATUS	Top of the Greater Tubercle	Works with deltoid, initiates abduction of humerus
HUMERUS	INFRASPINATUS	Lateral End of Greater Tubercle	Carries out lateral rotation and abduction of the humerus
HUMERUS	TERES MINOR	Back of Greater Tubercle	Laterally rotate the humerus
HUMERUS	PECTORALIS MAJOR	Greater tubercular crest, floor of intertubercular groove	Medial rotation of the humerus, adductor/flexor at shoulder joint
HUMERUS	LATISSIMUS DORSI	Lesser tubercular crest, floor of intertubercular groove	Adducts and flexes the humerus at shoulder joint, medially rotates the humerus at shoulder
HUMERUS	TERES MAJOR	Medial end of the lesser intertubercular crest	Adducts and medially rotates the humerus at the shoulder joint
HUMERUS	DELTOID	Deltoid Tuberosity	Produces flexion and extension at shoulder, principle adductor at shoulder joint

Table 13—Continued

HUMERUS	CORACOBRACHIALIS	Medial Humeral Shaft	Weak flexion and adduction at shoulder
HUMERUS	COMMON EXTENSORS	Lateral epicondyle, distal humerus	Group of muscles which carry out extension and supination of forearm
HUMERUS	COMMON FLEXORS	Medial epicondyle, distal humerus	Group of muscles which carry out pronation of the forearm and weak flexion at the elbow
ULNA	BRACHIALIS	Coronoid Process, tubercle of ulna	Strong flexor at the elbow joint
ULNA	ANCONEUS	Lateral end of the Olecranon Process	Extension at the elbow, abducts ulna during pronation
ULNA	TRICEPS BRACHII	Olecranon Process	Strong Extensor of the Elbow Joint
RADIUS	BICEPS BRACHII	Radial Tuberosity	Weak flexor at the shoulder, strong flexor at the elbow, supinates the forearm
RADIUS	PRONATOR TERES	Pronator Tuberosity	Pronates the forearm and flexes at the elbow
RADIUS	SUPINATOR	Proximal $1/3^{rd}$ of lateral radius	Function is to supinate the forearm
RADIUS	PRONATOR QUADRATUS	Distal $1/4^{th}$ of anterior radius	Pronates the forearm

Entheseal changes were scored using similar methods conducted by Hawkey and Merbs (1995) which provide a basic method for scoring three categories of stress i.e. robusticity, cortical defect, and ossification exostosis. Descriptions of each category were paired with its corresponding numerical standard and can be found below.

Robusticity is observed by localized swelling and/or ridging of the bone at the attachment site (Hawkey and Merbs, 1995; Peterson, 1998; Weiss, 2007; Auerbach and Raxter, 2008; Machicek, 2011). Scores ranged from the lack of observable features to strong mounds or crests on the bone (Table 14).

Table 14. Robusticity scoring methods

0	Absent	Feature not visible
1	Faint	Cortex is slightly rounded, elevation scarcely visible but apparent to touch
2	Moderate	Cortex uneven, with defined margin and easily observable mounding
3	Strong	Strong mounding with distinct sharp crests or ridges

Figure 1. Robusticity scoring methods at the costoclavicular ligament

Cortical defect is shown as pitting or furrowing at the muscle or ligament attachment site (Hawkey and Merbs, 1995; Peterson, 1998; Weiss, 2007; Auerbach and Raxter, 2008; Machicek, 2011). They are known as 'stress lesions' and occur from isolated and non-pathological incidents at the attachment site. Scores range from unobservable to large pits or furrows (Table 15).

Table 15. Cortical defect scoring methods

0	Absent	Feature not visible
1	Faint	Shallow pit/furrow, less than 1mm in depth
2	Moderate	Medium pit/furrow, 1-3mm deep and <5mm long
3	Severe	Marked pit/furrow, >3mm deep or >5mm long

Figure 2. Cortical defect scoring methods at the costoclavicular ligament

Ossification exostosis refers to bony spurs that project from the cortex of a ligament or muscle attachment site. Unlike robusticity and cortical defect, ossification exostosis is due to a 'macro-trauma' to the bone (Hawkey and Merbs, 1995; Peterson, 1998; Weiss, 2007; Auerbach and Raxter, 2008; Machicek, 2011). This type of trauma may occur from a sudden tear at the attachment site which may prompt new bone growth (Kennedy, 1989; Hawkey and Merbs, 1995). Scores range from absent to a marked exostosis which covers a large area on the attachment site (Table 16).

Table 16. Ossification exostosis scoring methods

0	Absent	Feature not visible
1	Faint	Slightly rounded exostosis, extends <2mm from surface
2	Moderate	Distinct exostosis, extends 2-5mm from surface
3	Strong	Marked exostosis, extends >5mm or covers extensive amount of bone cortex

Figure 3. Ossification exostosis example at the triceps brachii

The categories of robusticity and cortical defect are considered chronic responses from long term activity and stress sustained throughout a person's lifetime. Therefore, they are considered interrelated whereas ossification exostosis represents an abrupt change because of a sharp injury at the attachment site. Because of this, for some parts of the study, robusticity and cortical defect were combined following previous studies such as Hawkey and Merbs, 1995; Peterson, 1998; Lieverse et al., 2009; Machicek, 2011). Ossification exostosis was left as an independent variable. Robusticity and cortical defect were then rescored and combined using the following standard.

Robusticity score of 0=0
Robusticity score of 1=1
Robusticity score of 2=2
Robusticity score of 3=3
Cortical Defect score of 0=0
Cortical Defect score of 1=4
Cortical Defect score of 2=5
Cortical Defect score of 3=6

Each individual was assessed for entheseal markings on the post-cranial skeleton at the 23 upper limb attachment sites. Robusticity, cortical defect and ossification exostosis were examined on both the left and right side of the upper limb. Results from both robusticity and cortical defect as well as data from both the left and right sides were then rescored and averaged for each individual muscle marker following Lieverse et al. (2009), as most independent samples, at least 50%, were deemed statistically insignificantly different.

Muscle Groups

Robusticity, cortical defect and ossification exostosis were also arranged into seven different muscle groups (Table 17) as it was hypothesized that biological stress due to labor or activity patterns might be more observable in groups rather than specific sites. They were arranged per types of movement including adduction, abduction, rotation, pronation, extension, flexion, and stabilization of the upper limb (Figure 4) (Gosling, 1994).

Table 17. Upper limb muscle groups based on entheseal attachment sites

MUSCLE GROUPS EXAMINED							
	MUSCLE GROUP 1	MUSCLE GROUP 2	MUSCLE GROUP 3	MUSCLE GROUP 4	MUSCLE GROUP 5	MUSCLE GROUP 6	MUSCLE GROUP 7
ATTACHMENT SITES	PECTORALIS MINOR SUBCLAVIUS TRAPEZIUS TRAPEZOID LIGAMENT CONOID LIGAMENT	PECTORALIS MAJOR LATISSIMUS DORSI TERES MAJOR CORACOBRACHIALIS	DELTOID SUPRASPINATUS	INFRASPINATUS TERES MINOR	TRICEPS BRACHII ANCONEUS COMMON EXTENSORS	COSTOCLAVICULAR LIGAMENT BICEPS BRACHII BRACHIALIS COMMON FLEXORS	PRONATOR TERES PRONATOR QUADRATUS SUPINATOR
BONES	CLAVICLE AND SCAPULA	HUMERUS	HUMERUS	HUMERUS	HUMERUS AND ULNA	CLAVICLE, HUMERUS, ULNA, RADIUS	RADIUS
FUNCTION	Stabilize pectoral girdle and reinforces joints	Adducts arm	Abducts arm	Rotates arm laterally	Extends forearm	Flexes forearm	Pronates and supinates the forearm
NUMBER OF TOTAL SITES RECORDED (n = 118)	2,309	1,866	934	930	1,400	1,858	1,408

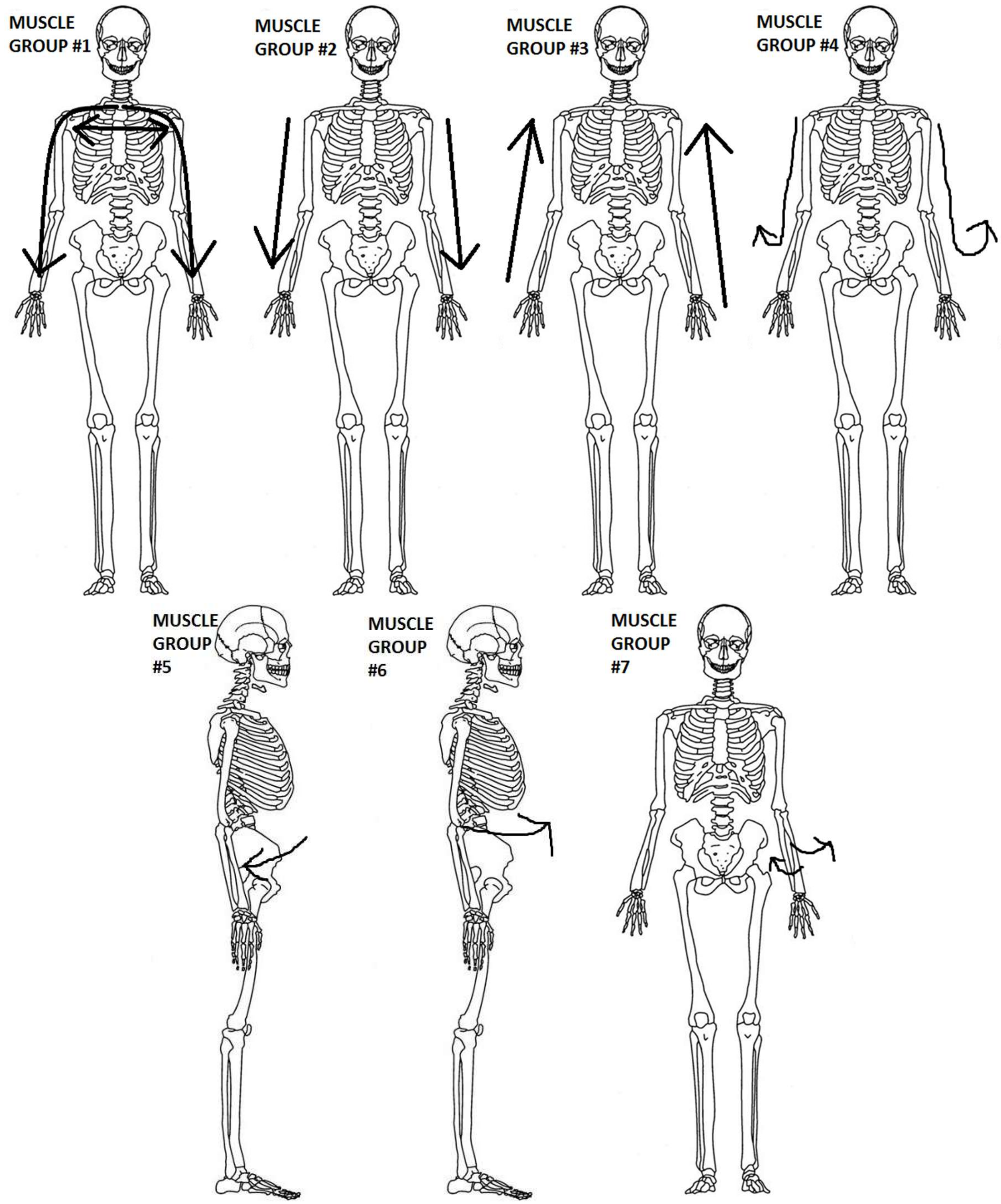


Figure 4. Anatomical movements performed by each muscle group

Osteoarthritis

For osteoarthritis, upper limb skeletal material was assessed macroscopically at three different joint sites; the acromioclavicular, shoulder and elbow (Table 18).

Table 18. Upper limb joint sites for osteoarthritis

JOINT	BONE	LOCATION
SHOULDER	Scapula	Glenoid Fossa
SHOULDER	Humerus	Proximal Humerus, Head
ACROMIOCLAVICULAR	Clavicle	Lateral Acromial End
ACROMIOCLAVICULAR	Scapula	Medial Acromion Process
ELBOW	Humerus	Distal Humerus, Trochlea
ELBOW	Humerus	Distal Humerus, Capitulum
ELBOW	Radius	Proximal Radius, Head
ELBOW	Ulna	Proximal Ulna, Olecranon Process

For this study, the goal is to include all possible indicators of abnormal remodeling and growth as a sign of osteoarthritis. Therefore, the prevalence and severity of osteoarthritis was based on five characteristics from Waldron and Rogers (1991) which includes eburnation, lipping, joint contour, porosity/pitting, and new bone formation (Table 19). For the joint to be consider osteoarthritic, two of the following instances must be present; osteophyte formation (e.g. lipping), joint contour deformation, porosity/pitting on the joint surface or new bone formation (ankyloses). The exception to this rule is the presence of eburnation (the destruction or cartilage and rubbing of bones) which is regarded as a supported criterion of osteoarthritis based upon previous literature (Waldron and Rogers, 1991).

Table 19. Osteoarthritis indicators

EBURNATION	A smoothing reaction in which bones rub against each other because of the loss of cartilage and create a shiny, ivory-like and waxy feel on the bone surface	
LIPPING ON BONE	The development of a bony overgrowth that oftentimes either extends from the bone or covers a portion of preexisting bone	
JOINT CONTOUR	The twisting and/or compression of the bone, could be minor or severe	
POROSITY AND PITTING ON BONE	The development of small holes or opening on the surface of the bone, in severe cases, the bone looks like it is eaten away or missing	

Table 19—Continued

NEW BONE FORMATION (ANKYLOSES)	The development of extra bone either extending from the bone or covers a portion of preexisting bone (oftentimes in conjunction with lipping)	

Each characteristic was then scored one of the following; no osteoarthritis, trace or minimal, minor, moderate, or severe (Waldron and Rogers, 1991) (Table 20).

Table 20. Osteoarthritis scoring methods

0	NO OSTEOARTHRITIS	Feature not visible
1	TRACE OR MINIMAL	Feature slightly visible by touch or observation (usually single locations)
2	MINOR	Feature visible on bone by touch or observation (single or multiple locations)
3	MODERATE	Feature visible and is adequately present on a good amount of bone
4	SEVERE	Feature is considerably present and covers a significant amount of bone

Statistical Methods

Entheseal changes and osteoarthritis were then analyzed using statistical tests in both Microsoft Office Excel version 2016 and SPSS versions 23 and 24. For entheseal changes and osteoarthritis, paired and unpaired t-tests and Mann-Whitney U tests were used to test for significant mean differences among the variables with two samples such as chronic and sudden/acute conditions, bilateral asymmetry, sex, and biological affinity, with a level of significance set at $p \leq 0.05$. For age, which was a three-sample test, significant mean differences were tested using one-way ANOVA with significance set at $p \leq 0.05$. Spearman's Correlation tests were used to examine ranked entheses category scores i.e. robusticity, cortical defect, and ossification exostosis with significance set at $p \leq 0.01$. Other non-statistical tests including rank ordering and frequency counts.

Analysis Methods

The overall results for the entheseal attachment sites were first analyzed per each attachment site and then combined and reanalyzed again based on anatomical muscle groups. Left and right sides were combined for each enthesis marker and muscle group but were separated by type of entheseal stress i.e. robusticity, cortical defect and ossification exostosis. Robusticity and cortical defect scores were compared side by side as they are often analyzed together because they are the result of long term and sustained activity whereas ossification exostosis represents an abrupt injury to the bone, as stated previously (Hawkey and Merbs, 1995), and was separated from the others. The entheses were then combined into seven muscle groups which were created according to corresponding muscle movements (Table 17). The same ranking procedures were employed based on the muscle groups as well with robusticity and cortical defect compared side by side. Spearman's Rho Correlations tests were used to track these trends among both specific entheseal attachments sites as well as muscle groupings.

Results for osteoarthritis joints were first analyzed per each joint site e.g. glenoid fossa, proximal humerus head etc. Then each of the sites were combined to their corresponding joint e.g. glenoid fossa and proximal humerus scores were combined to create the shoulder joint. Left and right sides were combined for each site and joint and analyzed using correlation and frequency tests.

Biological and Cultural Variables

The next chapter presents the results of the entheseal changes and osteoarthritis analyses. A portion of this research examines understanding entheseal and osteoarthritic stress between different sub-groups which were divided into variables such as ill-health status, directional and bilateral asymmetry, sex, age, and biological affinity. While skeletal methods can often be used to determine these variables, in this study, historical and demographic information was available. Records provided information on each individual's sex, stated age, biological affinity, place of origin and cause of death (Table 21).

Table 21. Sample size for demographic and cultural variables

VARIABLE	**GROUPINGS**	**SAMPLE SIZE FOR EACH**	**RESTRICTIONS**
ILL-HEALTH STATUS/CAUSE OF DEATH	CHRONIC AND SUDDEN/ACUTE	41 Chronic 11 Sudden/acute	No restrictions outside missing information which was excluded
DIRECTIONAL AND BILATERAL ASYMMETRY	LEFT AND RIGHT SIDES	118	No restrictions
GEOGRAPHIC ORIGIN	US BORN AND FOREIGN BORN	62 US Born 56 Foreign Born	No restrictions outside missing information which was excluded

Table 21—Continued

SEX	MALE AND FEMALES	47 females 71 males	No restrictions, uneven between the sexes due to sampling and more males than females in the collection
AGE	AGES 25-35 (Young adult) AGES 36-59 (Middle Adult) AGES 60-73 (Old Adult)	30 (25-35) 60 (36-59) 28 (60-73)	Ages were fixed between 25-75 to allow for entheseal formation and control somewhat for the aging process
BIOLOGICAL AFFINITY (RACE)	CAUCASIANS AND AFRICAN AMERICANS	73 Caucasians 45 African Americans	Excluded other 'races' due to lack of skeletal material

Biological Compensation to Ill-health Status

This section's research was carried out using selected individuals based on their state of ill-health (n=52, sudden/acute conditions, n=11 and chronic conditions n=41). Sudden/acute conditions were defined as those in which cause of death occurred quickly enough so that entheseal muscle markers would not or could not drastically change because of stagnant usage (Henderson, 2013). Examples include gun-shot wounds, hangings, sudden infections, accidents, and suicides. Chronic conditions, on the other hand, were defined as those in which case entheseal changes would more likely decrease over the course of the condition because of weakened muscle mass due to pathological forces such as pathogens or cellular conditions. Examples include tertiary syphilis, tuberculosis, malnutrition, and cancer (Table 22). While sex and age were not completely controlled for in this study, the table demonstrates that for age, the average age range for each condition minus the suicide category are within a ten to fifteen-year age range which is consistent with current aging practices for archaeological samples (Buiskstra and Ubelaker, 1994). Sex, however, was slightly skewed towards males over females due to the limitations of the sample and because of this, these preliminary results may change once a more robust sample is collected and analyzed.

Table 22. Sample size and demographic composition for ill-health status/cause of death

INDIVIDUALS RECORDED WITH DISCERNABLE TRAUMA			
TYPE OF TRAUMA	**n =**	**# OF MALES/FEMALES**	**AVERAGE AGE**
INFECTION ON BONE	2	F = 1 & M = 1	48.5 YEARS
FRACTURES	4	F = 0 & M = 4	56.5 YEARS
INDIVIDUALS RECORED WITH CHRONIC CONDITIONS			
CHRONIC CONDITION	**n =**	**# OF MALES/FEMALES**	**AVERAGE AGE**
TUBERCULOSIS	13	F = 3 & M = 10	37.46 YEARS
MALNUTRITION/ANEMIA	3	F = 2 & M = 1	42.67 YEARS
SYPHILIS (ALL STAGES)	14	F = 5 & M = 9	45.29 YEARS
CANCER	7	F = 5 & M = 2	46.14 YEARS
INDIVIDUALS RECORDED WITH SUDDEN CONDITIONS			
SUDDEN CONDITION	**n =**	**# OF MALES/FEMALES**	**AVERAGE AGE**
STROKE	3	F = 1 & M = 2	49.33 YEARS
ACCIDENT	2	F = 0 & M = 2	40.5 YEARS
GUNSHOT WOUND	2	F = 0 & M = 2	36 YEARS
SUICIDE	2	F = 0 & M = 2	27.5 YEARS
INFECTION	2	F = 0 & M = 2	49.5 YEARS

Standard methods for entheseal analysis were used (see methods above) and then tested with documented health status which was recorded for each individual as either cause of death (e.g. presence of chronic or sudden/acute conditions) or observed in the skeletal material (e.g. presence of healed or unhealed trauma).

Biological compensation to trauma was also observed as case studies for six specific individuals who demonstrated such trauma at time of death. This was examined by calculating the bilateral asymmetry from entheseal markers. It was evaluated by dividing the mean left side entheseal scores by the right-side scores and then multiplying it by 100 (Peterson, 1998). Results indicate either a left side bias, right side bias or no asymmetry between the sides. Those scores that are greater than 100 indicate a left side bias, scores under 100 indicate a right-side bias and scores that are exactly 100 demonstrate symmetry between both sides. Future research should clarify how this type of compensation impacts activity stresses on a population scale.

Directional and Bilateral Asymmetry

The analysis was carried out using two different population sample sizes. The beginning part of the chapter section analyzed the ranking and statistical differences among the left and right sides of entheses and osteoarthritis, using the entire (n=118) sample. The second part of the section calculated directional and bilateral asymmetry using a sub-sample (n=60) of the original sampled population. For each bone, entheseal attachments or osteoarthritis were divided into either the left or right side of the body. In order to get a relatively equal collection of individuals, none of the variables e.g. sex, age, biological affinity etc. were controlled for, however the sample sizes still allow for productive testing.

The first part of this section examined the ranking and significant differences among the left and right sides of the body. These protocols followed the same methods found above for data collection of entheses and osteoarthritis.

The second part of this section examined the directional and bilateral asymmetry on a smaller segment of the population. Directional asymmetry quantifies how far the bias between the left and right sides is on an individual or population level (Waidhofer et al., 2015). In this case, directional asymmetry will be used to understand how significantly biased each one is to either the left or right sides. For directional asymmetry, the maximum length was measured for each upper limb bone i.e. clavicle, humerus, radius and ulna and then averaged among the entire sample size. Directional asymmetry was then calculated by taking the right maximum length and subtracting the left maximum length, then dividing that score by the average of both left and right scores combined and multiplying it by 100 (Waidhofer et al., 2015). Results would indicate either a positive or negative value in which a positive value indicates right side asymmetry or a negative value indicates left side asymmetry (Waidhofer et al., 2015).

Bilateral asymmetry was also calculated per each individual of the sample. Bilateral asymmetry refers to the differences between the left and right sides of the body either individually or on a population level. In this case, bilateral asymmetry was used to not determine handedness but possibly examine work load difference among individuals and across the entire sample. Bilateral asymmetry was calculated using the robusticity scores of specific entheses sites. The calculation takes the mean left scores divided by the mean right scores and then multiplies the result by 100 (Peterson, 1998). Results that are less than 100 indicate a right-side bias, those that are over 100 indicate a left side bias, and the results that are equal to 100 indicate that there is symmetry between the left and right sides. Calculations for both directional and bilateral asymmetry were then reanalyzed among the population variables of sex, biological affinity, and geographic origin (defined as place of birth, inside or outside the United States) to consider if specific groups of individuals had similar or different responses to bilateral stress.

Sex

The analysis was carried out using all sampled individuals (n=72 males and n=46 females). While age was not completely controlled for in this section, there is a relatively even number of individuals of both young and older ages which averaged out the lower and higher degrees of stress found in the markers (confirmed by statistical tests). Biological affinity was also not controlled for due to the lack of a robust sample for African American females.[2]

Age

Age analysis was carried out using all sampled individuals (n=30 young adults, n=60 middle adults, and n=28 old adults). The young adult age category was defined as 25-35 years old which represents the beginning of the development of entheseal stress markers (Henderson et al., 2005). The middle adult age category was defined as 36-59 years old, representing middle age into menopause (for females) and one generation of occupations in Cleveland, as industries were constantly changing. Lastly, the old adult category was defined as 60-73 years old demonstrating the later years of an individual's life and those who have made it passed the average life expectancy and may have had different life experiences and occupational stress from other age groups (U.S. Census Bureau, 1999). Due to these reasons and the sampling methods utilized in this study, the age brackets are skewed towards middle adults. The implications of this will be discussed further in the discussion chapter of this study.[3]

Biological Affinity

The analysis for biological affinity was carried out using all sampled individuals (n=73 Caucasians and n=45 African Americans). Individuals were divided into these two categories based on country/place of birth in accordance with stated 'race' on the autopsy file. Other

---

[2] A robust sample is defined as $n \geq 30$, which allows for productive statistical testing (Hogg and Tanis, 2005).
[3] This study also does not address the issue of life expectancy in the United States at this time which was 47.3 years from birth in 1900. (U.S. Census Bureau, 1999) Future research will seek to create new age categories reflecting this to examine if and how the results are different.

variables such as sex and age were not controlled for in this study due to lack of complete samples in addition to sampling methods. Further research seeks to identify potential differences between Caucasians and African Americans separating out sex because both variables i.e. sex and biological affinity resulted in different social and economic experiences.

CHAPTER IV

RESULTS

Entheseal Changes

The overall results for the entheseal attachment sites were first analyzed in a separate section to understand activity and labor stress across a population level. From there, the results were then analyzed among the different variables to see how biological, social, and cultural constructs impacted activity pattern stresses in this sample.

Specific Entheseal Attachment Site Rankings

Table 23 below are the results for specific entheseal sites for robusticity and cortical defect for the entire sample. For robusticity, the highest enthesis mean scores was the pectoralis major (first), the brachialis (second) and the biceps brachii (third). All three of these attachment sites flex the elbow in some capacity and may demonstrate that physiologically, flexing the elbow is either a movement used in many different occupations or everyday anatomical movement that may not be impacted by occupation. The lowest mean entheses scores for robusticity were the coracobrachialis (ranked 21), supinator (ranked 22) and pronator quadratus (ranked 23), most of which focus on the pronation and supination of the forearm.

Cortical defect mean scores were ranked as follows: supraspinatus was first, costoclavicular was second, and brachialis was ranked third. All these attachment sites either stabilize other muscles/bones such as the costoclavicular or create a large range of movements such as flexing the arm (brachialis) or lifting the humerus over the head (supraspinatus). This may indicate that those are more frequently used movements which resulted in sharp, isolated incidents in which the muscle was unattached from the bone causing the pit. On the other hand, the lowest ranked scores for cortical defect were coracobrachialis, common flexors and anconeus, all ranked 21, and had no indications of any cortical defect and were not stressed enough to causing pitting and lesions.

Table 23. Robusticity and cortical defect rankings for entheses

ROBUSTICITY RESULTS				**CORTICAL DEFECT RESULTS**			
MUSCLE/ LIGAMENT	**RANK**	**ENTHESIS SCORE**	**NUMBER OF SITES PER MARKER**	**MUSCLE/ LIGAMENT**	**RANK**	**ENTHESIS SCORE**	**NUMBER OF SITES PER MARKER**
Pec. Major	1	2.922	226	Supraspin.	1	0.785	233
Brachialis	2	2.829	227	Costoclav.	2	0.752	233
Biceps Br.	3	2.770	228	Brachialis	3	0.559	227
Comm. Ext.	4	2.732	228	Pec. Major	4	0.231	226
Deltoid	5	2.632	236	Teres Major	5	0.223	233
Conoid Lig.	6	2.631	236	Trapezoid	6	0.219	232
Supraspin.	7	2.570	233	Biceps Br.	7	0.195	228
Costoclav.	8	2.539	233	Infraspin.	8	0.094	234
Trapezoid	9	2.526	232	Teres Minor	9	0.056	234
Teres Major	10	2.493	233	Pron. Teres	10	0.051	233
Trapezius	11	2.487	233	Latiss Dorsi	11	0.047	234
Pron. Teres	12	2.451	233	Deltoid	12	0.034	236
Pec. Minor	13	2.364	234	Trapezius	13	0.033	233
Teres Minor	14	2.215	232	Subclavius	14	0.026	235
Triceps Br.	15	2.183	232	Comm. Ext.	15	0.025	228
Comm. Flx.	16	2.149	234	Triceps Br.	16	0.017	232
Anconeus	17	2.145	234	Pron. Quad.	16	0.017	234
Infraspin.	18	2.098	234	Conoid Lig.	18	0.013	236

Table 23—Continued

Latiss. Dorsi	18	2.098	234	Pec. Minor	19	0.008	234
Subclavius	20	1.823	235	Supinator	19	0.008	235
Coracobrac	21	1.811	235	Coracobrac.	21	0	235
Supinator	22	1.808	235	Comm. Flx.	21	0	235
Pron. Quad.	23	1.491	234	Anconeus	21	0	234

While the ranking scores between robusticity and cortical defect are not identical, there are some similar elements between the two. For example, pectoralis major was ranked first for robusticity but also ranked number 4 in cortical defect. Brachialis was ranked second in robusticity and third in cortical defect. The same can be said for the lower ranked markers as well. The coracobrachialis and supinator in both robusticity and cortical defect had low scores. The similarities demonstrate the possibility that these entheses sites are not utilized as often and over a longer period of time than other sites which are ranked differently among the two categories. It can also point to attachment sites which receive the most stress from upper limb activity. Lower enthesis scores can also mean that those attachment sites are either not as used as often compared to other sites. However, it is also possible that the rankings demonstrate physiological difference in attachment sites between two categories. For example, the difference in ranking between the robusticity and cortical defect such as the deltoid (ranked 5 in robusticity and 12 in cortical defect) and conoid ligament (ranked 6 in robusticity and 18 in cortical defect).

Entheseal means results were also examined and scored for ossification exostosis. High ranking mean scores were very similar to the scores from the robusticity category. In the ossification exostosis analysis, the top three attachment sites were first pectoralis major, second biceps brachii and third, brachialis. This follows the overall trend of the robusticity category top three except for the brachialis which was ranked second and biceps brachii third. Therefore, even though ossification exostosis represents a strong quick change in the bone versus the long term build up found in robusticity, there are some similarities among the two. This suggests that some attachment sites are either used more frequently over an individual's lifetime or some sites react to muscle movement stress in different ways.

Table 24. Ossification exostosis rankings for entheses

OSSIFICATION EXOSTOSIS RESULTS			
MUSCLE/ LIGAMENT	**RANK**	**ENTHESIS SCORE**	**NUMBER OF SITES PER MARKER**
Pec. Major	1	1.673	226
Biceps Br.	2	1.561	228
Brachialis	3	1.491	227
Comm. Ext.	4	1.409	228
Deltoid	5	1.354	236
Conoid Lig.	6	1.328	236
Supraspin.	7	1.188	233
Costoclav.	8	1.154	233
Teres Major	9	1.124	233
Trapezoid	10	1.083	232
Trapezius	11	1.038	233
Pron. Teres	12	0.991	233
Pec. Minor	13	0.961	234
Teres Minor	14	0.870	234
Triceps Br.	15	0.824	232
Infraspinatus	16	0.785	234
Comm. Flx.	17	0.717	234
Anconeus	18	0.713	234
Latiss. Dorsi	19	0.596	234
Subclavius	20	0.519	235
Coracobrach.	21	0.405	235
Supinator	22	0.382	235
Pron. Quad.	23	0.256	234

Low ranking scores were also similar among the robusticity and ossification exostosis categories. In ossification exostosis, the lowest scores were coracobrachialis (rank 21), supinator (rank 22) and pronator quadratus (rank 23). These scores align perfectly with the ranking method in robusticity as coracobrachialis, supinator, and pronator quadratus were ranked 21,22 and 23 respectively in that category. Again, this may indicate that certain attachment sites are used less than others over all three categories or they also may be collective outliers from the sample size.

Specific Entheseal Attachment Site Correlations

In order to understand the degree to which each category relates to the others, the mean rankings from each category were correlated with one another to observe the trends and distributions of each category. The results, indicated in Figure 45, of the appendix, demonstrate statistically significantly different positive correlations among each category and that each category in relation to the others increase on a consistent linear plane (Figure 5).

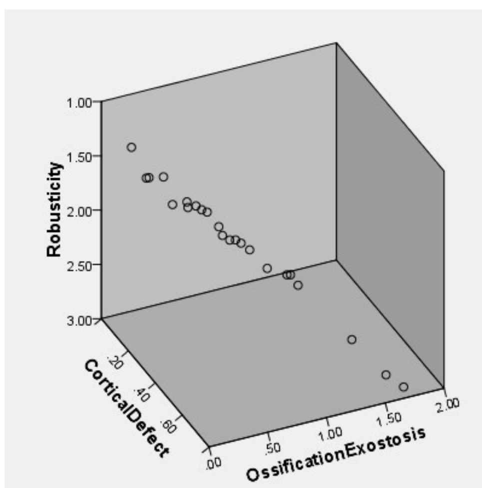


Figure 5. Correlation among entheses between robusticity, cortical defect and ossification exostosis

These results reconfirm previous research about entheseal stress and its positive correlation among all three categories. However, these results also demonstrate the distribution of mean ranked scores among all three categories in this sample from the Hamann-Todd. In this sample, there is a clear linear progression of ranking scores but there is a cluster of scores near the upper left section of Figure 5. This demonstrates that among this sample, some of the mean rank scores are similar among each category, which is expected given the numerical mean results. The following sections will examine and extrapolate possibilities for this cluster of scores and whether similar trends hold among different factors such as sex, age, and biological affinity.

Muscle Group Entheseal Attachment Site Rankings

The entheses were then combined and re-averaged and ranked per corresponding muscle group. Tables 25 and 26 below list out the mean score for each muscle group among robusticity, cortical defect and ossification exostosis. For robusticity, the highest mean scores were found in muscle group #3 (first) and group #6 (second) (see Table 17 and Figure 4) which abducts the arm and flexes the forearm respectively. The lowest ranking scores were group #4 (sixth) and group #7 (seventh) which rotate the arm laterally and pronates and supinates the forearm. Cortical defect results were similar among the higher but not the lower ranking scores. Again, muscle groups #3 (first) and #6 (second) had the highest ranked means just like in robusticity. However, muscle group #7 (sixth) and muscle group #5 (seventh) were ranked as the lowest scores, both of which move the forearm and are unlikely to have high levels of cortical defect as they extend and twist the arm rather than lift or lower the arms.

Table 25. Robusticity and cortical defect rankings for muscle groups

ROBUSTICITY RESULTS				CORTICAL DEFECT RESULTS			
MUSCLE GROUP	RANK	ENTHESIS SCORE	NUMBER OF SITES PER GROUP	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE	NUMBER OF SITES PER GROUP
Group #3	1	2.701	469	Group #3	1	0.409	469
Group #6	2	2.591	922	Group #6	2	0.376	922
Group #1	3	2.276	1170	Group #2	3	0.125	928
Group #5	4	2.378	694	Group #4	4	0.075	468
Group #2	5	2.301	928	Group #1	5	0.059	1170
Group #4	6	1.986	468	Group #7	6	0.025	702
Group #7	7	1.916	702	Group #5	7	0.014	694

The similarities among the first and second place ranking among robusticity and cortical defect demonstrate that out of the seven muscle groups, #3 and #6 seem to have highest degree of repetitive entheseal stress. This trend holds true for the mean ranking results for ossification exostosis. The highest mean ranked scores were found in muscle group #3 (first) and muscle group #6 (second). The lowest ossification exostosis scores matched up with the lowest robusticity scores with muscle group #4 ranked sixth and muscle group #7 ranked seventh. Similar to the high-ranking scores of all three categories in groups #3 and #6, it seems that group #4 and group #7 have the lowest amount of entheseal stress associated with them in both robusticity and ossification exostosis. This is very likely the result of the fact that those muscles deal with more fine motor movements rather than heavy repetitive stresses which is found in other categories such as muscle group #3.

Table 26. Ossification exostosis rankings for muscle groups

OSSIFICATION EXOSTOSIS RESULTS			
MUSCLE GROUP	**RANK**	**ENTHESIS SCORE**	**NUMBER OF SITES PER GROUP**
Group #3	1	1.422	469
Group #6	2	1.185	922
Group #5	3	1.026	1170
Group #2	4	0.927	694
Group #1	5	0.862	928
Group #4	6	0.749	468
Group #7	7	0.543	702

Muscle Group Entheseal Attachment Site Correlations

Mean rankings from each muscle group were also correlated with each entheseal stress category to understand the trends and distributions of each muscle group ranking. Each category was correlated with the remaining two using Spearman's Correlation tests. The results, indicated in Figure 46 in the appendix, demonstrate more statistically significantly different positive correlations among each category and that each category in relation to the others increases on a consistent linear plane (Figure 6).

These results are consistent with specific muscle attachment sites as both datasets have a statistically significantly different positive correlation among all three categories. These results also demonstrate the distribution of mean ranked scores among all three categories in this sample. The linear progression of ranking scores is visible but is not as clear as the specific attachment sites correlation hence the difference among the p values, $p = 0.000$ for specific sites and $p = 0.007$ for muscle groups. The scatter points in Figure 6 also demonstrate a wide range of mean scores among each category except for the top center two points which represent the highest mean ranked values among each category which was confirmed in the tables to be muscle group #3 and muscle group #6 which abducts the arm and flexes the forearm. Further research in the following sections will examine if muscle groups #3 and #6 have the highest ranked scores among different variables such as sex, age and biological affinity which would provide more evidence for the suggestion that there are some attachment sites and muscle groups that are more prone to entheseal stress than others.

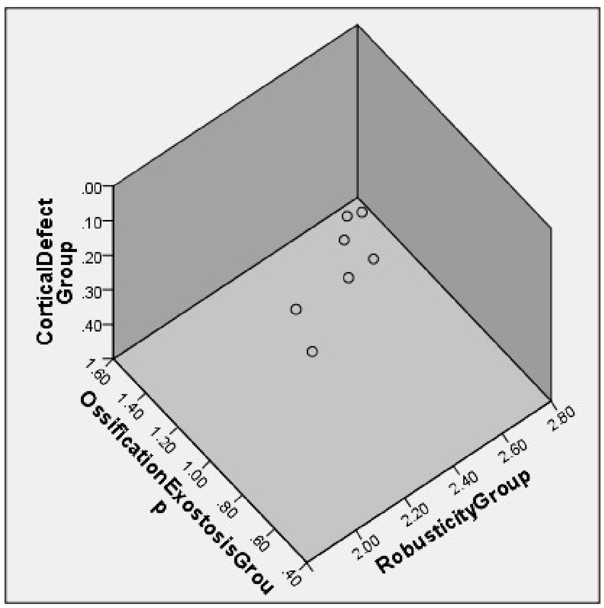


Figure 6. Correlation among muscle groups between robusticity, cortical defect and ossification exostosis

Osteoarthritis

The overall results for the osteoarthritis were also analyzed to understand activity and labor stress across a population level. From there, the results were then analyzed among the different variables to see how biological, social, and cultural constructs impacted activity pattern stresses in this sample.

Osteoarthritis Site Rankings

For the eburnation results, the medial acromion process of the scapula has the highest results (Table 27). However, all the joints examined contained at least one example of eburnation at each site apart from both the proximal humeral head and the olecranon process of the ulna which had no instances of eburnation at all. An examination of the lipping results demonstrates a more even distribution among the results compared to the eburnation. In this case, the glenoid fossa had the highest instances of bone lipping whereas the trochlea of the humerus and the proximal head of the radius had the lowest scores. Despite the ranking, it seems that in this sample, the average scores for each joint site has an osteoarthritic score of between one and two for lipping, demonstrating that out of the five different osteoarthritis indicators, there seems to be a consistent distribution of lipping across the sample.

Table 27. Eburnation and lipping rankings for osteoarthritis

EBURNATION RESULTS				**LIPPING RESULTS**			
JOINT SITE	**JOINT**	**RANK**	**OSTEOARTH. SCORE**	**JOINT SITE**	**JOINT**	**RANK**	**OSTEOARTH. SCORE**
MAP	ACRO	1	0.090	GLF	SHOU	1	1.770
LAC	ACRO	2	0.075	LAC	ACRO	2	1.687
DHC	ELB	3	0.073	MAP	ACOR	3	1.686
PRR	ELB	4	0.036	PRH	SHOU	4	1.545
DHT	ELB	5	0.0181	PRU	ELB	5	1.540
GLF	SHOU	6	0.0180	DHC	ELB	6	1.479
PRH	SHOU	7	0	DHT	ELB	7	1.345
PRU	ELB	7	0	PRR	ELB	8	1.312

Joint contour was also ranked according to joint site and it seems that the medial acromion process of the scapula and the lateral acromial end of the clavicle have significantly higher scores than the rest of the joint sites (Table 28). This observation was tested for statistical significance and was found to be significantly different at p= 8.63E-05. It is very likely that the data demonstrate the possibility that the acromioclavicular joint experienced more twisting and torsion because of high stress labor in the upper limb, e.g. lifting and/or carrying heavy objects and materials. This possible pattern is less discernable based on the porosity/pitting results. In this case, the same locations from the acromioclavicular joint have the highest ranked mean scores. However, after the top two ranked scores, the distribution of joint sites between the shoulder and elbow joints seem to be more evenly spread, in which both the shoulder and the elbow joints have both high and low pitting scores. It is possible that some sections of the bone may be more prone to pitting versus other indicators.

Table 28. Joint contour and porosity/pitting rankings for osteoarthritis

JOINT CONTOUR RESULTS				**POROSITY/PITTING RESULTS**			
JOINT SITE	**JOINT**	**RANK**	**OSTEOARTH. SCORE**	**JOINT SITE**	**JOINT**	**RANK**	**OSTEOARTH. SCORE**
MAP	ACRO	1	1.300	LAC	ACRO	1	1.725
LAC	ACRO	2	1.274	MAP	ACRO	2	1.450
GLF	SHOU	3	0.752	DHC	ELB	3	1.200
DHC	ELB	4	0.593	GLF	SHOU	4	1.162
PRU	ELB	5	0.550	PRR	ELB	5	0.891
DHT	ELB	6	0.468	PRU	ELB	6	0.850
PRR	ELB	7	0.303	PRH	SHOU	7	0.754
PRH	SHOU	8	0.286	DHT	ELB	8	0.636

The last type of osteoarthritis indicators that was examined and scored was the creation of new bone at the joint site, also known as ankyloses (Table 29). Again, the lateral acromial end of the clavicle and the medial acromion process were ranked in the top two, demonstrating that the acromioclavicular joint has the most osteoarthritis overall. For the lower ranked scores, the proximal ends of both the radius and the humerus were again ranked the bottom two consistent with the rankings for the other types of osteoarthritis.

Table 29. New bone rankings for osteoarthritis

NEW BONE RESULTS			
JOINT SITE	**JOINT**	**RANK**	**OSTEOARTH. SCORE**
LAC	ACRO	1	1.241
MAP	ACRO	2	1.231
GLF	SHOU	3	1.063
DHC	ELB	4	0.990
DHT	ELB	5	0.827
PRU	ELB	6	0.813
PRR	ELB	7	0.592
PRH	SHOU	8	0.581

Ultimately, the ranks for the highest scores among each type of osteoarthritis were relatively consistent in that both joint sites of the acromioclavicular ranked first and second. The only exception was for lipping, the glenoid fossa ranked first, followed by the acromioclavicular sites. As for the lower scores, there was some variation between shoulder and elbow joint sites however, when quantified, the elbow joint overall ranked lower. This is consistent with the results of the overall entheseal attachment scores which shows higher wear patterns on the upper bones i.e. clavicle, scapula and humerus rather, than those found on the forearm.

Osteoarthritis Joint Rankings

The joint sites were combined for each joint and re-ranked accordingly. The results mimic those found when joint sites were separated in which the acromioclavicular joint was ranked highest and the elbow was ranked last (Table 30). These results demonstrate that on the upper limb, there are higher amounts of stress at the top of the upper limb at the clavicle, scapula and humerus whereas there are lower amounts of entheseal and osteoarthritic stress at the elbow and forearm. Therefore, associated labor patterns and frequencies may be more top heavy rather than distributed evenly across the entire upper limb. [4]

Table 30. Osteoarthritis joint rankings

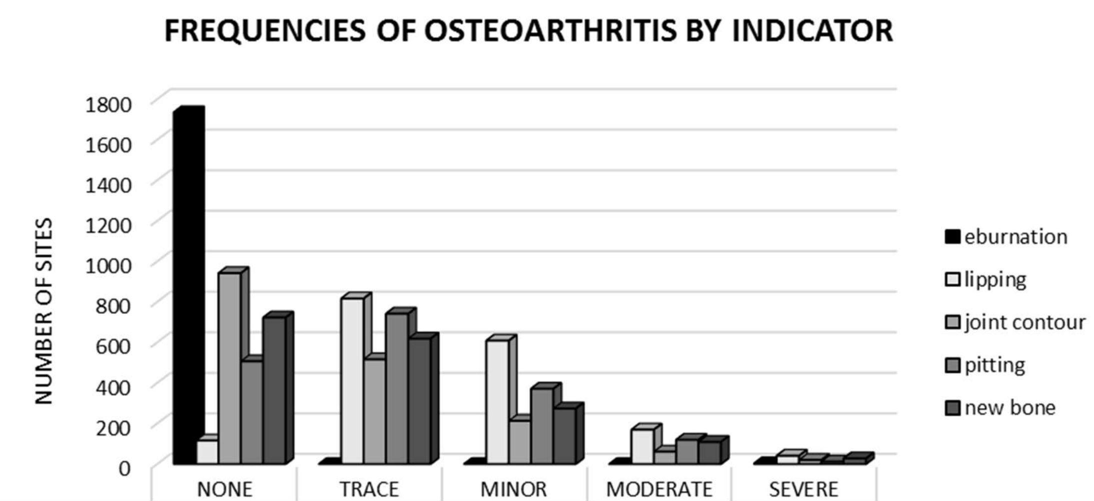
JOINT LOCATION RANKING		
JOINT	**RANK**	**OSTEOARTHRITIS SCORE**
ACRO-CLAV	1	1.175
SHOULDER	2	0.794
ELBOW	3	0.725

Frequencies of Osteoarthritis

Frequencies for osteoarthritis were calculated on a population level based on each of the five indicators; eburnation, lipping, joint contour, pitting and new bone. The results, shown in Figure 7, demonstrate that all the osteoarthritic indicators except for lipping have the highest frequencies in the absent/none column. Lipping, on the other hand, had the highest frequencies in the trace column demonstrating that most individuals in the sample had some sort of trace lipping on their upper limb joints. Moreover, most osteoarthritic occurrences in the sample where either trace or minor with fewer sites found in the moderate and severe categories. Based on the raw data collected, those individuals who had a moderate or severe score for one part of the joint, often had a similar score on the rest of the joint. For example, individuals who scored a 3 or 4 for

[4] Unlikely caused by uneven sample sizes are the shoulder and acromioclavicular joints sites roughly equal the same number of sites scores for the elbow joint

the glenoid fossa of the scapula, tended to have a 3 or 4 for the proximal head of the humerus. Because of this, the number of sites scored in the moderate and severe categories of osteoarthritis tend to be from a select group of individuals. Future case studies would be able to separate those individuals with a high amount of osteoarthritis.



	NONE	TRACE	MINOR	MODERATE	SEVERE
eburnation	1736	0	0	0	4
lipping	116	817	609	170	41
joint contour	942	517	213	61	20
pitting	507	742	372	120	12
new bone	723	619	274	109	28

Figure 7. Frequencies of osteoarthritis per indicator

Ill-Health Status/Cause of Death

This section focuses on preliminary research which takes a comparative approach towards understanding human biological compensation patterns as evidenced in individuals of historically documented health status and cause of death. Individuals with ‘sudden/acute’ causes of death (under the baseline assumption of a ‘normal’ activity load throughout life) were compared to those who were known to have suffered more prolonged or ‘chronic’ conditions which may have impacted entheseal robusticity patterning because of non-usage or weakened muscle mass. The aim of this section was to identify, if possible, potential compromises in entheseal changes among the Hamann-Todd sample because of ill-health status and traumatic injury.

Results indicate that while there are a few instances of biological compensation to pathology and trauma within and between each of the muscle groups, most demonstrate statistically insignificant differences between individuals of both sudden/acute and chronic conditions. The charts below represent the mean comparison for both sudden/acute and chronic individuals among both attachment sites as well as each of the muscle groups.

Specific Entheseal Attachment Site Rankings

Table 88 in the appendix examines the statistical differences among specific attachment sites between chronic and sudden/acute condition mean scores. The findings demonstrate that there is an even distribution of higher mean scores between the chronic and sudden/acute health conditions. This suggests that biological stress from specific entheseal markers may not be as impacted from health status as originally thought. As a result, ill-status individuals may not have to be removed from a sample when analyzing patterns of entheseal stress. The other possibility could be that in this sample set, individuals with ill-health continued to be impacted by habitual anatomical movements up until time of death despite their health status.

Left and Right Separate

When each muscle attachment was separated out based on the left or right side of the body, only three out of the 138 sites were deemed statistically significantly different, about 2.1%

(Table 31). In this case, two out of the three were in the cortical defect category and last one was in the robusticity category. Both cortical defect sites showed that the sudden/acute health conditions had the higher mean scores whereas the robusticity score, found on the pronator quadratus, shows a higher mean score for those individuals who had chronic health conditions. This suggests that chronic health conditions may not impact entheses longevity as originally hypothesized. In other words, entheseal stresses did not start to disappear because of a pathological condition.

Table 31. Results of the Mann-Whitney U Test for differences among left and side sides between chronic and sudden/acute conditions

NUMBER	SITE	TYPE AND SIDE (L/R)	p VALUE	AVG. CHRONIC CONDITIONS	AVG. SUDDEN/ACUTE CONDITIONS
1	Costoclav.	Cor. Def (R)	0.018	0.74	1.81
2	Brachialis	Cor. Def (R)	0.036	0.59	1.18
3	Pro. Quad	Robust (L)	0.054	1.43	1.00

Left and Right Combined

Once the left and right scores for each attachment site were combined, there was a greater number of significant values between chronic and sudden/acute health status individuals about six out of 69 or 8.6% of the markers (Table 32). The subclavius and two supraspinatus groups (i.e. robusticity and cortical defect) were now considered significant once both left and right side scores were combined. In this grouping, there were four cases of cortical defect and two cases of robusticity. While only one of the markers from the last group had a higher mean for chronic conditions, in this grouping, four out of the six had higher mean scores. This suggests that some attachment sites are more prone to higher amounts of entheseal stress versus other attachment sites especially since robusticity and cortical defect both represent a long-term development of activity stresses.

Table 32. Results of the Mann-Whitney U Test for differences with combined left and right sides between chronic and sudden/acute conditions

NUMBER	SITE	TYPE	p VALUE	AVG. CHRONIC CONDITIONS	AVG. SUDDEN/ACUTE CONDITIONS
1	Costoclav.	Cortical Def	0.011	0.60	1.40
2	Subclavius	Cortical Def	0.083	0.04	0.00
3	Supraspin.	Robusticity	0.041	2.62	2.36
4	Supraspin.	Cortical Def	0.029	0.945	0.636
5	Brachialis	Cortical Def	0.024	0.567	1.090
6	Pro. Quad	Robusticity	0.007	1.567	1.190

Robusticity and Cortical Defect Combined, Left and Right Separate

In order to consider if the specific muscle sites were in themselves significant, both robusticity and cortical defect were reanalyzed and combined per each group and a separate t-test was carried out using rescored values. The results match the original t-test constructed for specific attachment sites on both the left and right sides of the body, three out of 46 (6.5%) (Table 33). The costoclavicular, brachialis and pronator quadratus were still considered statistically significantly different on both the left or the right side. In this case, the right side tends to be more significant among the two health status groups but it is likely that those differences are a product of bilateral asymmetry such as handedness or activity patterns that favor the right side over the left side. Again, the pronator quadratus has a higher mean score among the chronic conditions rather than the sudden/acute ones.

Table 33. Results of the 2 tailed, unpaired t-tests for differences with combined robusticity and cortical defect, left and right sides separate between chronic and sudden/acute conditions

NUMBER	SITE	SIDE (L/R)	p VALUE	AVG. CHRONIC CONDITIONS	AVG. SUDDEN/ACUTE CONDITIONS
1	Costoclav.	Right	0.036	2.30	3.36
2	Brachialis	Right	0.044	2.50	3.13
3	Pro. Quad	Left	0.054	0.71	0.50

Robusticity and Cortical Defect Combined, Left and Right Combined

Lastly, the right and left sides were again combined distinguishing those values even further in which those would be considered more statistically significantly different than the previous ones. The results indicate that only one specific attachment site, the pronator quadratus, had statistically significantly different values (Table 34). While it is uncertain why the pronator quadratus has a higher chronic mean score, it suggests that chronic health status individuals were could have been using some of their entheseal markers while ill or that health status does not impact the markers as significantly as it was previously hypothesized.

Table 34. Results of the 2 tailed, unpaired t-tests for differences with combined robusticity and cortical defect, left and right sides combined between chronic and sudden/acute conditions

NUMBER	SITE	p VALUE	AVG. CHRONIC CONDITIONS	AVG. SUDDEN/ACUTE CONDITIONS
1	Pro. Quad	0.044	0.78	0.59

Muscle Group Entheseal Sites

The specific attachment sites were then combined into one of the seven muscle groups as multiple muscle and ligament sites work together to create different activity patterns and movements. The results for both tests indicate that there were no significantly different values among the muscle groups between chronic and sudden/acute conditions. Left and right scores were separated for each group for a total of zero out of 14 and once combined, the other test showed a final score of zero out of seven. The distribution of mean scores among each muscle group was plotted in Figures 8 and 9.

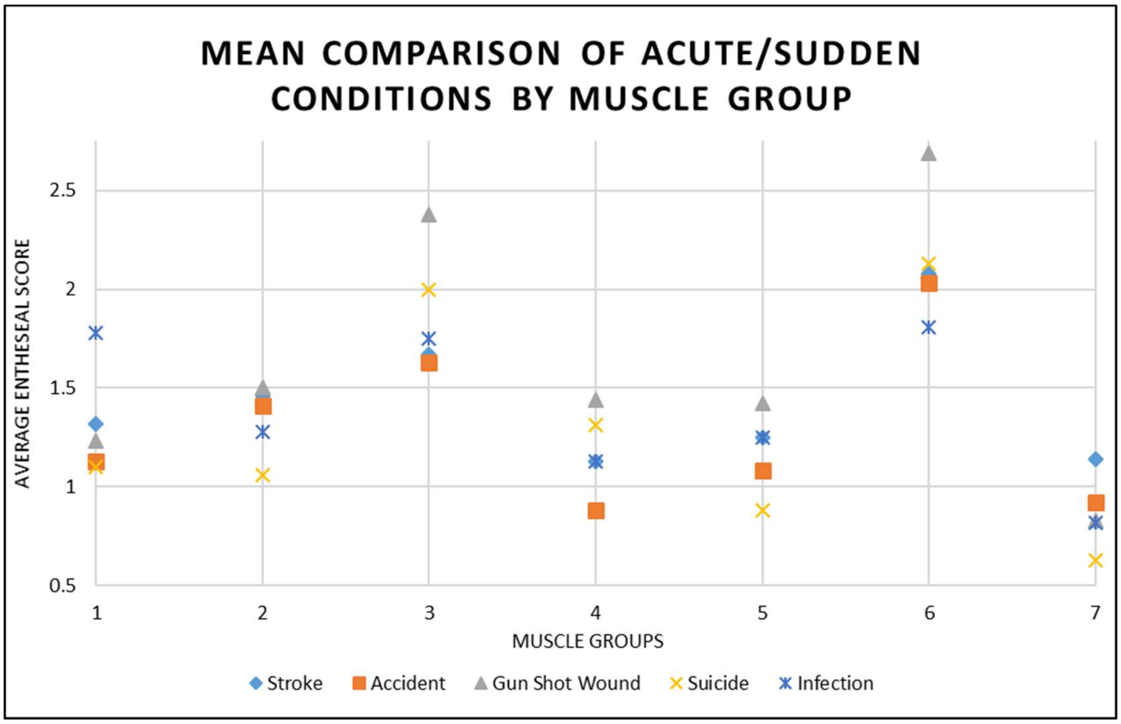


Figure 8. Mean comparisons of sudden/acute conditions per muscle group

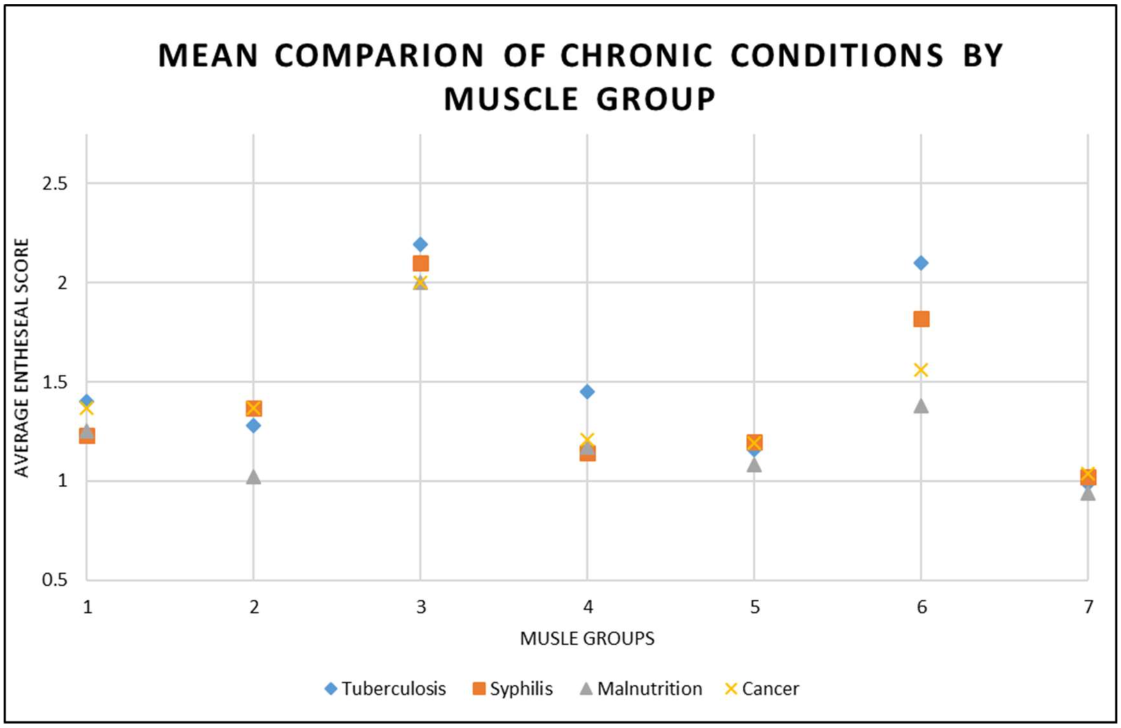


Figure 9. Mean comparisons of chronic conditions per muscle group

Both the chronic and sudden/acute groups seem to follow a consistent pattern among all the muscle groups, with muscle groups #3 and #6 having the highest average scores. There are some differences associated with certain conditions or causes of death such as the higher results among individuals with gunshot wounds yet that was not statistically significantly different between the two health statuses. It is likely that these patterns demonstrate possible physiological impacts among each muscle group rather than compensation to chronic pathological conditions or are influenced by the small sample size.

Bilateral Asymmetry Compensation to Traumatic Injury

Even though the majority of the comparisons among the sudden/acute and chronic categories regarding entheseal changes are statistically insignificantly different, a few specific examples of biological compensation were identified regarding traumatic injury and infection. These were excluded from the other analyses above since their pathological conditions would create biased results. Figure 10 demonstrates the degree of bilateral asymmetry found in the seven specific individuals who had either healed fractures or bone infections. Each individual is discussed below along with the evidence of bilateral compensation due to trauma or infection.

MUSCLE GROUPS AND COMPENSATION	INDIVIDUAL 1	INDIVIDUAL 2	INDIVIDUAL 3	INDIVIDUAL 4	INDIVIDUAL 5	INDIVIDUAL 6	INDIVIDUAL 7
TRAUMA LOCATION AND SIDE OF BODY	**FRACTURES** RIGHT CLAVICLE AND HUMERUS	**INFECTION** RIGHT CLAVICLE	**FRACTURE** LEFT CLAVICLE	**FRACTURE** LEFT CLAVICLE	**INFECTION** LEFT HUMERUS	**FRACTURE** LEFT RADIUS	**FRACTURE** RIGHT RADIUS
MUSCLE GROUP #1	▲ 90.48	■ 163.64	■ 115.38	● 100	■ 109.09	▲ 92.30	▲ 75
MUSCLE GROUP #2	■ 136.36	▲ 90	● 100	▲ 61.54	● 100	▲ 93.75	■ 111.11
MUSCLE GROUP #3	● 100	▲ 90	■ 200	■ 111.11	● 100	■ 166.67	▲ 80
MUSCLE GROUP #4	● 100	▲ 50	■ 175	▲ 75	▲ 80	● 100	■ 120
MUSCLE GROUP #5	▲ 87.5	▲ 66.67	▲ 75	■ 114.29	▲ 66.67	▲ 88.89	● 100
MUSCLE GROUP #6	▲ 40	● 100	▲ 48	■ 105.26	▲ 58.82	● 100	■ 144.44
MUSCLE GROUP #7	▲ 87.5	▲ 45.45	▲ 83.33	■ 120	▲ 83.33	● 100	■ 137.5
EVIDENCE OF BILATERAL COMPENSATION?	YES	YES	NO	POSSIBLE	POSSIBLE	POSSIBLE	POSSIBLE
WHICH MUSCLE GROUP?	GROUP #2	GROUP #1	CONTINUED USE OF LEFT SIDE IN GROUP #1	USE OF LEFT AND RIGHT SIDES IN GROUP #1	USE OF LEFT AND RIGHT SIDES IN GROUP #2/#3	USE OF LEFT AND RIGHT SIDES IN GROUPS #6/#7	USE OF LEFT SIDE IN GROUP #6/#7, MAY BE LEFT HANDED

KEY
TRIANGLE = RIGHT
SQUARE = LEFT
CIRCLE = SYMMETRICAL

Figure 10. Case studies of biological compensation to trauma and infection

Individual I

Individual I was a Caucasian male, aged 50. He displayed healed fractures on both the right clavicle and humerus (shown in Figures 11 and 12) Based on the bilateral asymmetry calculations using entheseal changes, he demonstrated biological compensation to those fractures by using the alternate side of the body. Muscle group #2, which contains the humerus where the fracture would be present, had a high left side bias score. All the other scores were either symmetrical or right side biased. Therefore, he compensated for a broken humerus for some time since the majority of the other muscle groups have significantly lower scores under 100 which indicate a right-side bias and that enough time had passed for him to develop a strong left-side bias for muscle group #2. Since muscle group #2 is responsible for the adduction of the arm, it is likely that the break and subsequent compensation may have been the result of a high stress related activity.

Figure 11. Individual I right humerus fracture

Figure 12. Individual I right clavicle trauma

Individual II

Individual II was a Caucasian male, aged 55. He had a bone infection, possibly an abscess on the right clavicle (Figure 13). Like individual I, the bilateral asymmetry calculations demonstrated another clear instance of compensation due to pathology. Muscle group #1 which contains the clavicle had a strong left bias score. This score is an outlier when compared to this individual's other asymmetry scores which show lower numbers, demonstrating a higher right-side bias. Therefore, it is likely that the individual had this infection for an extended period of time as it took time to build up the entheseal stress markers to shift the asymmetry in the bones from the right to left side. It is also possible that the rest of the makers were subtly shifting to a left side bias as well. For example, muscle groups #2 and #3 which would use group #1 to help raise and lower the arm both have a borderline symmetry score of 90. These scores are quite different from the other right side biased scores which are lower numbers under 50.

Figure 13. Individual II right clavicle infection

Individual III

Individual III was a Caucasian male, aged 53. He had a fracture on his left clavicle. Unlike the previous examples, this individual continued to utilize the left side of his body rather than compensate for the trauma. Muscle group #1 demonstrates a strong left side bias score. An assumption can be made that he probably had a left side bias overall at the top portion of the upper limb since muscle group #3 and #4 scores which are responsible for large scale movement show high left side bias scores. Overall, it seems that the individual continued to use the left side despite the break or that the individual did not perform enough activity to necessitate compensation.

Individual IV

Individual IV was a Caucasian male, aged 60. He displayed a healed fracture on his left clavicle which was not completely realigned and caused some shortening of the bone (Figure 14). The length of the left clavicle was 129.41mm compared to his right clavicle which was 150.54mm. Bilateral asymmetry results demonstrate the possibility that he could have been compensating for the shorten clavicle, however it is unclear whether this is the case because muscle group #1 shows a perfect symmetry between the left and the right sides of the body. Most of his other markers indicate that he more than likely has a left side bias overall. An argument could be made that perhaps this individual was in the process of compensating for this break as the score in muscle group #1 is the third lowest score overall. However, since the pattern is not completely clear, this individual is only a possible, not a definite case for compensation.

Figure 14. Individual IV left clavicle fracture

Individual V

Individual V was a Caucasian female, aged 42. She has a possible infection on the distal end of her left humerus indicated in Figure 15. Like the previous case study, both muscle groups #2 and #3 which feature the humerus have symmetrical scores of 100 each. Despite this, all her other markers, apart from muscle group #1, demonstrate a strong right-side bias. The clavicle is the only bone which showed a slight left side bias. Therefore, it is possible that she compensated for the break but it is extremely unlikely as she already had a right-side bias and would not have needed to compensate for the trauma by using the alternate upper limbs.

Figure 15. Individual V left humerus infection

Individual VI

Individual VI was a Caucasian male, aged 63. He had either a fracture that healed or a strong force caused the bone to bend at his left radius (Figure 16). Whether compensation occurred is uncertain as muscle groups #6 and #7 which look at the entheses on the radius have perfect symmetrical scores of 100 each. Despite this, the other muscle groups primarily demonstrate a right-side bias with one slight left side bias at muscle group #3. It is unclear then whether he used one side of the body over the other as three of the seven muscle groups have perfect symmetrical scores. Therefore, this individual may have compensated but not enough time has passed for this to be clearly demonstrated.

Figure 16. Individual VI left radius fracture

Individual VII

Individual VII, was a Caucasian male, aged 55. It is possible that he had a fracture at the distal end of the right radius which may have developed into an infection as shown by the discoloration and bone growth in Figure 17. The bone is slightly shorter (204.90mm) than the left radius (217.51mm). This case is a possible example in which the individual damaged the perceived non-dominant side of the body. For example, individual #7 shows a left side bias in both muscle groups #6 and #7. However, some of the other muscle groups also demonstrate a left side bias perhaps indicating that he was left handed or used the left side of his body consistently. Therefore, a fracture and/or infection to the right side of the body would not show much compensation as it was not used as often as the left. Another possibility is that he completely compensated from the right to left side however since the fracture/infection at the right radius is not as drastic as other examined cases, this explanation is less likely.

Figure 17. Individual VII right radius fracture

Directional and Bilateral Asymmetry

This section includes the results and discussion based on the examination of bilateral and directional asymmetry from the Hamann-Todd sample. Previous studies have indicated the possibility of determining handedness from bilateral asymmetry within different populations (Steele, 2000). However, few studies have utilized directional and bilateral asymmetry to understand bias among workloads by using both maximum lengths and entheseal attachment sites (Peterson, 1998). Therefore, the first part of this section will examine the same format as previous section i.e. determining the ranking and significant differences among both entheseal sites and osteoarthritis. The second part then will examine directional and bilateral asymmetry to look for patterns that may imply work load bias among the entire population as well as some biological and cultural variables.

Specific Entheseal Attachment Site Rankings

The following section ranks both entheses and osteoarthritis scores to examine the differences between the left and right sides of the upper limb. Results indicate the attachment sites, muscle groups and joints overall lean towards a right-side bias versus those that have a left side bias. However, some results show statistically insignificant different results which may indicate that while the majority lean right side, there are some cases of symmetry among the population probably due to activity or occupational workloads.

In order to examine which entheses sites had a higher left and right side bias at the upper limb, each category of entheseal marker was scored and ranked for both the left and right sides.

The results are found in tables 35 to 37 demonstrate both similarities and differences regarding the highest and lowest rank scores.

Robusticity scores between the left and right sides of the upper limb demonstrate the highest ranked scores are the same among the left and the right sides (Table 35). The pectoralis major and brachialis are ranked for both first and second for the left and right sides. Pectoralis major seems relatively consistent between the left and right side as the mean scores only vary by 0.034 whereas the brachialis scores begin to show larger differences between the two sides, about 0.153 different with the right side having the higher mean score. However, neither of those differences were deemed statistically significant. The lowest ranked scores for robusticity are similar but not exactly the same. For the left side of the upper limb, the two lowest scores were the supinator and pronator quadratus whereas for the right side, the two lowest were the coracobrachialis and the pronator quadratus. In this case, both the left and right sides ranked the pronator quadratus as the lowest score yet have different attachment sites for the second ranking lowest score. It is unlikely that those differences are statistically significant however, because both the coracobrachialis and the supinator are still ranked low at the other side. Instead, the coracobrachialis and the supinator probably are either the last attachment sites to develop entheses or activity patterns in Cleveland did not utilize those muscles as much.

Table 35. Left and right side robusticity rankings for entheses

ROBUSTICITY SCORES RANKING SCORES					
LEFT SIDE			RIGHT SIDE		
MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE
Pec. Major	1	2.905	Pec. Major	1	2.939
Brachialis	2	2.752	Brachialis	2	2.905
Bic. Brach.	3	2.686	Bic. Brach.	3	2.854
Com. Ext.	4	2.629	Com. Ext.	4	2.836
Conoid Lig.	5	2.584	Deltoid	5	2.726
Teres Major	6	2.564	Conoid Lig.	6	2.678
Deltoid	7	2.538	Supraspin.	7	2.649
Suprspin.	8	2.491	Trapezius	8	2.618
Costcoclav.	9	2.486	Costoclav.	9	2.591
Trap. Lig.	10	2.460	Trap. Lig.	9	2.591
Trapezius	11	2.355	Pro. Teres	11	2.564
Pro. Teres	12	2.338	Pec. Minor	12	2.449
Pec. Minor	13	2.279	Teres Major	13	2.422
Com. Flex.	14	2.145	Teres Minor	14	2.301
Ter. Minor	15	2.129	Tri. Brach.	15	2.256
Tri. Brach.	16	2.111	Anconeus	16	2.188
Lat. Dor.	17	2.102	Infraspin.	17	2.179
Anconeus	17	2.102	Com. Flx.	18	2.153
Infrapsin.	19	2.017	Lat. Dor.	19	2.094
Coraco.	20	1.794	Supinator	20	1.940
Subclavius	21	1.725	Subclavius	21	1.921
Supinator	22	1.677	Coraco.	22	1.829
Pro. Quad	23	1.376	Pro. Quad.	23	1.606

Cortical defect was also ranked highest to lowest between the left and right sides of the upper limb (Table 36). The top two ranked score for both the right and left sides were very close but not the same. For the left side, the supraspinatus was ranked first and the costoclavicular was ranked second. The right side ranked the costoclavicular as first and the supraspinatus second. Despite the ranking scores, the difference in means between the supraspinatus and costoclavicular were close. The mean difference between the left and right sides at the supraspinatus was 0.019 with the right side a little higher than the left, although not statistically significantly different. The costoclavicular was also right sided bias with a difference of 0.204.

Overall, the high-ranking scores are relatively the same between the left and right sides. The lowest ranked scores demonstrate a different pattern. The lowest scores for the left side had a three-way tie at the coracobrachialis, common flexors, and anconeus with no entheseal stress at all. For the right-side scores, there were five attachment sites that did not have any entheseal stress scores. They are the coracobrachialis, common flexors, anconeus, triceps brachii, and pronator quadratus. There are similarities between both sides as three of the right side lowest scores were ranked the same among the left side. However, the right side has two other attachment sites ranked last which are both ranked fourteen among the left side scores. This demonstrates that there are some attachment sites that have higher scores among the left side than the right side and may be indicative of varying activity pattern stresses between the left and right sides of the body.

Table 36. Left and right side cortical defect rankings for entheses

CORTICAL DEFECT RANKING SCORES					
LEFT SIDE			RIGHT SIDE		
MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE
Supraspin.	1	0.775	Costoclav.	1	0.852
Costoclav.	2	0.648	Supraspin.	2	0.794
Brachialis	3	0.529	Brachialis	3	0.589
Teres Major	4	0.316	Pec. Major	4	0.275
Trap. Lig.	5	0.230	Bic. Brach.	5	0.256
Pec. Major	6	0.188	Trap. Lig.	6	0.208
Bic. Brach.	7	0.135	Teres Major	7	0.129
Infraspin.	8	0.077	Infraspin.	8	0.111
Teres Minor	9	0.068	Pro. Teres	9	0.059

Table 36—Continued

Lat. Dor.	10	0.059	Teres Minor	10	0.043
Subclavius	11	0.044	Com. Ext.	11	0.034
Trapezius	12	0.042	Lat. Dor.	11	0.034
Pro. Teres	12	0.042	Deltoid	13	0.025
Deltoid	14	0.034	Trapezius	14	0.008
Tri. Brach.	14	0.034	Subclavius	14	0.008
Pro. Quad.	14	0.034	Conoid Lig.	14	0.008
Conoid Lig.	17	0.017	Pec. Minor	14	0.008
Pec. Minor	18	0.008	Supinator	14	0.008
Com. Ext.	18	0.008	Coraco.	19	0.000
Supinator	18	0.008	Com. Flx.	19	0.000
Coraco.	21	0.000	Anconeus	19	0.000
Com. Flx.	21	0.000	Tri. Brach.	19	0.000
Anconeus	21	0.000	Pro. Quad.	19	0.000

Lastly, ossification exostosis was ranked among the left and right sides of the upper limb (Table 37). The highest ranked scores were the same for both the left and right sides with the pectoralis major ranked first and the biceps brachii ranked second. The differences between the ranked scores for both sides demonstrated a right-side bias in which both attachment sites had higher mean scores on the right rather than the left side. For the lower ranked scores, the results were again the same for the right and left sides. Both the supinator and pronator quadratus were ranked 22nd and 23rd respectively. Overall, it seems that for all three categories of entheseal stresses, the right-side means are higher than the left side, demonstrates a right-side bias for this sample.

Table 37. Left and right side ossification exostosis rankings for entheses

OSSIFICATION EXOSTOSIS RANKING SCORES					
LEFT SIDE			**RIGHT SIDE**		
MUSCLE/ LIGAMENT	**RANK**	**ENTHESIS SCORE**	**MUSCLE/ LIGAMENT**	**RANK**	**ENTHESIS SCORE**
Pec. Major	1	1.572	Pec. Major	1	1.775
Bic. Brach.	2	1.466	Bic. Brach.	2	1.658
Brachialis	3	1.376	Brachialis	3	1.606
Com. Ext.	4	1.310	Com. Ext.	4	1.508
Deltoid	5	1.307	Deltoid	5	1.401
Conoid Lig.	6	1.274	Conoid Lig.	6	1.382
Supraspin.	7	1.129	Supraspin.	7	1.247
Teres Major	8	1.119	Costoclav.	8	1.234
Costoclav.	9	1.072	Trapezius	9	1.194
Trap. Lig.	10	0.973	Trap. Lig.	10	1.191
Pro. Teres	11	0.940	Teres Major	11	1.129
Trapezius	12	0.881	Pec. Minor	12	1.084
Pec. Minor	13	0.838	Pro. Teres	13	1.042
Teres Minor	14	0.784	Teres Minor	14	0.956
Tri. Brach.	15	0.769	Infraspin.	15	0.888
Com. Flex.	16	0.692	Tri. Brach.	16	0.880
Infraspin.	17	0.681	Anconeus	17	0.752
Anconeus	18	0.675	Com. Flx.	18	0.743
Lat. Dor.	19	0.529	Lat. Dor.	19	0.663
Subclavius	20	0.460	Subclavius	20	0.578
Coraco.	21	0.341	Coraco.	21	0.470
Supinator	22	0.313	Supinator	22	0.452
Pro. Quad.	23	0.188	Pro. Quad.	23	0.324

Muscle Group Entheseal Attachment Site Rankings

Entheses were then combined into one of the seven muscle groups and then ranked to determine which muscle groups are ranked the highest and the lowest as well as to examine the degree of right-side bias like the previous section.

Robusticity scores between the left and the right sides were very similar (Table 38). The two highest ranked muscle groups for both sides were muscle group #3 and muscle group #6. However, the only difference is that the left side ranked muscle group #6 first and group #3 second whereas the right side ranked group #3 first and group #6 second. The difference between the mean scores was very small however for both muscle groups the right side was slightly higher, solidifying the right-side bias found in the previous section. For the lowest scores, both sides ranked muscle group #4 in sixth place and muscle group #7 in seventh place. However, muscle group #7 scores demonstrated that the left side had a higher means than the right side. This suggests that most scores have a right-side bias while only one group has a left side bias. It is possible that this result indicates that the attachment sites within muscle group 7 may be all left side biased or could indicate that for group #7, which pronates and supinates the arm, there was a higher level of stress on the left side of the upper limb versus the right side, indicative of using the left lower arm for occupational or everyday activities.

Table 38. Left and right side robusticity rankings for muscle groups

ROBUSTICITY RANKING SCORES					
LEFT SIDE			RIGHT SIDE		
MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE
Group #6	1	2.518	Group #3	1	2.688
Group #3	2	2.515	Group #6	2	2.626
Group #2	3	2.341	Group #1	3	2.453
Group #1	4	2.281	Group #5	4	2.452
Group #5	5	2.280	Group #2	5	2.320
Group #4	6	2.073	Group #4	6	2.240
Group #7	7	1.886	Group #7	7	1.389

Cortical defect scores were also examined for muscle groups and demonstrates a similar pattern among the left and right sides as the robusticity category did (Table 39). For example, the highest muscle groups for cortical defect among both sides were muscle group #3 and #6. The pattern however switched in that the highest ranked for the left side was group #3, followed by group #6 (they were opposite in the robusticity category). The same occurred for the right side ranked scores. For cortical defect on the right side, the highest ranked was group #6, followed by group #3 (again was the opposite in the robusticity category). In both cases, the right side mean scores were higher than the left side, indicative of a right-side bias among the population. For the lowest scores, both sides rank the same muscle groups. Muscle group #7 is ranked in sixth place and muscle group #5 is ranked seventh or last. The scores between the sides for muscle group #5 are the same i.e. 0.014 demonstrating that the sides are virtually identical and symmetrical but not statistically significantly different. However, muscle group #7 again demonstrates a higher left side mean score than a right one. Since the results indicate another left side bias for muscle group #7, it is likely that the physiology of muscle group #7 may factor into this determination or that there may be movements from different occupations found in this population which resulted in right side biased scores for the top of the upper limb i.e. clavicle and humerus and left side bias scores for the radius of the forearm.

Table 39. Left and right side cortical defect rankings for muscle groups

CORTICAL DEFECT RANKING SCORES					
LEFT SIDE			RIGHT SIDE		
MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE
Supraspin.	1	0.775	Costoclav.	1	0.852
Costoclav.	2	0.648	Supraspin.	2	0.794
Brachialis	3	0.529	Brachialis	3	0.589
Teres Major	4	0.316	Pec. Major	4	0.275
Trap. Lig.	5	0.230	Bic. Brach.	5	0.256
Pec. Major	6	0.188	Trap. Lig.	6	0.208
Bic. Brach.	7	0.135	Teres Major	7	0.129
Infraspin.	8	0.077	Infraspin.	8	0.111
Teres Minor	9	0.068	Pro. Teres	9	0.059
Lat. Dor.	10	0.059	Teres Minor	10	0.043
Subclavius	11	0.044	Com. Ext.	11	0.034
Trapezius	12	0.042	Lat. Dor.	11	0.034
Pro. Teres	12	0.042	Deltoid	13	0.025
Deltoid	14	0.034	Trapezius	14	0.008
Tri. Brach.	14	0.034	Subclavius	14	0.008
Pro. Quad.	14	0.034	Conoid Lig.	14	0.008
Conoid Lig.	17	0.017	Pec. Minor	14	0.008
Pec. Minor	18	0.008	Supinator	14	0.008
Com. Ext.	18	0.008	Coraco.	19	0.000
Supinator	18	0.008	Com. Flx.	19	0.000
Coraco.	21	0.000	Anconeus	19	0.000
Com. Flx.	21	0.000	Tri. Brach.	19	0.000
Anconeus	21	0.000	Pro. Quad.	19	0.000

Ossification exostosis muscle group ranking scores were determined to be the same among both the left and right sides (Table 40). For the highest ranked scores, muscle group #3 was ranked first and muscle group #6 was ranked second. In both cases, the higher mean scores were determined to be on the right-hand side with difference of only a few tenths of a score. For the lowest ranked scores, both the left and right sides ranked muscle group #4 in sixth place and muscle group #7 in seventh place. Both muscle groups had higher mean scores on the right side than the left side. Overall, the muscle group rankings demonstrate a most right-side bias with one a couple left side biased scores.

Table 40. Left and right side ossification exostosis rankings for muscle groups

OSSIFICATION EXOSTOSIS RANKING SCORES					
LEFT SIDE			RIGHT SIDE		
MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE
Group #3	1	1.218	Group #3	1	1.324
Group #6	2	1.153	Group #6	2	1.311
Group #5	3	0.917	Group #1	3	1.087
Group #2	4	0.891	Group #5	4	1.045
Group #1	5	0.885	Group #2	5	1.008
Group #4	6	0.732	Group #4	6	0.922
Group #7	7	0.514	Group #7	7	0.821

Statistical Analysis of Entheseal Attachment Sites

Entheses attachment and osteoarthritis joint scores were also analyzed to test for significant differences between the left and right sides of the upper limb. The results, recorded below, demonstrate that most the markers are right side biased with only a few indicators of left side bias which complements the rankings.

Overall results for entheses scores indicate that there are a few select instances of statistically significantly different results among the population. However, most the results for both the entheseal attachment sites and muscle groups were statistically insignificantly different. Tables 88 (appendix) and 41 (below), represent the mean comparisons for both the left and right sides among specific attachment sites as well as the muscle groups.

Specific Enthesis Sites

Table 88 in the appendix lists out the statistically significantly different results among specific entheses attachment sites. Out of 138 specific attachment sites, 25 were determined to be statistically significantly different or about 18.11%. Out of those results, a few attachment sites were significant among at least two categories of entheseal stress, oftentimes both robusticity and cortical defect. These include the teres major, trapezoid ligament, trapezius, teres minor, common extensors, biceps brachii, brachialis, supinator, and pronator quadratus. Most these attachment sites also favor a right-side bias with the exception of the ossification exostosis of the teres major which had a left side bias among the sample.

Muscle Groups

The specific attachment scores were then averaged and re-analyzed among the seven muscle groups (Table 41) Out of the 21 potential scores, only seven were deemed statistically significantly different or about 33.33%. Six out of those were significant in the robusticity category and only one in the cortical defect category. Similar to the entheses ranked scores, muscle group #7 was the only group that had a higher left side mean score than right side. This indicates a left side bias for group #7 but it is important to point out that the difference between the two is only 0.006 which is very slight yet statistically significantly different.

Table 41. Results of the 2 tailed, paired t-tests for differences between left and right side muscle groups

NUMBER	MUSCLE GROUP	TYPE	p VALUE	AVG. LEFT	AVG. RIGHT
1	Group #1	Robusticity	4.51E -06	2.281	2.453
2	Group #3	Robusticity	0.0003	2.515	2.688

Table 41—Continued

3	Group #4	Robusticity	0.004	2.073	2.240
4	Group #5	Robusticity	0.007	2.280	2.425
5	Group #6	Robusticity	0.003	2.518	2.626
6	Group #6	Cor. Def.	0.047	0.323	0.422
7	Group #7	Robusticity	3.01E -11	0.028	0.022

Osteoarthritis Rankings

Osteoarthritis was also ranked according to joint sites at the acromioclavicular, shoulder or elbow joints (Table 42). The highest ranked results between the left and right sides were at the acromioclavicular ligament. On the left side, the lateral acromial end was ranked first and the medial acromion process was ranked second. For the right side, the joints were switched. The medial acromion process was ranked first and the lateral acromial end was ranked second. In both cases, the right side had a higher mean score than the left side. For the lowest ranked scores, there is a little bit of a difference. On the left side, the seventh ranked joint was the proximal end of the radius and the eighth ranked score was the proximal head of the humerus. Opposite that, on the right side, the distal end of the humerus at the trochlea was ranked seventh and the proximal end of the radius was labeled eighth. Despite these slight differences, among all the lower ranked scores, the right-side means are still higher than the left side, indicating that like the entheseal score, osteoarthritis scores are right side biased as well.

Table 42. Left and right side osteoarthritis joint site rankings

LEFT SIDE RESULTS				**RIGHT SIDE RESULTS**			
JOINT SITE	**JOINT**	**RANK**	**OSTEOARTH. SCORE**	**JOINT SITE**	**JOINT**	**RANK**	**OSTEOARTH. SCORE**
LAC	ACROM	1	1.141	MAP	ACROM	1	1.264

Table 42—Continued

MAP	ACROM	2	1.041	LAC	ACROM	2	1.260
DHC	ELBOW	3	0.801	GLF	SHOU	3	1.109
GLF	SHOU	4	0.796	DHC	ELBOW	4	0.932
PRU	ELBOW	5	0.705	PRU	ELBOW	5	0.796
DHT	ELBOW	6	0.60	PRH	SHOU	6	0.720
PRR	ELBOW	7	0.581	DHT	ELBOW	7	0.718
PRH	SHOU	8	0.547	PRR	ELBOW	8	0.672

The osteoarthritis joint scores were then combined and re-ranked according to their joint group i.e. acromioclavicular, shoulder or elbow (Table 43). Both the left and right sides ranked the acromioclavicular as first with the joint having a higher right side bias than left. For ranking two and three, the left side ranked the elbow second and shoulder third while the right side ranked the shoulder second and the elbow third. Both the shoulder and the elbow display a right-side bias mean scores as well which is consistent with the right-side biases displayed from the entheseal analysis.

Table 43. Left and right side osteoarthritis joint rankings

LEFT SIDE RESULTS			**RIGHT SIDE RESULTS**		
JOINT	**RANK**	**OSTEOARTH. SCORE**	**JOINT**	**RANK**	**OSTEOARTH. SCORE**
ACROM	1	1.091	ACROM	1	1.262
ELBOW	2	0.6717	SHOU	2	0.914
SHOU	3	0.6716	ELBOW	3	0.779

The osteoarthritis scores were also reanalyzed and tested for statistically significant differences between the left and right sides using both joint site locations as well as complete joints. For the joint locations, out of the forty possible sites, eleven of them were considered statistically significantly different or about 27.5% (Table 44). Out of all the sites, the glenoid fossa which is a part of the shoulder joint had the most significant values among each of the osteoarthritis indicators in which everything except eburnation was deemed statistically significantly different. All the osteoarthritis joints sites were right side biased as they had higher mean scores on the right than left sides. When combined into each joint, the results indicated that there were no significant values between the left and right sides on any of the joints. Therefore, it is likely that in the Hamann-Todd sample, there are relatively even mean scores of osteoarthritis on both the left and right sides of the upper limb.

Table 44. Results of the Mann-Whitney U Test for differences of osteoarthritis joint sites between the left and right sides

NUMBER	JOINT SITE	TYPE	p VALUE	AVG. LEFT	AVG. RIGHT
1	GLF	LIPPING	6.29E -06	1.486	2.054
2	GLF	JOINT CON.	0.006	0.585	0.918
3	GLF	PITTING	0.045	1.045	1.279
4	GLF	NEW BONE	0.005	0.864	1.261
5	PRH	LIPPING	0.0004	1.363	1.727
6	PRH	JOINT CON.	0.012	0.181	0.390
7	LAC	LIPPING	0.037	1.566	1.809
8	MAP	EBURN.	0.024	0.000	0.183
9	MAP	NEW BONE	0.006	1.054	1.412
10	DHT	LIPPING	0.016	1.200	1.490
11	DHC	PITTING	0.028	1.100	1.300

Frequencies of Osteoarthritis

Frequencies for osteoarthritis were calculated for each upper limb joint i.e. the shoulder, acromioclavicular and the elbow, that were scored and then separated between the left and the right sides to ascertain asymmetry or symmetry among each. For all three joints, most of the sites on both the left and the right side did not have any indicators of osteoarthritis. Despite this, different patterns emerged among each of the joints. At the shoulder joint, most of the osteoarthritis indicators on both sides were scored as trace and the lowest amounts were found in the severe category. (Figure 18) When left and right sides are compared, there was more trace sites of osteoarthritis on the left side compared to the right but the other scores demonstrated a higher frequency on the right side instead. This demonstrates there is a right-side bias regarding osteoarthritis as the left side was still used (shown by the trace scores) but not as much as the right side which shows higher numbers for minor, moderate and severe osteoarthritis.

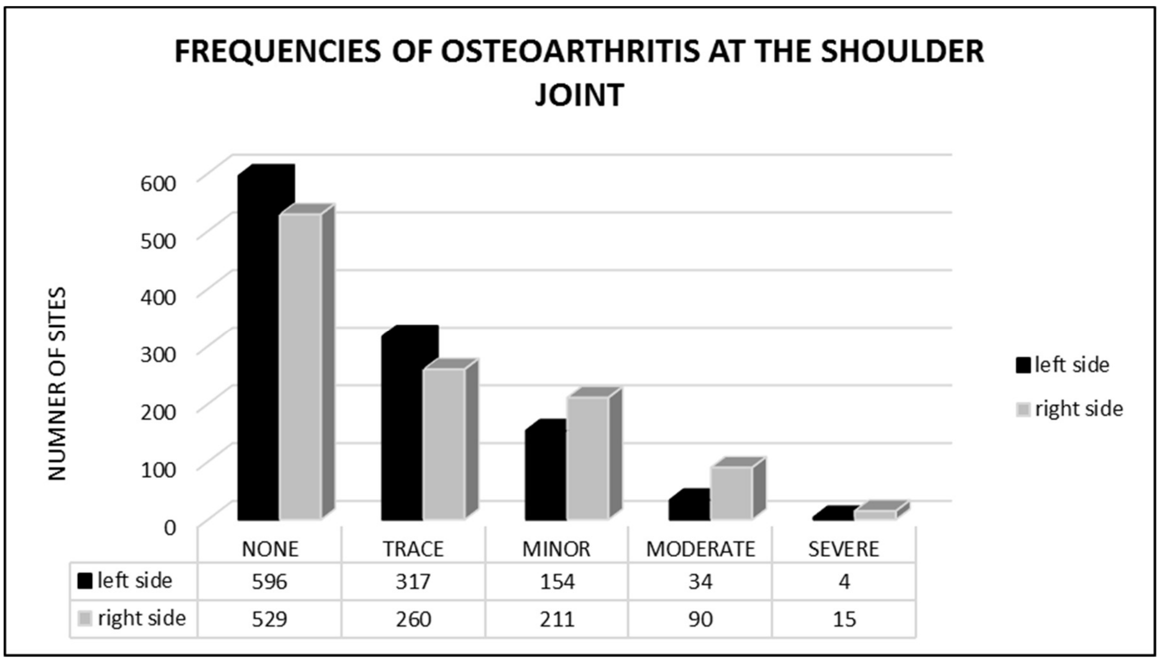


Figure 18. Frequencies of osteoarthritis at the shoulder joint between the left and right sides

At the acromioclavicular joint, the osteoarthritis frequencies are higher than either the shoulder or the elbow joints as show in Figure 19 below. On the left side, the frequencies between the none/absent and trace category are almost identical which shows that at least half of the individuals in this sample had at least a trace of osteoarthritis at the acromioclavicular joint.

However, like the shoulder joint, the left side had a higher frequency of trace osteoarthritis than the right. This could be because individuals may have developed osteoarthritis on the right side sooner than they did the left because of repetition and favoring one side over the other. As a result, the left side had smaller amounts of osteoarthritis versus the right side. As the severity increased though, the right side had higher frequencies than the left side, almost doubling by the severe category which is once again either indicative of a right side biased population or activity patterns which require the use of the right side of the upper limb over the left.

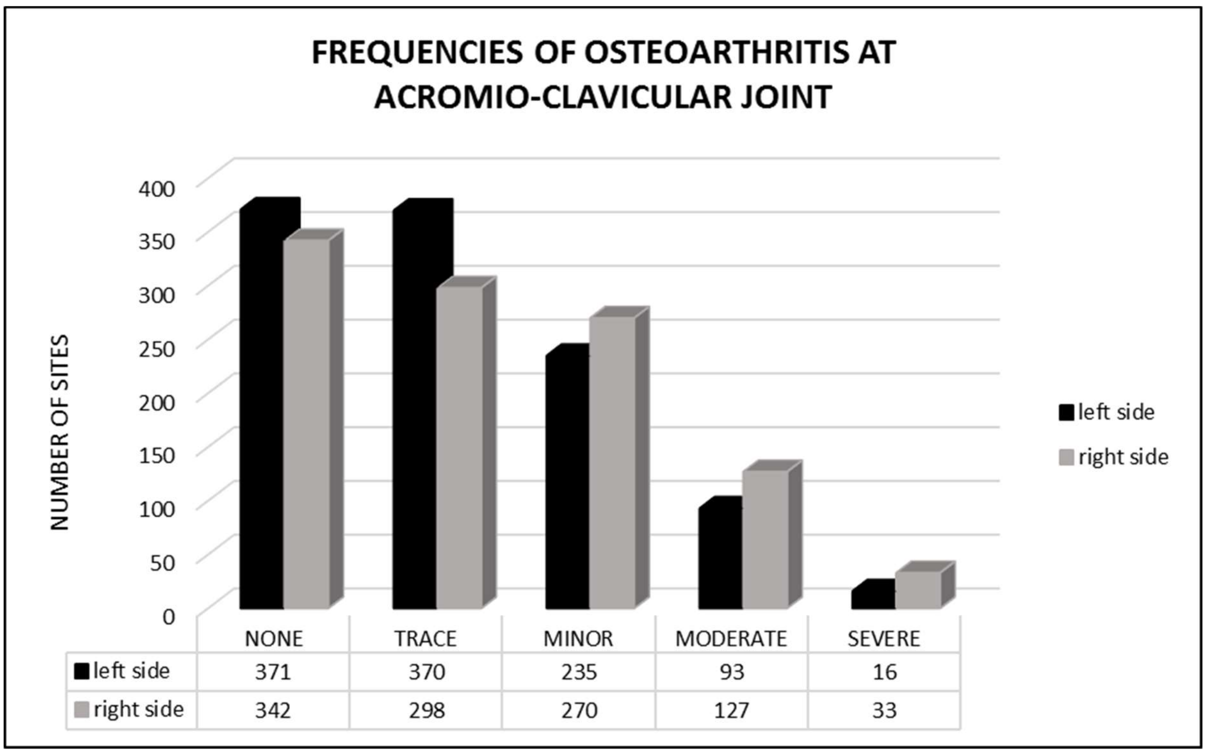


Figure 19. Frequencies of osteoarthritis at the acromioclavicular joint between the left and right side

Lastly, osteoarthritis frequencies were also calculated for the elbow joint. The results indicate that the frequencies of scores tended to be more symmetrical between the sides as shown in Figure 20. For example, the trace, moderate and severe categories show even and almost even numbers of sites between the left and the right sides. Unlike the shoulder and acromioclavicular joint which were more right side skewed, the elbow seems to only have a slight right side bias. These results demonstrate that the activity patterns and movements on the forearm are more symmetrical among both sides of the body than the upper limb portions such as the shoulder and acromioclavicular which are more right side biased. It is feasible then that activity patterns and occupations that required more delicate and focused movements seemed to use both the left and right sides whereas larger scale movement such as lifting or carrying items required more strength and tended to lean probably towards an individual preference i.e. their dominant hand.

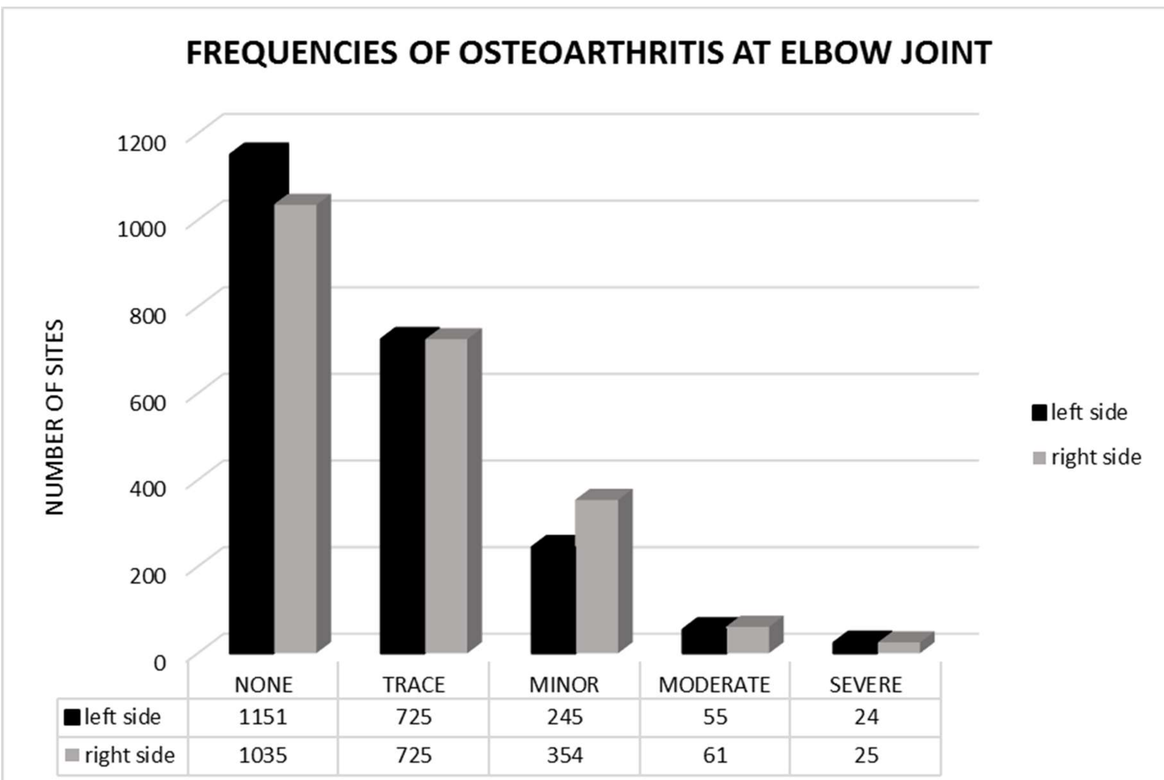


Figure 20. Frequencies of osteoarthritis at the elbow joint between the left and right sides

Directional Asymmetry

In the second part of this section, both the directional and bilateral asymmetry results will be examined to see if there are right side bias patterns present also. Directional asymmetry was examined for the population sample using the biological and cultural variables of sex, biological affinity, and geographic origin. Results indicate that almost all the scores show some type of right side directional asymmetry.

Sex

Maximum lengths were collected for 30 males and 30 females. The results were then tested for significance using one-tailed t-tests to examine how far in one direction, either right or left, the results were significant. The male results, shown in Figure 47 in the appendix, had the highest significant values were found at the clavicle, humerus and ulna whereas the female results had the most significant values at the clavicle and the humerus. There was one result for the females that was not significant at all which was the ulna, demonstrating that it is closer or more symmetrical to the left side than the other scores.

Figure 21 below displays the results from the directional asymmetry analysis, compared between males and the females. In this case, all the bones of the upper limb display right side biased scores except for the clavicle. However, according to Steele et al., 2000, the clavicle is smaller on the dominant side thereby creating a backward result in which a right side dominated score would look like a left side score. This result holds true for this study as well. Overall, the chart and figure demonstrate that directional asymmetry among males and females is more variable than expected. Females tended to have higher directional asymmetry score for each bone, which suggests that workload and activity for females was more right side dominant than it was for males. The males scores which range closer to the zero mark represent more symmetrical scores between the left and right side which may be indicative of occupations or labor activities where both sides of the upper limb are needed such as carrying or lifting of materials.

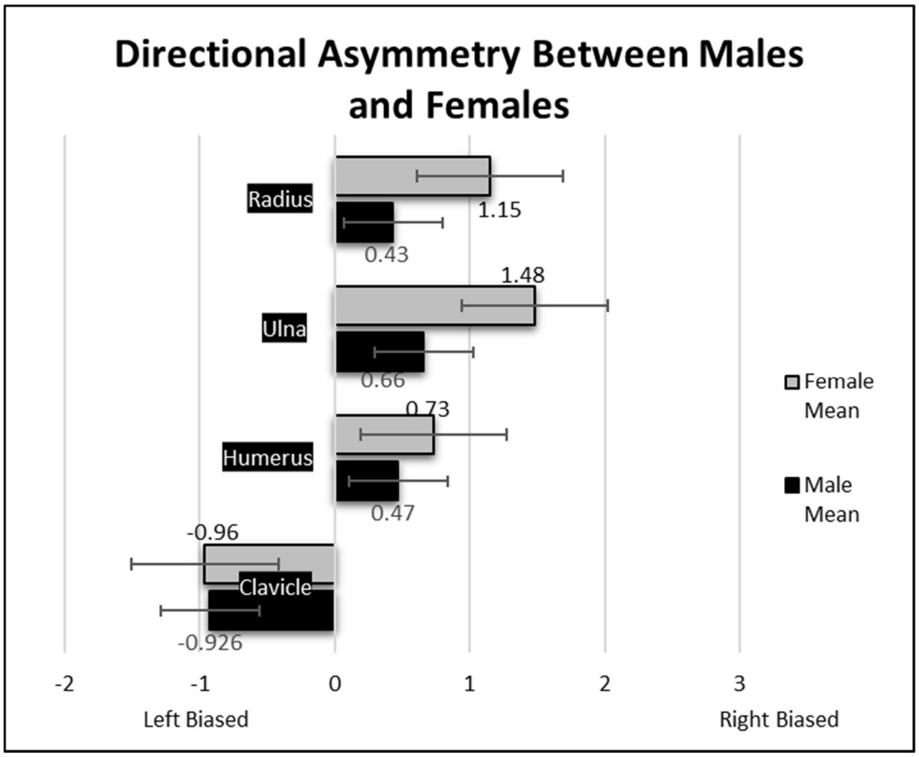


Figure 21. Directional Asymmetry between males and females [5]

Biological Affinity

For biological affinity, the same calculations were made, examining the possible differences between those of Caucasian ancestry and those of African-American ancestry. The tests show that there are mixed results between the two ancestral groups. For instance, both the

[5] All column charts use standard error bars

Caucasians and African Americans have similar high results at the clavicle and the ulna however the African American population has higher results than the Caucasians among the humerus and radius. These results, however, demonstrate a right side directional bias (Figure 22).

Figure 48, in the appendix, examined these mixed results in more detail. For the clavicle and ulna, African Americans have higher directional asymmetry results than Caucasians. The Caucasians, however, have higher results at the humerus and radius. It is unclear though which group has more asymmetry overall as the results are mixed with no discernable pattern between the upper limb bones i.e. upper limb clavicle and humerus versus forearm radius and ulna.

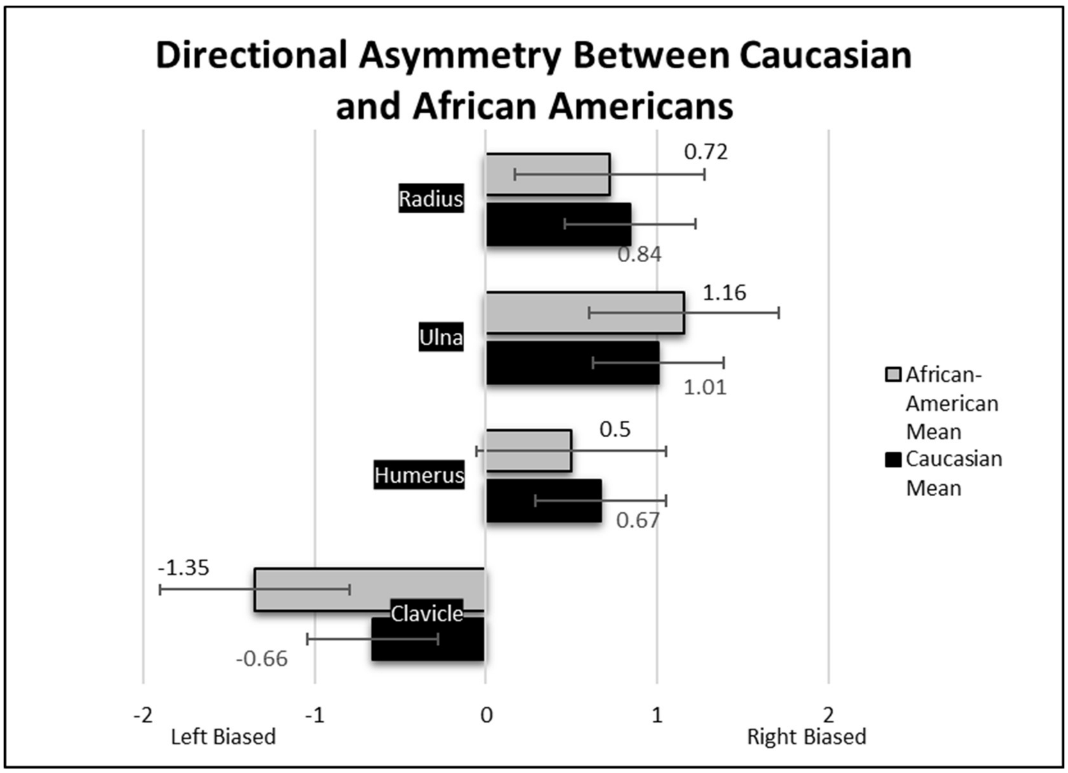


Figure 22. Directional asymmetry between Caucasians and African Americans

Geographic Origin

Lastly, geographic origin was tested to determine if different work patterns or loads were discernable or existed among those born inside or outside the U.S. The results were again mixed in the amount of directional asymmetry however the p values were similar between the two groups. For example, the highest p values were found at the clavicle, humerus and ulna for both groups and the radius for both had the second highest significance (Figure 49 in the appendix).

Figure 23 demonstrates more clearly why the results between these two groups were mixed. In this case, all the results were significantly right biased but one group was not completely significant over the other. For example, those individuals who were born inside the United States had more directional asymmetrical values at the clavicle and ulna whereas those individuals who were born outside the United States had those results at the humerus and radius. Even though these results do not completely demonstrate workload patterns between those two locations, these results were analogous to those observed based on biological affinity. That is, Caucasian individuals and those who lived outside the United States both had significant directional results at the humerus and the radius. African Americans and those who were born inside the United States had significant results at the clavicle and ulna. This possibly demonstrates that place of birth and ancestry category corresponds with variation in different workload or activity patterns, especially since the Hamann-Todd Collection has most African Americans born inside the United States and Caucasians from outside the United States. This is more likely the reason that there were differing life experiences relating to workload and anatomical stresses due to biological affinity rather than geographic origins especially since both groups had different social and economic statuses in society.

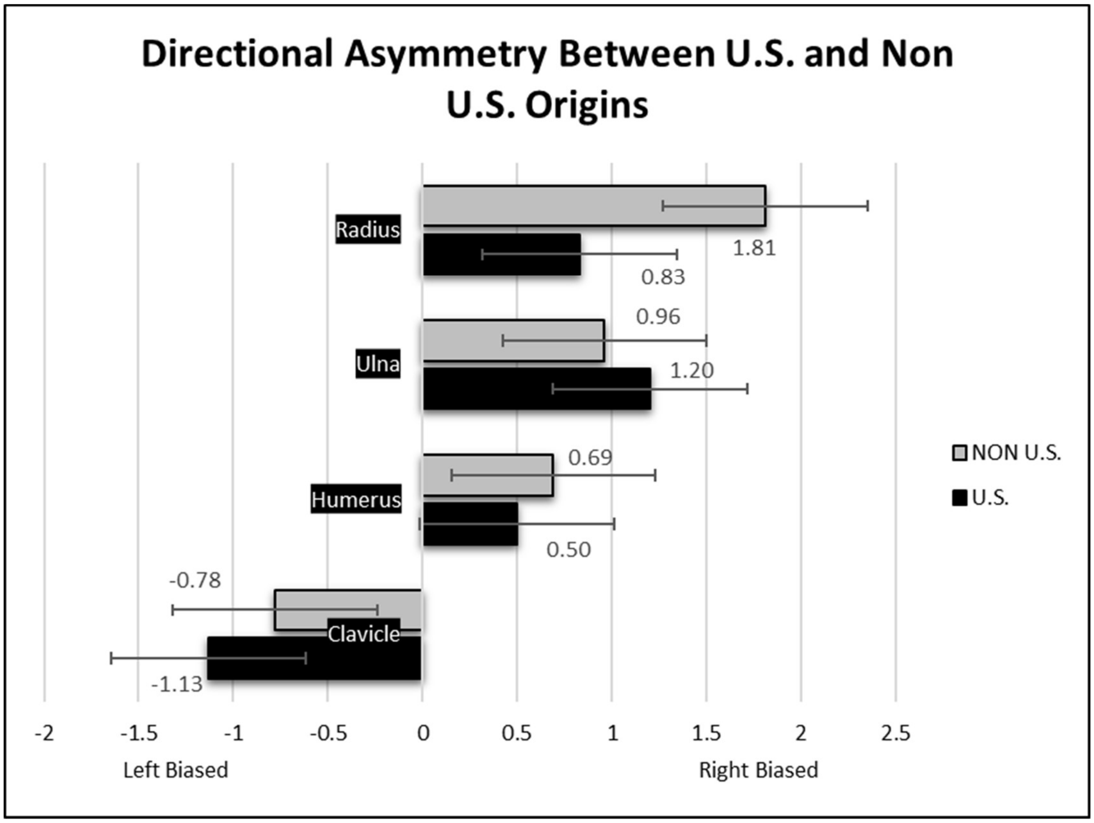


Figure 23. Directional asymmetry between U.S. and non-U.S. origins

Bilateral Asymmetry

Bilateral asymmetry was also examined among the muscle groups using sex, biological affinity, and geographic origin as variable categories. The results were less clear than the directional asymmetry findings, however some patterns are still observable.

Muscle Group Entheseal Attachment Sites

Each entheseal attachment site (n=21) was combined into one of seven muscle groups (Figure 24) which is different from the other muscle group chart stated in the methods chapter which included the common flexors and extenders of the humerus. Each muscle group correlated with a muscle movement including stabilization of the clavicle, adduction, abduction, extension, flexion, pronation, and rotation of the upper limb (Gosling, 1994).

MUSCLE GROUPS EXAMINED							
	MUSCLE GROUP 1	MUSCLE GROUP 2	MUSCLE GROUP 3	MUSCLE GROUP 4	MUSCLE GROUP 5	MUSCLE GROUP 6	MUSCLE GROUP 7
MUSCLES	-Pectoralis minor -Subclavius -Trapezius	-Pectoralis major -Latissimus Dorsi -Teres major -Coracob-rachialis	-Deltoid -Supraspi-natus	-Infraspin-atus -Teres Minor	-Triceps brachii -Anconeus	-Biceps brachii -Brachialis	-Pronator teres -Pronator quadratus
BONES	Clavicle/ Scapula	Humerus/ Clavicle	Humerus	Humerus	Ulna	Ulna/ Radius	Radius
FUNCTION	Stabilize pectoral girdle	Adducts arm	Abducts arm	Rotates arm laterally	Extends forearm	Flexes forearm	Pronates forearm

Figure 24. Muscle groups examined for ill-health status analysis

Each bilateral asymmetry score from every individual was calculated and averaged to examine possible trends. Figure 25 below lists out the bilateral symmetry scores including right side biased scores, left side biased scores, symmetrical scores as well the total number or sites scores for each muscle group for all individuals. Results indicate that there are more symmetrical scores among the muscle groups than previously hypothesized. However, when comparing left and right sides, the right side has higher scores than the left side.

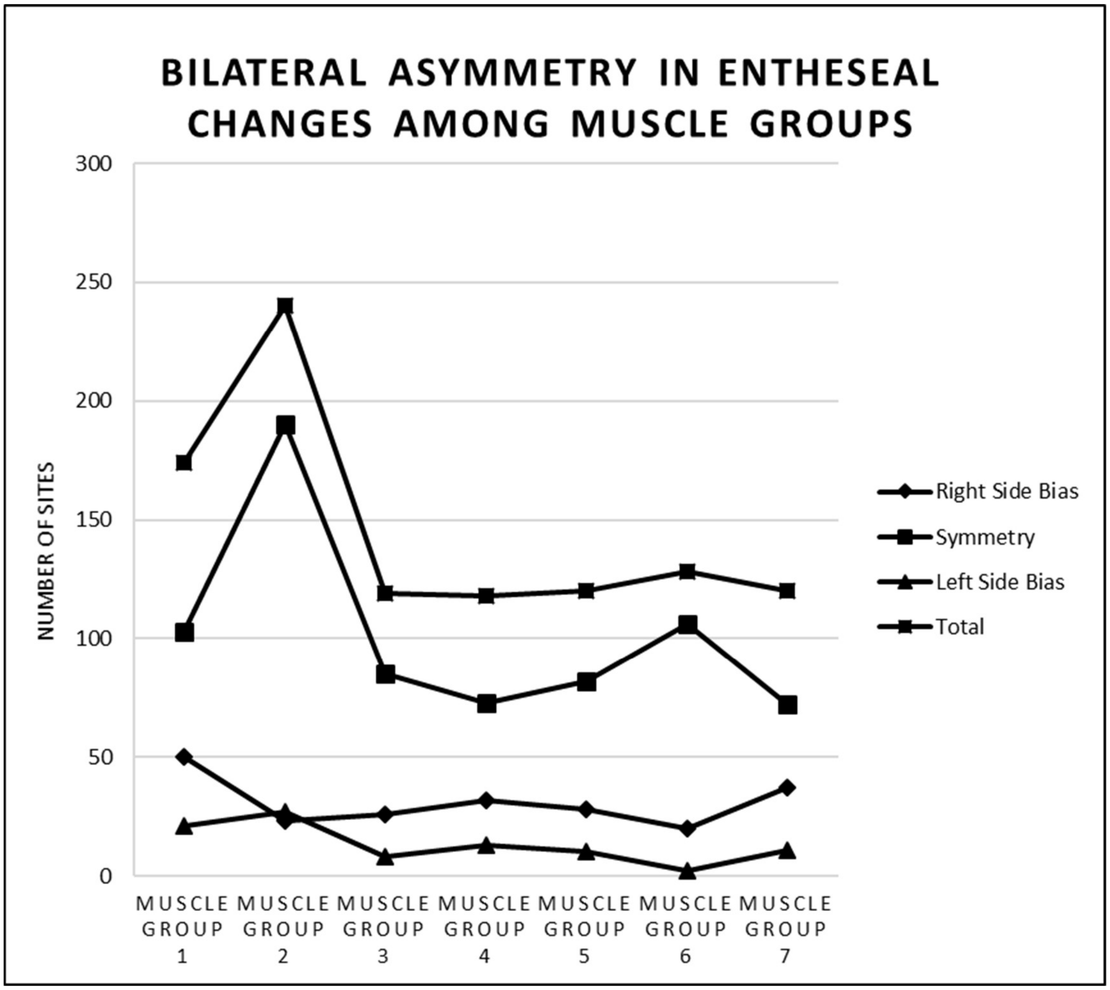


Figure 25. Bilateral asymmetry in entheseal changes among muscle groups

Among the Variables

Bilateral asymmetry was also examined among each of the variables using the methods from Peterson, 1998. Out of 21 possibilities, only one was considered statistically significantly different which was muscle group #7 for the biological affinity category (Figure 26). In this case, Caucasians demonstrated higher asymmetrical scores than the African Americans in which Caucasians demonstrates more of a right-side bias than African Americans.

LEVELS OF SIGNIFICANCE							
	MUSCLE GROUP 1	MUSCLE GROUP 2	MUSCLE GROUP 3	MUSCLE GROUP 4	MUSCLE GROUP 5	MUSCLE GROUP 6	MUSCLE GROUP 7
SEX	0.917	0.727	0.208	0.883	0.186	0.226	0.227
BIO. AFFINITY	0.958	0.725	0.347	0.945	0.434	0.068	0.046
GEO. ORIGIN	0.879	0.966	0.200	0.825	0.382	0.145	0.108
(p< 0.05)							

Figure 26. Levels of significance among muscle groups per each variable

Figure 27 below examines the insignificant and significant differences from the Figure 26. Similar to the overall bilateral asymmetry scores, most scores across all variable categories are symmetrical rather than right or left side bias. However, between the left and right sides, there are more right side bias scores as opposed to left side scores.

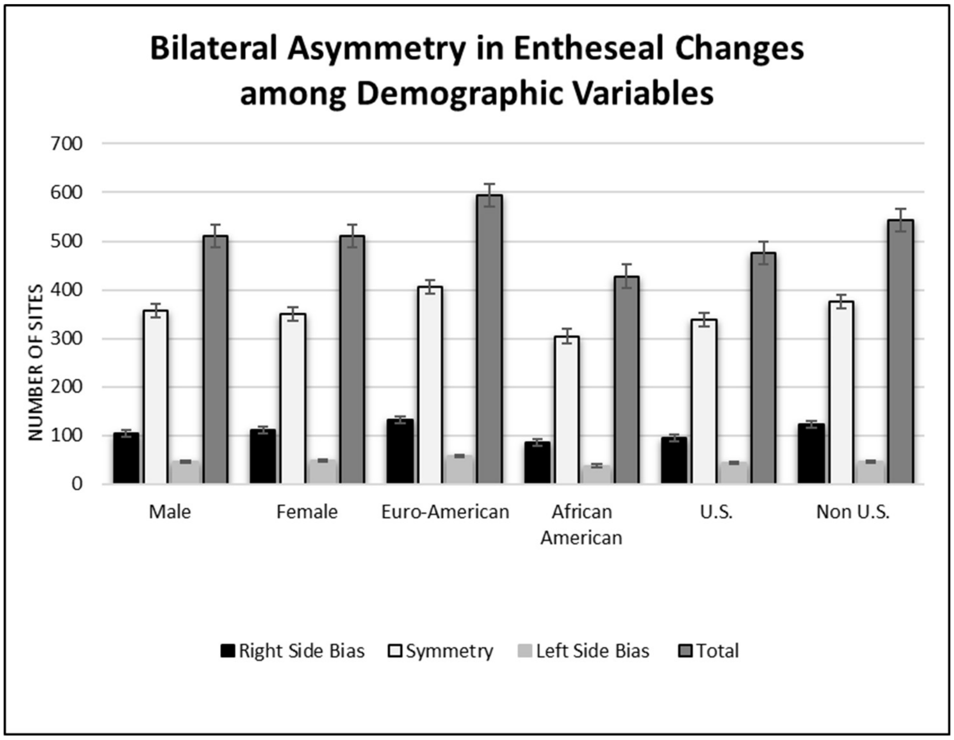


Figure 27. Bilateral asymmetry in entheseal changes among the variables

Sex

This section includes the results of the assessment of entheseal changes and osteoarthritis scores between the two sexes using statistical testing and ranking methods. As demonstrated in the literature review, sex differences in relation to entheseal changes and osteoarthritis are often used in bioarchaeology and osteology to examine possible evidence of a sexual division of labor (Villotte and Knüsel, 2014). While this assessment will examine possible instances of a sexual division of labor through ranking entheses and degree of osteoarthritis, it will also comment on whether or not males and females experienced similar or different life stresses that were recorded in their markers. The results were analyzed using both specific attachments sites as well as compared in muscle groups to identify possible patterns among the sexes.

Specific Entheseal Attachment Site Rankings

This section provides the ranks and statistical analysis for both entheseal attachment sites between males and females. Results demonstrate possible patterns between the sexes which may be indicative of either gendered based labor activities or sexual dimorphic physiological differences.

In order to understand a possible division of labor or at least whether males and females had different life stresses, both entheseal changes and osteoarthritis scores were analyzed separately for each sex. The results indicated in tables 45-47 below demonstrate both similarities and differences regarding the highest and the lowest ranked scores. Robusticity scores between the sexes demonstrate that females had the highest score among the pectoralis major and brachialis while males had the highest scores at the costoclavicular and the supraspinatus at. These results indicate that females demonstrated higher results for movements relating to the rotation of the shoulder as well as a strong flexion in the elbow joint. Males, on the other hand, showed higher results at the costoclavicular attachment, which anchors the clavicle and prevents displacement as well as the abduction of the humerus which lifts the arms upwards towards and over the head.

Table 45. Robusticity rankings scores for entheses between males and females

ROBUSTICITY RANKING SCORES					
FEMALE			MALE		
MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE
Pec. Maj.	1	2.901	Costoclav.	1	2.654
Brachialis	2	2.847	Supraspin.	2	1.732
Conoid Lig.	3	2.632	Brachialis	3	1.704
Bic. Brach.	4	2.630	Pec. Major	4	1.612
Com. Ext.	5	2.622	Bic. Brach.	5	1.545
Trap. Lig.	6	2.586	Com. Ext.	6	1.457
Deltoid	6	2.586	Ter. Maj.	7	1.415
Supraspin.	8	2.582	Trap. Lig.	8	1.397
Pro. Teres	9	2.478	Deltoid	8	1.387
Trapezius	10	2.391	Trapezius	10	1.381
Teres Major	11	2.373	Conoid Lig.	11	1.375
Costoclav.	12	2.356	Pro. Teres	12	1.307
Pec. Minor	13	2.304	Pec. Minor	13	1.250
Teres Minor	14	2.244	Tri. Brach.	14	1.197
Infraspin.	15	2.197	Ter. Minor	15	1.176
Com. Flex.	16	2.130	Anconeus	16	1.154
Tri. Brach.	17	2.010	Lat. Dor.	17	1.140
Lat. Dor.	18	1.934	Infraspin.	18	1.098
Anconeus	18	1.934	Com. Flex.	19	1.084
Supinator	20	1.771	Subclavius	20	1.021
Coraco.	21	1.695	Supinator	21	0.979
Subclavius	22	1.655	Coraco.	22	0.943
Pron. Quad.	23	1.423	Pro. Quad	23	0.859

The lower average robusticity scores compared between males and females show similar trends but are not the same. For females, the lowest ranking scores are the subclavius and pronator quadratus at while scores for males are the lowest at the coracobrachialis and pronator quadratus attachment sites. It seems that for both sexes, the pronator quadratus, responsible for pronation of the forearms, is the weakest attachment for robusticity. However, while the second to last ranked scores are different between males and females, it seems that there is a similarity among the lowest four scores. For both sexes, the lowest four scores are the supinator, coracobrachialis, subclavius and pronator quadratus. The only difference is that minus the pronator quadratus, they are ranked in a different order. This result could be explained by the fact that these attachment sites may not be as prone to developing robust markers versus other ones and that sex is not a factor in their ranking but rather their mean scores. In this case, females have higher robusticity mean scores than males.

When cortical defect scores were compared between the sexes, a similar picture emerged among the highest-ranking sites. For females, the highest ranked sites were the supraspinatus and the brachialis. For males, it was the costoclavicular and the brachialis. Both males and females had high results at the brachialis attachment sites which is responsible for flexion at the elbow. This again could be indicative of a commonly used attachment site for all individuals rather than mean scores being controlled for by sex.

Table 46. Cortical defect ranking scores for entheses between males and females

CORTICAL DEFECT RANKING SCORES					
FEMALE			MALE		
MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE
Supraspin.	1	0.769	Costoclav.	1	1.158
Brachialis	2	0.543	Brachialis	2	1.028
Costoclav.	3	0.252	Pec. Major	3	1.021
Trap. Lig.	4	0.229	Bic. Brach.	4	1.000
Teres Major	5	0.164	Supraspin.	5	0.971
Bic. Brach.	6	0.076	Com. Ext.	6	0.753
Infraspin.	7	0.054	Ter. Major	7	0.690
Teres Minor	8	0.044	Deltoid	8	0.676
Pec. Major	9	0.043	Conoid Lig.	9	0.617
Subclavius	10	0.034	Trap. Lig.	10	0.574
Lat. Dor.	11	0.032	Pro. Teres	11	0.510

Table 46—Continued

Deltoid	11	0.032	Trapezius	12	0.465
Tri. Brach.	13	0.021	Pec. Minor	13	0.437
Pec. Minor	14	0.010	Tri. Brach.	14	0.422
Supinator	14	0.010	Infraspin.	15	0.394
Pro. Quad.	14	0.000	Anconeus	16	0.387
Conoid Lig.	17	0.000	Ter. Minor	17	0.380
Trapezius	17	0.000	Com. Flex.	18	0.352
Coraco.	17	0.000	Lat. Dor.	19	0.323
Com. Ext.	17	0.000	Subclavius	20	0.257
Com. Flex.	17	0.000	Coraco.	21	0.197
Anconeus	17	0.000	Supinator	22	0.167
Pro. Teres	17	0.000	Pro. Quad	23	0.105

The lower cortical defect scores demonstrate two completely different patterns between males and females. The lowest scores for the females were found at eight different attachment sites which included the anconeus, coracobrachialis, and pronator teres to name a few. These attachment sites had no indications of cortical defect. Among males, however, all the attachment sites had some degree of cortical defect with the lowest scores found at the supinator and pronator quadratus. Overall, these results demonstrate that males have higher instances overall of cortical defect which represents the possibility of a higher stress workload among males than females. This would require incidents in which the muscles were pulled from the bone, developing the pits and stress lesions at the attachment sites.

Lastly, ossification exostosis scores were also tallied and ranked between the sexes. Results indicate that for females, the highest scores were at the pectoralis major and brachialis attachment sites whereas for males, it was the biceps brachii and pectoralis major sites. Mean scores were somewhat similar however males tended to have a little bit higher ossification exostosis scores than females. Overall, scores among specific attachment sites between males and females demonstrate some similarities in the lower ranked mean scores while differences among most of the higher ranked scores which could be indicative of diverging life experiences.

Table 47. Ossification exostosis ranking scores for entheses between males and females

OSSIFICATION EXOSTOSIS RANKING SCORES					
FEMALE			MALE		
MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE
Pec. Maj.	1	1.637	Bic. Brac.	1	2.034
Brachialis	2	1.445	Pec. Major	2	1.992
Deltoid	3	1.358	Brachialis	3	1.936
Bic. Brach.	3	1.358	Teres Minor	4	1.922
Conoid Lig.	5	1.344	Conoid Lig.	5	1.909
Com. Ext.	6	1.244	Trap. Lig.	6	1.900
Supraspin.	7	1.197	Tri. Brach.	7	1.895
Costoclav.	8	1.057	Teres Major	8	1.873
Trap. Lig.	8	1.057	Com. Ext.	8	1.873
Teres Major	10	1.021	Trapezius	10	1.784
Pro. Teres	11	1.010	Pec. Minor	11	1.769
Trapezius	12	0.989	Com. Flex.	12	1.746
Teres Minor	13	0.955	Lat. Dor.	13	1.725
Pec. Minor	14	0.934	Deltoid	14	1.640
Infraspin.	15	0.879	Supraspin.	15	1.598
Com. Flex.	16	0.695	Coraco.	15	1.598
Tri. Brach.	17	0.684	Costoclav.	17	1.574
Anconeus	18	0.597	Subclavius	18	1.542
Lat. Dor.	19	0.439	Anconeus	19	1.514
Subclavius	20	0.413	Infraspin.	20	1.450
Supinator	21	0.391	Pro. Teres	21	1.370
Coraco.	22	0.347	Supinator	22	0.915
Pro. Quad.	23	0.173	Pro. Quad.	23	0.210

Muscle Group Entheseal Attachment Site Rankings

Entheses were then combined into the seven muscle groups and then ranked accordingly between males and females to examine whether large scale changes found in muscle groups are different in relation to sex (Table 48). Robusticity scores between the sexes were quite similar in which both muscle groups #3 and group #6 had the highest scores. The only exception was group #3 was higher for females than #6 and group #6 was higher than #3 for males. Overall, male mean scores were a little higher than female means scores. Group #3 is comprised of the deltoid and supraspinatus which abducts the arm while group #6 composed of the costoclavicular, biceps brachii, brachialis and common flexors is responsible for flexing the forearm. It seems that in this case, both males and females had similar stress workloads regarding the movement of those muscle groups however, if they had similar occupations cannot be determined due to the large amount of occupations that require the use of these two muscle groups.

Table 48. Robusticity ranking scores for muscle groups between males and females

ROBUSTICITY RANKING SCORES					
FEMALE			**MALE**		
MUSCLE GROUP	**RANK**	**ENTHESIS SCORE**	**MUSCLE/ LIGAMENT**	**RANK**	**ENTHESIS SCORE**
Group #3	1	2.584	Group #6	1	2.623
Group #6	2	2.493	Group #3	2	2.612
Group #1	3	2.314	Group #5	3	2.460
Group #2	4	2.224	Group #1	4	2.401
Group #4	5	2.220	Group #2	5	2.399
Group #5	6	2.186	Group #4	6	2.116
Group #7	7	1.891	Group #7	7	1.934

For lower robusticity scores, females and males had the same result in which the lowest ranked muscle group was #7. Muscle group #7 is comprised of the pronator teres, pronator quadratus and supinator and these attachments are responsible for the pronation and supination of the forearm. It is likely that group #7, in general, does not have as robust markers as the other muscle groups and that sex does is not a primary factor for there are small scores to begin with. For the second lowest ranking score, females were group #5 and males group #4, which extends the forearm and rotates the arm laterally.

For the highest ranked cortical defect scores, males and females displayed the same patterns as the robusticity section (Table 49). For females, groups #3 and #6 were ranked first and second whereas for males, groups #6 and #3 were ranked first and second. These results are not surprising as oftentimes robusticity and cortical defect are paired together because they both are examples of microtrauma to the bone as well as having long term development i.e. it takes more time for robusticity and cortical defect to develop high scores on the attachment sites versus short term trauma like ossification exostosis.

Table 49. Cortical defect ranking scores for muscle groups between males and females

CORTICAL DEFECT RANKING SCORES					
FEMALE			**MALE**		
MUSCLE GROUP	**RANK**	**ENTHESIS SCORE**	**MUSCLE/ LIGAMENT**	**RANK**	**ENTHESIS SCORE**
Group #3	1	0.398	Group #6	1	0.473
Group #6	2	0.217	Group #3	2	0.415
Group #2	3	0.060	Group #2	3	0.167
Group #1	4	0.053	Group #5	4	0.147
Group #4	5	0.049	Group #4	5	0.091
Group #5	6	0.0073	Group #1	6	0.063
Group #7	7	0.0072	Group #7	7	0.037

The lower scores in the cortical defect category once again demonstrate that muscle group #7 has the lowest ranked mean scores between females and males. However, the second ranked lowest scores are a little different. In the case of females, muscle group #5 had the second lowest ranked scores but for males it was muscle group #1. This demonstrates that for females, there was less entheses emphasis on the extension of the forearm while males had less emphasis on the stabilization of the pectoral girdle. These differences could indicate a possible sexual division of labor in which different muscle groups experience different forms of entheseal stress.

Ossification exostosis scores were also re-ranked according to muscle group (Table 50). The higher ranked scores followed the same pattern as the robusticity and cortical defect categories regarding males and females. The lower ranked scores were a little different. Muscle group #7 again was ranked the lowest among both males and females. However, the second lowest ranked scores were a little different. For females, muscle group #5 has the second lowest score while for males it was group #4.

Table 50. Ossification exostosis ranking scores for muscle groups between males and females

OSSIFICATION EXOSTOSIS RANKING SCORES					
FEMALE			MALE		
MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE
Group #3	1	1.278	Group #6	1	1.291
Group #6	2	1.140	Group #3	2	1.267
Group #1	3	0.948	Group #5	3	1.072
Group #4	4	0.917	Group #1	4	1.011
Group #2	5	0.860	Group #2	5	1.007
Group #5	6	0.839	Group #4	6	0.771
Group #7	7	0.525	Group #7	7	0.556

Statistical Analysis of Entheseal Attachment Sites

Entheseal attachment scores and osteoarthritic scores were also analyzed to look for statistically significantly differences within the population between males and females. The results demonstrate that males and females have both similarities and differences regarding entheseal and osteoarthritic stress.

Overall results indicate that while there are some instances of entheseal differences among the sexes, most of the results demonstrated statistically insignificantly different results. The charts and tables below represent the mean comparisons for both males and females among specific attachment sites as well as muscle groups. Most significant values between the sexes demonstrated higher mean results among males while a few others were higher among females.

Left and Right Separate

Table 90 in the appendix lists out the statistically significantly different results among specific attachment sites between the sexes separating out left and right sides as well as each category of robusticity, cortical defect and ossification exostosis. Out of 138 specific attachment sites, 25 of them were determined to be statistically significantly different, about 18.11%. The statistically significantly different results, most were found on the right side of the skeleton and in the robusticity category. Only two out of the 25 significant results demonstrated higher mean female results compared to male results. They are found in the robusticity and ossification results of the infraspinatus which carries out lateral rotation and abduction of the humerus.

Left and Right Combined

Left and ride side scores from specific attachment sites were then combined and reanalyzed using t-tests to discern if there are significant differences in the results between the sexes (Table 91 in the appendix). Out of 69 potential scoring sites, 22 of them were deemed statistically significantly different among the sexes which is about 31.88%, about 12% higher than the results that were separated between the left and right sides of the body. Comparison among mean scores between males and females show that females had the higher scores among nine out of the 22 scores, about 40.9%. For females, most the higher mean scores were found in the robusticity categories whereas males scores were found among all three categories. No discernable patterns were found regarding which types of movements are more likely to occur in one sex over the other. However, later analysis will examine these differences among muscle groups rather than specific attachment sites.

Robusticity and Cortical Defect Combined, Left and Right Separate

Next, robusticity and cortical defect scores were combined and analyzed. Result show that the percentage of statistically significantly different scores decreased dramatically, demonstrating that previous significant values, most which are robusticity scores, are muted once combined with the cortical defect scores. However, the scores that are left in this grouping demonstrate more significant differences among the sexes than other values. The table (51) below demonstrates the four sites out of 46 (8.6%), separated among left and right sides, have significantly different values. In all the cases, males have higher mean scores when compared to females. The attachment sites are the coracobrachialis, pectoralis major and biceps brachii, all of which provide either strong anchorage among the muscles or represent strong adduction and flexion of the upper limb. The fact that the higher scores are found in males suggest that they had more larger movement stresses rather than smaller, intricate movements, consistent with large scale industry and factory work.

Table 51. Results of the 2 tailed, unpaired t-tests for differences with combined robusticity and cortical defect, left and right sides separate between males and females

NUMBER	SITE	SIDE (L/R)	p VALUE	AVG. MALE	AVG. FEMALE
1	Costco.	Left	2.66E -06	2.529	1.441
2	Costco.	Right	2.12E -07	2.823	1.579
3	Pect. Major	Right	0.005	2.098	1.500
4	Bic. Brachii	Right	0.009	2.028	1.478

Robusticity and Cortical Defect Combined, Left and Right Combined

Lastly, the specific attachment sites were reanalyzed combining scores from the left and right side of the skeleton. The results displayed in the table 52 below demonstrate a very small difference from the previous table. Since the costoclavicular was significant on both the left and the right sides, once combined the results for this site remained statistically significantly different. In sum, significant differences among males and females are found in the costoclavicular ligament, pectoralis major and biceps brachii, where males have the higher mean scores than females.

Table 52. Results of the 2 tailed, unpaired t-tests for differences with combined robusticity and cortical defect, combined left and right sides between males and females

NUMBER	SITE	p VALUE	AVG. MALE	AVG. FEMALE
1	Cost.	2.34E -12	2.679	1.511
2	Pec. Major	0.002	1.993	1.538
3	Bic. Brachii	0.002	1.849	1.418

Statistical Analysis of Muscle Group Entheseal Attachments

Robusticity and Cortical Defect Combined, Left and Right Separate

For muscle group analysis, robusticity and cortical defect were combined and re-analyzed. The results, displayed in table 53 indicate that both muscle group #2 and #6 had significant results for each sex, representing four of 14 sites or 28.5%. All the mean scores were higher for males than females. This demonstrates that the adduction of the arm (group #2) and flexion of the forearm (group #6) in males is statistically higher and may be indicative of differing life experiences in which males are engaging more extensively in heavy labor involving the upper arm, compared with females.

Table 53. Results of the 2 tailed, unpaired t-tests for differences among muscle groups with separate left and right sides between males and females

NUMBER	MUSCLE GROUP	SIDE (L/R)	p VALUE	AVG. MALE	AVG. FEMALE
1	Group #2	Left	0.040	1.457	1.266
2	Group #2	Right	0.001	1.447	1.165
3	Group #6	Left	0.002	1.872	1.549
4	Group #6	Right	4.84E -06	2.105	1.607

Robusticity and Cortical Defect Combined, Left and Right Combined

Lastly, once left and right scores were combined and reanalyzed, another muscle group was deemed notable for a total of three out of seven or 42.8% of total muscle groups. Muscle group #5 was also deemed significant between males and females. The results of all muscle groups for this section are posted in table 54. Figure 28 shows that between the sexes, muscle groups #2, #5 and #6 which are responsible for the adduction of the arm and the extension and flexion of the forearm are statistically significantly different and that males have much higher mean scores than females.

Table 54. Results of the 2 tailed, unpaired t-tests for differences among muscle groups with left and right sides combined between males and females

NUMBER	MUSCLE GROUP	p VALUE	AVG. MALE	AVG. FEMALE
1	Group 2	0.000	2.004	1.216
2	Group 5	0.017	1.267	1.102
3	Group 6	6.25E -08	1.988	1.578

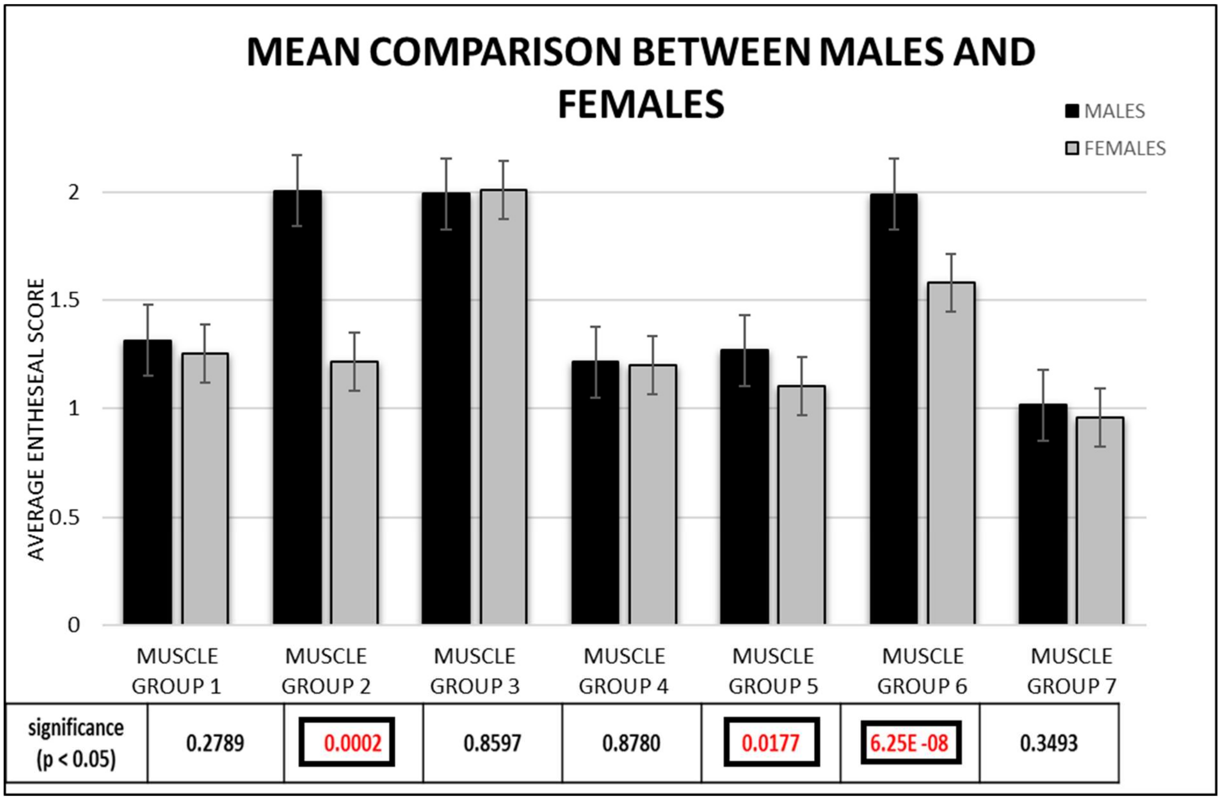


Figure 28. Mean comparisons among muscle groups between males and females

Osteoarthritis Rankings

Osteoarthritis joint scores were also ranked between the sexes (Table 55). The highest results among both males and females are the same with LAC or the lateral acromion of the clavicle ranked first while the medial acromion process of the scapula was ranked second. Both joint sites belong to the acromio-clavicular joint which makes sense in conjunction with the scores from muscle group #3 which adducts the arm as the acromio-clavicular joint allow an individual to raise their arm above their head.

The lowest ranking mean scores were for females, the distal trochlea of the humerus and the proximal head of the radius whereas for males the proximal head of the radius and the proximal head of the humerus had the lowest results. These scores demonstrate that except for the proximal head of the humerus, all the lowest scores are found in the elbow joint which indicates that out of the three possibilities, the elbow between both sexes has less osteoarthritic overall.

Table 55. Osteoarthritis joint site ranking scores between males and females

FEMALE RESULTS				MALE RESULTS			
JOINT SITE	**JOINT**	**RANK**	**OSTEOARTH. SCORE**	**JOINT SITE**	**JOINT**	**RANK**	**OSTEOARTH. SCORE**
LAC	ACRO	1	0.956	LAC	ACRO	1	1.356
MAP	ACRO	2	0.920	MAP	ACRO	2	1.306
GLF	SHOU	3	0.897	GLF	SHOU	3	0.989
DHC	ELB	4	0.827	DHC	ELB	4	0.893
PRU	ELB	5	0.688	PRU	ELB	5	0.792
PRH	SHOU	6	0.654	DHT	ELB	6	0.686
DHT	ELB	7	0.618	PRR	ELB	7	0.684
PRR	ELB	8	0.540	PRH	SHOU	8	0.619

When each osteoarthritic joint site is combined into their respective joints, the same pattern becomes clearer (Table 56). In both males and females, the acromio-clavicular joint has the highest mean scores and the elbow joint has the lowest ranking scores. This is possibly indicative of higher degrees of larger range motion over a long period of time rather than smaller single range motion found in the hinge joint of the elbow.

Table 56. Osteoarthritis joint ranking scores between males and females

FEMALE RESULTS			**MALE RESULTS**		
JOINT	**RANK**	**OSTEOARTH. SCORE**	**JOINT**	**RANK**	**OSTEOARTH. SCORE**
ACRO-CLAV	1	0.937	ACRO-CLAV	1	1.311
SHOULDER	2	0.776	SHOULDER	2	0.806
ELBOW	3	0.668	ELBOW	3	0.764

Statistical Analysis of Osteoarthritis

Osteoarthritis was also scored and analyzed to examine possible differences between males and females and demonstrate whether the osteoarthritis scores corresponded with the statistically significantly different scores found in the muscle groups.

Results for each statistically significantly different osteoarthritis joint site are displayed in table 57. Out of a possible eight sites, four of them were deemed statistically significantly different between the sexes. Two of the results were from the acromio-clavicular joint and two of them were from the elbow joint. These results match up with the muscle group results from the entheses because muscle group #2 is associated with the acromio-clavicular joint as it allows the arm to be raised over the head and muscle groups #5 and #6 are associated with the elbow joint as they extend and flex the forearm.

Table 57. Results of the Mann-Whitney U Test for differences per each joint site between males and females

NUMBER	JOINT SITE	JOINT	p VALUE	AVG. MALE	AVG. FEMALE
1	LAC	ACRO-CLAV	5.97 E -10	1.356	0.956
2	MAP	ACRO-CLAV	6.60 E -10	1.306	0.920
3	PRR	ELBOW	0.002	0.619	0.540
4	PRU	ELBOW	0.049	0.792	0.688

Once combined into joints rather than joint sites, the pattern remains the same in which both the acromio-clavicular and elbow joints were considered statistically significantly different (Table 58).

Table 58. Results of the Mann-Whitney U Test for differences per joint between males and females

NUMBER	JOINT	p VALUE	AVG. MALE	AVG. FEMALE
1	ACRO-CLAV	1.95 E -18	1.331	0.937
2	ELBOW	0.0002	0.764	0.668

Figure 29 below shows the mean scores for each osteoarthritis joint sites compared between males and females. In this case, while the statistically significantly different scores have a higher male means compared with females, it seems that those scores that are not significant still have a higher male average than females. This is possible evidence for higher biological stress among males than females because of either different activity loads or a possible sexual division of labor in addition to other factors such as age.

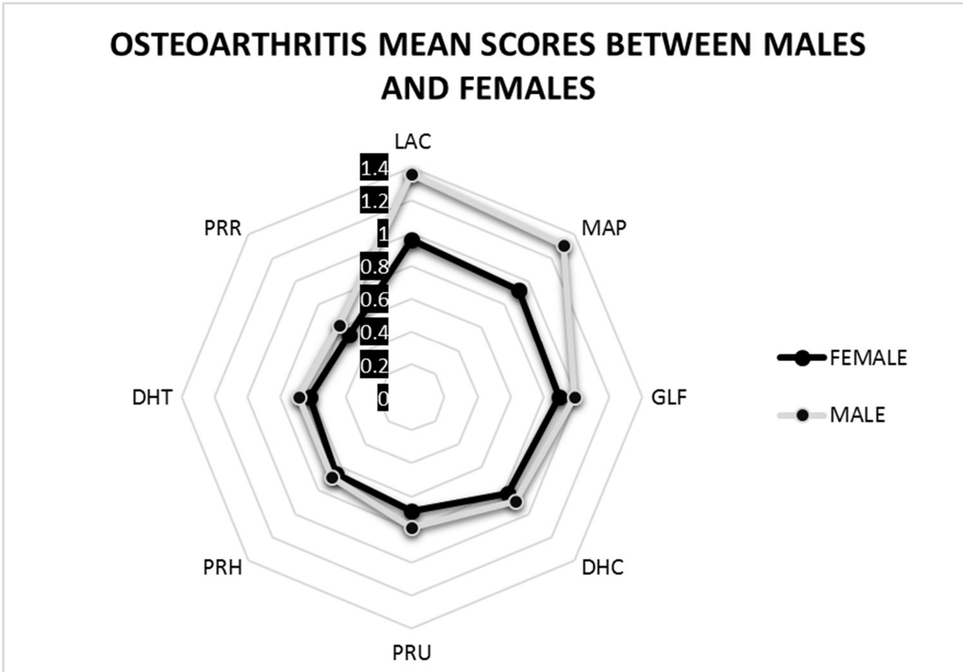


Figure 29. Osteoarthritis mean scores between males and females

Frequencies of Osteoarthritis

Frequencies of osteoarthritis were calculated at the shoulder, acromioclavicular and elbow joints between males and females to highlight possible similarities and differences which indicate a sexual division of labor. For all three of the joints, males had the highest frequencies for each category demonstrated overall higher levels of stress among males, however each joint was examined separately to determine trends between slight and heavy osteoarthritis. Figure 30 below examines the results for the shoulder joint. In this case, males had higher cases of both slight and heavy osteoarthritis indicative of more intense and repetitive labor perhaps which began at an early age and build up over time. For females, there are less osteoarthritis sites and less severity across the board as females in this sample did not have any severe osteoarthritis at the shoulder and very few moderate sites. This demonstrates that for females, osteoarthritis was less developed than males which may be indicative of a later start for heavy workloads or employment in domestic occupations which required less force and stress when compared to the heavy force and stress of industrial factory jobs where more males were employed.

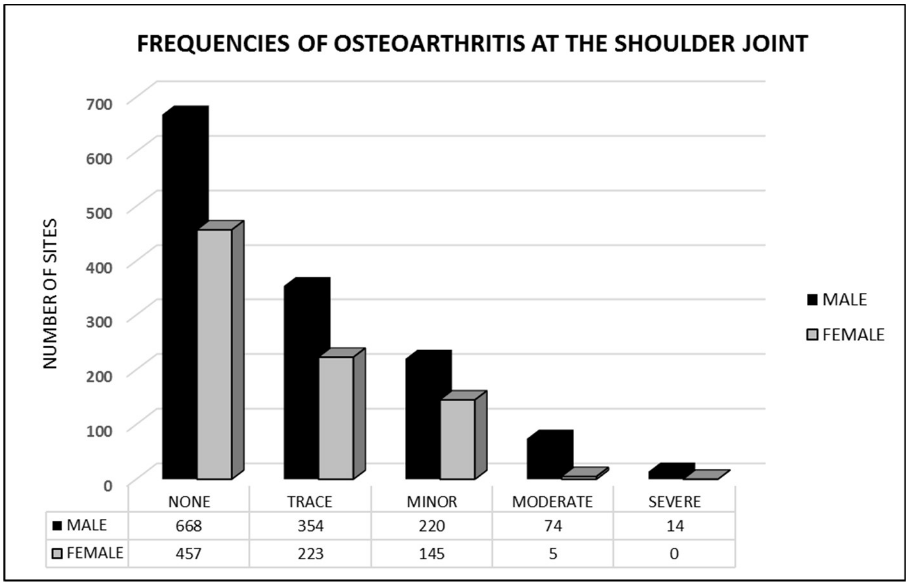


Figure 30. Frequencies of Osteoarthritis at the should joint between males and females

Frequencies were also calculated among the acromioclavicular joint with surprisingly different results than the shoulder joint (Figure 31). At this joint, males still have a higher number of osteoarthritis sites compared to females but the range between the trace, minor and moderate categories is bigger than at the shoulder joint. For the trace sites, males and females are almost equal in the number of sites scored. This is a likely result of the acromioclavicular joint rather than a sexual division of labor as the acromioclavicular joint is responsible for raising and lowering the arms over the head, a movement which is used in both occupational and non-occupational activities. The minor category however shows a large discrepancy in the number of sites between males and females in which males have more than double the number of sites that females do. This pattern continued at the moderate and severe categories were males have double and six times the frequencies of scores than females. While compared to the shoulder and elbow joints, the acromioclavicular is the most used for both males and females, the large differences at the acromioclavicular joint point to a sexual division of labor regarding occupational activities and stress. As demonstrated in the literature review, males and females seemed to have their own occupational spheres however there was room to cross those boundaries as shown by female industrial workers and male domestic workers. The osteoarthritis scores seem to support the literature as occupations for both males and females had similar locations of stress but the amount of stress on the body differed based on the occupational sphere in which males had more stress and females less.

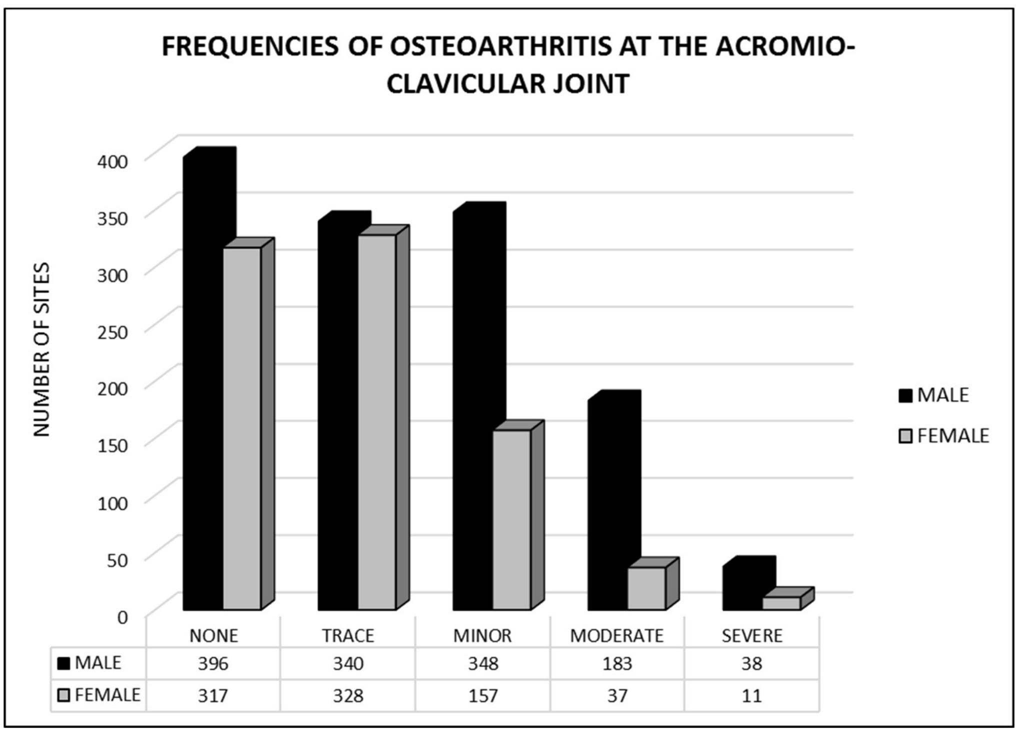


Figure 31. Frequencies of osteoarthritis at the acromioclavicular joint between males and females

Lastly, frequencies were also calculated at the elbow joint and then compared between males and females (Figure 32). Like the results from the shoulder joint, the elbow joint frequencies follow a pattern in which males had higher frequencies of osteoarthritis at every stage than females. Despite this, females had higher amounts of stress at the elbow joint compared to the shoulder indicative of activity patterns which require more forearm flexion and extension rather than larger scale shoulder movements. This matches up with the literature as many female occupations focused on domestic duties such as cleaning or laundry, both which used a back and forth motion which extends and flexes the elbow continuously.

The results are similar for males in which the elbow joint has a higher frequency that the shoulder joint. While there are some instances of males performing domestic duties, most occupations during this time were either non-forceful clerical duties or heavy industrial labor. As a result, the repetition of using a machine or working on an assembly line could explain the similar patterns of osteoarthritis stress demonstrated in this sample. It is very likely that both males and females had similar movement patterns to perform their occupations.

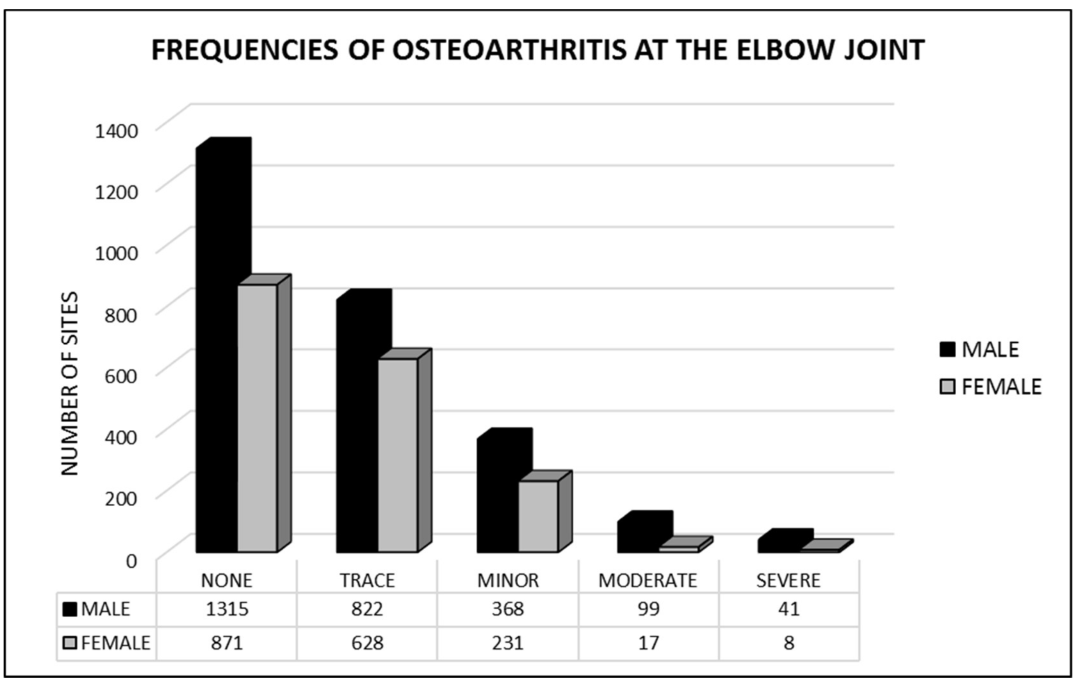


Figure 32. Frequencies of osteoarthritis at the elbow joint between males and females

Age

This section examines entheseal changes and osteoarthritis scores among three age categories of adults. Young adults were aged 25-35 years, middle adults 36-59 years and old adults 60-73 years. As demonstrated in the literature review, biological stresses are often contingent on age as the body wears down over time and builds up higher levels of stress. While this section examines instances in which older adults had higher scores of activity stresses, it also comments on whether different age groups experience similar or diverse life stresses recorded in their markers. The results were analyzed using both specific attachment sites as well as muscle groups to identify possible patterns among the age groups.

Specific Entheseal Attachment Site Rankings

In order to examine which attachment sites per age groups had the highest and lowest scores, both entheseal changes and osteoarthritis scores were ranked separately for each age group. The results indicated in tables 59-61 below show that there are some similarities and differences among each of the groups.

Robusticity between all three age groups was examined first. The pectoralis major muscle was ranked first among all three of the age group as having the highest mean score per each age categories. Once those three scores were compared, the old adult group had the highest mean for that site, followed by middle adult, and then young adult group. Despite the higher scores among the older adults, the differences between the mean scores seems slight and was statistically tested later along with the other markers to see if those slight variations were significantly different. The second highest ranked score was the brachialis among both the young adult and middle adult age groups whereas it was ranked third in the older adult group, with the biceps brachii ranked as second.

Table 59. Robusticity ranking scores for entheses among age groups

ROBUSTICITY RANKING SCORES								
YOUNG ADULT			MIDDLE ADULT			OLD ADULT		
MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE
Pec. Major	1	2.800	Pec. Major	1	2.956	Pec. Major	1	2.982
Brachialis	2	2.750	Brachialis	2	2.827	Bic. Brach	1	2.982
Com. Ext.	3	2.616	Bic. Brach	3	2.752	Brachialis	3	2.913
Bic. Brach	4	2.600	Com. Ext.	4	2.710	Deltoid	4	2.896
Costoclav.	5	2.438	Deltoid	5	2.689	Com. Ext.	4	2.896
Supraspin.	6	2.416	Con. Lig.	6	2.657	Con. Lig.	6	2.842
Con. Lig	7	2.368	Trap. Lig.	7	2.578	Teres Maj	7	2.736
Trap. Lig.	8	2.315	Supraspin.	8	2.577	Supraspin.	8	2.719
Deltoid	9	2.266	Costoclav.	9	2.548	Trapezius	9	2.706
Teres Maj	10	2.200	Trapezius	10	2.542	Pro. Teres	10	2.655
Pro. Teres	11	2.166	Teres Maj	11	2.525	Trap. Lig.	11	2.631
Trapezius	11	2.166	Pro. Teres	12	2.495	Costoclav.	12	2.625
Pec. Min	13	2.083	Pec. Min	13	2.398	Pec. Min	13	2.586
Teres Min	14	2.033	Tri. Brach.	14	2.318	Tri. Brach.	14	2.551

Table 59—Continued

Com. Flx.	14	2.033	Teres Min	15	2.275	Anconeus	15	2.448
Infraspin.	16	1.950	Com. Flx.	16	2.206	Lat. Dor.	16	2.350
Anconeus	17	1.800	Anconeus	17	2.172	Teres Min	17	2.285
Lat. Dor.	18	1.750	Lat. Dor.	18	2.155	Infraspin.	18	2.175
Supinator	19	1.583	Infraspin.	19	2.137	Com. Flx.	19	2.155
Tri. Brach.	20	1.566	Coraco.	20	1.931	Subclavius	20	2.088
Subclavius	21	1.509	Subclavius	21	1.850	Supinator	21	2.068
Coraco.	22	1.450	Supinator	22	1.794	Coraco.	22	1.948
Pro. Quad.	23	1.283	Pro. Quad.	23	1.482	Pro. Quad.	23	1.724

For the lower ranked scores, all three age groups showed the pronator quadratus was ranked last and demonstrated higher scoring averages among the oldest age category. The second lowest ranked score, at 22nd place, was the same among the younger and older adults age groups but was different for the middle adult group. The coracobrachialis was ranked 22nd for the young and old adult groups. Instead of the coracobrachialis, the middle adult group ranked the supinator at the 22nd spot and the coracobrachialis had a higher mean score in this group, appearing in 20th place rather than 22nd.

Cortical defect was also examined among all three age groups to determine which group had the higher ranked scores at certain attachment sites. For the highest cortical defect scores, both the young adult and middle adult age categories ranked the supraspinatus first. The older adult group instead ranked the costoclavicular ligament as the attachment site with the highest mean average. It is notable that while the older age group did not rank the supraspinatus first among the attachment sites, the mean score of the first-place site for the young adult group was higher than the first ranked site for the old adult group. The difference was 1.016 (young adult) to 0.750 (old adult). This could demonstrate that in younger age groups, cortical defect may represent instances of higher stress labor patterns which eventually even out as individuals get older or are reabsorbed back into the skeleton once remodeling is finished. If this is correct, it may be possible to get an understanding of whether the types of labor (and associated stresses) individuals worked differed because of age.

Table 60. Cortical defect ranking scores for entheses among age groups

CORTICAL DEFECT RANKING SCORES								
YOUNG ADULT			MIDDLE ADULT			OLD ADULT		
MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE
Supraspin.	1	1.016	Supraspin.	1	0.698	Costoclav.	1	0.750
Costoclav.	2	0.894	Costoclav.	2	0.681	Supraspin.	2	0.719
Brachialis	3	0.633	Brachialis	3	0.612	Pec. Major	3	0.421
Bic. Brach	4	0.233	Trap. Lig.	4	0.210	Brachialis	4	0.379
Trap. Lig.	5	0.210	Pec. Major	5	0.189	Teres Maj	5	0.350
Infraspin.	6	0.183	Teres Maj	5	0.189	Bic. Brach	6	0.258
Teres Maj	7	0.166	Bic. Brach	7	0.145	Trap. Lig.	7	0.245
Pec. Major	8	0.133	Infraspin.	8	0.051	Lat. Dor.	8	0.122
Teres Min	9	0.083	Teres Min	8	0.051	Pro. Teres	9	0.1034
Subclavius	10	0.052	Pro. Teres	10	0.427	Infraspin.	10	0.087
Tri. Brach.	11	0.050	Trapezius	11	0.033	Deltoid	11	0.086
Com. Ext.	12	0.033	Com. Ext.	12	0.0263	Teres Min	12	0.035
Trapezius	12	0.033	Subclavius	13	0.026	Trapezius	13	0.034

Table 60—Continued

Lat. Dor.	14	0.016	Con. Lig.	13	0.026	Tri. Brach.	14	0.017
Pro. Teres	14	0.016	Lat. Dor.	15	0.025	Com. Ext.	14	0.017
Pro. Quad.	14	0.016	Deltoid	15	0.025	Subclavius	16	0
Supinator	14	0.016	Pro. Quad.	15	0.025	Con. Lig.	16	0
Con. Lig.	18	0	Pec. Min	18	0.016	Pec. Min	16	0
Pec. Min	18	0	Supinator	19	0.008	Coraco.	16	0
Deltoid	18	0	Coraco.	20	0	Com. Flx.	16	0
Coraco.	18	0	Com. Flx.	20	0	Anconeus	16	0
Com. Flx.	18	0	Anconeus	20	0	Supinator	16	0
Anconeus	18	0	Tri. Brach.	20	0	Pro. Quad.	16	0

Cortical defect lower scores, however, were different among all the age groups. For young adults, the conoid ligament, pectoralis minor, deltoid, coracobrachialis, common flexors and anconeus were all ranked last. For the middle adults, the coracobrachialis, common flexors, anconeus and triceps brachii were all ranked last. For the old adult category, the subclavius, conoid ligament, pectoralis minor, coracobrachialis, common flexors, anconeus, supinator and pronator quadratus were all ranked last. While some of these attachment sites overlap each of the groups, it seems as if older adult individuals have less indications of cortical defect than the other two groups. This could possibly demonstrate that either the cortical defects were eventually repaired by bone processes over time or that this could be a possible generational shift in activities between older and younger generations. The results, however, are unclear to favor one explanation over the other.

Lastly, ossification exostosis was also ranked among each of the age groups. For the highest score, all three age groups ranked the pectoralis major first. This is consistent with most of the previous patterns which show higher mean scores are found in older age individuals. The second ranked score, however, varied a little among the groups. Both the middle adult and old adult age groups ranked the biceps brachii as the second highest. For the young adult age category, the brachialis was ranked second.

Table 61. Ossification exostosis ranking scores for entheses among age groups

OSSIFICATION EXOSTOSIS RANKING SCORES								
YOUNG ADULT			MIDDLE ADULT			OLD ADULT		
MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE
Pec. Major	1	1.400	Pec. Major	1	1.715	Pec. Major	1	1.877
Brachialis	2	1.350	Bic. Brach	2	1.547	Bic. Brach	2	1.827
Bic. Brach	3	1.333	Brachialis	3	1.465	Com. Ext.	3	1.758
Com. Ext.	4	1.000	Com. Ext.	4	1.447	Deltoid	4	1.724
Supraspin.	5	0.966	Deltoid	5	1.413	Brachialis	5	1.689
Costoclav.	6	0.965	Con. Lig.	6	1.412	Con. Lig.	6	1.543
Con. Lig.	7	0.947	Costoclav.	7	1.221	Supraspin.	7	1.385
Deltoid	8	0.883	Supraspin.	8	1.206	Teres Maj	8	1.368
Trap. Lig.	9	0.842	Teres Maj	8	1.206	Pro. Teres	9	1.258
Teres Maj	10	0.733	Trap. Lig.	10	1.149	Trapezius	10	1.224
Teres Min	11	0.700	Trapezius	11	1.127	Costoclav.	11	1.214
Trapezius	12	0.683	Pro. Teres	12	1.034	Trap. Lig.	12	1.192
Pro. Teres	13	0.650	Pec. Min	13	1.033	Pec. Min	13	1.189
Pec. Min	14	0.600	Teres Min	14	0.922	Tri. Brach.	14	1.120

Table 61—Continued

Infraspin.	14	0.600	Tri. Brach.	15	0.905	Anconeus	15	0.982
Com. Flx.	16	0.566	Infraspin.	16	0.827	Teres Min	16	0.946
Anconeus	17	0.466	Com. Flx.	17	0.801	Infraspin.	17	0.894
Tri. Brach.	18	0.383	Anconeus	18	0.706	Lat. Dor.	18	0.789
Subclavius	19	0.333	Lat. Dor.	19	0.655	Com. Flx.	19	0.706
Lat. Dor.	20	0.300	Subclavius	20	0.522	Subclavius	20	0.701
Supinator	21	0.183	Coraco.	21	0.482	Supinator	21	0.655
Coraco.	22	0.166	Supinator	22	0.350	Coraco.	22	0.500
Pro. Quad.	22	0.166	Pro. Quad.	23	0.241	Pro. Quad.	23	0.431

In the lowest ranking results, a similar pattern emerges. For the last ranked attachment site (23rd), all three age groups ranked the pronator quadratus in that spot. The 22nd ranked score however varied among one of the age groups. In this case, the young adult and the older adult age group ranked the coracobrachialis in that spot whereas for the middle adult category, the supinator held that ranking spot.

Muscle Group Entheseal Attachment Site Rankings

The specific entheses attachment sites were then combined into the seven muscle groups and then ranked among each of the age categories to examine whether the frequency and locations of large scale movements varied among age. (Table 62 below)

Robusticity and cortical defect scores were combined for this ranking as the ranking patterns among both of those variables were close for each of the age groups. Results indicate that both the highest ranked muscle group and the lowest ranked one were the same across all three age groups. The highest muscle group was #3. Unlike previous patterns observed based at specific attachment sites, it appears that for the muscle groups, the middle adult age group had a higher mean score than the old adult group which indicates that middle adults experienced more stress than older adults at the time the collection was curated. The second-highest muscle group followed the same pattern in which it was consistently ranked second among all the age categories and the middle age individuals had the highest ranked score.

Most lower scores were also consistent across each age category. The lowest ranked muscle group was #7. When these results are compared with the other results, the two highest ranked group, #3 and #6 were the only groups in which the middle adult age group had a higher mean than the older adult group. This finding provides additional evidence for the possibility that the middle adult individuals were performing different types of activity loads than previous generations.

Table 62. Ranking scores for muscle groups among age groups

MUSCLE GROUP RANKING SCORES								
YOUNG ADULT			MIDDLE ADULT			OLD ADULT		
MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE
Group #3	1	1.929	Group #3	1	2.065	Group #3	1	1.931
Group #6	2	1.584	Group #6	2	1.947	Group #6	2	1.839
Group #1	3	1.232	Group #2	3	1.397	Group #2	3	1.502
Group #4	4	1.214	Group #1	4	1.316	Group #5	4	1.322
Group #2	5	1.147	Group #5	5	1.227	Group #1	5	1.302
Group #5	6	1.042	Group #4	6	1.187	Group #4	6	1.250
Group #7	7	0.892	Group #7	7	1.017	Group #7	7	1.057

Statistical Analysis of Entheseal Attachment Sites

Entheseal attachment and osteoarthritis scores were also analyzed to determine if statistically significant differences could be observed within the population between the respective age groups. The results, provided below, demonstrate that while most of the sites favored the old adult age groups, there were some instances in which the middle and even the younger adult age groups had the highest means regarding stress.

Using ANOVA tests, the overall results indicate that there is a strong relationship between high entheseal stress and the older adult age group however this finding is also not without exceptions. Tables 92-93 in the appendix represent the mean comparisons for young, middle, and older age groups among specific attachment sites as well as the muscle groups.

Left and Right Separate

Table 92 in the appendix lists out the statistically significantly differences among the specific attachment sites between all three age groups, separating out left and right sides as well as each entheseal category i.e. robusticity, cortical defect and ossification exostosis. Out of 138 specific attachment sites, 65 of them were determined to be statistically significantly different, about 47.1%. Almost all the 23 entheseal markers collected had at least one significant result, the exceptions were costoclavicular ligament, supraspinatus, and infraspinatus. While many the results had higher mean score for the older adults, there were instances of higher averages among middle adults. For example, the ossification exostosis of the right-side trapezius ligament demonstrates a higher mean result in the middle adult category.

Left and Right Combined

Once left and right scores were combined to examine determine if any variation was observable, the results in table 93 in the appendix show a higher ratio of statistically significantly different to insignificant results. Out of 69 possible sites, 45 of these were considered statistically significantly different or about 65.2% which is higher than the previous category. In this case, there were some instances in which the young adult individuals had higher mean scores than both the middle and older adult individuals. One was found at the cortical defect of the supraspinatus in which the young adult score was 1.016, the middle adult was 0.692 and the old adult score was 0.719. The other instance was found on the cortical defect of the infraspinatus whereas the young adult mean score was 0.183 compared to the middle adults at 0.051 and older adults at 0.087. This is consistent with the previous findings however it is interesting to note that neither the supraspinatus nor the infraspinatus were statistically significantly different on either the left or right side but once combined they were significant.

Robusticity and Cortical Defect Combined, Left and Right Separate

The attachment site scores were then re-combined and averaging the scores for each for robusticity and cortical defect. Once this was completed, the percentage of statistically significantly different scores decreased markedly, demonstrating that previous significant results are muted once both robusticity and cortical defect results are combined. However, the scores that are left over in this grouping demonstrate higher mean scores at the middle adult age group rather than the older adult age category as hypothesized. Table 63 below demonstrates that three out of the 46 markers, about 6.5%, were statistically significantly different between the age groups. Out of the three sites, two of them, the right costoclavicular ligament and the left biceps brachii showed higher mean scores among the middle age adults rather than the older or young age groups.

Table 63. Results of the ANOVA tests for differences with combined robusticity and cortical defect, combined left, and right sides between the age groups

NUMBER	SITE	SIDE (L/R)	p VALUE	AVG. YOUNG ADULT	AVG. MIDDLE ADULT	AVG. OLD ADULT
1	Costoclav.	Left	0.000	1.321	2.354	2.410
2	Costoclav.	Right	0.000	1.465	2.728	2.482
3	Bic. Brac.	Left	1.00E -05	1.383	1.652	1.517

Robusticity and Cortical Defect Combined, Left and Right Combined

When left and right scores are then combined per each attachment site, there are more instances of statistically significantly different results. Out of 23 possible attachment sites, five of them (about 21.7%) are statistically significantly different (Table 64). The average mean scores show that out of those five significant scores, three of them have higher values among the middle adult age category rather than the young or old adult categories. The three instances are at the costoclavicular, pectoralis major and biceps brachii. This demonstrates that for certain attachment sites and entheses categories, middle adult individuals are experiencing higher amounts of stress than younger or older age individuals which may indicate either more forceful types of labor or even entirely different occupations.

Table 64. Results of the ANOVA tests for differences with combined robusticity and cortical defect, combined left, and right sides between the age groups

NUMBER	SITE	p VALUE	AVG. YOUNG ADULT	AVG. MIDDLE ADULT	AVG. OLD ADULT
1	Costoclav.	0.000	1.394	2.544	2.447
2	Pec. Maj.	0.005	1.491	2.00	1.775
3	Lat. Dor.	0.021	1.025	1.038	1.322
4	Ter. Maj.	0.025	1.322	1.603	1.862
5	Bic. Brac.	0.050	1.408	1.837	1.646

Statistical Analysis of Muscle Group Entheseal Attachment Sites

Robusticity and Cortical Defect Combined, Left and Right Separate

For the muscle groups, robusticity and cortical defect were combined and re-analyzed. The results in table 65 show that out of a possible 14 site locations, only two of them were considered significant. Out of the seven possible muscle groups, group #2 which is involved with the adduction of the arm, was the only one that had significant values on both the left and right sides of the body. Yet, in this case, both examples demonstrate that the highest mean results are found in the older adult age categories.

Table 65. Results of ANOVA tests for differences among muscle groups with separate left and right sides between the age groups

NUMBER	MUSCLE GROUP	SIDE (L/R)	p VALUE	AVG. YOUNG ADULT	AVG. MIDDLE ADULT	AVG. OLD ADULT
1	Group #2	Left	0.045	1.191	1.424	1.495
2	Group #2	Right	0.005	1.102	1.370	1.508

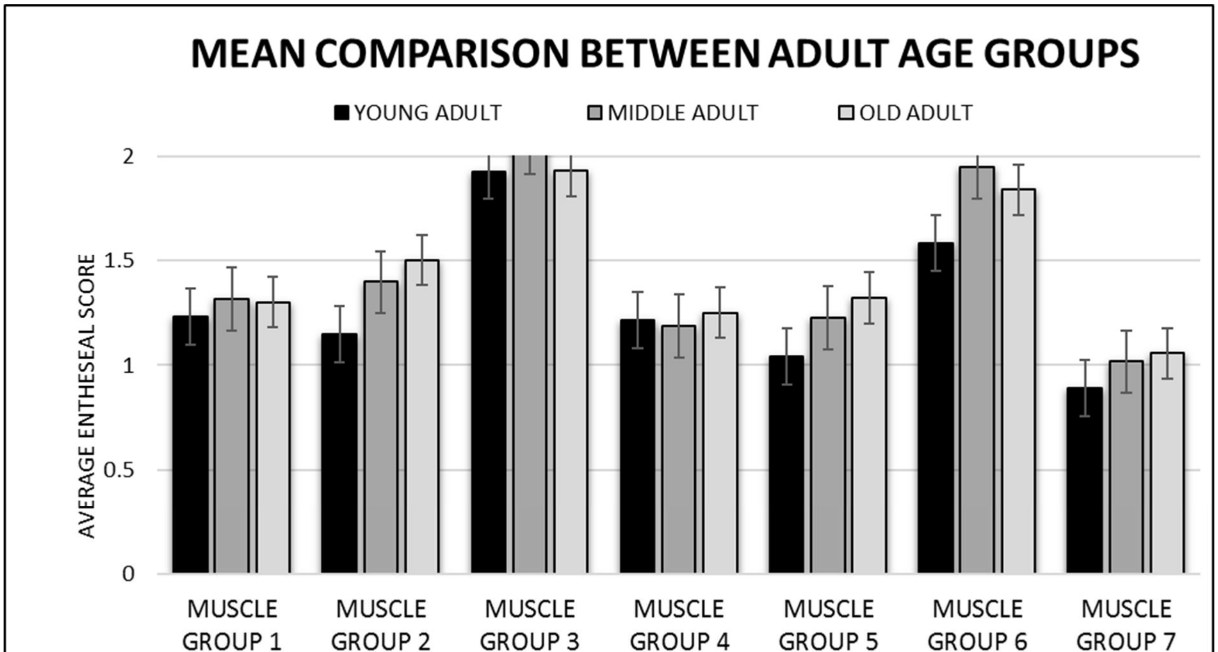
Robusticity and Cortical Defect Combined, Left and Right Combined

Lastly, once left and right scores were combined and analyzed, two other muscle groups in addition to muscle group #2 were considered statistically significantly different among the age groups (Table 66). The overall results indicate that three of the seven muscle group (42.8%) were considered significantly different among the age groups, muscle groups were #2, #5 and #6. Muscle group #2 which controls adduction of the arm and muscle group #5 which extends the forearm both had the highest mean scores in the old adult category. On the other hand, muscle group #6 which flexes the forearm had a higher value in the middle adult category rather than the old adult.

Table 66. Results of the ANOVA tests for differences among muscle groups with combined left and right dies between the age groups

NUMBER	MUSCLE GROUP	p VALUE	AVG. YOUNG ADULT	AVG. MIDDLE ADULT	AVG. OLD ADULT
1	Group #2	0.000	1.147	1.397	1.502
2	Group #5	0.013	1.042	1.227	1.322
3	Group #6	0.000	1.584	1.947	1.839

Figure 33 below reexamines the significant differences among each muscle group for age. As mentioned above, groups #2, #5 and #6 show significance among the variables. However, it is also important to point out that for other non-significant muscle groups such as #1 and #3, the average scores were highest in the middle adult group rather than the old adult group.



significance ($p < 0.05$)	0.4591	0.0003	0.4332	0.8263	0.0128	0.0004	0.1165

Figure 33. Mean comparisons among muscle groups between adult age groups

Biological Affinity

This section examines the results of entheseal changes and osteoarthritic scores between the two biological affinities, also known as ‘race’; African Americans and Caucasians (the majority represents second and third wave European immigration). Previous literature has demonstrated that while there are no biological indicators to differentiate each race, there are social consequences and therefore inherently biological consequences (Andreasen, 2000). The focus of this part of the component seeks to understand if there are labor or activity differences between African Americans and Caucasians or if as marginalized groups both of their types of stresses were similar.[6] The results were analyzed using both specific attachment sites as well as muscle groups to identify possible patterns.

Specific Entheseal Attachment Site Rankings

In order to assess whether there were activity and labor stress differences among the groups, entheseal changes were ranked for each group. The results indicated in tables 67-69 below show both similarities and differences for high and low ranked scores among each category i.e. robusticity, cortical defect and ossification exostosis.

Robusticity between the two groups show that most both the high and low ranked attachment sites are the same. For the higher ranked scores, the pectoralis major was ranked first among both African American and Caucasian groups. In this case, the mean for African Americans has slightly higher than in the Caucasian group.

Table 67. Robusticity ranking scores for entheses between African Americans and Caucasians

ROBUSTICITY RANKING SCORES					
AFRICAN AMERICAN			**CAUCASIAN**		
MUSCLE/ LIGAMENT	**RANK**	**ENTHESIS SCORE**	**MUSCLE/ LIGAMENT**	**RANK**	**ENTHESIS SCORE**
Pec. Major	1	2.932	Pec. Major	1	2.916
Brachialis	2	2.766	Brachialis	2	2.868
Bic. Brach.	3	2.722	Bic. Brach.	3	2.800
Deltoid	4	2.644	Com. Ext.	4	2.788
Com. Ext.	4	2.644	Conoid Lig.	5	2.657
Suprspin.	6	2.600	Deltoid	6	2.625
Conoid Lig.	7	2.590	Costoclav.	7	2.608

[6] second and third wave European immigrants were often ‘othered’ or marginalized from other segments of the population socially and economically due to their ethnic or immigrant status

Table 67-Continued

Trap. Lig.	8	2.522	Supraspin.	8	2.552
Teres Major	9	2.471	Trap. Lig.	9	2.528
Trapezius	10	2.444	Trapezius	10	2.513
Costoclav.	11	2.431	Pro. Teres	11	2.510
Pec. Minor	12	2.422	Teres Major	12	2.506
Pro. Teres	13	2.355	Pec. Minor	13	2.328
Teres Minor	14	2.258	Anconeus	14	2.291
Infraspin.	15	2.177	Tri. Brach.	15	2.256
Com. Flx.	16	2.144	Teres Minor	16	2.188
Lat. Dor.	17	2.078	Com. Flx.	17	2.152
Tri. Brach.	18	2.066	Lat. Dor.	18	2.111
Anconeus	19	1.911	Infraspin.	19	2.048
Coraco.	20	1.777	Subclavius	20	1.928
Supinator	21	1.722	Supinator	21	1.862
Subclavius	22	1.659	Coraco.	22	1.833
Pro. Quad.	23	1.460	Pro. Quad.	23	1.510

The lowest robusticity scores demonstrate some similarities and difference between the two groups. The lowest ranked score, in 23rd place, was the pronator quadratus for both groups. The second lowest ranked score (22nd place) was different among the two groups. For African Americans, it was the subclavius and for Caucasians, it was the coracobrachialis.

When cortical defect scores were examined as well, a similar picture emerged. Both African Americans and Caucasians had the same top three ranked attachment site results for cortical defect except they were ranked in a different order. For African Americans, the supraspinatus was ranked first, the brachialis was ranked second and the costoclavicular ligament was ranked third. On the other hand, the Caucasian ranking was a little different in that the costoclavicular was ranked first, the supraspinatus was ranked second and the brachialis, third.

Table 68. Cortical defect ranking scores for entheses between African Americans and Caucasians

CORTICAL DEFECT RANKING SCORE					
AFRICAN AMERICAN			CAUCASIAN		
MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE
Supraspin.	1	0.733	Costoclav.	1	0.855
Brachialis	2	0.730	Supraspin.	2	0.818
Costoclav.	3	0.590	Brachialis	3	0.451
Teres Major	4	0.292	Pec. Major	4	0.263
Trap. Lig.	5	0.250	Bic. Brac.	5	0.234
Pec. Major	6	0.179	Trap. Lig.	6	0.200
Bic. Brach.	7	0.133	Teres Major	7	0.180
Trapezius	8	0.044	Infraspin.	8	0.125
Infraspin.	8	0.044	Teres Minor	9	0.076
Pro. Teres	8	0.044	Lat. Dor.	10	0.055
Lat. Dor.	11	0.033	Pro. Teres	10	0.055
Tri. Brach.	11	0.033	Deltoid	12	0.048
Teres Minor	13	0.024	Com. Ext.	13	0.042
Subclavius	14	0.022	Subclavius	14	0.028
Deltoid	15	0.011	Trapezius	15	0.027
Supinator	15	0.011	Conoid Lig.	16	0.021
Pro. Quad.	15	0.011	Pro. Quad.	17	0.020
Conoid Lig.	18	0	Pec. Minor	18	0.013
Pec. Minor	18	0	Tri. Brach.	19	0.006
Coraco.	18	0	Supinator	19	0.006
Com. Ext.	18	0	Coraco.	21	0.000
Com. Flx.	18	0	Com. Flx.	21	0.000
Anconeus	18	0	Anconeus	21	0.000

Despite the differences in the higher ranked scores, both groups had very similar lower ranked scores. For African Americans, the conoid ligament, pectoralis minor, coracobrachialis, common extensors, common flexors, and anconeus were all ranked last. Similarly, the Caucasian lowest ranking attachment sites were the coracobrachialis, common flexors and anconeus, some of the same attachment sites as the African American group. The only difference stems from the fact that there were more instances of cortical defect among the Caucasian group at more attachment sites than the African American group.

Lastly, ossification exostosis scores were also tallied and ranked between African Americans and Caucasians. The results show that the top two ranked scores were the same among both groups. The pectoralis major was ranked first and the biceps brachii was ranked second, demonstrating that either there are similar occupations between the two groups or those entheses are more likely to incur entheseal stress versus others.

Table 69. Ossification exostosis ranking scores for entheses between African Americans and Caucasians

OSSIFICATION EXOSTOSIS RANKING SCORE					
AFRICAN AMERICAN			CAUCASIAN		
MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE	MUSCLE/ LIGAMENT	RANK	ENTHESIS SCORE
Pec. Major	1	1.685	Pec. Major	1	1.666
Bic. Brach.	2	1.455	Bic. Brach.	2	1.627
Deltoid	3	1.400	Brachialis	3	1.562
Brachialis	4	1.377	Com. Ext.	4	1.478
Supraspin.	5	1.333	Conoid Lig.	5	1.364
Com. Ext.	6	1.300	Deltoid	6	1.326
Conoid Lig.	7	1.272	Costoclav.	7	1.210
Teres Major	8	1.101	Teres Major	8	1.138
Costoclav.	9	1.068	Supraspin.	9	1.097
Trap. Lig.	9	1.068	Trap. Lig.	10	1.092
Trapezius	11	1.055	Pro. Teres	11	1.048
Pec. Minor	12	1.011	Trapezius	12	1.027
Infraspin.	13	0.955	Pec. Minor	13	0.931
Teres Minor	14	0.910	Tri. Brach.	14	0.875
Pro. Teres	15	0.900	Teres Minor	15	0.846
Tri. Brach.	16	0.744	Anconeus	16	0.805
Com. Flx.	17	0.711	Com. Flx.	17	0.722
Lat. Dor.	18	0.595	Infraspin.	18	0.678
Anconeus	19	0.566	Subclavius	19	0.647

Table 69—Continued

Coraco.	20	0.433	Lat. Dor.	20	0.597
Supinator	21	0.333	Supinator	21	0.413
Subclavius	22	0.318	Coraco.	22	0.388
Pro. Quad.	23	0.168	Pro. Quad.	23	0.310

For the lowest scores, both groups had similar and different attachment sites. For example, the pronator quadratus was ranked last among both groups. The second to last ranked score, however, was different between the two groups. African Americans ranked the subclavius in 22nd place (second to last) and Caucasians ranked the coracobrachialis second to last.

Muscle Group Entheseal Attachment Site Rankings

Entheses were the combined into the seven muscle groups and the ranked accordingly between African Americans and Caucasians to examine if large scale changes are found in the muscle groups due to biological affinity because of similar or different life experiences.

Robusticity scores between both groups were quite similar in which both muscle groups #3 and #6 were ranked in the top two (Table 70). However, the order among the groups was opposite in which African Americans had muscle group #6 ranked as first and group #3 ranked second whereas the Caucasians had group #3 ranked first and #6 second. The lower robusticity scores for each group were the same with muscle group #4 scored second to last (in 6th place) and muscle group #7 was ranked last.

Table 70. Robusticity ranking scores for muscle groups between African Americans and Caucasians

ROBUSTICITY RANKING SCORES					
AFRICAN AMERICANS			CAUCASIANS		
MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE
Group #6	1	2.485	Group #3	1	0.372
Group #3	2	2.455	Group #6	2	0.366
Group #1	3	2.328	Group #2	3	0.162
Group #2	4	2.138	Group #7	4	0.101
Group #5	5	2.063	Group #1	5	0.057
Group #4	6	2.055	Group #4	6	0.056
Group #7	7	1.470	Group #5	7	0.011

For the highest ranked cortical defect scores, both the African American and Caucasian groups ranked the same groups in the same order (Table 71). Muscle group #3 was ranked first with a higher mean score among the African Americans and muscle group #6 was ranked second, again with a higher African American mean. The lowest ranked scores among the two groups were relatively similar. Both African Americans and Caucasians ranked muscle group #5 as having the lowest amount of entheseal stress however African Americans ranked muscle group #7 in sixth place versus the Caucasians muscle group #4.

Table 71. Cortical defect ranking scores for muscle groups between African Americans and Caucasians

CORTICAL DEFECT RANKING SCORES					
AFRICAN AMERICANS			CAUCASIANS		
MUSCLE GROUP	RANK	ENTHESIS SCORE	MUSCLE GROUP	RANK	ENTHESIS SCORE
Group #3	1	0.466	Group #3	1	0.372

Table 71—Continued

Group #6	2	0.384	Group #6	2	0.366
Group #4	3	0.105	Group #2	3	0.162
Group #2	4	0.066	Group #7	4	0.101
Group #1	5	0.063	Group #1	5	0.057
Group #7	6	0.037	Group #4	6	0.056
Group #5	7	0.018	Group #5	7	0.011

Ossification exostosis scores were also assessed according to muscle group (Table 72). The higher ranked scores were again flipped between the two groups in which the African Americans ranked muscle group #6 first and group #3 second while Caucasians ranked them the opposite way. For the lower scores, both biological affinities scores muscle group #7 last. African Americans though had a 6^{th} place score for muscle group #5 while Caucasians had a 6^{th} place score for muscle group #4.

Table 72. Ossification exostosis ranking scores for muscle groups between African Americans and Caucasians

OSSIFICATION EXOSTOSIS RANKING SCORES					
AFRICAN AMERICANS			**CAUCASIANS**		
MUSCLE GROUP	**RANK**	**ENTHESIS SCORE**	**MUSCLE GROUP**	**RANK**	**ENTHESIS SCORE**
Group #6	1	1.090	Group #3	1	1.397
Group #3	2	1.072	Group #6	2	1.320
Group #1	3	0.945	Group #5	3	1.152
Group #2	4	0.741	Group #2	4	1.080
Group #4	5	0.716	Group #1	5	1.012
Group #5	6	0.705	Group #4	6	0.898
Group #7	7	0.507	Group #7	7	0.767

Statistical Analysis of Entheseal Attachment Sites

Entheseal attachment and osteoarthritis scores were also analyzed to examine possible statistically significantly different differences within the population for both African Americans and Caucasians. The results, recorded below demonstrate that African Americans and Caucasians share similar and differences regarding entheseal and osteoarthritic stress.

Left and Right Separate

Table 94 in the appendix lists out the statistically significantly different results among specific attachment sites between African Americans and Caucasians, separating out left and right sides as well as each category (robusticity, cortical defect and ossification exostosis). Out of 138 possible attachment sites, thirteen of them were considered significant at $p < 0.05$ or about 9.4%. Out of the significant results, the majority were robusticity and ossification scores on the right side the upper limb. About three out of these thirteen sites, (23.07%) had higher mean values for African Americans versus Caucasians. There were found at the supraspinatus, infraspinatus, and the brachialis. The rest of the results demonstrated higher means among Caucasians.

Left and Right Combined

Left and right scores from specific attachment sites were then combined and reanalyzed using t-tests to discern whether or not there are more or less significantly different results between African Americans and Caucasians (Table 95). Out of 69 potential sites, fifteen of them were considered significant about 21.7% which was higher than the 9.4% when the left and right side scores were separated out. The comparison between the two groups shows that in this case, there was a lower percentage of higher mean scores among African American groups than Caucasian groups from the previous section. Three out of fifteen had higher African American mean scores, about 20% compared to the 23% of the previous section.

Robusticity and Cortical Defect Combined, Left and Right Separate

Robusticity and cortical defect were then combined for analysis. Once this was completed, the percentage of statistically significantly different scores decreased dramatically from around 20% to 6%. This possibly demonstrates that once scores are combined for the particular groups, outliers and significant values can be hidden by more even mean scores.

In table 73, shown below, the rescored attachment sites were separated by either left or right side of the upper limb. Out of a possible 46 attachment site scores, only four of them (6.7%) were considered statistically significantly different. Most of them were found on the right side of the upper limb of the costoclavicular ligament, the pectoralis major and the biceps brachii. Unlike previous analyses, in this case, all the mean scores were higher for the Caucasian group rather than the African American group, again demonstrating the possibility that certain scores may be washed out when averaged.

Table 73. Results of the 2 tailed, unpaired t-tests for differences with combined robusticity and cortical defect, separate left and right sides between African Americans and Caucasians

NUMBER	SITE	SIDE (L/R)	p VALUE	AVG. AFRICAN AMERICAN	AVG. CAUCASIAN
1	Costoclav	Left	3.76E -06	1.440	2.514
2	Costoclav	Right	5.73E -07	1.593	2.798
3	Pec. Maj.	Right	0.006	1.500	2.090
4	Bic. Brac.	Right	0.013	1.488	2.013

Robusticity and Cortical Defect Combined, Left and Right Combined

Lastly, the specific attachment sites were reanalyzed, combining scores from both the left and the right sides (Table 74). Out of 23 possible scoring sites, four of them were statistically significantly different, about 17.3%. All the attachment sites from the previous grouping remained the same except for the teres major which was not considered significant on either the left or right side along but were once combined. In all cases, the Caucasian group demonstrated higher mean scores when compared to the African American group.

Table 74. Results of the 2 tailed, unpaired t-tests for differences with combined robusticity and cortical defect, combined left and ride sides between African Americans and Caucasians

NUMBER	SITE	p VALUE	AVG. AFRICAN AMERICAN	AVG. CAUCASIAN
1	Costoclav.	8.76E -12	1.517	2.659
2	Pec. Maj.	0.003	1.593	1.986
3	Teres Maj	0.045	1.421	1.704
4	Bic. Brac.	0.003	1.422	1.841

Statistical Analysis of Muscle Group Entheseal Attachment Sites

Robusticity and Cortical Defect Combined, Left and Right Separate

For muscle group analysis, robusticity and cortical defect were combined and re-analyzed yet separated among the right and left sides of the upper limb. The results, displayed below in table 75, indicate that there were two muscle groups out of the seven which had significant differences among the two groups. Since left and right side scores were separated, out of the possible 14 score sites, four of them (about 28.5%) were significant. Muscle group #2 and muscle group #6 demonstrated significant results in which the Caucasian mean scores were higher than the African American scores, demonstrating the possibility that Caucasian individuals had higher stress adducting the arm and flexing the forearm.

Table 75. Results of the 2 tailed, unpaired t-tests for differences among muscle groups with separate left and right sides between African Americans and Caucasians

NUMBER	MUSCLE GROUP	SIDE (L/R)	p VALUE	AVG. AFRICAN AMERICAN	AVG. CAUCASIAN
1	Group #2	Left	0.027	1.255	1.461
2	Group #2	Right	0.000	1.152	1.451
3	Group #6	Left	0.003	1.553	1.863
4	Group #6	Right	1.49E -05	1.617	2.092

Robusticity and Cortical Defect Combined, Left and Right Combined

Once left and right side scores were combined, another muscle group, #5, was also statistically significantly different, creating the total of three out of the seven groups which is 42.8%. In all three of these muscle groups, Caucasian mean scores were once again higher than African Americans. The results for all muscle groups, significant and insignificant differences are shown in table 76 and figure 34 below. In most cases, Caucasians seemed to have higher mean scores than African Americans however, some insignificant muscle groups such as group #3 and #4 show that average scores among the two groups were relatively even demonstrating the possibility that they engaged in similar work and life stresses.

Table 76. Results of the 2 tailed, unpaired t-tests for differences among muscle groups with combined left and right sides between African Americans and Caucasians

NUMBER	MUSCLE GROUP	p VALUE	AVG. AFRICAN AMERICAN	AVG. CAUCASIAN
1	Group #2	0.000	1.204	1.456
2	Group #5	0.015	1.098	1.267
3	Group #6	2.48E -07	1.585	1.978

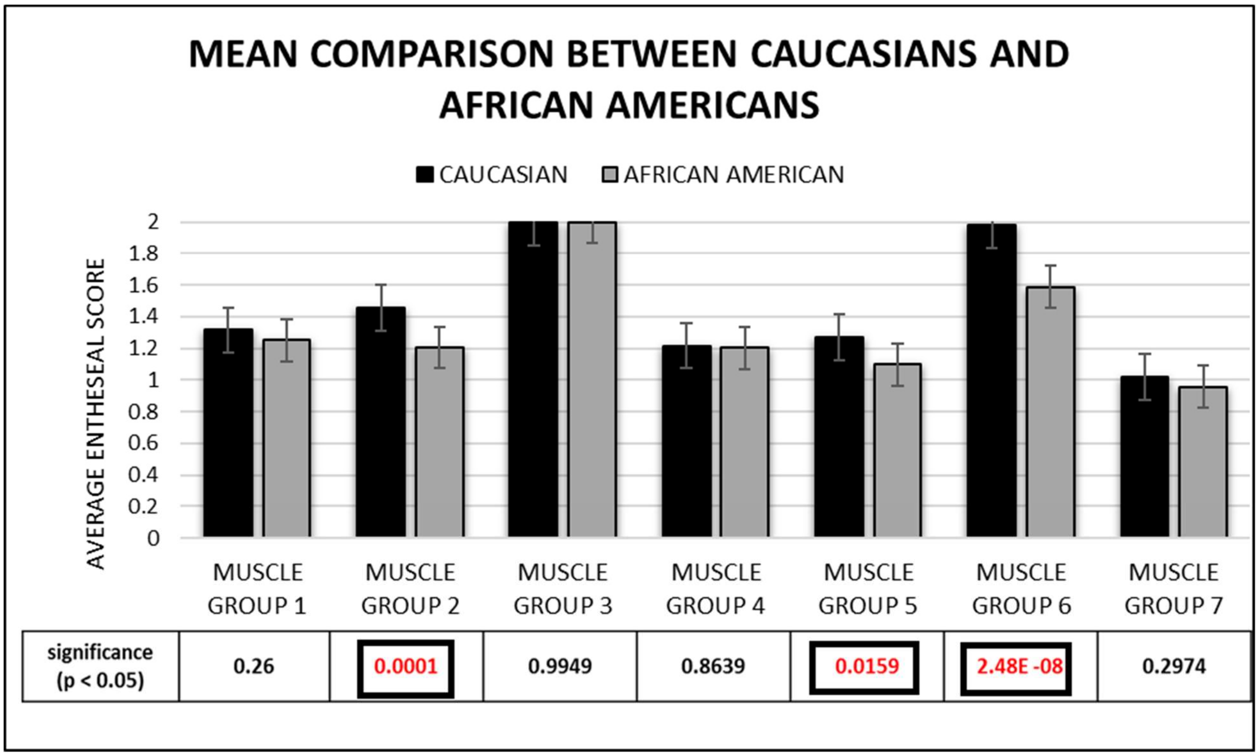


Figure 34. Mean comparisons among muscle groups between African Americans and Caucasians

Osteoarthritis Rankings

Osteoarthritis joint scores were also examined and considered based on biological affinity. The highest two results were the same among the African American and Caucasians groups, however the osteoarthritis mean scores were higher in Caucasians versus African

Americans (Table 77). The LAC or lateral acromion of the clavicle was ranked first while the medial acromion process of the scapula was ranked second. Both joint sites belong to the acromio-clavicular joint which helps stabilize the upper limb as well as work in conjunction with muscle group #3 which was ranked high for each sub-group.

For African Americans, the lowest ranking mean scores observed were the proximal head of the humerus from the shoulder joint and the proximal head of the radius from the elbow joint. For Caucasians, the lowest scores were the distal end of the humerus at the trochlea at the elbow and the proximal humerus at the shoulder joint.

Table 77. Osteoarthritis joint site ranking scores between African Americans and Caucasians

AFRICAN AMERICAN RESULTS				CAUCASIAN RESULTS			
JOINT SITE	**JOINT**	**RANK**	**OSTEOARTH. SCORE**	**JOINT SITE**	**JOINT**	**RANK**	**OSTEOARTH. SCORE**
LAC	ACRO	1	1.075	LAC	ACRO	1	1.285
MAP	ACRO	2	1.050	MAP	ACRO	2	1.219
DHC	ELB	3	0.952	GLF	SHOU	3	0.988
GLF	SHOU	4	0.900	DHC	ELB	4	0.807
PRU	ELB	5	0.786	PRU	ELB	5	0.727
DHT	ELB	6	0.744	PRR	ELB	6	0.601
PRH	SHOU	7	0.704	DHT	ELB	7	0.595
PRR	ELB	8	0.665	PRH	SHOU	8	0.586

When each osteoarthritis joint site was combined into their respective joints, there is the same pattern among African Americans as there is Caucasians. In both groups, the acromio-clavicular joint has the highest mean scores and the elbow joint has the lowest ranking scores (Table 78). This is possibly indicative of higher stress found at the top of the upper limb at the clavicle, scapula and humerus rather than the smaller single range motions found in the hinge joint of the elbow at the radius and ulna.

Table 78. Osteoarthritis joint ranking scores between African Americans and Caucasians

AFRICAN AMERICAN RESULTS			CAUCASIAN RESULTS		
JOINT	**RANK**	**OSTEOARTH. SCORE**	**JOINT**	**RANK**	**OSTEOARTH. SCORE**
ACRO	1	1.062	ACRO	1	1.252
SHOU	2	0.802	SHOU	2	0.787
ELB	3	0.787	ELB	3	0.682

Osteoarthritis was also scored and analyzed to examine possible differences between African Americans and Caucasians. They were also assessed to determine if the osteoarthritis scores are consistent with the statistically significantly different scores found in the muscle groups of the entheseal results.

Results for each osteoarthritis joint site collected are displayed in table 79 below. Out of eight possible sites, five of them were deemed statistically significantly different among the two group, about 62.5%. Two of the results were from the acromioclavicular ligament, two from the elbow joint and one from the shoulder joint. These results appear to be similar to the entheses scores from the specific attachment sites as both muscle group #2 and #6 use both the acromioclavicular ligament and the elbow joint in their movement. However, unlike the entheses scores, most results have higher mean scores in the African American group rather than the Caucasian group, about three out of the five. An explanation for this variation could possibly be related to discrimination in access to medical care and access to resources such as food among both groups but more research is needed to consider this factor.

Table 79. Results of the Mann-Whitney U Test for differences per each joint site between African Americans and Caucasians

NUMBER	JOINT SITE	JOINT	p VALUE	AVG. AFRICAN AMERICAN	AVG. CAUCASIAN
1	PRH	SHOU	0.029	0.704	0.586
2	LAC	ACRO	0.001	1.075	1.285
3	MAP	ACRO	0.008	1.050	1.219
4	DHT	ELB	0.002	0.754	0.595
5	DHC	ELB	0.010	0.952	0.807

Once each site was combined into their respective joints, the results demonstrate significant values at both the shoulder and elbow joints, two out of three possible joints (66.6%) Table 80). For the shoulder joint, Caucasians demonstrate higher mean scores and for the elbow joint, African Americans have the higher mean scores.

Table 80. Results of the Mann-Whitney U Test for differences per joint between African Americans and Caucasians

NUMBER	JOINT	p VALUE	AVG. AFRICAN AMERICAN	AVG. CAUCASIAN
1	SHOULDER	2.03E -05	1.062	1.251
2	ELBOW	7.94E -05	0.789	0.682

Lastly, Figure 35 below shows the mean scores for each osteoarthritis joint site between African Americans and Caucasians. Based on these findings, Caucasians have the higher mean score among the acromioclavicular ligament and part of the shoulder whereas African Americans display higher means scores at the other part of the shoulder and the elbow joint. This is possibly indicative of different types of labor and activity stresses carried out over time between the groups.

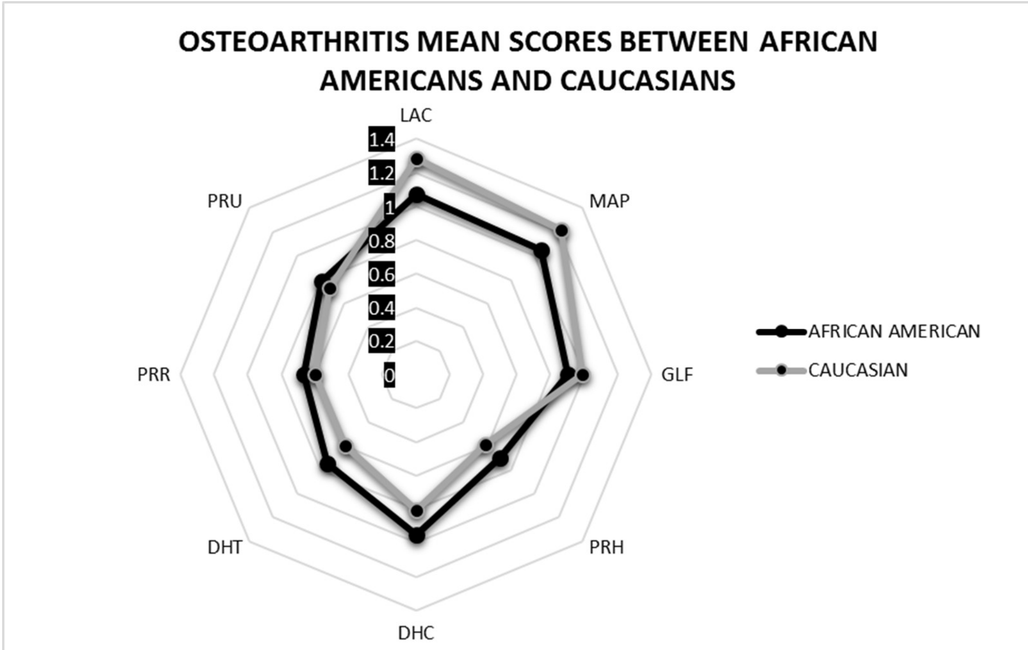


Figure 35. Osteoarthritis mean scores between African Americans and Caucasians

Frequencies of Osteoarthritis

The frequencies of osteoarthritis were also calculated and compared among African Americans and Caucasians. Overall, Caucasians had a higher frequency of osteoarthritis among each category and each joint however this is likely a result of the sampling methods. Despite this, there are elements within each joint which demonstrate possible patterns regarding stress and activity patterns between the two groups. At the shoulder joint, there is a pretty large difference in the frequencies between African Americans and Caucasians in the “none” and “trace” categories (Figure 36). However, this gap begins to close as the minor, moderate and severe categories are examined. By the severe category, there is only a difference of three sites. Based on these results and the historical literature, there are two possibilities for the similarities among osteoarthritis scores. The literature mentions that most African Americans were not employed in factory work until after World War I due to the limit on European immigration with the National Origins Act of 1924.

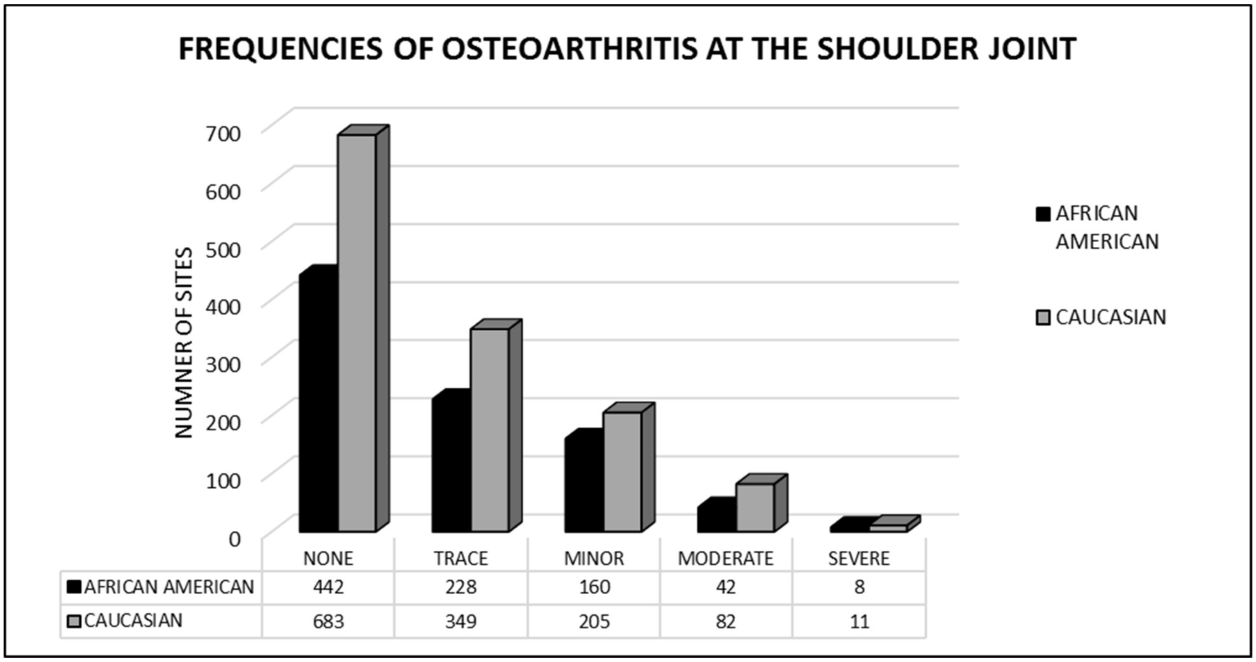


Figure 36. Frequencies of osteoarthritis at the shoulder joint between African Americans and Caucasians

Frequencies were also calculated for the acromioclavicular joint. Unlike the shoulder, these results show a more consistent even pattern between African Americans and Caucasians except for the minor and moderate categories (Figure 37). Overall, the acromioclavicular joint seems to have the higher numbers for each joint out of any of the three joints which can be explained by the fact that the joint has large, broad movements associated with it which are often utilized in industrial labor. Once broken down further, the trace category shows that most individuals from both African Americans and Caucasians groups have some sort of osteoarthritis indicator which demonstrates that there is long term stress in this population possibly due to their occupation workload. For the severe category, both African Americans and Caucasian have some indicators of high osteoarthritis stress which is indicative of a repetitive high stress activity or occupation which fits with the historical literature.

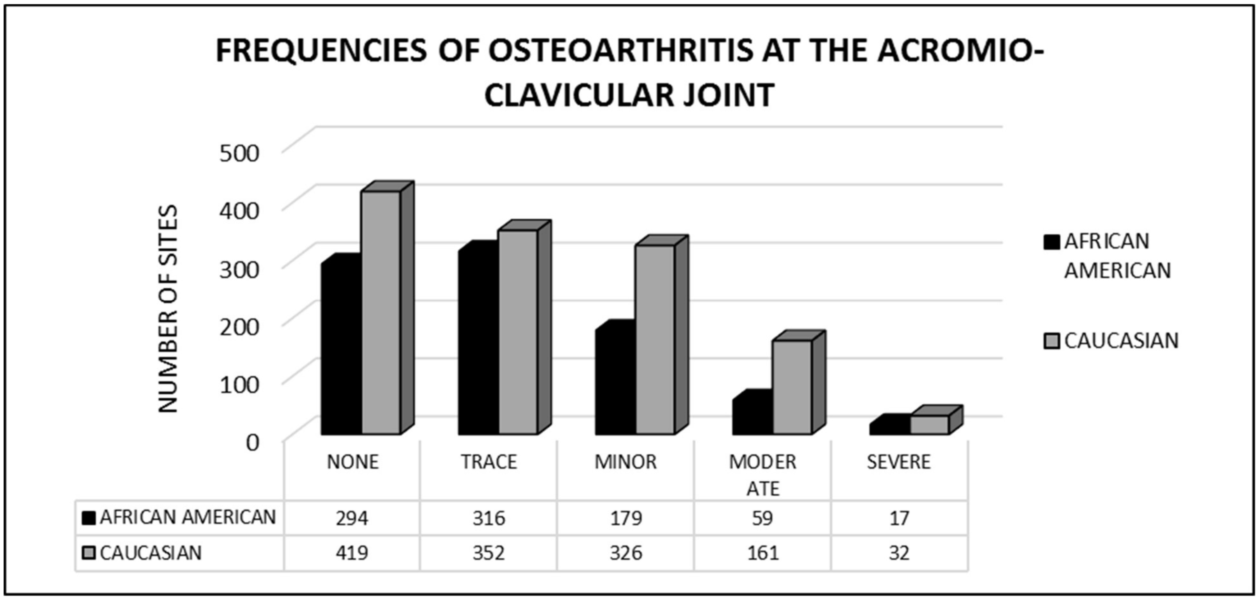


Figure 37. Frequencies of osteoarthritis at the acromioclavicular joint between African Americans and Caucasians

Lastly, osteoarthritis frequencies were calculated among African Americans and Caucasians for the elbow joint (Figure 38). Like the acromioclavicular joint, the elbow joint has relatively even numbers of sites at both the moderate and severe forms of osteoarthritis. The severe numbers in both groups are just about the highest among all three joints demonstrating that the elbow joint shows that more severe stress than the other joints. The moderate category has a difference of only four while the severe category has a difference of one site between the two groups. The evenness among the moderate and severe forms of osteoarthritis among African Americans and Caucasians shows that despite have different occupations (most of the time), there are similar and in some cases even higher amounts of stress for African Americans than Caucasians.

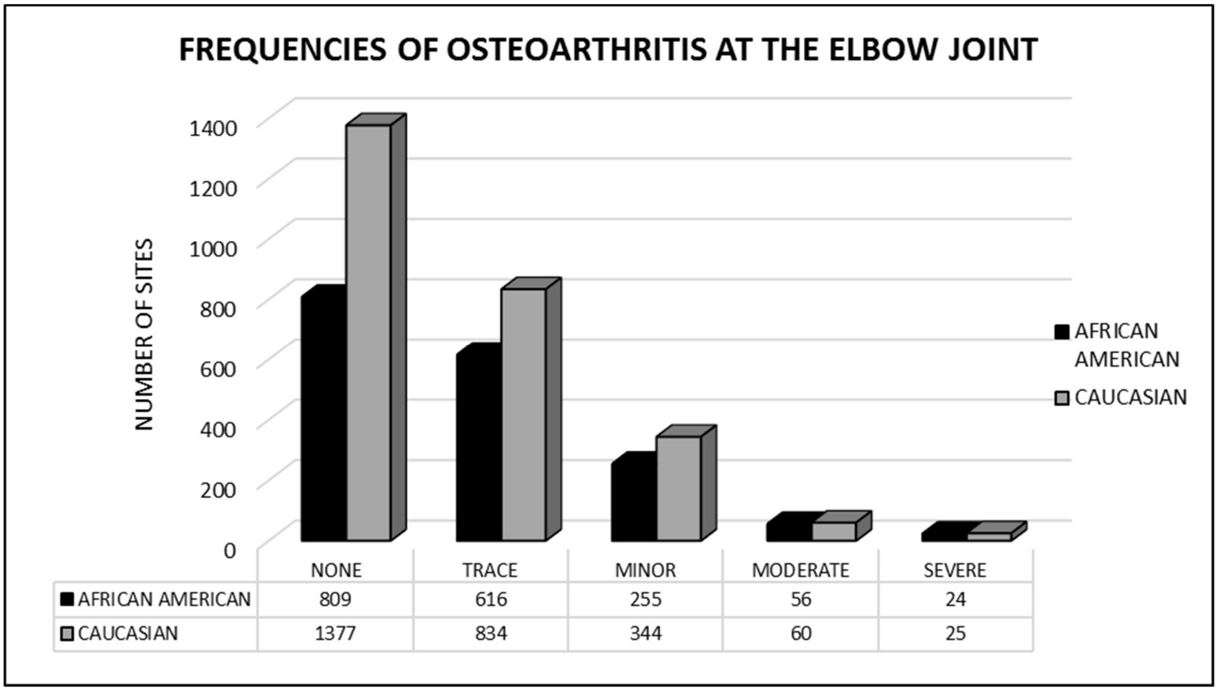


Figure 38. Frequencies of osteoarthritis at the elbow joint between African Americans and Caucasians

CHAPTER VI

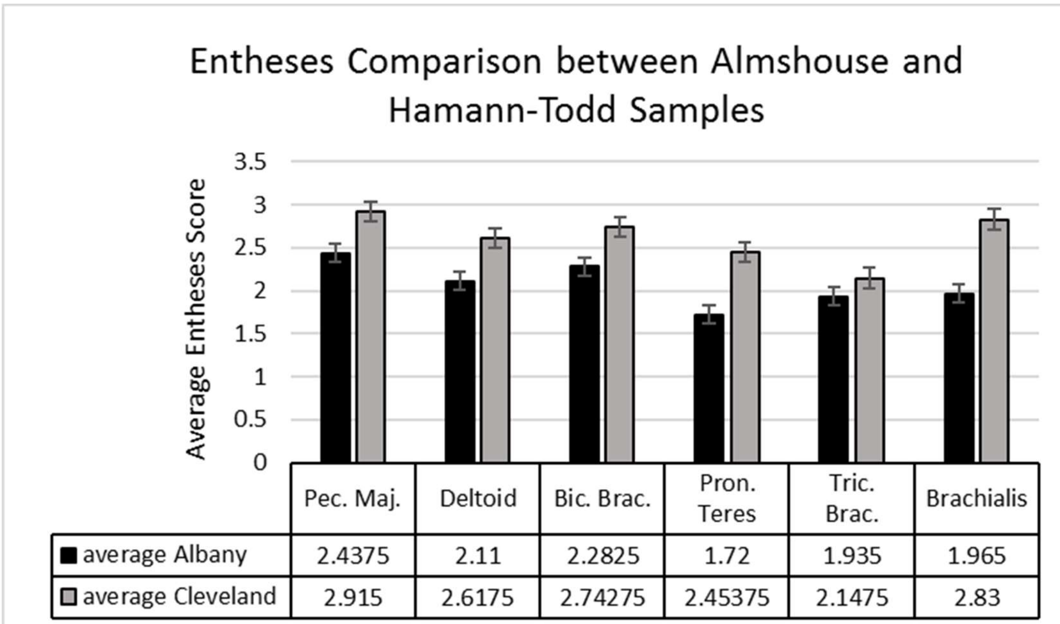
DISCUSSION

Entheseal Patterns

Overall, the results from this sample of the Hamann-Todd Collection pose interesting questions regarding labor and activity patterns in early 20th century Cleveland. When compared to other lower class Industrial populations of the time, such as the Almshouse in Albany, New York (1825-1925), there are similarities regarding locations of entheseal stress (Solano, 2006). Both samples demonstrate high entheseal stress at the upper limb indicative of strenuous work throughout these individuals' lives. Since both collections encompass mostly lower-class individuals, it is likely that their high entheseal stress patterns began during childhood as most children would stop schooling at a young age to go to work (Van Tassel and Grabowski, 1996). In rural areas, they would most likely work on farms while in urban areas children often worked in manufacturing due to their small size. Their size would be utilized for delicate machine work and in tight spaces where adults could not go. A small sample of children even worked in domestic tasks, which would transition into other service talks in adulthood such as house keepers, servants, and hotel wait staff. It was not until the 1930s that federal laws prohibited child labor, which occurred after both the Hamann-Todd Collection and the Almshouse sample (Solano. 2006). As a result, these individuals, like the sample from the Almshouse, show signs of high entheseal stress patterning because of increased buildup of physical activity.

Despite similar locations, the two sample show differences in the amount of stress on the upper limb. The Hamann-Todd sample overall had higher entheseal mean scores than the

Almshouse sample (Figure 39). These high entheseal frequencies between the samples can be broken down into specific attachment sites. All the attachment sites compared had statistically significantly different values, with a significance level set at $p<0.05$, except for the triceps brachii ($p= 0.101$)[7].



*modified from the original (Solano, 2006), combined robusticity averages for comparison

Figure 39. Entheses Comparison between the Almshouse (Solano, 2006) and Hamann-Todd Samples*

One of the most striking examples between the two samples were the results for the pectoralis major. The results from the Hamann-Todd sample demonstrate that for each category of enthesis, i.e. robusticity, cortical defect, and ossification exostosis, the pectoralis major ranks among the top as they had the highest mean scores. The same ranked scores were found at the Almshouse population as well, as pectoralis major was ranked highest among the rest of the

[7] Pectoralis major (discussed in the text), deltoid ($p= 0.01$), biceps brachii ($p= 0.013$), pronator teres ($p=0.0007$) and brachialis (discussed in the text)

compared site (Solano, 2006). Despite the rankings, however, the pectoralis major mean scores were statistically significantly higher than the Almshouse sample ($p=0.013$).

The pectoralis major is responsible for four different actions; the flexion on the humerus, adduction of the humerus, rotation of the humerus and protraction and rotation of the scapula. These actions correspond to movements such as throwing a ball or lifting items, flapping the arms, arm-wrestling, and lifting and lowering the arms. These movements would translate into a variety of different high intense occupations such as factory work (especially in metal work such as iron or steel), farming and even some trade skills such as butchers and carpenters, most of which were known occupations for both Albany and Cleveland during the duration of the samples (Solano, 2006). Actions such as lifting or carrying materials or the pushback force from machinery would results in higher entheseal changes at the pectoralis major especially if the workload was constantly repeated over an individual's lifetime. The significant difference between the two mean scores therefore could be attributed to the fact that among early 20th century northern industrial cities, Cleveland had more manufacturing and factories than Albany, which translated into higher amounts of visible stress.

Another difference between the entheseal frequencies of both samples is at the brachialis. This attachment site on the ulna was almost a whole number higher in the Hamann-Todd sample versus the Almshouse sample, 2.83 (Solano, 2006) versus 1.96 and was statistically significantly different at $p<0.001$. The brachialis which attaches at the coronoid process and tubercle of the ulna, is responsible for the flexion of the elbow joint. This action could correspond to a variety of "back and forth" movements in both high and low force activities such as scrubbing or washing clothes, sanding down wood for building, operating machinery, and farming to name a few. This attachment site would also demonstrate higher mean results if individuals performed the same types of activities throughout their lives. The difference between these two populations regarding the brachialis could come from a variety of different sources. It is possible that the samples could be skewed towards one section of the city. For example, it is possible that the majority of the sample from the Hamann-Todd sample could be from Ward I of the city. Based on historical documentation, at the beginning of the 20th century, Ward I was mostly an industrial area with factories and manufacturing. It also housed many of the city's Italian immigrant population, many of whom were unskilled and lower class working in the factories. As a result, they would have high means for certain attachment sites such as the brachialis compared to a more evenly distributed sample. However, if this variation is a result of activity stress differences between the two, then the Hamann-Todd sample demonstrates higher entheseal stress at the brachialis site. This would suggest that individuals either could have had similar occupations over the course of their lifetime or that Cleveland, as one of the top ranked cities for manufacturing in the country at that time, had enough continuous manual labor to keep individuals occupied over their lifetimes.

Osteoarthritis Patterns

The osteoarthritis results demonstrate similarities and differences when compared to the Almshouse sample (Table 81). Both sample sets exhibit moderate and severe forms of osteoarthritis at the shoulder and elbow joint of the upper limb. This is indicative of repetitive and degenerative stress to certain areas of the upper limb which may demonstrate activity patterns. The shoulder joint which is comprised of the glenoid fossa and proximal humerus had a higher percentage in the Almshouse sample than the Hamann-Todd. For moderate scores of osteoarthritis, the Almshouse had 13.3% (Solano, 2006) compared to the Hamann-Todd at 5.6%.

Severe scores were also different in which the Almshouse was 4.4% (Solano, 2006) versus 0.8% of the Hamann-Todd. The elbow joint, comprised of the trochlea and capitulum of the distal humerus and the proximal head and olecranon process of the radius and ulna respectively was also collected and compared. For moderate scores, the Almshouse was 13.3% (Solano, 2006) versus the Hamann-Todd at 2.6%. Severe scores were 7.7% for the Almshouse (Solano, 2006) and 1.1% for the Hamann-Todd.

Table 81. Osteoarthritis Comparisons among the Almshouse* (Solano, 2006) and Hamann-Todd Samples

PERCENTAGES OF OSTEOARTHRITIS AMONG THE ALMSHOUSE AND HAMANN-TODD SAMPLES				
	SHOULDER		**ELBOW**	
	ALMSHOUSE	**HAMANN**	**ALMSHOUSE**	**HAMANN**
ABSENT	66.07	50.9	55.1	49.6
MINOR	16.07	42.6	23.8	46.5
MODERATE	13.3	5.6	13.3	2.6
SEVERE	4.4	0.8	7.7	1.1

*modified from the original (Solano, 2006), combined osteoarthritis averages for comparison

When compared to the corresponding entheseal attachment sites such as the pectoralis major and brachialis, the results contradict one another. In other words, the entheseal attachment sites have higher means for the Hamann-Todd sample whereas the corresponding osteoarthritic joints have a higher percentage for the Almshouse. These mixed results demonstrate that while in both populations, individuals did not live that long due to poor health and lack of resources, it is possible that despite the relatively similar stress loads, the Almshouse sample was developing more moderate and severe forms of osteoarthritis sooner than this study's sample from the Hamann-Todd Collection. It also shows the differences among industrial cities regarding labor patterns and activities at turn of the 20th century. For the Hamann-Todd Collection, Cleveland in the year 1900 was the seventh largest city in the United States whereas Albany, was 40th (U.S. Census Bureau, 1998). These population differences would suggest that there was more variety of work including heavy industrial jobs in Cleveland rather than Albany and that perhaps lower class individuals had yearly work along with better access to resources such as food and medicine as well as help from missionary churches that would prevent an early onset of osteoarthritis.[8]

Ultimately, the results among the two samples demonstrate that despite a similar amount of high entheseal stress in both populations, it is obvious that individuals in Cleveland responded differently to that stress than individuals in Albany.

Ill-Health Status/Cause of Death

The results from this preliminary study on the impact of chronic health on entheseal changes are largely inconclusive but there are some interesting possibilities. Based on the results, there are three attachment sites that were always significant different between chronic and acute/sudden populations: the costoclavicular, the brachialis and the pronator quadratus. Both the costoclavicular and the brachialis had higher mean scores among the sudden/acute conditions. Both the costoclavicular which is responsible for the anchoring of the clavicle and the brachialis which is a strong flexor at the elbow are attachment sites which scored high ranking overall and among other variables such as sex and age. These sites are likely the result of high strenuous activity and those individuals who died due to sudden/acute causes recorded that high stress in their bones up until death. On the other hand, those individuals with chronic conditions perhaps

[8] Due to sampling techniques and preservation, age was not selected for and compared between these two groups. Another possibility is that the differences seen between the samples could be skewed to favor one age groups over another. Further research would address this issue.

had higher entheseal stress at one point but lost it due to either their health conditions or by not using those muscle for a long time causing them to shrink and the bone along with it. The pronator quadratus, however, had a higher mean score among the chronic condition. The pronator quadratus helps pronate the forearm and is usually ranked last or near last compared to other attachment sites. It is likely that the individuals with chronic conditions perhaps still used their forearms for smaller movements rather than the larger upper limb movements.

The results from the muscle groups indicate that there were no statistically significantly different differences between individuals with chronic and acute conditions. This is interesting because it demonstrates the possibility that despite the attachment sites differences mentioned above, the overall stress levels controlling the seven movements were relatively the same among both groups. It is very likely then that those with chronic health conditions were still working heavy industrial occupations despite their health status. Entheseal loss, therefore, would not have occurred quickly enough to impact bone surfaces demonstrating that individuals with chronic conditions might have had to still work through their comprised health.

The results of this initial study help identify several areas for future consideration. When attempting to reconstruct habitual anatomically movements, through entheseal patterns on a population level, it is standard practice to exclude individuals whose skeletal remains appear adversely impacted by ill-health (Hawkey and Merbs, 1995). The degree and nature of this impact is currently not well understood.

Another avenue of future study regards testing biological compensation to ill-health status in archaeological samples. While the demographic information is less clear in those situations, using historic populations as a comparison with archaeological samples may offer a way to understand how individuals in the past compensated to the everyday challenges and anatomical stresses. The chart below illustrates the results for individuals of known pathological parameters compared with an archaeological test sample.

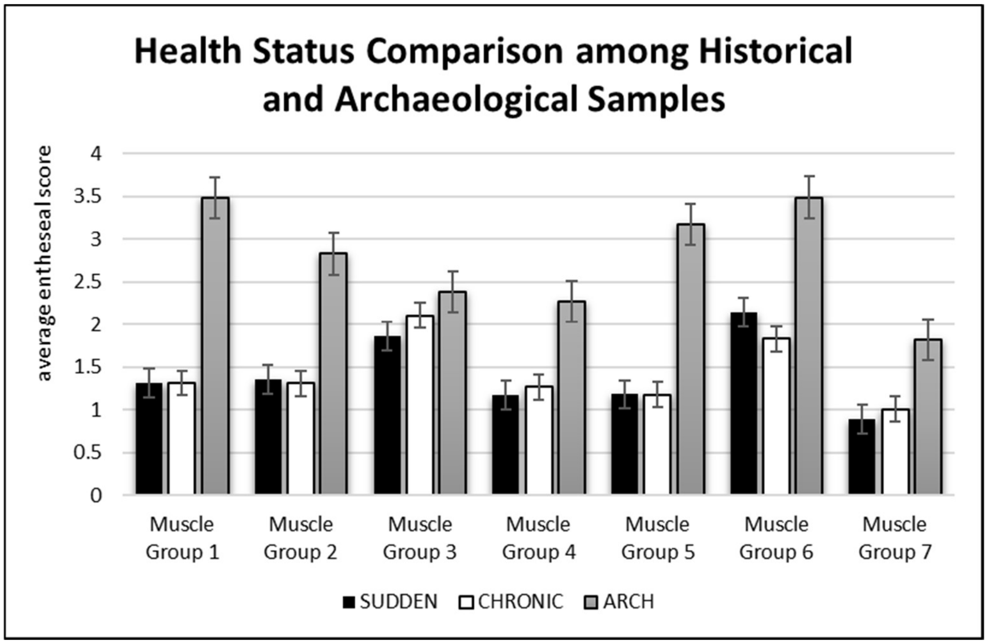


Figure 40. Health status comparisons between historical and archaeological samples

This added data set is derived from 20 individuals excavated from the Iron Age (c. 500 BC- AD 100) Pazyryk sites from the Altai region of Siberia (Machicek, 2008). Overall, there is a similar trend in the patterning of entheseal scores across the muscle groups, with notable exceptions in muscle groups 1,5 and 6. It is likely that this result is reflective of variation in habitual anatomical movements accumulated throughout the life-cycle. Daily activities, locomotion, as well as dietary and health variation between individuals from the archaeological sample, as compared to the historical industrial era, likely differed to a large extent. The comparative archaeological data provide an indication of where results may fall when health and cause of death parameters may be indeterminate.

The final objective in this exploratory study would be to narrow the focus of the research to studying the specific disease mechanisms on entheseal changes, such as, the impact of tuberculosis and syphilis. The research will then apply a modified standardization protocol to archaeological cases where these conditions may have been identified. This might be a productive way to move forward towards achieving the object of providing a more reliable method of understanding the impact of pathological conditions on compensatory patterns of entheseal changes.

Directional and Bilateral Asymmetry

The overarching results from all the bilateral and directional asymmetry assessment presented here complement and agree with previous studies which found that most population usually are right sided biased (Steele et al., 2000). There are a few cases among some of the entheses which indicate a left side bias but that could be due to the physiological nature of those groups or even the sampling of the population. Despite this right biased population, the results from the osteoarthritis scores demonstrate some symmetry among the left and right side of the elbow joint. What this likely means is that although individuals prefer one hand over the other, their occupations require both the left and right arms to run. Based on the historical literature, it is more likely that these occupations are more intricate industrial jobs such as piece work for garment factories which requires delicate fingers.

Directional asymmetry demonstrated some differences among each of the variables. For sex, more directional asymmetry was found among females rather than males. For biological affinity and geographic origin, there were mixed results among both groups, however, there was a pattern between them in which there seems to be a relationship between biological affinity, geographic origin and directional asymmetry which may tie into race relations and labor politics during this time. Lastly, bilateral asymmetry was also examined on both an individual and population level. Most markers were found to be symmetrical and almost all of the tests between the biological and cultural variables showed no significance. Overall, the differences between the left and right sides of the upper limb seems to be more discernable in some groups of this sample versus other which may indicate different work and labor stresses during this period in Cleveland.

Future studies would look to increase the sample size from the Hamann-Todd collection as well as add in other potential factors that may impact this symmetry such as age, pathology, or trauma (see section of biological compensation to ill-health status for more details). Lastly, constructing individual profiles for the sample would demonstrate how variable these average scores are. In other words, examining different types of life experiences and responses to stress would provide a clearer indication of how different individuals responded to their own activity stresses.

Sex

The results of both the entheseal changes and osteoarthritis scores show variable results between males and females but with some patterns. At select specific attachment sites, there is evidence for statistically significantly different differences in which there are higher female mean averages compared to the male average. These entheses include the infraspinatus, subclavius, trapezius, latissimus dorsi, and coracobrachialis. These attachment sites are involved with more medial and lateral rotation of the upper arm rather than the adduction of the arm and the extension and flexion of the forearm found in males. This could demonstrate that lower socio-economic individuals in Cleveland experienced a division of labor among the sexes in which women experienced had different occupations such as domestic duties while males completed more industrial heavy labor.

Despite these mixed results, there is possible patterning between the sexes which is indicative of not only the type of stresses they were exposed to but possibly the types of occupations. For the ranked attachment sites, Figure 40 below shows the top two ranked attachment sites for robusticity, cortical defect and ossification exostosis. While the frequencies are different, the result show that the same sites were used the most in both males and females apart from the costoclavicular and biceps brachii for males which do not appear on the female. It is likely that these similarities are the result of the fact that the pectoralis major, supraspinatus, and brachialis are commonly used attachment sites for the entire population because of everyday movement instead of activity or occupational stress.

The same can be said for muscle groups. The results also indicated that males and females also share similar stresses among muscle groups. After ranking the entheses for both sexes, muscle group #3 and group #6 had the highest markers among both males and females. This is indicative of shared biological stress however whether that is the result of similar labor or occupational duties or if muscle group #3 and #6 normally have high entheses, it is difficult to tell. However, when the muscle groups are analyzed for significant differences, the result become clearer. Muscle groups #2, #5 and #6 were found to be statistically different between males and females in which males had the higher mean scores. Muscle group #2 adducts the arm while muscle group #5 and #6 extend and flex the forearm. These results demonstrate that in overall movement, not specific entheseal sites, males seem to demonstrate higher scores for both large scale arm movement as well as smaller forearm movements. It is possible that these results show that on average males had high stress labor jobs compared to females and that they employed both large and small scale movements perhaps working with machines in addition to carrying materials or supplies.

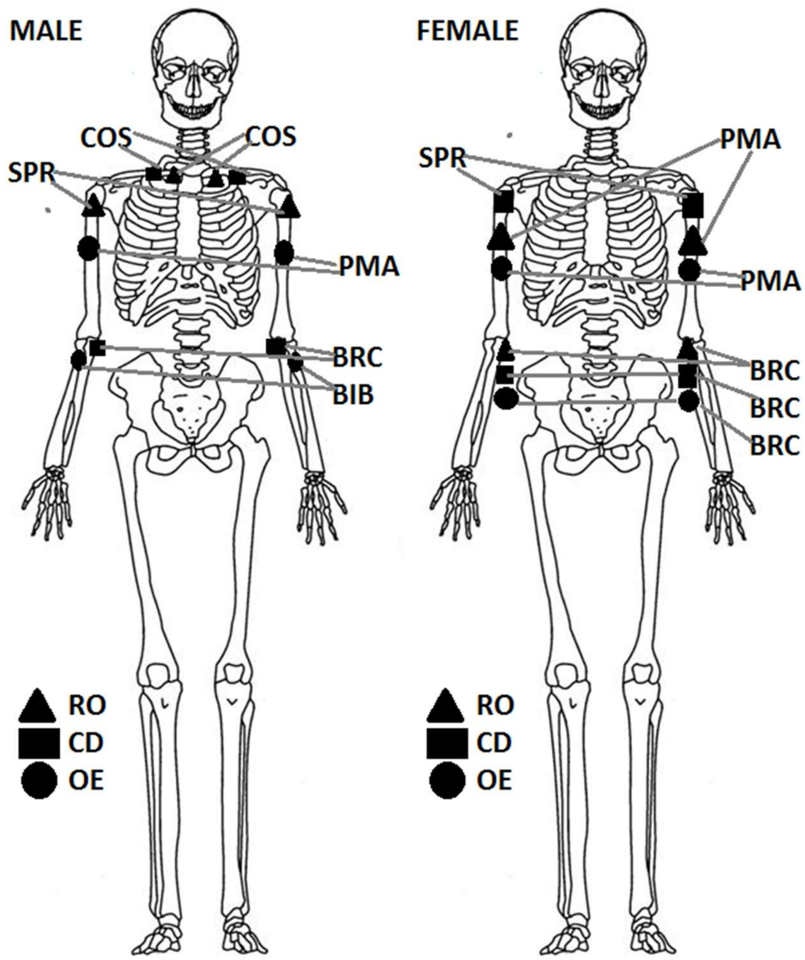


Figure 41. Top ranked entheseal attachment sites per each category among males and females

When both entheseal attachment sites and osteoarthritis frequency scores are examined together, another difference between males and females emerges. Out of all the statistically significantly different differences recorded in the results section, there are instances of higher mean scores among both males and females. For males, the higher means tend to be at the forearm. Examples include the triceps brachii which is a strong extensor of the elbow, the biceps brachii, which is a strong flexor at the elbow, and the pronator teres, which pronates and flexes the forearm. On the other hand, the higher results for the females were found more at the upper arm. Examples are the subclavius which anchors and depresses the clavicle, the trapezius which retracts and rotates the scapula and the latissimus dorsi which adducts, flexes and medially rotates the humerus. The osteoarthritis scores seem to complement these results as well as males have high frequencies of osteoarthritis at the elbow joint and females have more osteoarthritis at the acromioclavicular joint compared to the shoulder and the elbow.

These results demonstrate a sexual division of labor in which males have higher results at the forearm and elbow whereas females have higher results at the clavicle and scapula of the upper arm. This demonstrates that males are likely creating the higher entheseal stress by carrying materials whereas females are lifting materials over their heads. This suggestion fits with some of the occupations listed in the census from Cleveland. For example, there were occupations that required males to carry heavy materials such as rods for industrial work or bricks for infrastructure. On the other hand, females who work as laundresses oftentimes lift baskets of laundry and place them on their shoulders.

Overall, there is no single distinguishable pattern found between the sexes which would demonstrate one clear sexual division of labor. Instead, the results are mixed and there are many different patterns between them which demonstrate that there were many different sexual divisions of labor in Cleveland at the beginning of the 20^{th} century with the possibility of crossing gender lines as seen in the census by female farm hand and day laborers.

Age

The results of both entheseal changes and osteoarthritis scores show mixed results across all three age categories. The majority of the specific entheseal attachment sites demonstrate significantly higher means among the old adult age categories. Figure 41 below shows the highest ranked entheses among robusticity, cortical defect and ossification exostosis for each age group. The results show that almost all the same attachment sites are used among each of the age groups. The exception is the biceps brachii which does not appear at the young adult category but at the middle and old adult categories, possibly demonstrating that over time high stress labor in Cleveland uses both the upper arm and the forearm.

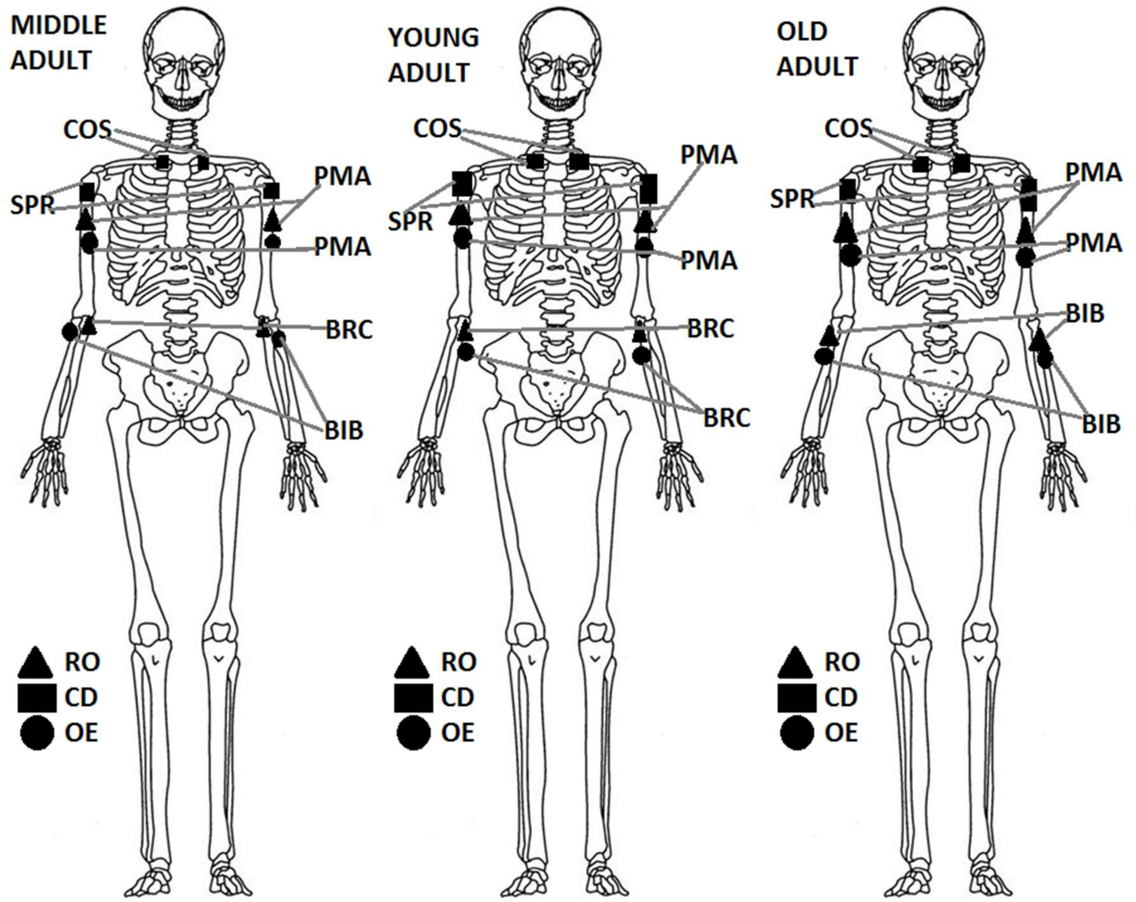


Figure 42. Top ranked entheseal attachment sites per each category between the adult age groups

However, once attachment sites tested for statistically significantly different differences, there were some interesting results. It is expected that due to increased age and the buildup of activity stresses over time that old adult individuals would have the highest mean scores out of any age category. The costoclavicular and the biceps brachii showed higher mean scores among the middle adult age group rather than the old adult group. The costoclavicular is responsible for the anchoring of the clavicle and the biceps brachii is a strong flexor at the elbow and supinates the forearm. Because the sample included a variety of individuals at different life stages, this demonstrates the possibility that entheseal patterns and stress has changed over time in response to the new types of industries in Cleveland at the beginning of the 20th century. By the time that the old adult individuals surpassed the life expectancy of late 40s, they may have no longer been working at heavy industrial occupations as there were plenty of younger men who were stronger and looking for work. Therefore, by the time that these individuals stopped working really stress heavy occupations, it would be around 1900 or so. This period represents one of the many labor shifts in Cleveland in which new types of manufacturing are being created and old ones are declining. As a result, the 'new' industrial stress of the middle adults could emphasize completely different attachment sites than the previous age group.

Lastly, when the scores were combined into the muscle groups, the old age individuals had the highest mean score in every group except #6 which showed higher scores among middle adult individuals. Muscle groups #2, #5 and #6 were found to be statistically different between all the age categories in which old adults had the higher mean scores. Muscle group #2 adducts the arm while muscle group #5 and #6 extend and flex the forearm. These results demonstrate that in overall movement, not specific entheseal sites, old adults seem to demonstrate higher scores for both large scale arm movement as well as smaller forearm movements.

The results from age groups show conflicting data about the relationship between entheses, osteoarthritis and age and appears to be more complex than originally hypothesized as generational differences were not considered. Based on the results, old age individuals do not have the highest scores for all factors which would be expected if the markers and joint disease increase over time without fail. However, it seems that other factors such as geographic and temporal conditions i.e. where and when individuals are living/working in Cleveland, as well as generational differences should be further examined. This is critical because the differing frequencies among each age group may be due to the change in labor patterns or work load over decades. Therefore, if middle age individuals lived into old age, it is likely that they would still have different locations and frequencies of stress than the current old age sample. Future studies are needed to test these possibilities.

Biological Affinity

The results of both entheseal changes and osteoarthritis score show mixed results between African Americans and Caucasians[9]. For the ranked attachment sites, Figure 42 below shows the top two ranked attachment sites for robusticity, cortical defect and ossification exostosis. While the frequencies are different, the result show that the same sites were used the most in both African Americans and Caucasians apart from the costoclavicular for Caucasians which does not appear on the African American group. It is likely that these similarities are because the pectoralis major, supraspinatus, and brachialis are commonly used attachment sites for the entire population because of everyday movement instead of activity or occupational stress.

At select specific attachment sites, there is evidence for statistically significantly different higher mean score among African Americans groups when compared to the Caucasians group. However, once combined into muscle groups, the Caucasian group had the higher significant mean scores. This could demonstrate that on average, Caucasians scores were just higher than African American score demonstrating different life experiences. It is even possible that because African Americans were restricted from working in heavy industry in Cleveland during this time which resulted in their displaying of lower entheseal stress markers compared to their Caucasian counterparts or that the sampling methods in this study skewed the patterning between the two.

[9] Possibly due to sampling methods and lack of representative material as well

Further research must be carried out to completely understand the relationship between the African Americans and Caucasians.

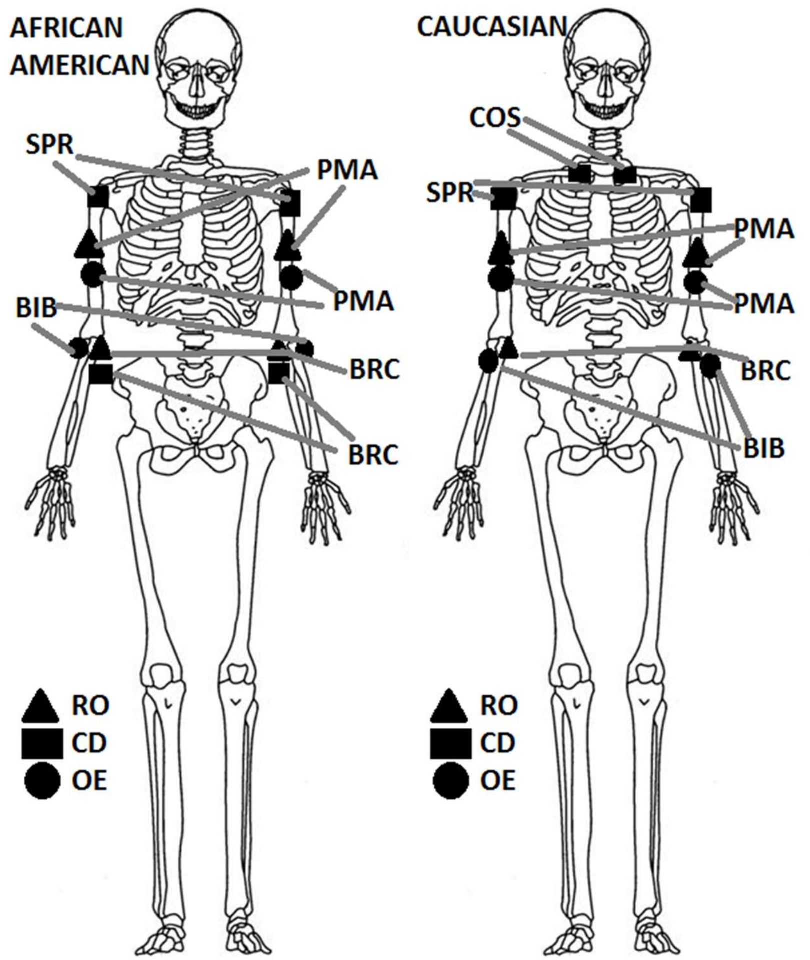


Figure 43. Top ranked entheseal attachment sites per each category between African Americans and Caucasians

There are some statistically significant differences between African Americans and Caucasians in attachment sites. While most significant results showed differences in which the Caucasians had the higher mean scores, the supraspinatus, infraspinatus, and brachialis demonstrated higher mean scores among African Americans. The supraspinatus is responsible for the abduction of the humerus, the infraspinatus abducts and laterally rotates the humerus and the brachialis is a strong flexor at the elbow joint. These results demonstrate that African Americans collectively were abducting or lifting their arms more often or with heavier stress than Caucasians. It could be a result of being a part of the service industry which requires lifting and carrying things rather than the back and forth movements for factories. However, these results are not especially clear.

Despite the select differences found among the individuals based on variation in biological affinity, the results also indicated that African Americans and Caucasians shared some similarities regarding ranked entheseal attachment sites and muscle groups. After ranking the entheses, it was found that both muscle group #3 and #6 had the highest ranking among both groups. However, since the same result was also found regarding analyses based on sex, it is more likely that physiologically, muscle group #3 and group #6 normally display elevated entheseal scores as a result of habitual anatomical stresses in those groups as compared to others. Muscle groups #2, #5 and #6 were also found to be statistically different between Caucasians and African Americans in which males had the higher mean scores. Muscle group #2 adducts the arm while muscle group #5 and #6 extend and flex the forearm. These results suggest that in overall movement, not specific entheseal sites, Caucasians seem to have higher scores for both large scale arm movement as well as smaller forearm movements. It is possible that these results show that on average Caucasians had high stress labor jobs compared to African Americans and that they employed both large and small scale movements. This complements the literature as African Americans were mostly employed in the service industry as waiters, cooks and hotel personnel which fits with a lower amount of entheseal stress.

Regarding osteoarthritis scores, the results indicate that the acromioclavicular ligament and part of the shoulder have higher results among Caucasians and the elbow and other part of the shoulder have higher results among African Americans. This reiterates some of the results found in the entheseal scorings as more osteoarthritis developed in conjunction to those attachment sites and left evidence of continued wear and tear on the joint. However, as most are noted for both analyses, the skewed age of the samples, whereby there were many more older aged individuals in the Caucasian sample than the African American one, may be another reason the scores were higher in the Caucasian sample.

Therefore, it is likely that the individuals in this sample that died after this were employed in the industrial factories than in previous years when African Americans were employed in the service industry. The other likelihood is that African Americans experienced more activity intense stress due to the cultural and social barriers they faced at the time such as institutionalized racism.

While the higher osteoarthritis stress for Caucasians most likely comes from continuous, repetitive, and forceful industrial occupations, for African Americans, the cause is slightly more social. What is interesting to note though is that for some immigrant groups called Caucasian such as Italian immigrants, there were social consequences regarding housing and access to resources. Because this sample is made up of some European immigrants, it is also likely that the higher stress seen among Caucasians is a result of lower class immigrant groups engaging in high stress occupations that were either too dangerous or deemed inferior by other groups of individuals.

Overall, there are some distinguishable patterns found between African Americans and Caucasians which demonstrated that both groups engaged in different habitual labor activity than the other but had stresses at similar locations. These patterns were created from the social and racial climate of the early 20th century which treated African Americans and European immigrants differently.

CHAPTER VII

CONCLUSION AND FUTURE DIRECTIONS

This research study examined not only some interesting questions about the past American experience but also how biological and cultural variables impact activity reconstruction. By expanding current methods as well as exploring other biological and cultural variables, this research project explored the differences between frequencies and locations of physical activity patterns among different population sub-groups. The following table below reexamined the hypotheses presented at the beginning of this study combined with whether the expectations were met (Table 82).

Table 82. Central hypotheses and expectations revisited

VARIABLE	HYPOTHESIS	EXPECTATION	EXPECTATION MET? (50%)
Overall Population (based on sample size)	Based on rigor and stress of the 20th century industry, individuals in the population will have similar rates of entheseal and osteoarthritic stress compared to other industrial populations of the time such as the Almshouse in Albany, New York	Individuals from this collection should have highest indicators of stress than other historical populations	**Met**, as individuals seems to have similar higher stress indicators in conjunction with the expected amount of industry in Cleveland and in other industrial areas

Table 82—Continued

Ill-health Status/Cause of Death	Higher degree of entheseal and osteoarthritic stress in individuals with sudden/acute conditions due to chronic diseases often lead to the wasting of the muscles and subsequent bones	Chronic conditions should have lower entheseal and osteoarthritic stress	**Partially met**, mixed results among both groups, further testing is needed.
Directional and Bilateral Asymmetry	Higher degree of right side bias based upon American cultural practices of the right hand as the dominant hand	Most individuals should be on the right side biased with a few left side biased individuals	**Met**, most scores indicate a right-side bias among the population
Sex	Differences in male and female entheseal stress indicative of a sexual division of labor	Frequencies and locations of entheseal and osteoarthritis will differ between males and females	**Met**, some varying instances of differences in entheseal stress between the sexes, indicative of possible differing life experiences
Age	Higher amount and degree of entheseal changes and osteoarthritis in older individuals	Frequencies of entheseal changes and osteoarthritis will be higher in old adults versus middle and young adults	**Partially met**, a significant number of cases showed that middle and young age adult had higher overall stress than older adults
Biological Affinity	Higher amount of entheseal stress and osteoarthritis in African-American populations than Caucasians due to possible stresses of institutionalized racism and movement from Great Migration	Frequencies of entheseal changes and osteoarthritis will be higher in African American individuals	**Not met**, Caucasians overall had higher amounts of activity stresses than African Americans, possible indicative of African Americans being barred from working heavy industry but could also be because of sampling methods

For overall population size, the expectation was met as the sample from the Hamann-Todd collection had similar average scores than other populations in the literature such as the Almshouse in Albany New York (Solano, 2006). Despite this difference, further research will have to be carried out among other American industrial populations to see where Cleveland is situated. Second, the expectations for entheseal stress and pathology was partially met as there were instances in which individuals with chronic conditions displayed lower makers than those who had died from sudden/acute conditions, but some individuals with chronic conditions demonstrated higher markers as well. Given the small sample size of those with chronic conditions analyzed, this study needs further testing to establish whether that hypothesis is valid.

Third, the expectations for directional and bilateral asymmetry were met in which the population demonstrated a right-side bias regarding handedness; however, there were some specific attachment sites which hinted at more symmetrical activity patterns. Fourth, the expectations for a possible division of labor between the sexes was met. There was evidence between the sexes that some sort of pattern existed; however, the particulars and the boundaries established by those patterns i.e. cultural stigmas regarding men's work and women's work were not identified. For age, expectations were partially met in that older individuals, on average, had higher mean scores than younger or middle adult individuals. However, this expectation was not completely met as there were instances in which younger and middle age adults had higher amounts of physical stress.

Lastly, the expectation that African Americans would have higher rates of entheseal and osteoarthritic stress than their Caucasian counterparts was not met as it was found that Caucasians overall had higher instances of stress. This could be explained because of Cleveland industrial culture in which African Americans were mostly barred from participating in industrial work during this time or because of the skewed sample from the collection. Despite this, there are cases where African Americans have higher average entheseal scores than Caucasians, which is potentially a result of a combination of activity patterns and social and economic status.

Labor Patterns in Early 20th Century Cleveland

Ultimately, this study revealed some interesting patterns regrading labor and activity patterns in early 20th century Cleveland. At this time, Cleveland is expanding its industries and manufacturing companies to include factories such as garment work, large scale metal works and building projects while seeing high levels of immigration from both African Americans and second and third wave European immigrants who sought the opportunity to start over. Traditionally, it was thought that labor during this time was very polarizing. Males worked in factory work and females worked at home or in domestic work. Old and young age individuals would have similar stresses due to similar types of labor. African Americans and Caucasians had separate occupations from one another due to their social statuses, and so forth. This research and other literature shows that these polarizing patterns are not always the case.

Labor in Cleveland was very divided in some respects but it was also very fluid. For males and females, there are clear sexual divisions of labor but corresponding stress frequencies. This may be because some females had similar occupations to males as some of them worked in factories or farms and could have had stresses on the same attachment site locations as males. Entheses and osteoarthritis scoring using age not only played an important role in understanding how these changes build up over time but also demonstrated that while Cleveland was shifting their manufacturing and industrial pathways, the individuals who worked them shifted too. For Caucasians and African Americans, the racial, social, and economic tensions between and among the groups transitioned into the workforce to a certain extent, but there were also exceptions. African Americans were barred from many of the industrial occupations until after the immigration ban in 1924 but in turn they created their own niche of service workers and small business owners and even worked the industrial field as strike breakers. Some European immigrant groups such as the Italians also had social and economic tensions derived from their Italian born status. They would often be offered the lowest industrial jobs and lived often segregated from other parts of the population in ghetto neighborhoods such as the east side of Ward I.

Despite these patterns, labor in Cleveland and in many other industrial cities at this time was still a whirlwind of opportunity and a clashing of different social and economic classes. This study has demonstrated that further research is needed to completely unpack all the patterns that show how labor and activity was viewed and understood by the individuals working it and how that translates into biological stress indicators such as entheses and osteoarthritis.

Future Directions

Since many of the results were inconclusive or partially met, future directions regarding this topic are widespread. As always, a larger sample size would clarify the smaller yet significant differences between population sub-groups. Concurrently, more studies are needed to examine the results if two or more variables are analyzed together to determine if one impacts the other. For example, this study demonstrated the possibility of a sexual division of labor; however, this pattern may change or disappear once age in factored in as well. Since the sample size of this study was too small to answer those questions with confidence, they are left for future studies.

Despite these limitations, this study contributed to paleopathology and investigations of activity as well as corroborated (to a certain extent) the historical narratives of Cleveland at the turn of the twentieth century. This study examined how select individuals of Cleveland's lower industrial and unskilled classes dealt with activity and physical stress over their lifetimes. In addition, certain variables were considered based on biological and cultural backgrounds such as age, sex, biological affiliation and other factors and how their positions in Cleveland society were shown through these skeletal stresses. The utilization of the Hamann-Todd Osteological Collection with the corresponding documentation helped uncover more details regarding these individuals' lives. There is much potential to continue this avenue of research to create a more robust and comprehensive narrative of the lives of these past peoples, which in the end, contributes to our growing awareness of how we view the past and understand it.

BIBLIOGRAPHY

Al-Oumaoui I., Jiménez-Brobeil S., Souich PD., 2004. Markers of activity patterns in some populations of the Iberian Peninsula. International Journal of Osteoarchaeology 14, 343–359

Alt, K.W., Pichler, S.L., 1998. Artificial modifications of human teeth. In: Alt, K.W., Rosing, F.W., Teschler-Nicola, M. (Eds.), Dental Anthropology. Fundamentals, Limits, and Prospects. Springer, Wien, pp. 387‑415.

Auerbach, B. M., Raxter, M. H., 2008. Patterns of clavicular bilateral asymmetry in relation to the humerus: variation among humans. Journal of Human Evolution, 54, 663-74.

Baker, B. J., Terhune, C. E., Papalexandrou, A., 2012. Sew Long? The Osteobiography of a Woman from Medieval Polis, Cyprus. In A. L. Stodder & A. M. Palkovich (ed. 1), The Bioarchaeology of Individuals (pp.151-161). Gainesville: University of Florida.

Baker, J., Pearson O.M., 2006. Statistical methods for bioarchaeology: applications of age-adjustment and logistic regression to comparisons of skeletal populations with differing age-structures. Journal of Archaeological Science 33:218–226.

Barber, R.J., Berdan, F., 1998. The Emperor's Mirror: Understanding Cultures Through Primary Sources. University of Arizona Press.

Brennaman, A., 2011. Examination of osteoarthritis for age-at-death estimation in a modern population.

Brickley, M., Ives R., 2008. The bioarchaeology of metabolic bone disease. Amsterdam: Elsevier/Academic Press.

Bridges, PS., 1993. The effect of variation in methodology on the outcome of osteoarthritic studies. International Journal of Osteoarchaeology 3:289–295.

Bridges, PS., 1994. Vertebral arthritis and physical activities in the prehistoric Southeastern United States. American Journal of Physical Anthropology 93:83–93.

Buikstra, J.E., Ubelaker, D.H., 1994. Standards for Data Collection from Human Skeletal Remains: Proceedings of a Seminar at The Field Museum of Natural History. Fayetteville, Arkansas: Arkansas Archaeological Survey Research Series v 44.

Buikstra, J.E., Beck, L.A., editors. 2006. Bioarchaeology. The contextual analysis of human remains. San Diego: Elsevier.

Cant, M.V., 2014. Working to the Bone: A Comparative Health and Occupational Study of the Skeletal Remains from Rural Moorsel (c.ad 1000-1860). Medieval and Modern Matters 5:133–158.

Capasso, L., Kennedy K.A.R., Wilczak C.A., 1999. Atlas of occupational markers on human remains. Teramo, Italy: Edigrafial.

Cardoso, F.A., Henderson C., 2009. Enthesopathy formation in the humerus: Data from known age-at-death and known occupation skeletal collections. American Journal of Physical Anthropology 141:550–560.

Cardoso, F.A., Henderson C., 2012. The Categorisation of Occupation in Identified Skeletal Collections: A Source of Bias? International Journal of Osteoarchaeology 23:186–196.

Chapman, F.H., 1963. The Incidence and Age Distribution of Osteoarthritis in an Archaic American Indian Population. Indiana Academy of Science 73:64–66.

Chapman, F.H., 1964. Comparison of Osteoarthritis in Three Aboriginal Populations. Indiana Academy of Science 74:84–86.

Churchill, S.E., Morris, A.G., 1998. Muscle marking morphology and labour intensity in Prehistoric Khoisan foragers. Int. J. Osteoarchaeology. 8, 390–411.

Cleveland Directory Company. 1899. Map of the city of Cleveland for 1899-1900.

Cobb, W.M., 1935. Municipal History from Anatomical Records. The Scientific Monthly 40:157–162.

Cova, C.D.L., 2010. Race, health, and disease in 19th-century-born males. American Journal of Physical Anthropology 144:526–537.

Cova, C.D.L., 2010. Cultural Patterns of Trauma among 19th-Century-Born Males in Cadaver Collections. American Anthropologist 112:589–606.

Davis, C.B., Shuler K.A., Danforth M.E., Herndon K.E., 2012. Patterns of Interobserver Error in the Scoring of Entheseal Changes. International Journal of Osteoarchaeology 23:147–151.

Derevenski, J.R.S., 2000. Sex differences in activity-related osseous change in the spine and the gendered division of labor at Ensay and Wharram Percy, UK. American Journal of Physical Anthropology 111:333–354.

Doying, A., 2010. Differentiation of labor-related activity by means of musculoskeletal markers.

Eshed, V., Gopher, A., Galili, E., Hershkovitz, I., 2004. Musculoskeletal stress markers in Natufian hunter-gatherers and Neolithic farmers in the Levant: the upper limb. Am. J. Phys. Anthropol. 123, 303–315.

Ferguson, J.E., 2012. A Comparison of Robusticity of Archaic, Woodland, and Historic Period Populations within New York State as based on Musculoskeletal Markers.

Foster, A., Buckley, H., Tayles, N., 2012. Using Enthesis Robusticity to Infer Activity in the Past: A Review. J Archaeological Method Theory 21(3). Springer Science + Business Media: 511-533.

Galtés, I., Rodríguez-Baeza A., Malgosa A., 2006. Mechanical morphogenesis: A concept applied to the surface of the radius. The Anatomical Record Part A: Discoveries in Molecular, Cellular, and Evolutionary Biology 288A:794–805.

Godde, K., Taylor R.W., 2011. Musculoskeletal stress marker (MSM) differences in the modern American upper limb and pectoral girdle in relation to activity level and body mass index (BMI). Forensic Science International 210:237–242.

Gosling J.A., 1994. Human anatomy: text and colour atlas. St Louis: Wolfe.

Goyenchea, A., Eguren, E., Etxeberria, F., Herrasti, L., Iba˜nez, A., 2001. Morfología del desgaste dentario en fumadores de pipas de arcilla. Munibe 53, 151–157.

Grabowski, J.J., Grabowski D.E., Tebeau M., 2000. Cleveland: a history in motion: transportation, industry & community in Northeast Ohio. Carlsbad, CA: Heritage Media.

Havelkova, P., Villotte, S., Veleminsky, P., Polacek, L., Dobisikova, M., 2011. Enthesopathies and Activity Patterns in the Early Medieval Great Moravian Population: Evidence of Division of Labour. International Journal of Osteoarchaeology, 21, 487-504.

Hawkey, D.E., Merbs, C.F., 1995. Activity-Induced Musculoskeletal Stress Markers (MSM) and Subsistence Strategy Changes Among Ancient Hudson Bay Eskimos. International Journal of Osteoarchaeology 5(4). Wiley-Blackwell: 324-338.

Hawkey, D.E., 1998. Disability, compassion and the skeletal record: using musculoskeletal stress markers (MSM) to construct an osteobiography from early New Mexico. International Journal of Osteoarchaeology International Journal of Osteoarchaeology 8:326–340.

Henderson, C.Y., Craps, D.D., Caffell, A.C., Millard, A.R., Gowland, R., 2012. Occupational Mobility in 19th Century Rural England: The Interpretation of Entheseal Changes. International Journal of Osteoarchaeology International Journal of Osteoarchaeology 23:197–210.

Henderson C.Y., Cardoso, F.A., 2013. Special Issue Entheseal Changes and Occupation: Technical and Theoretical Advances and Their Applications. International Journal of Osteoarchaeology 23:127–134.

Henderson, C., 2013. Subsistence strategy changes: The evidence of entheseal changes. HOMO - Journal of Comparative Human Biology 64:491–508.

Henderson, C.Y., Mariotti, V., Pany-Kucera, D., Villotte, S., Wilczak, C., 2015. The New ‘Coimbra Method’: A Biologically Appropriate Method for Recording Specific Features of Fibrocartilaginous Entheseal Changes. International Journal of Osteoarchaeology.

Henderson, C., 2013. Do diseases cause entheseal changes at fibrous entheses? International Journal of Paleopathology 3:64–69.

Henderson, C.Y., Mariotti, V., Pany-Kucera, D., Lopreno, G.P., Villotte, S., Wilczak, C., 2015. The effect of age on entheseal changes at some fibrocartilaginous entheses.

Henderson, C., Mariotti, V., Pany-Kucera, D., Perreard-Lopreno, G., Villotte, S., Wilczak, C., 2015. Scoring entheseal changes: proposal of a new standardised method for fibrocartilaginous entheses.

Higgins, R.L., Haines, M. R., Walsh, L., 2002. The Poor in the Mid-Nineteenth Century Northeastern United States: Evidence from the Monroe County Almshouse, Rochester, New York. In the Backbone of History: Health and Nutrition in the Western Hemisphere. Richard H. Steckel and Jerome C. Rose, eds. pgs 162-184.

Hunt, D.R., Albanese J., 2005. History and demographic composition of the Robert J. Terry anatomical collection. American Journal of Physical Anthropology 127:406–417.

İşcan, M., Yaşar., K.A.R., 1989. Reconstruction of life from the skeleton. New York: Liss.

Johnson, C., 1879. History of Cuyahoga County, Ohio: in three parts: with portraits and biographical sketches of its prominent men and pioneers. Philadelphia: D.W. Ensign.

Jurmain R.D., Kilgore, L., 1995. Skeletal evidence of osteoarthritis: a palaeopathological perspective. Annals of the Rheumatic Diseases 54:443–450.

Jurmain R.D., 1977. Stress and the etiology of osteoarthritis. American Journal of Physical Anthropology 46:353–365.

Jurmain R.D., 1980. The pattern of involvement of appendicular degenerative joint disease. American Journal of Physical Anthropology 53:143–150.

Jurmain R., Cardoso, F.A., Henderson, C., Villotte, S., 2012. Bioarchaeology's Holy Grail: The Reconstruction of Activity. In: Grauer A, editor. A Companion to Paleopathology. Blackwell Publishing Ltd. p 531–552.

Kelley, M.A., El-Najjar, M.Y., 1980. Natural variation and differential diagnosis of skeletal changes in tuberculosis. American Journal of Physical Anthropology 52:153–167.

Kenneth, K.A.R., 1998. Markers of Occupational Stress: Conspectus and Prognosis of Research. International Journal of Osteoarchaeology 8(5). Wiley-Blackwell: 305-310.

Kern K., Todd, T.W., Pioneer of Modern American Physical Anthropology. Kirtlandia: The Cleveland Museum of Natural History 55:1–42.

Knüsel, C.J., Roberts, C.A., Boylston, A., 1996. When Adam Delved. . . An activity-related lesion in three human skeletal populations. Am. J. Phys. Anthropol. 100, 427–434.

Kusmer, K.L., 1976. A ghetto takes shape: Black Cleveland, 1870-1930. Urbana: University of Illinois Press.

Larsen, C.S., Williams, K.D., 2003. History of Behavior and Lifestyle in the Western Hemisphere: Osteoarthritis and Skeletal Robusticity. American Journal of Physical Anthropology Supplement 36:135-136.

Larsen, C. S., 1997. Bioarchaeology: Interpreting Behavior from the Human Skeleton pp.161-194. New York: Cambridge.

Lieverse, A.R., Weber, A.W., Bazaliiskiy, V.I., Goriunova, O.I., Savel'ev, N.A., 2006. Osteoarthritis in Siberia's Cis-Baikal: Skeletal indicators of hunter-gatherer adaptation and cultural change. American Journal of Physical Anthropology 132:1–16.

Lopreno, G.P., Cardoso, F.A., Assis, S., Milella, M., Speith, N., 2013. Categorization of Occupation in Documented Skeletal Collections: Its Relevance for the Interpretation of Activity-Related Osseous Changes. International Journal of Osteoarchaeology 23:175–185.

Maat, G.J.R., Mastwijk, R.W., Velde, E.A.V.D., 1995. Skeletal distribution of degenerative changes in vertebral osteophytosis, vertebral osteoarthritis and DISH. International Journal of Osteoarchaeology 5:289–298.

Machicek, M.L., 2011 Reconstructing Diet, Health and Activity Patterns in Early Nomadic Pastoralist Communities of Inner Asia. (Ph.D. Diss. University of Sheffield).

Maggiano, I. S., Schultz, M., Kierdorf, H., Sosa, T. S., Maggiano, C. M., Blos, V. T. 2008., Cross-sectional analysis of long bones, occupational activities and long-distance trade of the classic Maya from Xcambo´ —Archaeological and Osteological Evidence. American Journal of Physical Anthropology, 136, 470-477.

Marchi, D., Sparacello, V.S., Holt, B.M., Formicola, V., 2006. Biomechanical approach to the reconstruction of activity patterns in Neolithic western Liguria, Italy. Am. J. Phys. Anthropol. 131, 447–455.

Mariotti, V., Facchini, F., Bellcastro, M.G., 2004. Enthesopathies – Proposal of a Standardized Scoring Method and Applications. Coll. Antropol. 28(1): 145–159.

Mays, S., 1999. A biomechanical study of activity patterns in a medieval human skeletal assemblage. Int. J. Osteoarchaeol. 9, 68–73.

Meyer, C., Nicklisch, N., Held, P., Fritsch, B., Alt, K.W., 2011. Tracing patterns of Activity in the human skeleton: An overview of methods, problems, and limits of interpretation. HOMO- Journal of Comparative Human Biology, 62, 202-217.

Michopoulou, E., Nikita, E., Valakos, E.D., 2015. Evaluating the efficiency of different recording protocols for entheseal changes in regards to expressing activity patterns using archival data and cross-sectional geometric properties. American Journal of Physical Anthropology 158:557–568.

Miller, C.P., Wheeler, R.A., 1997. Cleveland: a concise history, 1796-1996. Bloomington: Indiana University Press.

Molnar, P., Ahlstrom, T.P., Leden, I., 2009. Osteoarthritis and activity-an analysis of the relationship between eburnation, Musculoskeletal Stress Markers (MSM) and age in two Neolithic hunter-gatherer populations from Gotland, Sweden. International Journal of Osteoarchaeology 21:283–291.

Mountrakis, C., Manolis, S., 2015. Entheseal Change of the Upper Limb in a Mycenaean Population from Athens. Mediterranean Archaeology and Archaeometry 15:209–220.

Myszka, A., Piontek, J., 2013. The Effect of Age on external bone morphology properties in adults. Anthropologie 1:409–420.

Neidich, D.L., 2014. A comparative study of mechanical stress in the pre-columbian Tennessee River Valley.

Nelson, A.E., Golightly, Y.M., Renner, J.B., Schwartz, T.A., Kraus, V.B., Helmick, C.G., Jordan, J.M., 2013. Differences in multijoint symptomatic osteoarthritis phenotypes by race and sex: The Johnston County Osteoarthritis Project. Arthritis & Rheumatism 65:373–377.

Niinimäki, S., 2009. What do muscle marker ruggedness scores actually tell us? International Journal of Osteoarchaeology 21:292–299.

Niinimäki, S., Baiges Sotos, L., 2013. The Relationship Between Intensity of Physical Activity and Entheseal Changes on the Lower Limb. Int. J. Osteoarchaeol., 23: 221–228.

Nolte, M., Wilczak, C., 2013. Three-dimensional Surface Area of the Distal Biceps Enthesis, Relationship to Body Size, Sex, Age and Secular Changes in a 20th Century American Sample. International Journal of Osteoarchaeology 23:163–174.

O'Connor, A., 2001. Poverty knowledge: social science, social policy, and the poor in twentieth-century U.S. history. Princeton, NJ: Princeton University Press.

Odien, J.K., 2015. Entheseal Morphology: What can muscle attachment sites tell us about the physical activities performed by the individuals buried at the Erie County Poorhouse Cemetery?

Palmer, J., 2012. Busy Bones: Osteoarthritis and musculoskeletal markers as evidence of physical activity and social differentiation in post-medieval the Netherlands.

Palmer, J. L. A., Hoogland, M. H. L., Waters-Rist, A. L., 2014. Activity Reconstruction of Post-Medieval Dutch Rural Villagers from Upper Limb Osteoarthritis and Entheseal Changes. International Journal of Osteoarchaeology. Wiley-Blackwell: n/a-n/a.

Pearson, O.M., Lieberman, D.E., 2004. The aging of Wolff's "Law": ontogeny and responses to mechanical loading in cortical bone. Yearbook, Physical Anthropology. 47, 63–99.

Perry, E.M., 2004. Bioarchaeology of Labor and Gender in the Prehistoric American Southwest.

Peterson, J., 1998. The Natufian Hunting Conundrum: Spears, Atlatls, or Bows? Musculoskeletal and Armature Evidence. International Journal of Osteoarchaeology. 8(5): 378–389.

Reichs, K., 1998. Forensic osteology: advances in the identification of human remains. Springfield, IL, U.S.A.: Charles C. Thomas.

Robb, J. E., 1998. The Interpretation of Skeletal Muscle Sites: A Statistical Approach. International Journal of Osteoarchaeology 8(5): 363–377.

Roberts, M.R., 1997. The culture of enthesopathies: differences in musculoskeletal stress markers between samples in a historic population.

Rodrigues, T., 2005. Gender and Social Differentiation within the Turner Population, Ohio, as Evidenced by Activity-Induced Musculoskeletal Stress Markers. In: Carr C, Case DT, editors. Gathering Hopewell: Society, Ritual, and Ritual Interaction. New York, NY: Kluwer Academic/Plenum Publishers. p 405–427.

Rogers J., Waldron T., 1995. A field guide to joint disease in archaeology. Chichester: J. Wiley.

Rothschild, B.M., Woods, R.J., 2012. Epidemiology and Biomechanics of Osteoarthritis. In: Epidemiology and Biomechanics of Osteoarthritis. INTECH Open Access Publisher.

Ruff, C. B., Larsen, C. S., Hayes, W.C., 1984. Structural changes in the femur with the Transition to agriculture on the Georgia Coast. American Journal of Physical Anthropology, 64, 125-136.

Ruff, C., Holt, B., Trinkaus, E., 2006. Who's afraid of the big bad Wolff?: "Wolff's Law" and bone functional adaptation. Am. J. Phys. Anthropol. 129, 484–498.

Santana-Cabrera J., Velasco-Vázquez J., Rodríguez-Rodríguez A., 2015. Entheseal changes and sexual division of labor in a North-African population: The case of the pre-Hispanic period of the Gran Canaria Island (11th–15th c. CE). HOMO - Journal of Comparative Human Biology 66:118–138.

Schrader S.A., 2012. Activity patterns in New Kingdom Nubia: An examination of entheseal remodeling and osteoarthritis at Tombos. American Journal of Physical Anthropology 149:60–70.

Schultz, J., 1998. A Comparison of Osteoarthritis in the Appendicular Joints of Individuals from the Hammond-Todd and Terry Collections University of Indianapolis Archeology & Forensics Laboratory.

Skinner, J.L., 2015. Entheses and Activities: The Multivariate Mechanisms of Entheseal Change for Individuals Represented by the 2013 Excavations of the Milwaukee County Institution Grounds Cemetery.

Solano, M.C., 2006. The life stresses of poverty skeletal and historical indicators of activity patterns in the Albany County Almshouse skeletal collection, 1825-1925.

Stager, S. M., 2001. Patterning of joint margin lipping in relation to the location of surface osteoarthritis within appendicular joints. American Journal of Physical Anthropology Supplement. (32): 141-142.

Steckel, R.H., Rose, J.C., 2002. The backbone of history: health and nutrition in the Western Hemisphere. Cambridge: Cambridge University Press.

Steele, J., 2000. Handedness in past human populations: Skeletal markers. Laterality 5:193–220.

Steen, S. L., Lane, R. W., 1998. Evaluation of Habitual Activities among Two Alaskan Eskimo Populations Based on Musculoskeletal Stress Markers. International Journal of Osteoarchaeology 8(5). Wiley-Blackwell: 341-353.

Stefanović, S., Porčić., M., 2011. Between-group Differences in the Patterning of Musculo-skeletal Stress Markers: Avoiding Confounding Factors by Focusing on Qualitative Aspects of Physical Activity. International Journal of Osteoarchaeology 23:94–105.

Stirland, A.J., 1998. Musculoskeletal evidence for activity: problems of evaluation. Int. J. Osteoarchaeol. 8, 354–362.

Tihanyi, B., Bereczki, Z., Molnar, E., Berthon, W., Revesz, L., Dutour, O., Palfi, G., 2015. Acta Biologica Szegediensis. Acta Biologica Szegediensis 59:65–77.

Titus Simmons & Titus. 1874. Map of Cuyahoga County. Atlas of Cuyahoga County, Ohio.

Trinkaus, E., 1997. Appendicular robusticity and the paleobiology of modern human emergence. Proc. Natl. Acad. Sci. U.S.A. (PNAS) 94, 13367–13373.

Trinkaus, E., Churchill, S.E., 1999. Diaphyseal cross-sectional geometry of Near Eastern Middle Palaeolithic humans: the humerus. J. Archaeol. Sci. 26, 173–184.

Tsuboi, M., Hasegawa, Y., Matsuyama, Y., Suzuki, S., Suzuki, K., Imagama, S., 2010. Do musculoskeletal degenerative diseases affect mortality and cause of death after 10 years in Japan? Journal of Bone and Mineral Metabolism 29:217–223.

U.S. Census Bureau., 1900. Official Report of Cuyahoga County

U.S. Census Bureau.,1999. Statistical Abstract of the United States

Van Tassel, D., Grabowski, J.J., 1987. The Encyclopedia of Cleveland history. Bloomington: Indiana University Press.

Villotte, S., Knüsel, C.J., 2012. Understanding Entheseal Changes: Definition and Life Course Changes. International Journal of Osteoarchaeology 23:135–146.

Villotte, S., Castex, D., Couallier, V., Dutour, O., Knüsel, C.J., Henry-Gambier, D., 2010. Enthesopathies as occupational stress markers: Evidence from the upper limb. American Journal of Physical Anthropology 42:224–234.

Villotte, S., Knüsel, C.J., 2012. Comment on "Musculoskeletal stress marker (MSM) differences in the modern American upper limb and pectoral girdle in relation to activity level and body mass index (BMI)" by K. Godde and R. Wilson Taylor. Forensic Science International 217:31.

Villotte, S., Knüsel, C.J., 2014. "I sing of arms and of a man…": medial epicondylosis and the sexual division of labour in prehistoric Europe. Journal of Archaeological Science 43:168–174.

Waldron, T., 2009. Palaeopathology. Cambridge: Cambridge University Press.

Waldron, T., 1992. Osteoarthritis in a Black Death cemetery in London. International Journal of Osteoarchaeology 2:235–240.

Waldron, T., 2002. Joint Disease. In: Grauer A, editor. A Companion to Paleopathology. Blackwell Publishing Ltd. p 513–530.

Walker, P.L., Hollimon, S.E., 1989. Changes in osteoarthritis associated with the development of a maritime economy among southern California Indians. International Journal of Anthropology 4:171–183.

Wanner, I.S., Sosa, T.S., Alt, K.W., Tiesler Blos, V., 2007. Lifestyle, occupation, and whole bone morphology of the Pre-Hispanic Maya coastal population from Xcambo, Yucatan, Mexico. Int. J. Osteoarchaeol. 17, 253‑268.

Watkins, R., 2010. Variation in health and socioeconomic status within the W. Montague Cobb skeletal collection: Degenerative joint disease, trauma and cause of death. International Journal of Osteoarchaeology 22:22–44.

Webb, M.L., 2010. Analysis of Osteoarthritis on Appendicular Joint Surfaces in Known Age and Sex Samples from the Terry and Spitalfields Collections.

Weiss, E., Jurmain, R., 2007. Osteoarthritis revisited: a contemporary review of aetiology. International Journal of Osteoarchaeology 17:437–450.

Weiss, E., Corona, L., Schultz, B., 2010. Sex differences in musculoskeletal stress markers: Problems with activity pattern reconstructions. International Journal of Osteoarchaeology 22:70–80.

Weiss, E., 2004 Understanding muscle markers: Lower limbs. Am. J. Phys. Anthropol., 125: 232–238.

Weiss, E., 2012. Examining Activity Patterns and Biological Confounding Factors: Differences between Fibrocartilaginous and Fibrous Musculoskeletal Stress Markers. International Journal of Osteoarchaeology 25:281–288.

Weiss E. 2006. Osteoarthritis and body mass. Journal of Archaeological Science 33:690–695.

Weiss, E., 2007. Muscle markers revisited: Activity pattern reconstruction with controls in a central California Amerind population. American Journal of Physical Anthropology 133:931–940.

White, T. D., 2000. Human Osteology. San Diego: Academic Press.

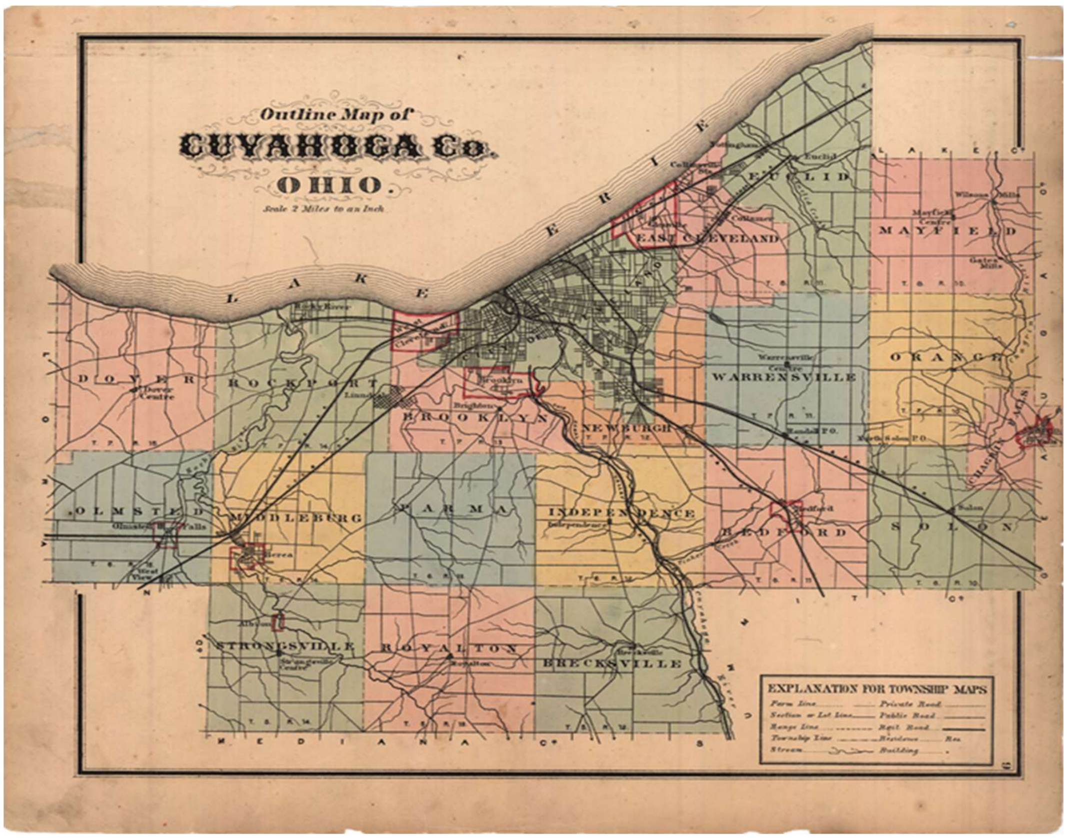
Wilczak, C.A., 1998. Consideration of sexual dimorphism, age, and asymmetry in quantitative measurements of muscle insertion sites. International Journal of Osteoarchaeology 8:311–325.

Yonemoto, S., 2015. Differences in the effects of age on the development of entheseal changes among historical Japanese populations. American Journal of Physical Anthropology 159:267–283.

Zampetti, S., Mariotti, V., Radi, N., Belcastro, M.G., 2016. Variation of skeletal degenerative joint disease features in an identified Italian modern skeletal collection. American Journal of Physical Anthropology 160:683–693.

APPENDIX

LITERATURE REVIEW



Titus Simmons & Titus, 1874

Figure 44. Map of Cuyahoga County township boundaries circa 1876

Table 82. Sampled Occupations from East Cleveland Township

SAMPLED OCCUPATIONS CIRCA 1900 FROM EAST CLEVELAND TOWNSHIP				
OCCUPATION	**TALLY**	**SEX**	**MOVEMENT GROUP ***	**NOTES**
CARPENTER	9	M	MANUAL SKILLED, FORCEFUL	
MILLWRIGHT	1	M	MANUAL SKILLED, FORCEFUL	DESIGNED, BUILT OR MAINTAINED MILLS OR MILL MACHINERY

Table 82—Continued

FARMER	25	M	MANUAL SKILLED, FORCEFUL	
CARPET WEAVER	1	M	MANUAL, NON-FORCEFUL	
SHOE MAKER	1	M	MANUAL, NON-FORCEFUL	
CARRIAGE DRIVER	2	M	NONMANUAL	
BASKET BRAIDER	1	F	MANUAL, NON-FORCEFUL	
MACHINIST	2	M	MANUAL SKILLED, FORCEFUL	
STEAM FITTER	2	M/F	MANUAL SKILLED, FORCEFUL	
PIANO TUNER	1	M	MANUAL SKILLED, NON-FORCEFUL	
SALESWOMAN	1	F	NONMANUAL	
QUARRYMAN	1	M	MANUAL SKILLED, FORCEFUL	BLUE FLAG STONE
GUM MAKER	2	F	MANUAL, NON-FORCEFUL	
FACTORY MANAGER	1	M	NONMANUAL	
MANUFACTURER	2	M	MANUAL SKILLED, FORCEFUL	STEAM FITTINGS, CIGAR
BOOK KEEPER	1	M	NONMANUAL	
HOUSE SERVANT	7	F	MANUAL, NON-FORCEFUL	
SERVANT	2	F	MANUAL, NON-FORCEFUL	
FARM HAND	1	M	MANUAL SKILLED, FORCEFUL	
REAL ESTATE DEALER	2	M	NONMANUAL	
MASON CONTRACTOR	2	M	NONMANUAL	
FARM LABORER	13	M	MANUAL UNSKILLED, FORCEFUL	
DRESS MAKER	4	F	MANUAL, NON-FORCEFUL	
CIRCUIT COURT	1	M	NONMANUAL	

Table 82—Continued

SCHOOL TEACHER	2	M/F	NONMANUAL	
TEAMSTER	2	M	MANUAL SKILLED, FORCEFUL	
TIN SMITH	1	M	MANUAL SKILLED, FORCEFUL	
LABORER	10	M	MANUAL UNSKILLED, FORCEFUL	
MANAGER	1	M	NONMANUAL	QUARRY
OWNER	1	M	NONMANUAL	QUARRY
CRANE HAND	1	M	MANUAL SKILLED, FORCEFUL	
PRESS HAND	1	M	MANUAL SKILLED, FORCEFUL	
METAL DEALER	2	M	NONMANUAL	
FOREMAN	1	M	NONMANUAL	
JEWELER	1	M	MANUAL, NON-FORCEFUL	
NIGHT WATCHMAN	2	M	NONMANUAL	
GROCER	2	M/F	NONMANUAL	
MOTORMAN	2	M	MANUAL, NON-FORCEFUL	OPERATOR OF A TRANSIT TRAIN
BLACKSMITH	3	M	MANUAL SKILLED, FORCEFUL	
BOARDING HOUSE	1	F	NONMANUAL	KEEPER
ATTORNEY	1	M	NONMANUAL	
PREACHER	1	M	NONMANUAL	
TRAVELING SALESMAN	1	M	NONMANUAL	
MILLINER	2	F	MANUAL, NON-FORCEFUL	WOMAN’S HAT MAKER
BUTCHER	2	M	MANUAL SKILLED, FORCEFUL	
GARDEN FARMER	1	M	MANUAL SKILLED, FORCEFUL	
ENGINEER	1	M	NONMANUAL	RAILROAD
MILK PEDDLER	8	M	NONMANUAL	
SALOON KEEPER	1	M	NONMANUAL	
BARTENDER	1	M	MANUAL, NON-FORCEFUL	

Table 82—Continued

HOUSE KEEPER	1	F	NONMANUAL	
RETIRED	1	M	NONE	PREVIOUS OCCUPATION UNKNOWN
DRIVER	1	M	NONMANUAL	COAL WAGON
DAIRYMAN	2	M	MANUAL, NON-FORCEFUL	
DEALER	1	M	NONMANUAL	FURNITURE
ROD CARRIER	1	M	MANUAL SKILLED, FORCEFUL	SURVEYOR
MANAGER	1	M	NONMANUAL	COAL COMPANY
STORE CONTRACTOR	2	M	NONMANUAL	
*based on Villotte et al., 2010				

U.S. Census Bureau, 1900

Table 83. Sampled occupations from Newburgh Township

SAMPLED OCCUPATIONS CIRCA 1900 FROM NEWBURGH TOWNSHIP				
OCCUPATION	**TALLY**	**SEX**	**MOVEMENT GROUP ***	**NOTES**
FARMER	50	M/F	MANUAL SKILLED, FORCEFUL	
FARM LABORER	28	M/F	MANUAL UNSKILLED, FORCEFUL	
ICE DEALER	1	M	MANUAL, NON-FORCEFUL	
BOOK KEEPER	1	F	NONMANUAL	
FLOUR SALESMAN	1	M	NONMANUAL	
ENGINEER	5	M	NONMANUAL	
CLERK	11	M	NONMANUAL	
LABORER	18	M	MANUAL UNSKILLED, FORCEFUL	
FIREMAN	4	M	NONMANUAL	
MOTORMAN	4	M	NONMANUAL	OPERATES A TRANSIT TRAIN
GROCER	1	M	NONMANUAL	
DOCTOR	3	M	NONMANUAL	
MILK DEALER	5	M	NONMANUAL	

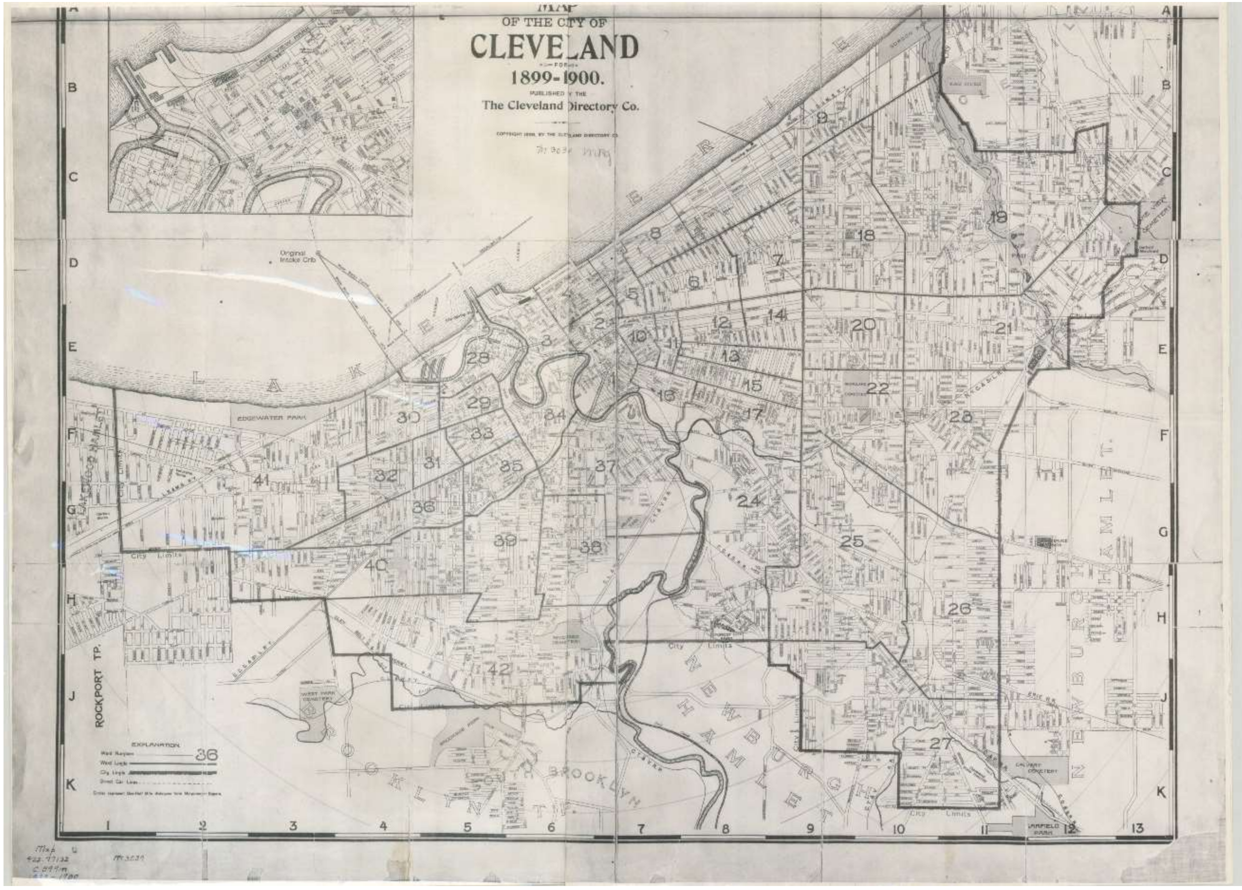
Table 83—Continued

CARPENTER	7	M	MANUAL SKILLED, FORCEFUL	
SHOOTING GROUND	1	M	NONMANUAL	KEEPER OF SHOOTING GROUND
BUTCHER	2	M	MANUAL SKILLED, FORCEFUL	
LIVERYMAN	2	M	MANUAL, NON-FORCEFUL	STABLE FOR RENTED HORSES
DRESSMAKER	1	F	MANUAL, NON-FORCEFUL	
PLUMER	1	M	MANUAL, NON-FORCEFUL	MADE ORNAMENTAL FEATHER PLUMES OR SOLD FEATHERS
TINNER	1	M	MANUAL SKILLED, FORCEFUL	TIN MINER OR TINSMITH
TEACHER	3	F	NONMANUAL	
PAPER MAKER	1	M	MANUAL, NON-FORCEFUL	
POWER MAKER	5	M	MANUAL SKILLED, FORCEFUL	GUNPOWER?
TEAMSTER	2	M	MANUAL SKILLED, FORCEFUL	ANIMAL DRIVER
FOREMAN	3	M	NONMANUAL	
BLACKSMITH	1	M	MANUAL SKILLED, FORCEFUL	
PIPE FITTER	1	M	MANUAL SKILLED, FORCEFUL	
RETIRED	1	M	NONE	PREVIOUS OCCUPATION UNKNOWN
SALOON KEEPER	2	M	NONMANUAL	
PLUMMER	1	M	MANUAL SKILLED, FORCEFUL	
LABOR MILLS	6	M/F	MANUAL UNSKILLED, FORCEFUL	WOOLING ETC.
SERVANT	2	M/F	MANUAL, NON-FORCEFUL	

Table 83—Continued

BRICK MASON	1	M	MANUAL SKILLED, FORCEFUL	
BARTENDER	1	M	MANUAL, NON-FORCEFUL	
WIRE DRAWER	3	M	MANUAL SKILLED, FORCEFUL	MADE WIRE BY DRAWING THE HOT METAL THROUGH DIES
ICE PEDDLER	2	M	NONMANUAL	
MERCHANT	1	M	NONMANUAL	LUMBER
SALESMAN	1	M	NONMANUAL	UNKNOWN WARES
SHOE MAKER	1	M	MANUAL, NON-FORCEFUL	
MILLER	1	M	MANUAL SKILLED, FORCEFUL	
STOVE CRATER	1	M	MANUAL UNSKILLED, FORCEFUL	BOXED STOVES
STONE MASON	2	M	MANUAL SKILLED, FORCEFUL	
CONTRACTOR	1	M	NONMANUAL	
WOODWORKER	1	M	MANUAL SKILLED, FORCEFUL	
TELEPHONE EX	1	F	NONMANUAL	OPERATOR
BUTTON MAKER	1	M	MANUAL, NON-FORCEFUL	
PAINTER	1	M	MANUAL, NON-FORCEFUL	
PRINTER	2	M/F	MANUAL, NON-FORCEFUL	
BRICK LAYER	2	M	MANUAL SKILLED, FORCEFUL	
CIGAR MAKER	1	M	MANUAL, NON-FORCEFUL	
*based on Villotte et al., 2010				

U.S. Census Bureau, 1900



Cleveland Directory Company, 1899

Figure 45. Map of Cleveland City limits and ward boundaries circa 1899-1900

Table 84. Sampled Occupations from Cleveland City Ward 1 (East Side)

SAMPLED OCCUPATIONS CIRCA 1900 FROM CLEVELAND CITY WARD I (EAST SIDE)				
OCCUPATION	**TALLY**	**SEX**	**MOVEMENT GROUP ***	**NOTES**
RESTAURANT KEEPER	2	M	NONMANUAL	
ERRAND BOY	2	M	MANUAL, NON-FORCEFUL	
DAY LABORER	43	M	MANUAL UNSKILLED, FORCEFUL	

Table 84—Continued

PAVER	3	M	MANUAL SKILLED, FORCEFUL	
HOD CARRIER	1	M	MANUAL SKILLED, FORCEFUL	MASON'S ASSISTANT
COOK	5	M/F	MANUAL, NON-FORCEFUL	
PORTER	7	M	MANUAL, NON-FORCEFUL	BILLIARD ROOM, HOTEL, DRY GOODS, FRUIT STORE, CLUB HOUSE
HOUSEKEEPE R	12	F	NONMANUAL	
JANITOR	2	M	MANUAL, NON-FORCEFUL	
SLATE ROOFER	1	M	MANUAL SKILLED, FORCEFUL	
MOUDLER	3	M	MANUAL SKILLED, FORCEFUL	
HOTEL WAITER	19	M/F	MANUAL, NON-FORCEFUL	
NEWSPAPER	1	M	NONMANUAL	EDITOR
LABORER	5	M	MANUAL UNSKILLED, FORCEFUL	
PAPER HANGER	2	M	MANUAL, NON-FORCEFUL	
BELLBOY	4	M	MANUAL, NON-FORCEFUL	HOTEL
BUTLER	1	M	MANUAL, NON-FORCEFUL	

Table 84—Continued

DAY WAITER	3	M	MANUAL, NON-FORCEFUL	
BARBER	2	M	MANUAL, NON-FORCEFUL	
ELEVATOR BOY	1	M	MANUAL, NON-FORCEFUL	
BLACKSMITH	1	M	MANUAL SKILLED, FORCEFUL	
BOILERMAKER	1	M	MANUAL SKILLED, FORCEFUL	INDUSTRIAL METALWORKER
TAILOR	2	M/F	MANUAL, NON-FORCEFUL	
SCHOOL TEACHER	1	F	NONMANUAL	
MINISTER	1	M	NONMANUAL	
INSURANCE AGENT	1	M	NONMANUAL	
DEALER	2	M	NONMANUAL	CIGAR, COAL
MACHINIST	3	M	MANUAL SKILLED, FORCEFUL	
DRESSMAKER	3	F	MANUAL, NON-FORCEFUL	
CARPENTER	5	M	MANUAL SKILLED, FORCEFUL	
BAKER	1	M	MANUAL SKILLED, FORCEFUL	
MAKER	2	M	MANUAL, NON-FORCEFUL	CIGAR
BUYER	1	M	NONMANUAL	DRY GOODS
BUTCHER	1	M	MANUAL SKILLED, FORCEFUL	

Table 84—Continued

AGENT	1	M	NONMANUAL	WASHING MACHINE
SALOONIST	1	M	NONMANUAL	
SALESMAN	5	M	NONMANUAL	SHOES, CARRIAGE, DRY GOODS
FACTOR WRAPPER	2	F	MANUAL, NON-FORCEFUL	
PAINTER	5	M	MANUAL, NON-FORCEFUL	
ENGINEER	1	M	NONMANUAL	STATIONARY
DINING CAR WAITER	1	M	NONMANUAL	
HATTING	2	M/F	MANUAL, NON-FORCEFUL	BLEACHER, SEWING
BARTENDER	3	M	MANUAL, NON-FORCEFUL	
SERVANT	7	M/F	MANUAL, NON-FORCEFUL	
HOTEL WORK	1	F	MANUAL, NON-FORCEFUL	
TEAMSTER	3	M	MANUAL SKILLED, FORCEFUL	
CLERK	1	M	NONMANUAL	
JOCKEY	1	M	MANUAL SKILLED, FORCEFUL	
PAINT MIXER	1	M	MANUAL, NON-FORCEFUL	
WATCHMAN	1	M	NONMANUAL	
RAILROAD	2	M	MANUAL SKILLED, FORCEFUL	SWITCHMAN, BRAKEMAN

Table 84—Continued

HUSKTER	2	M	NONMANUAL	RETAILER OF SMALL WARES IN SHOP
BOOK KEEPER	2	M/F	NONMANUAL	
BOOK BINDER	1	M	NONMANUAL	
FOREMAN	1	M	NONMANUAL	TELEPHONE
PATTERN MAKER	1	M	MANUAL, NON-FORCEFUL	
BRICK LAYER	1	M	MANUAL SKILLED, FORCEFUL	
WASHERWOMAN	2	F	MANUAL, NON-FORCEFUL	
LAKE BOAT CAPTAIN	1	M	MANUAL, NON-FORCEFUL	
MARKS BUTTONS	1	F	MANUAL, NON-FORCEFUL	
STAGE EMPLOYEE	1	M	MANUAL SKILLED, FORCEFUL	
LINEMAN	1	M	MANUAL SKILLED, FORCEFUL	ELECTRIC
METAL POLISHER	1	M	MANUAL SKILLED, FORCEFUL	
*based on Villotte et al., 2010				

U.S. Census Bureau, 1900

Table 865 Sampled occupations from Cleveland City Ward 1 (West Side)

SAMPLED OCCUPATIONS CIRCA 1900 FROM CLEVELAND CITY WARD I (WEST SIDE)				
OCCUPATION	**TALLY**	**SEX**	**MOVEMENT GROUP ***	**NOTES**
LANDLORD	3	M/F	NONMANUAL	
DAY LABORER	77	M	MANUAL UNSKILLED, FORCEFUL	GAS HOUSE, STREET PAVING, FISH HOUSE ETC.
CARPENTER	3	M	MANUAL SKILLED, FORCEFUL	
BOOK KEEPER	2	M/F	NONMANUAL	
METAL SPINNER	1	M	MANUAL SKILLED, FORCEFUL	
PICTURE FRAME MAKER	1	M	MANUAL, NON-FORCEFUL	
BARBER	4	M	MANUAL, NON-FORCEFUL	
PAPER HANGER	2	M	MANUAL, NON-FORCEFUL	
RAILROAD	1	M	MANUAL SKILLED, FORCEFUL	
AGENT	2	M	NONMANUAL	INSTALLMENT, INSURANCE
COOK	4	M/F	MANUAL, NON-FORCEFUL	HOTEL, RESTAURANT
COOPER	1	M	MANUAL SKILLED, FORCEFUL	CREATES BARRELS
ODD JOBS	1	M	MANUAL UNSKILLED, FORCEFUL	
JAPPANER	2	M	MANUAL SKILLED, FORCEFUL	VARNISHER
METAL POLISHER	1	M	MANUAL SKILLED, FORCEFUL	
JANITOR	1	M	MANUAL, NON-FORCEFUL	
HOSTLER	1	M	MANUAL SKILLED, FORCEFUL	LOOKS AFTER HORSES AT INN
ELECTRICIAN	2	M	MANUAL, NON-FORCEFUL	
PAWNBROKER	1	M	NONMANUAL	
MERCHANT	2	M	NONMANUAL	CIGAR, CLOTHES

Table 85—Continued

WASHWOMAN	2	F	MANUAL, NON-FORCEFUL	
FIREMAN	3	M	NONMANUAL	
TRUSS MAKER	1	M	MANUAL SKILLED, FORCEFUL	RAILROAD
MACHINIST	2	M	MANUAL SKILLED, FORCEFUL	
DRIVER	4	M	NONMANUAL	
CONFECTIONER	1	M	MANUAL, NON-FORCEFUL	
CLERK	6	M/F	NONMANUAL	
SHOEMAKER	1	M	MANUAL, NON-FORCEFUL	
SALOON KEEPER	3	M	NONMANUAL	
BRUSH MAKER	1	M	MANUAL, NON-FORCEFUL	
PIANIST	1	M	MANUAL, NON-FORCEFUL	
WAITER	5	M	MANUAL, NON-FORCEFUL	HOTEL, RESTAURANT
PEDDLER	3	M	NONE	
FOREMEN	2	M/F	NONMANUAL	KNITTING, GROCERY
TAILOR	9	M/F	MANUAL, NON-FORCEFUL	3 FEMALE
BOOK BINDING	1	M	MANUAL, NON-FORCEFUL	
DISH WASHER	2	M/F	MANUAL, NON-FORCEFUL	
FRUIT STAND KEEPER	4	M	NONMANUAL	
STONE MOLDER	1	M	MANUAL SKILLED, FORCEFUL	
SEWER	3	F	MANUAL SKILLED, FORCEFUL	SHIRT FACTORY
SAND PAPERING	1	M	MANUAL, SKILLED, FORCEFUL	MACHINE WORK
DRESS MAKER	1	F	MANUAL, NON-FORCEFUL	
CANDY MAKER	7	M	MANUAL, NON-FORCEFUL	
HUCKSTER	1	M	NONE	SELLER, PEDDLER

Table 85—Continued

MUSICIAN	1	M	MANUAL, NON-FORCEFUL	
PRINTER	1	M	MANUAL, NON-FORCEFUL	
BARTENDER	1	M	MANUAL, NON-FORCEFUL	
NURSE	1	M	MANUAL, NON-FORCEFUL	
BUTCHER	1	M	MANUAL, SKILLED, FORCEFUL	
BREEDING CANARIES	1	F	NONMANUAL	
GREEN GROCER	1	F	NONMANUAL	
SEAMSTRESS	1	F	MANUAL, NON-FORCEFUL	
HOUSE WORK	1	F	MANUAL, NON-FORCEFUL	
PAINTER	3	M	MANUAL, NON-FORCEFUL	
COBBLER	2	M	MANUAL SKILLED, FORCEFUL	
POLICEMAN	1	M	NONMANUAL	
LAUNDRY	1	M	MANUAL, NON-FORCEFUL	
TEAMSTER	5	M	MANUAL SKILLED, FORCEFUL	ANIMAL DRIVERS
HOD CARRIER	2	M	MANUAL UNSKILLED, FORCEFUL	BRICK CARRIER
CIGAR MAKER	1	M	MANUAL, NON-FORCEFUL	
STONE CUTTER	1	M	MANUAL SKILLED, FORCEFUL	
SERVANT	1	M	MANUAL, NON-FORCEFUL	
CABINET MAKER	1	M	MANUAL SKILLED, FORCEFUL	
	*based on Villotte et al., 2010			

U.S. Census Bureau, 1900

Table 86. Sampled occupations from Cleveland City Ward 9

SAMPLED OCCUPATIONS CIRCA 1900 FROM CLEVELAND CITY WARD IX				
OCCUPATION	**TALLY**	**SEX**	**MOVEMENT GROUP ***	**NOTES**
STEEL LABORER	15	M	MANUAL SKILLED, FORCEFUL	
CARPENTER	1	M	MANUAL SKILLED, FORCEFUL	
PATROLMAN	1	M	NONMANUAL	
MAIL CLERK	1	M	NONMANUAL	
INVENTOR	1	M	NONMANUAL	
SALOON KEEPER	3	M/F	NONMANUAL	
FIREMAN	1	M	NONMANUAL	
RAILROAD	3	M	MANUAL SKILLED, FORCEFUL	BRAKEMAN, LABORER
WIRE DRAWER	4	M	MANUAL SKILLED, FORCEFUL	
BUTCHER CLERK	1	M	NONMANUAL	
NAIL LABORER	1	M	MANUAL SKILLED, FORCEFUL	
FOUNDRYMAN	1	M	MANUAL SKILLED, FORCEFUL	CASTS METALS
BOARDING HOUSE	3	F	NONMANUAL	
MACHINIST	16	M/F	MANUAL SKILLED, FORCEFUL	
MILL MAN	3	M	MANUAL SKILLED, FORCEFUL	
DAY LABORER	7	M/F	MANUAL SKILLED, FORCEFUL	
HEATER	1	M	MANUAL SKILLED, FORCEFUL	STEEL

Table 86—Continued

SHOEMAKER	1	M	MANUAL NON-FORCEFUL	
STORE KEEPER	1	F	NONMANUAL	
ENGINEER	2	M	NONMANUAL	
CHIPPER	1	M	MANUAL SKILLED, FORCEFUL	IRON
ELECTRIC WORKER	1	M	MANUAL SKILLED, FORCEFUL	
TANNER	1	M	MANUAL SKILLED, FORCEFUL	
CONTRACTOR	1	M	NONMANUAL	
DYE MAKER	1	M	MANUAL, NON-FORCEFUL	
CLERK	1	F	NONMANUAL	
SERVANT	2	F	MANUAL, NON-FORCEFUL	
CHAIN MAKER	3	M	MANUAL SKILLED, FORCEFUL	
COOK	1	F	MANUAL, NON-FORCEFUL	
BOOK BINDER	1	F	MANUAL, NON-FORCEFUL	
LIVERY HAND	1	M	MANUAL SKILLED, FORCEFUL	
TEAMSTER	1	M	MANUAL SKILLED, FORCEFUL	
BLACKSMITH	5	M	MANUAL SKILLED, FORCEFUL	
IRON MOUDLER	5	M	MANUAL SKILLED, FORCEFUL	
COLLECTOR	1	M	NONMANUAL	
NIGHT WATCHMAN	1	M	NONMANUAL	
SHIPPER	1	M	MANUAL, NON-FORCEFUL	

Table 86—Continued

MAIL CARRIER	1	M	NONMANUAL	
PAINTER	2	M	MANUAL, NON-FORCEFUL	
ROD WORKER	1	M	MANUAL SKILLED, FORCEFUL	
DRIVER	1	M	NONMANUAL	
TELEGRAPH OPERATOR	1	M	NONMANUAL	
BOOKKEEPER	1	M	NONMANUAL	
BOIL MAKER	2	M	MANUAL SKILLED, FORCEFUL	INDUSTRIAL METALWORKER
SOLDIER	1	M	MANUAL UNSKILLED, FORCEFUL	
GALVANIZER	1	M	MANUAL SKILLED, FORCEFUL	METAL COATER
OFFICE BOY	1	M	MANUAL, NON-FORCEFUL	
WAITER	1	M	MANUAL, NON-FORCEFUL	
MUSICIAN	1	M	MANUAL, NON-FORCEFUL	
DRESSMAKER	1	F	MANUAL, NON-FORCEFUL	
DOMESTIC WORK	1	F	MANUAL, NON-FORCEFUL	
*based on Villotte et al., 2010				

U.S. Census Bureau, 1900

Table 87 Sampled occupations from Cleveland City Ward 41

SAMPLED OCCUPATIONS CIRCA 1900 FROM CLEVELAND CITY WARD XLI				
OCCUPATION	**TALLY**	**SEX**	**MOVEMENT GROUP ***	**NOTES**
SALOON KEEPER	1	M	NONMANUAL	
WEEKLY PAPER	1	M	NONMANUAL	CITY EDITOR
SERVANT	2	F	MANUAL, NON-FORCEFUL	
DOCTOR	1	M	NONMANUAL	
DRAUGHTSMAN	1	M	MANUAL SKILLED, FORCEFUL	TAILING
GROCERY CLERK	1	M	NONMANUAL	
BRUSH MAKER	1	M	MANUAL, NON-FORCEFUL	
UPHOLSTER	1	M	MANUAL, NON-FORCEFUL	
STRUCTURER	2	M	MANUAL SKILLED, FORCEFUL	IRON
DRAUGHTSMAN	3	M	MANUAL SKILLED, FORCEFUL	IRON
PACKER	1	M	MANUAL SKILLED, FORCEFUL	GLASSWORKS
CONTRACTOR CARPENTER	1	M	NONMANUAL	
JUSTICE OF THE PEACE	1	M	NONMANUAL	
MOLDER	1	M	MANUAL SKILLED, FORCEFUL	IRON
TEAMSTER	1	M	MANUAL SKILLED, FORCEFUL	
AUCTIONEER	1	M	NONMANUAL	
GARDEN LABORERS	1	M	MANUAL SKILLED, FORCEFUL	
GAS WORKS LABORERS	1	M	MANUAL SKILLED, FORCEFUL	
CONDUCTOR	1	M	MANUAL, NON-FORCEFUL	STREET RAILWAY
COMMERCIAL TRAVELER	1	M	NONMANUAL	SHIPS
POLICE	4	M	NONMANUAL	
LABORER IRON WORKS	1	M	MANUAL SKILLED, FORCEFUL	

Table 87—Continued

SOLDIER	1	M	MANUAL UNSKILLED, FORCEFUL	
BARBER	2	M	MANUAL, NON-FORCEFUL	
TUG MAN	1	M	MANUAL SKILLED, FORCEFUL	LAKE
CORKER	1	M	MANUAL SKILLED, FORCEFUL	SHIPS
CAPTAIN	1	M	NONMANUAL	LAKE
MACHINIST	3	M	MANUAL SKILLED, FORCEFUL	
HOUSEKEEPER	4	F	NONMANUAL	
CLERK CROCKERY SHOP	1	F	NONMANUAL	
STENOGRAPHER	1	F	MANUAL, NON-FORCEFUL	
SOLICITOR	1	F	NONMANUAL	
DRESSMAKER	3	F	MANUAL, NON-FORCEFUL	
SALESMAN	1	M	NONMANUAL	DRY GOODS
TEAMSTER	1	M	MANUAL SKILLED, FORCEFUL	GAS WORKS
CLERK GAS OFFICE	1	M	NONMANUAL	
SHIPPING CLERK	1	M	NONMANUAL	
BOOKKEEPER	3	M/F	NONMANUAL	
EGG DEALER	1	M	NONMANUAL	
LAUNDRESS	1	F	MANUAL, NON-FORCEFUL	
CARPENTER JOINER	1	M	MANUAL SKILLED, FORCEFUL	
TEACHER	2	F	NONMANUAL	MUSIC, SCHOOL
SUPERINTENDENT	1	M	NONMANUAL	WESTERN ELECTRIC WORKS
LETTER CARRIER	3	M	NONMANUAL	
CABINET MAKER	2	M	MANUAL SKILLED, FORCEFUL	
*based on Villotte et al., 2010				

U.S. Census Bureau, 1900

RESULTS

Spearman's Correlations for the Ranking of Separate Entheseal Attachment Sites

			Robusticity	Cortical Defect	Ossification Exostosis
Spearman's rho	Robusticity	Correlation Coefficient	1.000	.998**	1.000**
		Sig. (2-tailed)	.	**.000**	**.000**
		N	23	23	23
	Cortical Defect	Correlation Coefficient	.998**	1.000	.999**
		Sig. (2-tailed)	**.000**	.	**.000**
		N	23	23	23
	Ossification Exostosis	Correlation Coefficient	1.000**	.999**	1.000
		Sig. (2-tailed)	**.000**	**.000**	.
		N	23	23	23

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 46. Correlation chart for the ranking of specific entheseal attachment sites

Spearman's Correlations for the Ranking of Entheseal Attachment Sites in Muscle Groups

			Robusticity Group	Cortical Defect Group	Ossification Exostosis Group
Spearman's rho	Robusticity Group	Correlation Coefficient	1.000	.893**	1.000**
		Sig. (2-tailed)	.	**.007**	**.000**
		N	7	7	7
	Cortical Defect Group	Correlation Coefficient	.893**	1.000	.893**
		Sig. (2-tailed)	**.007**	.	**.007**
		N	7	7	7
	Ossification Exostosis Group	Correlation Coefficient	1.000**	.893**	1.000
		Sig. (2-tailed)	**.000**	**.007**	.
		N	7	7	7

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 47. Correlation chart for the ranking of muscle groups

Table 88. Results of the Mann-Whitney U Test for differences between the left and right sides

NUMBER	SITE	TYPE	p VALUE	AVG. LEFT	AVG. RIGHT
1	Teres Major	Robusticity	0.025	2.129	2.301
2	Teres Major	Ossific. Exo.	0.003	1.119	0.956
3	Subclavius	Robusticity	0.040	1.725	1.921
4	Trap. Lig.	Robusticity	0.047	2.460	2.591
5	Trap. Lig.	Ossific. Exo.	0.009	0.973	1.191
6	Trapezius	Robusticity	0.0001	2.355	2.618
7	Trapezius	Ossific. Exo.	0.0003	0.881	1.194
8	Pec. Major	Ossific. Exo.	0.003	1.572	1.775
10	Supraspin.	Robusticity	0.022	2.491	2.649
11	Deltoid	Robusticity	0.006	2.538	2.726
12	Infraspin.	Ossific. Exo.	0.015	0.681	0.888
13	Teres Minor	Robusticity	0.026	2.129	2.301
14	Teres Minor	Ossific. Exo.	0.048	0.784	0.956
15	Com. Ext.	Robusticity	0.001	2.629	2.836
16	Com. Ext.	Ossific. Exo.	0.025	1.310	1.508
17	Bic. Brach.	Robusticity	0.004	2.686	2.854
18	Bic. Brach.	Ossific. Exo.	0.019	1.466	1.658
19	Brachialis	Robusitcity	0.002	2.752	2.905
20	Brachialis	Ossific. Exo.	0.001	1.376	1.606
21	Pro. Teres	Robusticity	0.003	2.338	2.564
22	Supinator	Robusticity	0.0004	1.677	1.940
23	Supinator	Ossific. Exo.	0.040	0.313	0.452
24	Pro. Quad.	Robusiticty	0.007	1.376	1.606
25	Pro. Quad.	Ossific. Exo.	0.033	0.188	0.324

	MALE				FEMALE			
	MEAN	SD	SIG.	BIAS	MEAN	SD	SIG.	BIAS
CLAVICLE	-0.93	2.00	***	L (R)	-0.96	2.52	***	L (R)
HUMERUS	0.47	1.72	***	R	0.73	1.15	***	R
ULNA	0.66	1.15	***	R	1.48	1.71	NS	R

Figure 48—Continued

RADIUS	0.43	1.61	**	R	1.15	1.50	**	R

KEY
*** = (p< 0.05)**
**** = (p< 0.01)**
***** = (p< 0.001)**

Figure 48. Levels of significance among muscle groups between males and females

	CAUCASIAN				AFRICAN-AMERICAN			
	MEAN	SD	SIG.	BIAS	MEAN	SD	SIG.	BIAS
CLAVICLE	-0.66	2.24	***	L (R)	-1.35	2.25	***	L (R)
HUMERUS	0.67	1.66	**	R	0.50	1.13	***	R
ULNA	1.01	1.23	***	R	1.16	1.85	***	R
RADIUS	0.84	1.76	*	R	0.72	1.34	**	R

KEY
*** = (p< 0.05)**
**** = (p< 0.01)**
***** = (p< 0.001)**

Figure 49. Levels of significance among muscle groups between African Americans and Caucasians

	IN U.S.				OUTSIDE U.S.			
	MEAN	SD	SIG.	BIAS	MEAN	SD	SIG.	BIAS
CLAVICLE	-1.13	2.23	***	L (R)	-0.78	2.30	***	L (R)
HUMERUS	0.50	1.05	***	R	0.69	1.75	***	R
ULNA	1.20	1.76	***	R	0.96	1.25	***	R

Figure 50—Continued

RADIUS	0.83	1.32	**	R	0.75	1.81	**	R
KEY * = (p< 0.05) ** = (p< 0.01) *** = (p< 0.001)								

Figure 50. Levels of significance among muscle groups between individuals born inside and outside the U.S.

Table 89. Results of the Mann-Whitney U Test for differences among left and right sides between males and females

NUMBER	SITE	TYPE AND SIDE (L/R)	p VALUE	AVG. MALE	AVG. FEMALE
1	Costo.	Robust. (R)	0.002	2.718	2.386
2	Costo.	Cortical. (L)	3.9E -05	0.926	0.209
3	Costo.	Cortical. (R)	1.4E -05	1.197	0.295
4	Subclav.	Robust. (L)	0.040	1.842	1.534
5	Subclav.	Ossific. (R)	0.053	0.671	0.431
6	Infraspin.	Robust. (R)	0.024	2.084	2.326
7	Infraspin.	Ossific. (R)	0.042	0.788	1.043
8	Pect. Major	Cortical. (L)	0.043	0.267	0.065
9	Pect. Major	Cortical (R)	0.000	0.436	0.022
10	Lat. Dor.	Robust. (L)	0.038	2.197	1.956
11	Lat. Dor.	Robust. (R)	0.023	2.211	1.911
12	Lat. Dor.	Ossific. (R)	0.020	0.788	0.466
13	Teres Major	Robust. (L)	0.013	2.661	2.413
14	Coraco.	Robust. (L)	0.026	1.887	1.652
15	Comm. Ext.	Robust. (R)	0.033	2.901	2.733
16	Comm. Ext.	Ossific. (L)	0.013	1.436	1.111
17	Ancon.	Robust. (L)	0.002	2.253	1.869
18	Ancon.	Robust. (R)	0.006	2.309	2.000
19	Tric. Brachi.	Ossific. (R)	0.051	0.985	0.717
20	Bic. Brachii	Robust. (L)	0.008	2.791	2.521
21	Bic. Brachii	Robust (R)	0.004	2.929	2.739
22	Bic. Brachii	Cortical. (R)	0.004	0.366	0.086
23	Bic. Brachii	Ossific. (L)	0.000	1.625	1.217
24	Bic. Brachii	Ossific. (R)	0.021	1.760	1.500
25	Pro. Quad.	Ossific. (R)	0.036	0.408	0.195

Table 90. Results of the Mann-Whitney U Test for differences among combined left and right sides between males and females

NUMBER	SITE	TYPE	p VALUE	AVG. MALE	AVG. FEMALE
1	Costo.	Robusticity	0.001	2.654	2.356
2	Costo.	Cortical Def.	3.54E -10	1.158	0.252
3	Subclav.	Robusticity	0.007	1.021	1.655
4	Trapez.	Robusticity	0.028	1.381	2.391
5	Trapez.	Cortical Def.	0.032	0.465	0.000
6	Pect. Major	Cortical Def.	3.96E -06	1.021	0.043
7	Lat. Dors.	Robusticity	0.001	1.140	1.934
8	Lat. Dors.	Ossification	0.002	1.725	0.439
9	Teres Major	Robusticity	0.018	1.415	2.373
10	Coraco.	Robusticity	0.010	0.943	1.695
11	Comm. Ext.	Robusticity	0.011	1.457	2.622
12	Comm. Ext.	Cortical Def.	0.013	0.753	0.000
13	Comm. Ext.	Ossification	0.003	1.873	1.244
14	Ancon.	Robusticity	7.27E -05	1.154	1.934
15	Ancon.	Ossification	0.023	1.154	0.597
16	Tri. Brachii	Robusticity	0.008	1.197	2.010
17	Tri. Brachii	Ossification	0.024	1.895	0.684
18	Bic. Brachii	Robusticity	0.000	1.545	2.630
19	Bic. Brachii	Cortical Def.	0.003	1	0.076
20	Bic. Brachii	Ossification	0.000	2.034	1.358
21	Pron. Teres	Cortical Def.	0.013	0.510	0
22	Pron. Quad.	Ossification	0.029	0.210	0.173

Table 91. Results of the ANOVA Tests for differences among left and right sides between the age groups

NUMBER	SITE	TYPE AND SIDE (L/R)	p VALUE	AVG. YOUNG ADULT	AVG. MIDDLE ADULT	AVG. OLD ADULT
1	Subclav.	Robust. (L)	0.001	1.357	1.754	2.035
2	Subclav.	Robust (R)	0.026	1.655	1.946	2.137
3	Subclav.	Ossific. (R)	0.040	0.413	0.535	0.827
4	Trap. Lig.	Ossific. (L)	0.009	2.214	2.526	2.571
5	Trap. Lig.	Ossific. (R)	0.041	0.714	1.070	1.035
6	Conoid	Robust. (L)	0.021	2.357	2.614	2.750
7	Conoid	Robust (R)	0.000	2.379	2.701	2.931

Table 91—Continued

8	Conoid	Ossific. (L)	0.003	0.857	1.403	1.428
9	Conoid	Ossific. (R)	0.003	1.034	1.421	1.655
10	Trapez,	Robust (L)	0.001	2.100	2.406	2.517
11	Trapez.	Robust (R)	0.000	2.233	2.677	2.896
12	Trapez.	Ossific. (L)	0.007	0.566	0.949	1.068
13	Trapez.	Ossific. (R)	0.000	0.800	1.305	1.379
14	Pec. Min.	Robust (L)	0.010	2.0333	2.305	2.482
15	Pec. Min.	Robust (R)	0.000	2.1333	2.491	2.689
16	Pec. Min.	Ossific. (L)	0.001	0.4666	0.9322	1.034
17	Pec. Min.	Ossific. (R)	0.000	0.7333	1.135	1.344
18	Infraspin.	Ossific. (L)	0.015	0.400	0.775	0.785
19	Ter. Min.	Robust. (L)	0.031	1.900	2.241	2.142
20	Pec. Maj.	Robust. (L)	0.009	2.766	2.948	2.965
21	Pec. Maj.	Robust (R)	0.013	2.833	2.965	3.000
22	Pec. Maj.	Ossific. (L)	0.000	1.200	1.637	1.827
23	Pec. Maj.	Ossific. (R)	0.020	1.600	1.793	1.928
24	Lat. Dor.	Robust. (L)	0.001	1.766	2.155	2.344
25	Lat. Dor.	Robust (R)	0.001	1.733	2.155	2.357
26	Lat. Dor.	Ossific. (L)	0.005	0.233	0.586	0.724
27	Lat. Dor.	Ossific. (R)	0.016	0.366	0.724	0.857
28	Ter. Maj.	Robust (L)	0.045	2.366	2.586	2.724
29	Ter. Maj.	Robust (R)	0.000	2.033	2.465	2.750
30	Ter. Maj.	Ossific. (L)	0.000	0.700	1.189	1.413
31	Ter. Maj.	Ossific. (R)	0.009	0.766	1.224	1.321
32	Deltoid	Robust (L)	0.000	2.066	2.603	2.896
33	Deltoid	Robust (R)	0.000	2.466	2.775	2.896
34	Deltoid	Ossific. (L)	0.000	0.766	1.396	1.689
35	Deltoid	Ossific. (R)	0.000	1.000	1.431	1.758
36	Coraco.	Robust (L)	0.000	1.400	1.879	2.034
37	Coraco.	Robust (R)	0.000	1.500	1.982	1.862
38	Coraco.	Ossific. (L)	0.001	0.066	0.413	0.482
39	Com. Ext.	Robust (L)	0.030	2.500	0.551	2.862
40	Com. Ext.	Ossific. (L)	0.000	0.900	1.333	1.689
41	Com. Ext.	Ossific. (R)	0.000	1.100	1.561	1.827
42	Com. Flx.	Ossific. (L)	0.018	0.500	0.810	0.655
43	Ancon.	Robust. (R)	0.000	1.866	2.206	2.482
44	Ancon.	Ossific. (L)	0.001	0.366	0.706	0.931
45	Ancon.	Ossific. (R)	0.022	0.566	0.706	1.034
46	Tri. Brac.	Robust (L)	0.000	1.400	2.241	2.586
47	Tri. Brac.	Robust (R)	0.000	1.733	2.396	2.517
48	Tri. Brac.	Ossific. (L)	0.000	0.333	0.844	1.068
49	Tri. Brac.	Ossific. (R)	0.000	0.433	0.965	1.172

50	Bic. Brac.	Robust (L)	0.000	2.433	2.677	2.965
51	Bic. Brac.	Robust (R)	0.027	2.766	2.827	3.000
52	Bic. Brac.	Ossific. (L)	0.012	1.200	1.474	1.724
53	Bic. Brac.	Ossific. (R)	0.004	1.466	1.620	1.931
54	Pro. Teres	Robust (L)	0.000	2.000	2.372	2.620
55	Pro. Teres	Robust (R)	0.027	2.333	2.620	2.689
56	Pro. Teres	Ossific. (L)	0.000	0.533	0.983	1.275
57	Pro. Teres	Ossific. (R)	0.019	0.766	1.086	1.241
58	Supinator	Robust (L)	0.006	1.600	1.576	1.965
59	Supinator	Robust (R)	0.000	1.566	2.017	2.172
60	Supinator	Ossific. (L)	0.000	0.166	0.237	0.620
61	Supinator	Ossific. (R)	0.002	0.200	0.465	0.689
62	Pro. Quad	Robust (L)	0.038	1.133	1.413	1.551
63	Pro. Quad	Robust (R)	0.015	1.433	1.551	1.896
64	Pro. Quad	Ossific. (L)	0.031	0.066	0.172	0.344
65	Pro. Quad	Ossific. (R)	0.049	0.166	0.310	0.512

Table 92. Results of the ANOVA Tests for differences among combined left and right sides between age groups

NUMBER	SITE	TYPE	p VALUE	AVG. YOUNG ADULT	AVG. MIDDLE ADULT	AVG. OLD ADULT
1	Subclav.	Robusticity	6.00E -05	1.509	1.850	2.088
2	Subclav.	Ossification	0.010	0.333	0.522	0.701
3	Trap. Lig.	Robusticity	0.000	2.315	2.578	2.631
4	Trap. Lig.	Ossification	0.003	0.842	1.149	1.192
5	Conoid	Robusticity	0.000	2.368	2.657	2.842
6	Conoid	Ossification	2.00E -05	0.947	1.412	1.543
7	Trapezius	Robusticity	0.000	2.166	2.542	2.706
8	Trapezius	Ossification	0.000	0.683	1.127	1.224
9	Pec. Min.	Robusticity	0.000	2.083	2.398	2.586
10	Pec. Min.	Ossification	0.000	0.600	1.033	1.189
11	Supraspin.	Robusticity	0.007	2.146	2.577	2.719
12	Supraspin.	Cortical Def	0.016	1.016	0.692	0.719
13	Supraspin.	Ossification	0.004	0.966	1.206	1.385
14	Infraspin.	Cortical Def	0.045	0.183	0.051	0.087
15	Infraspin.	Ossification	0.033	0.600	0.827	0.894
16	Ter. Min.	Robusticity	0.021	2.033	2.275	2.285
17	Pec. Maj.	Robusticity	0.000	2.800	2.956	2.982
18	Pec. Maj.	Cortical Def	0.019	0.133	0.189	0.421
19	Pec. Maj.	Ossification	1.00E -05	1.400	1.715	1.877

Table 92—Continued

20	Lat. Dor.	Robusticity	0.000	1.750	2.155	2.350
21	Lat. Dor.	Cortical Def	0.046	0.016	0.025	0.122
22	Lat. Dor.	Ossification	0.000	0.300	0.655	0.789
23	Ter. Maj.	Robusticity	0.000	2.200	2.525	2.736
24	Ter. Maj.	Ossification	1.00E -05	0.733	1.206	1.368
25	Deltoid	Robusticity	0.000	2.266	2.689	2.896
26	Deltoid	Cortical Def	0.028	0.000	0.025	0.086
27	Deltoid	Ossification	0.000	0.883	1.413	1.724
28	Coraco.	Robusticity	0.000	1.450	1.931	1.948
29	Coraco.	Ossification	0.000	0.166	0.482	0.500
30	Com. Ext.	Robusticity	0.007	2.616	2.710	2.896
31	Com. Ext.	Ossification	0.000	1.000	1.447	1.758
32	Com. Flx.	Ossification	0.012	0.566	0.801	0.801
33	Brachialis	Ossification	0.003	1.350	1.465	1.689
34	Anconeus	Robusticity	0.000	1.800	2.172	2.448
35	Anconeus	Ossification	7.60E -05	0.466	0.706	0.982
36	Tri. Brac.	Robusticity	0.000	1.566	2.318	2.551
37	Tri. Brac.	Ossification	0.000	0.383	0.905	1.120
38	Bic. Brac.	Robusticity	2.10E -05	2.600	2.752	2.982
39	Bic. Brac.	Ossification	8.90E -05	1.333	1.547	1.827
40	Pro. Teres	Robusticity	0.000	2.166	2.495	2.655
41	Pro. Teres	Ossification	1.00E -05	0.650	1.034	1.258
42	Supinator	Robusticity	1.90E -05	1.583	1.794	2.068
43	Supinator	Ossification	0.000	0.183	0.350	0.655
44	Pro. Quad	Robusticity	0.001	1.283	1.482	1.724
45	Pro. Quad	Ossification	0.002	0.116	0.241	0.431

Table 93. Results of the Mann-Whitney U Test for differences among left and right sides between African Americans and Caucasians

NUMBER	SITE	TYPE AND SIDE (L/R)	p VALUE	AVG. AFRICAN AMERICAN	AVG. CAUCASIAN
1	Costoclav.	Robust (R)	0.052	2.444	2.685
2	Subclavius	Robust (R)	0.017	1.733	2.043
3	Subclavius	Ossific. (L)	0.012	0.279	0.571
4	Subclavius	Ossific. (R)	0.001	0.355	0.724
5	Supraspin.	Ossific. (R)	0.003	1.466	1.111
6	Infraspin.	Ossific. (R)	0.010	1.088	0.763
7	Com. Ext.	Cor Def. (R)	0.024	0.000	0.070
8	Brachialis	Cor Def. (L)	0.013	0.755	0.388

Table 93—Continued

9	Anconeus	Robust (L)	0.009	1.888	2.236
10	Anconeus	Robust (R)	0.001	1.933	2.347
11	Anconeus	Ossific. (L)	0.048	0.533	0.763
12	Anconeus	Ossific. (R)	0.053	0.600	0.847
13	Bic. Brac.	Robust (R)	0.029	2.755	2.916

Table 94. Results of the Mann-Whitney U Test for differences among combined left and right sides between African Americans and Caucasians

NUMBER	SITE	TYPE	p VALUE	AVG. AFRICAN AMERICAN	AVG. CAUCASIAN
1	Costcoclav.	Robusticity	0.049	2.431	2.608
2	Subclavius	Robusticity	0.005	1.659	1.928
3	Subclavius	Ossification	7.00E -05	0.318	0.647
4	Supraspin.	Ossification	0.011	1.333	1.097
5	Infraspin.	Cortical Def	0.039	0.044	0.125
6	Infraspin.	Ossification	0.001	0.955	0.678
7	Com. Ext.	Robusticity	0.045	2.644	2.788
8	Com. Ext.	Cortical Def	0.013	0.000	0.042
9	Com. Ext.	Ossification	0.054	1.478	1.478
10	Brachialis	Cortical Def	0.006	0.733	0.4513
11	Brachialis	Ossification	0.014	1.377	1.562
12	Anconeus	Robusticity	3.22E -05	1.911	2.291
13	Anconeus	Ossification	0.005	0.566	0.805
14	Bic. Brach.	Ossification	0.044	1.455	1.627
15	Pro. Quad.	Ossification	0.019	0.168	0.310