1997

The culture of enthesopathies: Differences in musculoskeletal stress markers between samples in a historic population

Michael R. Roberts
The University of Montana

Recommended Citation

Roberts, Michael R., "The culture of enthesopathies: Differences in musculoskeletal stress markers between samples in a historic population" (1997). *Graduate Student Theses, Dissertations, & Professional Papers*. 6395.
https://scholarworks.umt.edu/etd/6395

THE CULTURE OF ENTHESOPATHIES:

DIFFERENCES IN MUSCULOSKELETAL

STRESS MARKERS

BETWEEN SAMPLES

IN A HISTORIC POPULATION

by

Michael R. Roberts

B.S. University of Houston, 1994

presented in partial fulfillment of the requirements

for the degree of

Master of Arts

University of Montana

1997

Approved by:

Randall R.

Chairperson

Dean, Graduate School

12-8-97

Date

Roberts, Michael R., M.A., November 1997 Anthropology

The Culture of Enthesopathies: Differences in Musculoskeletal Stress Markers Between Samples in a Historic Population (71 pp.)

Director: Randall R. Skelton R.S.

Musculoskeletal stress markers have been used by Physical Anthropologists to determine the activity patterns of people represented by skeletal remains. For the purposes of this study, these markers consist of increased prominence of areas of muscle attachments to the bones as well as lesions of these attachments. They are used here to determine the overall levels of musculoskeletal stress experienced by particular groups of people and to determine whether certain populations experienced varying degrees of this stress. This study will give insight into how the social position of different groups can be reflected in their skeletal structure, a long-standing interest of physical anthropology.

To test the hypothesis that the skeletons of African Americans in the early twentieth century experienced a greater amount of musculoskeletal stress than those of European Americans, data were collected from the Todd Collection at the Cleveland Museum of Natural History. This extensive collection of human skeletal material from the first three decades of the 20th Century allows certain variables that might skew the data, such as socioeconomic position and cause of death to be controlled for. One hundred twenty skeletons, thirty individuals representing four distinct categories, African American males, African American females, European American males, and European American females, were randomly chosen from the population and examined for the presence or absence of musculoskeletal stress markers and their relative degrees of expression.

The data were then analyzed to test the null hypothesis of no difference between the four categories or subsamples. The hypothesis that the skeletons of African Americans from this time period were subjected to a higher degree of musculoskeletal stress than those of their European American contemporaries, was supported.

ACKNOWLEDGEMENTS

This project would not have been possible without the assistance and guidance of numerous people. First and foremost, I would like to thank my thesis director, Dr. Randy Skelton for his time and invaluable input into not only my thesis project, but my graduate career up to this point. No project can be completed without access to data, to which I am indebted to the Physical Anthropology Department of the Cleveland Museum of Natural History. Dr. Bruce Latimer and Lyman Jellema were extremely accommodating to me for the use of their facilities and their input and interest in my thesis topic. I would also like to thank the remaining members of my thesis committee, Dr. Tom Foor, Department of Anthropology, and Dr. David Emmons, Department of History, University of Montana. Finally, I would like to thank Dr. Janis Hutchinson, Department of Anthropology, University of Houston, for teaching me to see the world through the eyes of an anthropologist.

TABLE OF CONTENTS

References:

LIST OF TABLES

CHAPTER 1: INTRODUCTION

"the form of the bone being given, the bone elements place or displace themselves in the direction of the functional pressure and increase or decrease their mass to reflect the amount of functional pressure"

-Wolff's Law of Transformation (qtd. in Kennedy, 1989).

Bone is not static. This simple statement lies at the heart of physical anthropology and functional anatomy. The fact that bones are often all that are left of long dead organisms belies the fact that these seemingly durable, unchanging objects are actually very plastic organic structures, as Wolff's Law of Transformation suggests. "Bones are the framework of the vertebrate body and thus contain much information about man's adaptive mechanisms to his environment" (Bass, 1987:1). Analysis of the structures of bones from different primates can give clues into evolutionary relationships because they reflect similarities and differences in past adaptations (Aiello and Dean, 1990). Aside from being a loyal reflection of an animal's functional anatomy, any traumatic or pathological event sustained by living bone will illicit a response in the form of a shift in structure. A traumatic or pathological event is one that effects the bone either directly or indirectly , and can take the form of a sudden, violent event or a series of more subtle events that work over time to modify a bone's structure (Merbs, 1983).

When a bone is fractured, the healing response of the body attempts to correct for the damage in predictable ways. This involves a complex combination of bone destruction and regeneration which eventually leaves the area of insult changed. The change is such that the bone often becomes more structurally sound on its way to complete healing (Ortner and Putschar, 1985:63). Osteoblastic and osteoclastic activity is responsible for this morphological restructuring, which is a continuous process in the skeletal system even in the absence of insult. Callus formation at a fracture site is an especially dramatic illustration of this phenomenon, but more often, the effects manifest themselves in more subtle ways that can only be recognized by an osteologist or radiologist (White, 1991:25). Hypertrophic bone formation and/or the reverse, loss of bone, at a particular site signals that some abnormal event has caused the body's repair system to adjust its structure, however minutely. This is evident in cases of osteoarthritis, or at those sites of the skeleton that are subjected to stress, strain, or shear, whether internal or external.

> These responses to the push and pull of force are involved in the formation of markers of occupational stress, becoming manifested macro-scopically if an area of bone is affected by a force or load that exceeds the bone's elastic limit so that the area of stress does not return to its original form. Pressure tolerance varies for different bones and for portions of the same bone, but excessive stress and strain can lead to bone destruction and necrosis. If the limits of elasticity are not exceeded, new bone formation is stimulated, a critical factor in healing (Kennedy, 1989:135).

Most activities that humans engage in over their lifetimes do not entail abnormal mechanical loading resulting in excessive stress, strain or shear. One of two conditions must be met for this distinction, as noted by Merbs (1983:1): " These generally are activities which place an abnormally large amount of stress upon the organism for a short period of time, or a normal amount of stress for an abnormally long period of time." These events will most likely leave their marks on the malleable structure of the skeleton. The points on the skeleton at which long duration defects will most likely be seen are at those areas of the skeletal structure to which the most stress is applied. These points include the areas of muscle origin and insertion. Bone defects of the muscle attachments are classified as enthesopathic lesions, and are the focus of this study. "Bony lesions at the sites of muscles or tendon insertions on the skeleton, or enthesopathies, are well known in sporting or occupational medicine to be associated with prolonged hyperactivity of the relevant muscles" (Dutour, 1986:221). As the muscles work to move the frame of the body in the execution of specific tasks, they are pulling at their insertion points, creating tension that, if given the conditions above, will cause the bone to react and change morphologically over time. "Tension increases osteogenesis and the mass of bone beneath the muscle, the result being an elevated area of insertion formed by Sharpey's fibers, which extend from the connective tissue mass of muscle directly into the cortical bone" (Kennedy, 1989:134).

These increased areas of muscle insertion can give clues into the general activity patterns of the people represented by a skeletal population. They can be a measure of the relative amounts of musculoskeletal stress a population was subjected to in reference to other populations. This fact has been clearly illustrated by a number of authors (Angel, 1975, 1976; Angel *et al*, 1987; Bridges, 1991; Kelley and Angel, 1987; Larsen and Ruff, 1991,1994; Rathbun, 1987; Ruff, 1992). Changes in activity patterns by both prehistoric and historic populations have given researchers intriguing insights into how human culture can affect human skeletal biology, a major interest of physical anthropology.

Major changes over time in activity patterns can be shown by comparing populations from the same geographic area at different periods. This is usually dictated by a major cultural shift, such as the introduction of agriculture to a previously nonagricultural society. This drastic change in subsistence activity can be reflected by a change in muscular activity as different tasks are being performed by different muscle groups not previously under stress. This was demonstrated by Bridges' (1991) comparisons of preagricultural and postagricultural Native Americans from the Southeast United States. Her research shows that this changed their activities in such a way that certain parts of the body were under more stress than others as a result of shifting subsistence patterns.

Another application of these techniques is to distinguish differences in activity patterns between contemporaneous subpopulations. Knowing which subpopulations experienced significantly more musculoskeletal stress can tell about the social structure of the entire population represented by these skeletons. One of the most dramatic examples of this are the studies done by Angel and his associates on African American slave populations in the 19th Century United States (Angel, *et al*, 1987; Kelly and Angel, 1987). They demonstrated that the slave populations they studied were indeed experiencing more mechanical stress than their "Free Black" contemporaries. However, they did not test the hypothesis that their level of stress was significantly different from that of other contemporary populations, especially the European American population.

This project is an attempt to fill this gap in our knowledge, albeit using a decidedly different sample population, as well as different methodology. This project focuses on the differences in enthesopathic lesions between African Americans and European Americans from the early twentieth century, some fifty years after Reconstruction. These differences will reflect the relative amounts of musculoskeletal stress experienced by these groups, which in turn will reflect the cultural atmosphere of race relations at that particular place and time. The hypothesis being tested is that the African American population from this time period experienced significantly higher levels of musculoskeletal stress than their European American contemporaries due to their limited access to less strenuous forms of labor. The differences in skeletal structure will then be a reflection of social conditions at this moment in American history.

In this way, this project has relevance to the field of anthropology as a whole. The benefits to physical anthropology are the most apparent, but archaeology and cultural anthropology will gain as well. Physical anthropologists are often involved with archaeological investigations . Their role is to analyze skeletal material from a particular site in order to add to the overall picture of that past population. Understanding the biological makeup of a population, such as the demographic aspects of disease, death rates, and overall health, can contribute greatly to an archaeological investigation. A study such as this one, which offers insight into activity patterns, would be very informative in this context. Many researchers have asked these questions of archaeological material (Angel, 1975, 1976; Angel et al, 1987; Bridges, 1991; Kelley and Angel, 1987; Larsen and Ruff, 1991,1994; Rathbun, 1987; Ruff, 1992; Ubelaker, 1979) using methods that focused more on osteoarthritis and cross-sectional geometry. However, using enthesopathies can possibly provide additional insight to help complete the picture. In contrast to methods that focus on osteoarthritis and cross-sectional geometry, knowing which muscles or muscle groups were used most frequently by a past population can "put into motion" the dry, skeletonized remains more clearly.

Cultural anthropologists will also find interest in this study because the subject matter deals with culture change and political economy in the past. When compared to similar studies on spatially and temporally distinct populations (Angel, 1975, 1976; Angel et al, 1987; Bridges, 1991; Kelley and

Angel, 1987; Larsen and Ruff, 1991,1994; Rathbun, 1987; Ruff, 1992), this project can give insight into what social conditions contribute to the differing phenomena indicated by the skeletal material. It would be of great interest to know, for example, if the African Americans of the late 19th Century were more or less stressed in relation to their European counterparts than those of the early 20th Century. This information would then be an indication of the presence or absence of a cultural change in regards to this particular aspect of "race relations". Understanding more precisely the social conditions of past peoples adds tremendously to the body of knowledge that cultural anthropologists draw upon to form and test their hypotheses about modern cultures.

This work may also contribute to forensic anthropology as an additional technique in aiding in cases of personal identification. Roberts (1997) analyzed ten randomly selected skeletons from the collections at the Physical Anthropology Laboratory of the University of Montana. This research showed that each individual had at least one musculoskeletal stress marker (including both enthesopathies and degenerative changes) that distinguished him or her from every other person in that sample. As research into this area becomes more refined, the ability to distinguish particular activities that an individual engaged in during his or her lifetime will be more readily discernible. Knowing whether certain markers on a set of skeletal remains indicates that they are consistent with those of a lumberjack or a ballerina will greatly reduce the search parameters of investigators attempting to solve a particular case. It must be emphasized, however, that this ability awaits further research and testing.

The method used in this study is distinct in that musculoskeletal stress is measured using the muscle attachments themselves. Many studies of this topic to date have analyzed overall stress level by measuring the amount of osteoarthritis. This approach is controversial because osteoarthritis has no proven single etiology, meaning that it may be the result of a combination of factors including genetics, disease, ontogeny and diet as well as mechanical stress. Roberts (1995) suggests that studies correlating osteoarthritis with activity patterns should be conducted on young skeletons to reduce this bias. In spite of these limitations, there has been some compelling work with osteoarthritis, especially that of Merbs (1983). He was successful in demonstrating activity patterns based mainly on osteoarthritis because he used a population in which he was able to control for genetics, diet, and other factors.

Other authors have not been so fortunate. Assuming that the observed pattern of osteoarthritis must be related to mechanical stress, Rose and Santeford (1985:143) attributed the arthritic changes in their Cedar Grove Arkansas skeletons to "hard physical lifestyle with severe back stress". While this is most likely true, the data are less convincing because it is fairly obvious that age was a critical factor in predicting who would have arthritic changes of the bones in the spinal column. In fact, the amount of vertebral osteoarthritis is used in forensic anthropology to estimate the age of an individual at death (Stewart, 1958). Their data may indeed indicate mechanical stress, but the authors were not able to adequately establish a control population. This problem was addressed by Ortner (1968) in his work comparing degenerative changes to the elbow between "Alaskan Eskimo" skeletal material and that of Native Americans from Chicama, Peru. He acknowledged that, "Whether this difference is genetically determined or results from a culturally patterned adaptation to a society's natural environment must await studies which control for these two variables" (145). This goal is often difficult to attain when dealing with human remains, especially from an archaeological context.

Control can be established by analyzing two or more contemporaneous populations or analyzing the same population through time. Both of these approaches have been used by researchers in the past. Larsen and Ruff (1994) showed that precontact and postcontact populations of native Guale skeletons display differing amounts of osteoarthritis which can be explained by the changing labor environment of Spanish colonization. Similarly, Bridges (1990, 1991) demonstrated that subsistence strategy changes in northwestern Alabama resulted in concomitant skeletal changes including differences in anatomical elements affected by osteoarthritis.

Parrington and Roberts (1990) compared the rates of osteoarthritis of urban Philadelphia African American skeletons to those studied by Rose and Santeford mentioned above, concluding that "black urban males in Philadelphia engaged in more strenuous work than their slightly later rural counterparts at Cedar Grove" (160). Although the control here is less rigorous than some researchers might desire, the authors' conclusions are well substantiated. However, the fact remains that osteoarthritis is simply not a predictable indicator of occupational, mechanical or musculoskeletal stress and should not be treated as such unless there is clinical evidence to back it up (Mintz and Fraga, 1973) or strict controls rule out other possibilities.

Roberts (1995:110) suggests combining other skeletal evidence of stress, including "enthesophytes and changes in the size and robusticity of bones" with osteoarthritis to arrive at more valid conclusions. For example, Bridges (1990,1991) and Larsen and Ruff (1994) not only established chronological control in their works, but combined osteoarthritis data with data on changes in cross-sectional geometry of the long bones. Known in engineering as Beam Theory, the cross-sectional geometry of a hollow beam structure directly correlates to that structure's strength or rigidity (Larsen and Ruff, 1994:23). These studies were able to demonstrate that the geometric properties of the long bones change to reflect a more stressful lifestyle that compliments the degenerative joint changes, showing that as the load on the hollow beam structures of the human skeleton increases, so does the level of osteoarthritis.

Other work in the field combines osteoarthritis data with that of enthesopathies. Kelley and Angel (1987) described some of the pathologies in their sample of slaves from the Catoctin Furnace site in Maryland (1790-ca. 1820) as being related to musculoskeletal stress. They looked at enthesopathies of the deltoid, pectoral, teres and supinator muscles. "In combination with shoulder and vertebral breakdown [osteoarthritis], including separated L5 arch and schmorl herniation, the picture of hard, heavy labor at a relatively young age is substantiated" (207). Owsley, *et al* (1987) showed that bone remodeling and build up of muscle attachment sites can be correlated with the heavy labor of their sample of slave skeletons from New Orleans. Osteoarthritic changes were also evident, further substantiating this conclusion. "Changes in the joint surfaces and spinal columns of selected individuals compliment the described pattern of hypertrophic bone formation and imply a background of physiological wear and tear" (193). Other studies (Angel *et al*, 1987; Rathbun, 1987) compared their respective populations to the Catoctin Furnace skeletons mentioned above. In both cases, the authors used arthritic changes in conjunction with muscle attachments to demonstrate the relative degrees of musculoskeletal stress experienced by their subjects.

The present study focuses exclusively on enthesopathies (although the clavicular syndesmoses are included as well) as they are more reliable as indicators of musculoskeletal stress than osteoarthritis, and less subject to varied etiologies. Diffuse Idiopathic Skeletal Hyperostosis (DISH) can lead to many of the same morphological changes, albeit on a scale that readily distinguishes that pathology with the more selective, random nature of enthesopathies. The comparisons made in this work exclude osteoarthritis simply because it is too unreliable, as noted above and as concisely summarized by Stirland (1988):

> The traditional clinical postulate has been that in osteoarthritis, particularly of the spine, an occupational component is present. In the public as well as the specialist mind, pathology of joints has often been associated with usage. This is reflected in the popular terminology often associated with overuse syndromes, such as "tennis elbow." However, the modern clinical view of the role of activity in the development of osteoarthritis is, to say the least, ambivalent (41).

Wolff's Law of Transformation provides a theoretical framework with which to analyze the observed skeletal changes, a foundation that is not present when using osteoarthritis to investigate the same patterns. Problems do arise, however when researchers attempt to correlate a specific bone defect or group of defects with a specific activity. These studies attempt to take the available evidence further than is currently possible (Stirland, 1988; Dutour, 1986, Kennedy, 1983). There is not yet enough clinical evidence to correlate a pathology with a specific activity pattern, rather, as in this study, conclusions must be more general, couched in terms such as "brachial activity" or kinesiological descriptions such as "angular displacement of the forearm as a result of medial rotation of the arm at the shoulder, shoulder and arm hyperextension, and abrupt shifts from forearm supination to pronation" (Kennedy, 1983:873), which is the biomechanical description of throwing a baseball. The trap that many authors seem unable to avoid is that of recognizing a contemporary example of this activity and extrapolating that onto skeletal material. Their interpretations may in fact be correct, but there is little evidence to date to validate them.

To test the hypothesis that different segments of the population experienced differing levels of musculoskeletal stress, a sample from a suitable skeletal population has to be studied. This material should be such that control can be established for the variables that would most greatly influence the data in a negative manner. The most important variables to control for, given the type of material being analyzed, are age, pathology, trauma, and socioeconomic position (affecting diet and overall health).

Age is a factor that can greatly influence the data because of the dynamic activities of skeletal maturation and ontogeny. The structure of a maturing skeleton is more likely to be influenced on a morphological level by internal and external forces. One example of this is Osgood-Schlatter disease. "Osgood Schlatter Disease, affecting adolescents, is caused by repeated usage of the knee extensors, resulting in a tearing or avulsion at the epiphysis of the tibial tuberosity, the point for attachment of the patellar tendon" (Luttgens, *et al*, 1992:238). What might be considered normal wear and tear in an adult skeleton can more profoundly affect a skeleton in its maturational stage, changing its morphology in ways that could be construed as pathological.

Similarly, as the skeleton ages, it begins to break down in such a way that it is less able to efficiently repair itself after an insult, resulting in persistence of defects that might be repaired in a younger individual. The most pertinent example of this is the arthritic changes of the vertebral column that are concomitant with advancing age. In the case of enthesopathies, the synergistic effects of a slower healing response and a lessened ability to engage in rigorous activity would decrease the visible signs of musculoskeletal stress. Therefore, the age group that would give the most unbiased results would be that of "middle-aged adults"; ages 26 to 40 in the present study.

Skeletal defects resulting from pathology and trauma would also affect those of musculoskeletal origin in a number of ways. First of all, diseases such as syphilis leave severe skeletal changes in their wakes (Steele and Bramblett, 1988:16). One of the more commonly found pathologies , especially in archaeological material, is secondary periostitis. In fact, even in the Todd Collection, this condition is present in almost 80% of the specimens (Latimer, 1997, pers. comm.). This condition manifests itself as an inflammation of the periosteum that results in a localized thickening of the bone that could be mistaken for, or mask, an enthesopathy. "Generally, inflammatory periosteal bone deposited over a long period of time tends to be unevenly distributed, not involving the entire bone. The surface tends to be irregular and the thickness often variable. The marked, uneven hypervascularity visible on dry bone ... is often striking" (Ortner and Putschar, 1981:129-130). This description could also apply to lesions of muscular attachments, except that they are more localized. A periosteal infection overlying a musculoskeletal stress marker could thereby "hide" that marker from the view of the researcher.

In the same way, a previous trauma to the bone would cause bone remodeling that could influence the visibility of a muscle marking, or, as in the case of traumatic myositis ossificans, create a lesion on the bone that might be construed as stress related. As described by Ortner and Putschar (1985:69), in myositis ossificans, an injury to the bone and overlying muscle causes a hematoma that involves both tissues. This hematoma causes not only the bone, but the muscle as well to become ossified, resulting in a bony excrescence that may be confused with or mask a muscle marking, or limit the function of the affected muscle(s). A researcher investigating musculoskeletal stress markers must therefore be able to distinguish between changes related to activity and those of traumatic origin.

Along with the morphological aspects of pathology and trauma, behavioral affects will bias the results. For example, if someone is afflicted by a severely debilitating disease or traumatic injury, it is unlikely that they will engage in their normal patterns of activity. Inactivity over long periods of time will result in the deterioration of muscles and their corresponding attachments on the bone. Also, if someone is crippled in such a way that it affects their normal usage of a limb, compensation usage of the other limb may cause the corresponding muscles to be more stressed than would be the case if there were no injury. A severe example of this would be the amputation of an arm. This would cause the remaining arm to become more muscular than it would be under normal circumstances simply because it would be used much more often. Paralysis would have the opposite effect, causing atrophy of the pertinent muscles, thereby reducing the areas on the bone normally needed to anchor them. Therefore, it is important in this study to limit the sample to those individuals unlikely to have been debilitated by disease or injury.

Socioeconomic position also needs to be controlled for because of its effects on the overall dietary health of an individual. The skeleton of a person who could not afford adequate nutrition would show morphological characteristics that would reflect this fact (Steele and Bramblett, 1988:17). The healing response of the body may be adversely affected if the person were under dietary stress. Also, socioeconomic position would affect behavior because the daily activities engaged in by people in lower economic strata are likely to be more rigorous due to more labor intensive occupations. To establish control for this variable, the chosen sample should be drawn from people of the same relative socioeconomic position. The variable of musculoskeletal stress, then, is not a reflection of "blue collar" versus "white collar" workers, but of social positions of the relevant sample.

It is hoped that this project will serve as the impetus for future research into the potential applications of enthesopathies using other populations or techniques. This project will also serve as a test of the method of using enthesopathic lesions in this way, in that the nature of the Todd Collection establishes strict controls for variables that may adversely effect other samples. This work will provide a new view into the social and physical aspects of American culture at the beginning of the 20th century, and will serve as a reference point for establishing these relationships within populations with less built-in control. If the skeletal and historical evidence agree, future researchers will be able to use these techniques to clarify aspects of their respective populations' cultures, the ultimate goal of many anthropologists.

CHAPTER 2: MATERIALS AND METHODS

All factors that can influence the data can readily be controlled for using the Hamman-Todd Osteological Collection housed at the Cleveland Museum of Natural History. This collection includes over three thousand human skeletons, along with detailed demographic data that is the direct result of the unique collection procedure. The bulk of the collection was amassed by Dr. T. Wingate Todd, between 1912 and 1938 (Jellema, 1997, pers. comm.). The skeletons were derived from cadavers that were either willed to the medical school at Cleveland's Case Western Reserve University, or from unclaimed bodies from the morgues of surrounding Cuyahoga County. As a result, extremely detailed records of age, sex, population affinity ("race"), height, weight, cause of death and pertinent medical history, to name just a few, accompany each skeleton. Therefore, controlling for such factors as age and disease is simply a matter of studying the records of the individual specimens.

The selected age range of 26 to 40 years yielded 804 skeletons from which 120 were randomly chosen for the test sample, 30 each from four subpopulations: African American males, African American females, European American males, European American females. Control for diseases that would have incapacitated an individual, such as leprosy or syphilis, was established by examining the cause of death listed for each specimen. Past trauma was controlled for by examining the skeletons on a case by case basis, as this information was usually not present in the medical records, unless the trauma was still affecting the person at the time of his or her death. These individuals were then excluded from further analysis.

The variable of socioeconomic position is controlled for in this collection because of the nature of the segment of the population from which the material was drawn. The people that ended up in the collection were, for the most part, those that could not afford the expense of a funeral. Cobb (1932) states that "[i]n occupational level the cadaver population exhibits considerable homogeneity. There is no essential difference between Negroes and Whites or any of the various nationalities composing the Whites, in the occupations officially listed of the 858 individuals in our series" (83). The data on occupations relates to the relative socioeconomic position of each subsample as well as the types of activities engaged in, a point that will be reiterated later. A total of 56% of the occupations of individuals cited by Cobb are general laborers, composed of 60% of the total African American population and 53.5% of the total European American population. Therefore, the bias of socioeconomic status is well controlled for in that all individuals are representative of the "working class" strata.

The combination of the rigid collection procedure of the Todd Collection and the selection procedure for data collection for this project provides the necessary control that leaves musculoskeletal stress as the critical variable for analysis. In this manner, differences in frequency and expression of enthesopathies will be a reflection of the social climate of early twentieth century America. The differences in the lifeways of people from this particular place and time will be reflected in their skeletal structure as a result of the differences in the overall amounts of musculoskeletal stress experienced during those persons' lifetimes. The different subsamples, African American males, European American males, African American females, and European American females will reflect different amounts of stress based on differential access to more or less physically demanding (menial) lifestyles.

The muscle markings chosen for this analysis are those that correspond to some of the more predominantly used postcranial muscles and/or muscle groups. Table 1 defines the muscle attachments analyzed as well as their kinesiological importance to the human body as defined by Luttgens, *et al* (1992). These muscles have fairly prominent attachments that can be readily evaluated in terms of musculoskeletal stress. As these muscles perform their specified functions, they are inducing stress to the corresponding bones to which they are attached. The kinesiology of the interactions between muscles and the bones can then be used to determine which motions were being made to produce the corresponding enthesopathic changes observed in the skeletal material. The activity patterns of the subjects can then be narrowed even further to give a clearer picture of the behavior behind the morphological

Table 1: Enthesopathies Analyzed

Bone	Muscle	Function
Humerus ‡	1. extensor carpi radialis longus 3. deltoid 4. pectoralis major 5. pronator teres	-radial flexion of wrist -abduction, inward rotation, all forward humeral movement -flexion, horizontal flexion, inward rotation of humerus -pronation of forearm
Radius	1. pronator teres 2. brachioradialis 3. biceps brachii	-pronation of forearm -flexion of the elbow -flexion and supination of forearm
Ulna	1. brachialis 2. supinator 3. anconeus 4. pronator quadratus	-flexion of the elbow -supination of the forearm -extension of the forearm -pronation of the forearm
Clavicle ‡	2. deltoid 3. costoclavicular ligament* 4. conoid ligament*	-same as above
Scapula ‡	2. deltoid 3. trapezius 4. triceps brachii	-same as above -elevation, upward rotation, adduction, depression -adduction, extension, hyperextension of humerus

Table 1 (continued)

Femur	1. linea aspera† 2. gluteus maximus 3. gastrocnemius 4. adductor magnus	 -extension of the hip -plantar flexion of the foot, maintains knee extension -adduction of the hip
Tibia	1. popliteus	-inward rotation, flexion of knee

* = ligamentous attachment, not muscle attachment
† = attachment site for gluteus maximus, adductor magnus, a. longus, a. brevis
‡ = Humerus 2, Clavicle 1 & Scapula 1 eliminated during data collection

phenomena.

A system of quantifying the degree of stress to each particular area is used. Angel, *et al*, (1987) note that "[m]uscle crests are nonmetric observations" and are treated as such in this study. Their method was to assign a rating system based on + marks, with more +'s signifying more stress. The method in this study is similar, except that a numerical value is assigned. Each musculoskeletal stress marker is assessed and assigned a numerical code representing the degree of stress at that point. A score of 0 indicates normal development of the attachment area, 1 indicates slight development, and 2 indicates marked development. The scores from the left and right sides are then added together. Therefore, the lowest possible score per marker, per individual is 0, while the highest possible score per marker, per individual is 4. For example, if the deltoid crest of the left humerus of an individual shows slight development (a score of 1) and the right shows marked development (a score of 2), the total score for the humeral deltoid attachment for that individual is 3.

The general differences between the subsamples are illustrated by calculating the total stress score per individual, then the average stress score per individual in that particular subsample. Total stress scores are calculated by adding the scores for each marker for each individual. Average stress score is calculated by dividing the total stress scores for all individuals in a subsample by the subsample size of thirty. The median, mode, range standard deviation and variance are also calculated to complete the general data set. While these data demonstrate overall trends in the sample, more sophisticated tests are necessary in order to ascertain which musculoskeletal elements are most significantly stressed between the subsamples.

These data were entered into a spreadsheet and analyzed statistically in order to test the null hypothesis of no difference between the subsamples, with a 95% confidence level. Analysis was accomplished using the SPSS computer program. Due to the ordinal nature of the data, the Mann-Whitney U/Wilcoxon Rank Sum W test, a nonparametric method, was used to test for significant differences between musculoskeletal stress scores. Each stress marker is a score that represents relative values that are ranked on a scale between 0 and 4. This test is appropriate because it compares these relative rankings to each other. Individual stress markers of African American males and females are compared to those of European American males and females, respectively. This will reveal that certain elements are relatively more or less significantly stressed between the subsamples.

Also of value are the Chi Square test and Discriminant analysis, which will further demonstrate which stress markers are contributing the most to any statistically significant differences between the total and average scores. The Chi Square test is used to analyze differences between the observed and expected scores, per variable, per individual. This method interprets which elements are significant based on their divergence from a random distribution. Discriminant analysis interprets stress scores as interval scale values, but analyzes which skeletal elements are contributing most to the overall variation between the selected subsamples. Therefore, this method indicates the significant differences between the subsamples as a whole, rather than comparing particular stress markers in isolation. All of these methods will give a slightly different view of the nature of the skeletal variations between the subsamples. The end result will be a more complete picture of the overall phenomenon of differences in activity patterns. This will in turn reflect cultural differences between these groups.

CHAPTER 3: RESULTS

The results of the statistical analysis of the data suggest some general trends. These data are summarized in Table 2. The raw data from which these analyses were drawn are presented in Appendix I. The mean score per individual for each group gives hints as to which groups were experiencing the most musculoskeletal stress. The African American Male mean is 15.1, the European American Male mean is 10.67, the African American Female mean is 7.567, and the European American Female mean is 5.724. This shows that the average African American male exhibits more stress markers than the average European American male. Also, in spite of a similar range, the standard deviation for African Americans males is less, showing that more of those

TABLE 2: General Population Statistics Based on Stress Marker Scores

	African American Males	European American Males	African American Females	European American Females
Mean	15.1	10.67	7.567	5.724
Median	14	8	4	5.5
Mode	14	4	0	4
Range	1-41	0-41	0-24	0-16
St. Deviation	8.539	9.987	7.482	4.389
Variance	72.92	99.75	55.98	19.26
Most Stressed Elements	Humerus 3 Femur 1 Femur 3	Femur 2 Clavicle 2 Humerus 3	Tibia 1 Humerus 3 Clavicle 3	Femur 2 Clavicle 4 Clavicle 3

scores cluster around the relatively high mean. For females, African Americans have a mean of 7.567, while European Americans have a mean of 5.724. The range for European American females is smaller than that of African Americans, with the standard deviation for the former showing a cluster around the relatively low mean. A t-test reveals that the male differences are significant at a 90% confidence level, while the female differences are not significant based on these general data.

The "Most Stressed Elements" section of Table 2 indicates the three elements in each subsample with the highest average stress marker scores. Certain skeletal elements turned out not to be useful for this analysis because they expressed enthesopathies rarely. Humerus 2 is only scored as stressed in 3 of the 120 (2.5%) cases, while Humerus 5 is only scored as stressed 6 (5.0%) times, all for African American Females.

While these data alone are informative, more sophisticated analysis reveals the exact nature of the differences between the samples. In all, 14 musculoskeletal stress markers are found to contribute significantly to the differences between the samples. Table 3 summarizes the statistical tests and their results with respect to significant differences. Appendix II contains the results of the statistical analyses for the most significant musculoskeletal stress markers.

The Mann-Whitney U/Wilcoxon Rank Sum W test reveals that there are certain skeletal elements that display significant differences in the amounts of musculoskeletal stress involved ($p<.05$). All of these values are higher for African Americans than for European Americans for both sexes. They are, Ulna 1, Humerus 4, and Femur 3 for males; Radius 2 and Ulna 4 for females, ranked in order of most significant difference. This test demonstrates that there

Table 3: Statistical Tests and Results ($p<.05$)

Marker	Mann/Whitney/ Wilcoxon	Chi Square	Discriminant Analysis
Males by PopAff			
-Ulna 1	.0155	.02938	heavily loaded
-Humerus 4	.0392	not significant	not loaded
-Femur 3	.0441	not significant	not loaded
-Femur 1	not significant	.03709	not loaded
-Femur 2	not significant	not significant	heavily loaded
-Humerus 1	not significant	not significant	heavily loaded
Females by PopAff			
-Radius 2	.0106	.03567	heavily loaded
-Ulna 4	.0402	not significant	not loaded
-Clavicle 4	not significant	.03352*	not loaded
-Tibia 1	not significant	not significant	heavily loaded
AAmericans by Sex			
-Humerus 4	N/A	.00699	heavily loaded
-Femur 4	N/A	.01676	heavily loaded
-Humerus 5	N/A	not significant	heavily loaded
EAmericans by Sex			
-Femur 4	N/A	.00697	heavily loaded
-Ulna 3	N/A	.04495	not loaded
-Clavicle 2	N/A	.04819	heavily loaded

* = stress value greater for European Americans; greater for African Americans in all other cases; stress greater for males in all cases.

are differences between the subpopulations that are based most significantly on these particular musculoskeletal stress markers.

The Chi-Square test uses the same data, arriving at similar conclusions for some markers and different conclusions for others. While both the Mann-Whitney/Wilcoxon and Chi-Square tests agree that the amount of stress to Femur 3, Ulna 1, and Radius 2 varies significantly between samples, the latter does not find differences in Humerus 4 or Ulna 4. It does reveal differences in Femur 1 and Clavicle 2, however. The Chi Square test is also used to distinguish differences on the basis of sex, concluding that the most significant musculoskeletal stress markers are Femur 4 and Humerus 4 for African Americans and Clavicle 2, Femur 4, and Ulna 3 for European Americans.

Discriminant analysis also detects significant differences between elements, choosing those elements that are most useful in classifying an individual into a certain subsample. The first tests attempt to classify males and females into their respective population affinities. The most useful (significantly different) elements for classifying males are Ulna 1, Femur 2, and Humerus 1, classifying African Americans correctly 53.3% of the time, while classifying European Americans correctly 90% of the time. The most useful elements for classifying females are Radius 2 and Tibia 1, classifying African Americans correctly 50% of the time, and European Americans correctly 86.7% of the time. This test is also used to determine whether there are significant differences related to sex. The most useful elements for classifying African Americans are Humerus 4, Femur 4, and Humerus 5, classifying males correctly 66.7% of the time and females 93.3% of the time. The most useful elements for classifying European Americans are Clavicle 2 and Femur 4, classifying males correctly 56.7% of the time and females 80% of the time.

Despite the differences in data treatment, all tests agree that Ulna 1 was significant for distinguishing between males while Radius 2 was significant for females. All of these methods are appropriate for the current research, but it is recognized that some statistical tests are more relevant than others. The fact that there are some elements that are significant in all the tests reinforces the critical nature of those elements in contributing to the differences between the subsamples.

CHAPTER 4: DISCUSSION

The results demonstrate that there are indeed significant differences between the subsamples and are restricted to certain elements of the musculoskeletal structure. Therefore, the null hypothesis of no difference is rejected. There are significant differences between African American males and European American males in that those elements selected are more stressed in the former. The same holds true for females, except that one marker is shown to be more stressed in European Americans. Sexual differences are also significant, with the results demonstrating that males were experiencing significantly more musculoskeletal stress than their female contemporaries. These results can be interpreted in a number of ways, but the integral question of what factors are contributing to these differences needs to be explored.

The differences between males and females can be most easily interpreted, due to the facts of sexual dimorphism and social division of labor. For this reason, no comparisons were made between African American females and European American males nor between European American females and African American males. Any differences in these analyses would foremost be due to sexual differences and would not contribute to this study. As for the differences between the samples of distinct population affinities, there are four possible interpretations of the data that are not accounted for by the imposition of the controls mentioned above. These are researcher bias, individuality, genetics, and social conditions.

Researcher bias can influence data in two important ways. First, as is the case in most scientific pursuits, the researcher is operating with a working hypothesis that he or she is attempting to reject or accept. This hypothesis is often based on an educated guess, so there are preconceptions existing that could negatively influence the data. The working hypothesis in this study was that African Americans experienced more musculoskeletal stress as a population than did European Americans. This problem is avoided in this study due to the fact that the data were collected from each individual without prior knowledge of his or her population affinity or sex. Second, the researcher may be inconsistent in making his or her observations. The second problem is difficult to assess because there are no standards for collecting this type of data except for the precedent of similar research as listed above. The data are highly subjective, but scoring them with respect to the relative size of the entire skeletal element serves to reduce this particular bias. To further refine this method, the relative amounts of stress on the musculoskeletal system for the entire 20th Century American population would have to be known before hand, but no study to date has been able to accomplish this.

Individuality can effect the data because of the fact that idiosyncratic behaviors cannot be controlled for, nor can the life histories of the individuals.

Activity patterns that are independent of labor patterns can nonetheless be strenuous. Recreational activities such as sports can put serious demands on the skeleton that can illicit some of the same types of responses as those in this study. In order for this to occur, the activity would have to meet Merb's criteria of either sudden and violent or enduring and repetitive. Unless someone is a professional athlete or can afford the costs of extensive recreation, the skeletal involvement should be minimal. The nature of the population represented by the Todd Collection does not support either of these assumptions. These were working class people who could not afford a proper burial, much less the luxury of participating in a habitual recreational activity.

Another aspect of individuality is a particular person's life history. The large majority of African Americans that settled in Cleveland during this time period were recent migrants from both the rural and urban South (Lynch, 1973). The individual medical histories of the cadavers seldom include detailed life histories that would give an idea into that person's activities prior to arriving in Ohio. More often, that person's most recent job was all that was listed. It is not known, for example, if someone came from a life of hard labor prior to migrating North, such as being a slave or tenant farmer. This concern is minimized, because the selected age range of 26 to 40 years precludes former slaves from being included in the sample. In 1910, a 40 year old would have been born five years after the demise of that institution. Also, because of the nature of bone remodeling, if the pertinent muscles fell into disuse after migration, they would, according to Wolff's Law, begin to normalize, thereby diminishing the effects of past labor patterns. This is an important factor to consider, but it is assumed that the relatively large sample size and strict controls serve to minimize any background "noise".

Similarly, the possible genetic component of the observed differences cannot be overlooked. It is well known that morphological differences exist between different populations. The terms "race" and "population affinity" reflect the social notion of distinct categories of humanity based on physical characteristics. With this in mind, it may be feasible that there are differences between populations with respect to how their skeletons react to stress. In other words, it must be decided whether or not particular populations have experienced selection for allelles that affect responses in either kind or scale to musculoskeletal stress. It seems unlikely that this is the case, and any speculation on this subject is beyond the scope of this project. Inquiry into whether or not there are genes that determine the efficiency of the healing response of the body awaits future research. Given the heterogeneity of both the European Americans and African Americans in the United States in general, and in the Todd Collection in particular, it is unlikely that genetic factors have any substantial influence on the data.

The final possible interpretation is that of social structure and its influences on the activity patterns of the people therein. In order to explore this interpretation, it is necessary to understand the social structure of Cleveland and Cuyahoga County, Ohio in the early decades of the Twentieth Century. In particular, the nature of race relations in this region of the country at this point in time must be examined to determine their possible effects on the activity patterns and the subsequent skeletal structures of these subpopulations.

In the immediate postslavery period, "[u]tilization of blacks in the expanding cities of the North was ruled out by prejudice, inertia, and the continuing availability of millions of European immigrants" (Taeuber and Taeuber, 1976:167). In the United States in general during this time period, African Americans were heavily discriminated against as a result of their being members of what Newman terms a caste society (1976: 252). Newman also cites working conditions that were far from favorable for the newly liberated African Americans. "From being expected to do virtually everything until the mid 1800's, most black people were thwarted from doing anything but the most menial work during much of the next one hundred years" (253). In spite of this fact, it is estimated that by 1910 "more than half of the nearly 3,700,00 black females in the United States . . . were gainfully employed, compared with less than 20% of the nearly 31,000,000 white women . . . . In many industries mass production would not have been undertaken if it had not been for the available, low-priced labor supply of black women" (Walker, 1976:349).

For the city of Cleveland, in particular, prior to World War I "there existed exceptional opportunities for the small black population" (Lynch, 1973:115). For African Americans in 1912, Cleveland was, by comparison, a city of vastly improved access to jobs, prompting a journalist of the period to dub the city "The Negro's Paradise" (Ouillin, quoted in Lynch, 1973:125). This article, from the March 7, 1912 issue of *Independent*, enumerates the citizens of that city who found not only jobs, but positions of prominence in government as well as labor. "The only other thing that I might mention is that this city has been unusually wise in solving a most distressful question and gives to the colored man full economic equality and lets social status rest upon natural law and ordinary good sense" (127). Although this statement is most likely exaggerated, it shows that during this time period there were sufficient opportunities to work in Cleveland for African Americans and European Americans alike.

The history of Cleveland after this time period is characterized by two major events. First, World War I brought about many changes including the cutting off of immigration from Europe, which led to a severe labor shortage (Phillips, 1996). This in turn gave African Americans increased job opportunities in northern industrial cities such as Chicago, Detroit and Cleveland. Southern African Americans, eager to reap the benefits of this new chance to work for better wages under better conditions, began what became known as the Great Migration beginning in 1915 (394). Even before this, the city of Cleveland was drawing immigrants from all over the world, including the southern United States:

> In 1910, Cleveland was the sixth-largest city in the country, its prospering economy resting on the manufacture of automobiles, finished iron and steel products, and textiles. Its population, swollen almost 50% since 1900, was ethnically diverse; only one-fifth of its citizens were native born of native parentage (Morton, 1985:452)

Needless to say, the effects of cutting off immigration from Europe would create an astronomical labor shortage in a city of this type.

Opportunities in the North were vastly improved by the wartime economy during the first World War. They were improved further by "the cutting off of immigration from Europe to the North and the consequently widespread demand for common labor" (Du Bois, qtd. in Adler, *et al*, 1969:50). Between 1910 and 1920, the African American populations of Cleveland, Detroit and Chicago grew 355.8%, while the average growth rate in the following decade was 138.9% (Lynch, 1973:182). "These were the centers of rapid expansion in the steel, automobile, oil, chemical, and food industries, resulting in a relative shortage of labor" (182). African American men and women were actively sought to fill this void, although they were still, for the most part, relegated to unskilled labor (182). The July 1924 issue of *Monthly Labor Review* shows that "on arriving in the North, he [the newly migrated African American] has had to start at the very bottom of the industrial ladder . . ." (qtd in Lynch, 1973:201). Foundry mills and machine working plants were the labor destinations of most of these people, occupations which place intense physical demands on workers, as Mintz and Fraga showed in their clinical study of modern foundry workers in Mexico City (1973).

Even though there were many opportunities for them in Cleveland, it is apparent that a higher percentage of the African American population was engaged in the most rigorous physical labor. A far smaller percentage of the European American population was similarly employed. The semiskilled and skilled labor that was generally less physically demanding was still predominantly performed by them (Lynch, 1973).

The second critical historical event to be considered is the Great Depression, beginning in 1930-31. The Great Migration swelled the ranks of African Americans in the labor force to such an extent that when the Great Depression hit, it was especially devastating to them. "The workers at the bottom of the hierarchy, specifically black women and older white women, were forced out of employment. . ." during the Depression, in order to make room for those at the top of the industrial hierarchy (Helmbold, 1988:138).

This is what Helmbold terms "downward occupational mobility", having the effect of increased unemployment for the entire population, especially African Americans, as well as demotion into more menial, demanding jobs for those in the next-to-the-lowest strata of the hierarchy. Morton (1985) cites that most lower class women were employed chiefly as domestic servants, factory workers, waitresses, and clerks in descending order. Helmbold's study revealed that the job preferences for women during this time period were ranked according to their relative degrees of difficulty in descending order: clerical, sales, public service, factory work, and domestic service. "Women judged [clerical] work to be easy, for it required the least physical labor . . ." (144). Factory labor was among the least desirable in part because the "primary requirements for factory employment were health, *physical stamina*, and the ability to adopt to *routine work*" (148; emphasis mine). The obvious pattern is that women were by and large employed in the least desirable jobs, with African American women at the bottom of the hierarchy.

In spite of the desirability of less physically demanding jobs, employers in Cleveland looking for clerical employees hired European American females almost exclusively (Helmbold, 1988:144). Most African American women were employed in domestic service, the least desirable of all categories not because of physical demands alone, but also because of a restricted freedom due to being in service. "For Afro-American women, largely restricted to domestic work, both factory jobs and public service jobs could be a step up the ladder" (149). Therefore, social circumstances pushed African American women to seek jobs that might have been more physically demanding in order to escape domestic servitude.

The same holds true for African American males in the city of Cleveland at this time. "By 1920, some employers publicly acknowledged that black workers were the largest 'available class' of labor and moved to incorporate them into the industrial setting, but only in specific jobs with limited mobility" (Phillips, 1996:395). Again, the least desirable occupations were available to African American males, with less rigorous work being gained only through rare advancement. Any advancements made by African American males, as was the case for females, would surely be reversed by the downward occupational mobility of the Great Depression, as European American males displaced them in the more lucrative, less physically demanding occupations.

Would these differences in social patterns be sufficient to manifest themselves in the skeletons of these people? As mentioned before, the studies by Angel and others demonstrated that the hardships of life for African Americans before the abolition of slavery left telltale signs on their skeletons. The question being asked in this thesis is whether or not these same phenomena manifested themselves half a century later in a major Northern industrial city. The results of the data analysis indicate that there are signs similar to those of the slave populations, but what social conditions are causing these phenomena to persist? The hypothesis tested is that unequal access to less physically demanding forms of labor resulted in African Americans being forced into common labor that was more rigorous than that of the European American population.

The population represented by the Todd Collection is decidedly from the lower strata of the social system of the city of Cleveland.

> The survey of the origins of our cadavers and the time of their arrival in the Laboratory have demonstrated that we are dealing with a population whose selection was determined by a definite industrial and economic background. The occupational analysis emphasizes that on the whole, it is from the lower strata of their respective peoples ,that our cadavers have come (Cobb, 1932:83)

The statistics on the percentages of general laborers stated above (60% for African Americans and 53.5% for European Americans) show that the majority of individuals in the subsamples were in the unskilled labor category no matter their race. Todd (1923) comments that while the African Americans in the collection are fairly representative of their population as a whole, "[whites are] not representative of the general population of the city, but is a shiftless population taken sometimes from the industrial elements, often from the waterfront, criminal districts and the underworld" (135) along with a large number of European immigrant laborers. This demonstrates that these European Americans, who were essentially from the same socioeconomic strata as the majority of the African American population, were considered socially inferior to the rest of their respective population.

There is little doubt that members of both populations were part of a large general labor force, but it is entirely possible that the European American population represents many more unemployed or "shiftless" individuals than the African American, which would bias the occupational data to some extent.

However, Cobb (1932) found that over half of the former group's members were employed in the general labor pool, made up for the most part by European immigrants. Out of a total of 2041 specimens in the collection at the time of Cobb's research, 858 of them have occupational listings (three of which are "bum"!). This total obviously does not include the very young, the very old, the unidentified specimens or the unemployed. Therefore, in spite of Todd's characterization of the European American population in his collection, the majority of these people were employed. The data are very detailed and further research could more precisely estimate the exact nature of the occupational statuses of these people. There were most certainly "shiftless" and unemployed people in the cadaver population, but it is unlikely that these specimens would bias the data in a significant manner.

The interpretation of social inequality is therefore the most tenable in that it is most consistent with the data collected for this project. Researcher bias, individuality and genetics are still possibilities, but given the social atmosphere of the early 20th Century, there is much more convincing evidence that social inequalities and injustices served to place physical demands on African Americans that are not present in the same proportions in European Americans. In the rush to fill the void in the labor force left by World War I, African Americans, who had little opportunities in both the postreconstruction South and the majority of the North, were willing and able to take on the most menial jobs in the labor hierarchy of cities such as Cleveland, Ohio.

The nature of the skeletal differences between the subsamples can be interpreted from the results of the statistical analyses as well. African American males exhibit more stress in the attachment sites for the brachialis, extensor carpi radialis longus, pectoralis major, gluteus maximus, adductor, and gastrocnemius muscles. This is an interesting pattern in that it involves three of the five lower limb muscles chosen for this study. This means that African American males were using these muscles significantly more than European American males. Analysis of the functions of these lower limb muscles shows that they are very important for movement under resistance or load bearing. The gluteus maximus is a powerful hip extensor, primarily "when moderate to heavy resistance to the movement exists (Luttgens, *et al*, 1992:184). The gastrocnemius helps to maintain knee extension under situations of load bearing (214), while the adductors adduct and flex the femur, especially against resistance when the hip is flexed. The fact that these muscles are more significantly stressed among individuals in the African American subsample demonstrates that loading stress was a more significant factor in the activity patterns of these people.

Significant levels of flexion of the humerus by the pectoralis major muscle, flexion of the elbow by the brachialis, and radial flexion of the hand by the extensor carpi radialis longus are indicative of more strenuous brachial activities that may involve lifting and carrying heavy loads. When paired with the data from the lower limbs, a picture of more strenuous load bearing activity patterns comes to light. Stirland (1988) showed that enthesopathies of the linea aspera, gluteal ridge, and brachialis attachment, among others, were seen in the skeletons of the crews responsible for moving and loading cannons and operating longbows aboard the *Mary Rose*, Henry VIII's flagship that was sunk off the coast of England in 1545 (42).

The female differences are less distinct and are therefore more difficult to interpret. African American females are more stressed at the attachment for the pronator quadratus, brachioradialis, and popliteal muscles. The first two of these are forearm muscles, while the third is a muscle of the lower limb. Pronation and flexion of the forearm as well as flexion and inward rotation of the knee are therefore executed under significantly more stress in that subsample. It is interesting to note that the brachioradialis participates in elbow flexion when the movement is resisted (Luttgens, *et al*, 1992:139), as might be expected in situations of load bearing, such as carrying heavy objects. The popliteus muscle is active during the load bearing portion of the walking stride (214), which could be consistent with long hours of walking and being on one's feet. In sum, this pattern could be consistent with working in domestic service and in factory jobs.

European American females are more stressed at the attachment of the deltoid muscle on the clavicle. More precisely, this attachment corresponds to the anterior portion of the deltoid which functions to aid in all forward movements of the arm, inward rotation of the humerus, and abduction (102). It is possible that this marker is related to repetitive stress rather than loading stress because this muscle is not active in load bearing. This is a possible clue as to the precise nature of the different activity patterns between the subsamples, but future investigation will be necessary to bear this out.

CHAPTER 5: Conclusion

The overall skeletal differences elucidated by the analysis are consistent with African Americans being subject to more musculoskeletal stress than European Americans during the first four decades of the 20th Century in the Northern industrial complex of the United States. Despite comparative equality in the labor force relative to both the past and other parts of the country, the African American citizens of Cleveland, Ohio were experiencing physical hardships that were significantly greater than those of people in different segments of the population. The data therefore support the hypothesis set out in the introduction of this thesis. The frequency and degree of enthesopathic lesions related to musculoskeletal stress in the African American subsample are significantly greater than those of European Americans due to the social forces that were acting during that time period. The city of Cleveland and surrounding Cuyahoga County were subject to the cultural parameters of the early 20th Century that included discrimination in the labor force.

Despite their crucial role in the growth and success of this city, African Americans were still subject to discrimination in the form of unequal access to employment. They were forced to engage in the most physically demanding, menial jobs for less wages and decreased job security in comparison to their European American coworkers. This culture of discrimination is apparent in historical research on the time period and is supported by examination of the skeletal remains of the people therein. The skeletal evidence is especially provocative in that it shows how this social system affected human beings on an individual level. Statistics and stories can tell great volumes about the past, but insights on the personal lives of those people makes the story relevant to everyone.

This fact reflects the nature of anthropology as a discipline. The primary sources of information about humans in the past and present are the people themselves. This can take the form of participant observation, excavation and analysis of material culture, or the analysis of the biological characteristics of members of a particular culture. This thesis has demonstrated its contribution to anthropology in that it has shown how human beings are affected by the cultures in which they participate. It has also demonstrated the intricate nature of culture change and that this change can be detected at times through the analysis of skeletal remains. Discrimination and prejudice are cultural phenomena that have been under intense scrutiny in the social sciences, including anthropology. It is hoped that the results of this research will add another dimension to these studies so that a comprehensive picture of these phenomena will emerge so that future cultures will learn from it and make the necessary adjustments that preclude people from being discriminated against.

Historical research on the nature of labor and activity patterns and how these reflect the circumstances of people in the past will also benefit from this research. The history of discrimination and prejudice can be explored from a new angle, one that includes the more personal data to be gained from analyzing the skeletal remains of individuals. The impact of major historical events on the lives of underrepresented segments of the population in question will add a personal dimension that will bring the picture of the past into sharper focus.

Future research problems to be addressed are also implicated by this study, many of which are mentioned in the body of this thesis. First and foremost, future researchers will need to be able to determine more specific activity patterns that correspond to the morphological differences observed in this type of research. Close collaboration between clinicians, kinesiologists and physical anthropologists will be necessary to accomplish this goal. Accordingly, the nature of bone remodeling as it relates to such factors as age, diet, disease and other factors demands further exploration. For example, as a person ages, how rapidly do acquired stress markers deteriorate? Along the same lines, it would be valuable to know how inactivity affects musculoskeletal stress markers. Are there indeed underlying genetic factors that allow for different rates of remodeling? Can traumatic origin be discerned from repetitive origin of enthesopathic lesions? All of these questions raise questions of their own that await further research.

The social implications also raise questions that are perhaps even more compelling. The major research problem for the future will be in determining whether the observed level of differences between the selected populations has substantially changed over time. Are the results of research performed by such luminaries as J. Lawrence Angel significantly different from those of this study? This would reflect whether living conditions improved or worsened for African Americans after approximately fifty years of Reconstruction. While Angel and other researchers explored the differences between slaves and "free blacks", it would be of great interest to perform similar analyses of the European American populations of that time period to determine whether or not the members of the social majority were also experiencing significant amounts of musculoskeletal stress. Does labor saving technology increase or decrease the frequencies and levels of certain stress markers?

This area of inquiry is wide open to the scrutiny of science. The problem exists, however, that suitable skeletal populations are very rare. The Todd Collection at the Cleveland Museum of Natural History is among a very rare group of collections that offer the necessary controls to carry out this research. However, if standards can be derived from collections such as these, populations represented by skeletal remains from various contexts can be analyzed successfully as a result. As the database from these types of studies increases for both archaeological and modern samples, the techniques will become more refined and thereby more useful to the field of anthropology.

By far the most crucial step to be taken involves the standardization of data collection. The data are indeed subjective and are therefore subject to interobserver variability. If methods can be devised to make the evaluation of enthesopathies universal for all scientists, the entire area of research will be vastly improved. Metric methods will most likely need to be developed so that quantification will become more standard. In the absence of this, a standard set of morphological changes such as those used by physical anthropologists to determine the age of an individual anthroposcopically, will need to be developed. This will be beneficial in that every researcher will develop data that can be directly compared to that of every other researcher.

For physical anthropology, this research is important because it demonstrates the utility of using musculoskeletal stress markers in answering questions about human behavior. After more advanced techniques have been developed, refined and improved upon, it is not unreasonable to assume that more precise estimations of an individual's lifestyle as represented by the skeletal manifestations of their unique activity patterns will be possible. Future research into this field will, for example, greatly influence forensic anthropology in that personal identification will be greatly enhanced. The usual demographic data that are standard in a forensic report will be supplemented by giving investigators ideas as to the actual occupations or habitual activities of the *corpus delecti*. Overzealous research studies of the past will eventually serve as the building blocks that will allow for diagnosis of occupationally related patterns of musculoskeletal stress. The assumptions of these works will have to stand the test of advancements in the field. This research will, for the most part, provide an additional avenue of investigation for physical anthropologists specializing in human osteology for exploring the intricate relationships between human biology and human culture.

APPENDIX I: Data Tables

AFRICAN AMERICAN MALES

	#0809	#1831	#0379	#3052	#2367	#2281	#0343	#0814	#1778	#1116	#1152	#1903	#3251	#0596	#2484
Ulna 1	0	1	0	0	0	0	2	2	0	0	1	1	0	0	2
Ulna 2	0	2	0	2	0	0	0	2	0	0	0	2	0	0	0
Ulna 3	0	2	1	2	0	2	0	0	0	0	0	0	0	1	0
Ulna 4	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0
Radius 1	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0
Radius 2	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0
Radius 3	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2
Humerus 1	0	2	1	2	0	0	0	1	4	2	0	0	0	0	0
Humerus 3	0	4	0	2	0	0	1	3	2	1	1	2	2	0	1
Humerus 4	0	4	0	2	0	0	1	2	0	0	0	1	0	0	1
Humerus 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavicle 2	0	4	0	0	0	0	0	1	1	0	0	2	0	4	0
Clavicle 3	1	2	0	2	0	0	0	1	0	0	2	4	0	1	0
Clavicle 4	0	0	0	0	2	0	0	0	0	0	3	2	0	0	0
Scapula 2	0	0	0	1	0	0	1	1	0	0	0	2	0	2	0
Scapula 3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Scapula 4	2	2	0	0	0	0	2	1	0	0	1	0	0	2	0
Femur 1	0	2	0	2	2	4	0	0	2	0	0	2	0	0	0
Femur 2	0	0	0	2	2	0	2	0	0	0	0	2	0	0	4
Femur 3	0	4	4	0	2	0	0	0	0	2	0	1	0	4	0
Femur 4	2	0	0	0	0	2	2	0	0	0	2	0	0	0	1
Tibia 1	2	2	0	0	0	1	2	0	0	2	2	2	1	0	0
TOTALS	7	31	7	17	11	9	15	16	11	9	12	23	3	20	11
Mean	15.1														
Stand Dev	8.539														
Median	14														
Mode	14														
Variance	72.92														

AFRICAN AMERICAN MALES

#3361	#2616	#1313	#2805	#3011	#1211	#0538	#1258	#1706	#3390	#1522	#3207	#1337	#1987	#2555	TOTAL
0	2	1	2	1	1	0	0	0	0	0	0	2	0	2	20
4	2	0	2	4	0	4	0	1	0	0	0	4	0	2	31
0	0	0	0	2	0	0	0	1	2	0	0	2	0	1	16
0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	8
0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	9
0	0	0	0	2	0	0	0	0	0	0	0	4	0	2	11
0	0	0	0	2	0	0	2	2	2	0	0	0	0	2	16
2	1	0	1	0	0	0	0	0	0	0	0	0	2	0	18
0	3	2	1	1	2	3	0	0	2	0	0	2	4	0	39
0	3	1	2	2	0	2	0	0	4	0	0	2	2	1	30
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	1	1	3	2	0	1	1	2	0	4	0	0	29
2	0	0	0	2	1	0	0	0	0	4	1	3	1	0	27
0	0	1	1	2	0	0	0	0	1	0	0	2	2	0	19
1	2	0	0	1	0	4	0	0	1	0	0	2	1	0	19
0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3
1	0	1	0	3	0	1	0	0	0	1	0	2	1	0	20
0	2	4	2	2	2	2	0	0	2	0	0	2	0	4	36
0	2	0	2	0	2	0	0	0	0	2	0	2	2	0	24
1	2	1	0	3	1	0	2	0	2	0	0	4	0	0	33
2	2	0	0	2	0	1	2	0	2	0	0	0	0	0	20
0	0	2	0	0	0	2	0	0	2	1	0	2	1	0	24
15	23	14	14	30	12	21	6	9	21	14	1	41	16	14	453

EUROPEAN AMERICAN MALES

	#0094	#1039	#0712	#0618	#1180	#1355	#0609	#0489	#0280	#0950	#1473	#1565	#2274	#2852	#3079	#2187
Ulna 1	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Ulna 2	3	2	0	0	0	0	0	0	2	0	0	0	2	0	0	2
Ulna 3	0	0	0	0	0	0	2	0	0	0	2	0	2	0	0	2
Ulna 4	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Radius 1	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Radius 2	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	1
Radius 3	2	0	0	3	0	0	0	0	2	0	0	0	0	0	0	2
Humerus 1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Humerus 3	4	0	0	0	0	0	2	0	2	0	0	0	4	0	0	0
Humerus 4	2	0	0	0	0	0	0	0	0	0	0	0	2	1	0	4
Humerus 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavicle 2	3	4	1	0	0	0	1	1	3	0	0	0	1	3	0	0
Clavicle 3	1	0	0	0	0	0	1	0	0	0	0	0	2	1	2	0
Clavicle 4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scapula 2	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Scapula 3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scapula 4	4	2	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Femur 1	2	0	0	0	0	0	0	0	3	0	0	0	2	0	1	0
Femur 2	4	0	4	0	4	0	2	0	0	0	0	0	2	0	1	0
Femur 3	2	0	3	0	0	0	0	0	0	0	3	2	0	0	0	0
Femur 4	2	0	2	0	0	2	0	0	0	0	2	0	0	0	0	2
Tibia 1	2	0	0	0	0	0	2	0	0	0	2	0	2	0	0	0
TOTALS	41	8	11	3	4	2	14	1	15	0	9	2	24	5	4	13
Mean	10.67															
Median	8															
Mode	4															
Stan Dev	9.987															
Variance	99.75															

EUROPEAN AMERICAN MALES

#1556	#2831	#0945	#0069	#0357	#0419	#0627	#1325	#1520	#1792	#1839	#2207	#2409	#2919	TOTAL
0	0	0	0	0	0	0	0	2	0	1	0	0	0	7
0	0	0	2	0	0	0	0	0	0	0	0	0	0	13
0	0	0	2	0	0	0	0	2	0	2	0	2	2	18
0	0	0	2	0	0	0	0	0	1	4	0	0	0	10
0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	0	0	2	0	0	0	0	0	0	3	0	0	0	9
0	0	1	4	0	0	0	0	2	2	2	0	2	0	22
0	0	0	1	0	0	0	0	2	1	0	0	0	1	6
0	0	0	2	0	2	0	2	2	3	2	1	1	2	29
0	0	0	1	0	0	0	0	0	4	0	1	0	0	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	3	2	4	0	0	0	1	4	2	0	0	0	35
0	0	0	1	3	0	0	2	0	0	0	2	0	2	17
0	0	2	0	0	0	0	0	0	0	1	0	0	4	9
0	0	0	1	0	0	0	0	0	0	1	0	0	2	8
0	0	0	2	0	0	0	0	0	0	0	0	0	0	3
0	0	0	2	0	0	0	0	0	2	0	0	0	1	13
0	0	0	2	0	0	0	0	2	0	2	0	0	3	17
1	1	2	4	4	0	0	2	2	0	2	0	0	2	37
0	0	0	0	0	0	0	2	0	0	0	0	0	3	15
0	0	0	0	0	0	0	0	2	0	2	0	2	0	16
0	0	0	0	0	0	0	3	1	0	2	0	0	1	15
3	2	8	30	11	4	0	11	18	17	26	4	7	23	320

AFRICAN AMERICAN FEMALES

	#1539	#1622	#2837	#1103	#2830	#2843	#3181	#1899	#1580	#1214	#3223	#1397	#0529	#0931	#2597	#0439
Ulna 1	0	0	0	0	0	0	2	0	0	0	2	0	1	0	0	2
Ulna 2	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	1
Ulna 3	0	0	0	0	0	0	1	2	0	0	2	0	0	0	0	0
Ulna 4	0	0	2	3	0	0	0	2	0	0	0	0	0	0	1	0
Radius 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Radius 2	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	2
Radius 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Humerus 1	1	0	0	0	0	0	0	2	0	0	2	0	0	0	0	3
Humerus 3	0	0	2	0	0	0	2	1	0	0	0	0	0	0	0	2
Humerus 4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
Humerus 5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
Clavicle 2	0	0	2	0	0	0	4	2	0	0	0	0	1	0	0	0
Clavicle 3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Clavicle 4	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	2
Scapula 2	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0
Scapula 3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Scapula 4	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	2
Femur 1	0	0	2	0	0	0	2	2	2	0	0	0	0	0	0	0
Femur 2	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0
Femur 3	0	0	2	0	0	0	0	1	0	0	2	0	0	0	0	0
Femur 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tibia 1	0	0	0	1	0	2	0	2	0	0	0	0	1	0	0	0
TOTALS	1	2	13	5	0	2	18	22	2	0	12	0	3	2	1	20
Mean	7.567															
Median	4															
Mode	0															
Stan Dev	7.482															
Variance	55.98															

AFRICAN AMERICAN FEMALES

#2172	#3234	#1515	#1516	#0673	#1489	#2028	#2853	#3332	#1345	#2612	#2827	#0442	#2298	TOTAL
0	0	0	0	0	0	0	0	0	0	0	2	0	0	9
0	0	2	0	2	0	0	0	2	0	2	0	2	0	15
0	0	0	0	0	2	0	2	0	0	0	0	3	0	12
0	0	0	0	0	0	0	0	1	0	0	0	0	0	9
0	0	0	0	0	0	0	3	2	0	0	0	2	0	7
0	0	0	0	0	0	0	0	0	2	2	0	1	0	9
0	0	0	0	2	0	0	2	0	0	2	0	0	0	8
0	0	0	0	0	0	0	1	0	2	1	0	0	0	12
0	0	0	0	2	2	0	2	0	0	1	0	3	0	17
0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	2	0	0	0	0	0	0	0	0	6
0	0	0	0	0	0	0	0	0	0	1	2	0	0	12
0	0	0	2	0	4	0	2	2	0	2	2	0	0	16
0	0	0	0	0	1	0	2	0	0	0	0	0	0	7
0	0	0	0	0	2	0	1	0	0	0	2	2	0	10
0	0	0	0	0	2	0	0	2	0	0	0	0	0	5
0	0	0	0	0	0	0	0	0	0	2	0	2	0	9
0	0	0	0	0	0	0	0	0	0	2	4	0	0	14
0	0	2	2	0	0	0	0	0	0	0	1	0	0	9
1	1	0	0	0	0	0	0	0	0	0	4	0	0	11
0	0	0	0	0	2	0	0	0	0	0	0	2	0	4
2	2	0	0	0	2	0	2	2	0	0	2	0	0	18
3	3	6	4	6	19	0	17	11	4	15	19	17	0	222

EUROPEAN AMERICAN FEMALES

	#1900	#1059	#1162	#1350	#0727	#2884	#0536	#1554	#0929	#1253	#2857	#0886	#1739	#2056	#1747	#1119
Ulna 1	0	0	2	0	0	0	2	0	0	0	0	0	2	0	0	0
Ulna 2	0	1	0	0	2	0	1	0	0	2	0	1	0	0	1	0
Ulna 3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Ulna 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Radius 1	0	0	0	0	0	0	0	2	1	0	0	0	1	0	0	0
Radius 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Radius 3	2	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0
Humerus 1	0	0	3	0	0	1	0	0	0	2	0	0	0	0	0	0
Humerus 3	0	0	0	0	0	0	0	0	0	2	0	1	4	0	1	0
Humerus 4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Humerus 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavicle 2	0	1	2	0	0	1	1	0	0	0	0	2	0	0	0	0
Clavicle 3	0	2	0	0	0	0	1	0	1	0	0	0	0	0	2	0
Clavicle 4	0	0	2	0	2	2	0	0	0	0	0	0	2	0	2	0
Scapula 2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Scapula 3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Scapula 4	0	2	0	0	0	0	1	0	0	0	1	2	0	1	2	0
Femur 1	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Femur 2	0	2	2	0	0	0	2	2	0	0	0	0	0	0	4	1
Femur 3	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Femur 4	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0
Tibia 1	0	0	0	0	0	0	0	2	0	1	2	0	0	0	0	0
TOTALS	6	9	16	0	6	4	10	8	2	7	3	7	9	1	14	1
Mean	5.724															
Median	5.5															
Mode	4															
Stan Dev	4.389															
Variance	19.26															

EUROPEAN AMERICAN FEMALES

#0631	#2125	#2199	#2923	#0339	#0774	#2254	#3111	#1279	#0243	#0249	#1049	#1759	#2713	TOTALS
0	0	0	0	1	0	0	0	0	0	2	0	0	2	11
0	2	2	0	0	0	0	0	0	0	0	0	0	0	12
0	0	0	0	0	0	0	1	0	0	0	0	0	2	5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	2	0	0	0	1	0	2	0	0	0	0	0	10
0	0	0	0	0	0	0	1	0	0	0	0	0	0	7
0	0	1	0	0	0	1	0	0	0	0	0	0	0	10
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	2	0	0	0	0	0	0	9
0	0	2	0	0	0	2	2	0	0	2	0	0	0	14
2	2	2	0	0	0	0	0	0	0	0	0	0	0	16
2	0	1	0	0	0	0	0	0	0	0	0	0	0	4
0	0	0	0	0	2	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	1	0	0	0	1	0	0	0	11
0	0	0	0	2	2	2	0	2	0	0	0	0	0	12
2	0	2	1	0	0	0	0	0	0	0	0	0	0	18
0	0	1	0	2	0	2	0	0	0	0	0	0	0	9
0	0	1	0	0	0	0	0	0	0	1	0	0	0	5
0	0	0	0	0	0	2	0	0	0	0	0	0	0	7
8	4	14	1	5	4	11	6	4	0	6	0	0	4	170

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
SEX:          1 (MALE)
  FEMUR3
 by POPAFF
   Mean Rank    Cases
       34.30       30  POPAFF = 1
       26.70       30  POPAFF = 2
                   --
                   60  Total
                                  Corrected for ties
         U           W                Z     2-Tailed P
       336.0       1029.0        -2.0135       .0441
  HUMERUS4
 by POPAFF
   Mean Rank    Cases
       34.50       30  POPAFF = 1
       26.50       30  POPAFF = 2
                   --
                   60  Total
                                  Corrected for ties
         U           W                Z     2-Tailed P
       330.0       1035.0        -2.0622       .0392
  ULNA1
 by POPAFF
   Mean Rank    Cases
       34.82       30  POPAFF = 1
       26.18       30  POPAFF = 2
                   --
                   60  Total
                                  Corrected for ties
         U           W                Z     2-Tailed P
       320.5       1044.5        -2.4201       .0155
SEX:          2 (FEMALE)
  RADIUS2
 by POPAFF
   Mean Rank    Cases
       33.50       30  POPAFF = 1
       27.50       30  POPAFF = 2
                   --
                   60  Total
                                  Corrected for ties
         U           W                Z     2-Tailed P
       360.0       1005.0        -2.5568       .0106
  ULNA4
 by POPAFF
   Mean Rank    Cases
       32.50       30  POPAFF = 1
       28.50       30  POPAFF = 2
                   --
                   60  Total
                                  Corrected for ties
         U           W                Z     2-Tailed P
       390.0        975.0        -2.0515       .0402
```

CHI SQUARE

```
SEX:          1 (MALE)
FEMUR1  by  POPAFF
                   POPAFF       Page 1 of 1
            Count  |
          Exp Val  |
                   |                   Row
                   |        1|       2| Total
FEMUR1     --------+--------+--------+
                0  |   15   |   22   |   37
                   |  18.5  |  18.5  | 61.7%
                   +--------+--------+
                1  |    0   |    1   |    1
                   |    .5  |    .5  |  1.7%
                   +--------+--------+
                2  |   12   |    5   |   17
                   |   8.5  |   8.5  | 28.3%
                   +--------+--------+
                3  |    0   |    2   |    2
                   |   1.0  |   1.0  |  3.3%
                   +--------+--------+
                4  |    3   |    0   |    3
                   |   1.5  |   1.5  |  5.0%
                   +--------+--------+
           Column      30       30       60
            Total    50.0%    50.0%   100.0%
      Chi-Square                   Value          DF            Significance
--------------------            ----------       ----           -----------
Pearson                         10.20668          4               .03709
Likelihood Ratio                12.62000          4               .01329
Mantel-Haenszel test for         4.02552          1               .04482
      linear association
Minimum Expected Frequency -     .500
Cells with Expected Frequency < 5 -     6 OF     10 ( 60.0%)
FEMUR3  by  POPAFF
                   POPAFF       Page 1 of 1
            Count  |
          Exp Val  |
                   |                   Row
                   |        1|       2| Total
FEMUR3     --------+--------+--------+
                0  |   16   |   24   |   40
                   |  20.0  |  20.0  | 66.7%
                   +--------+--------+
                1  |    4   |    0   |    4
                   |   2.0  |   2.0  |  6.7%
                   +--------+--------+
                2  |    5   |    3   |    8
                   |   4.0  |   4.0  | 13.3%
                   +--------+--------+
                3  |    1   |    3   |    4
                   |   2.0  |   2.0  |  6.7%
                   +--------+--------+
                4  |    4   |    0   |    4
                   |   2.0  |   2.0  |  6.7%
                   +--------+--------+
           Column      30       30       60
```

```
                Total    50.0%     50.0%    100.0%
      Chi-Square                    Value             DF                Significance
--------------------            ----------           ----               ------------
Pearson                           11.10000             4                   .02546
Likelihood Ratio                  14.25304             4                   .00653
Mantel-Haenszel test for           3.26434             1                   .07080
      linear association
Minimum Expected Frequency -      2.000
Cells with Expected Frequency < 5 -      8 OF     10 ( 80.0%)
ULNA1   by   POPAFF
                       POPAFF        Page 1 of 1
               Count  |
             Exp Val  |
                      |                   Row
                      |        1|        2| Total
ULNA1        ---------+---------+---------+
                   0  |    17   |    26   |    43
                      |   21.5  |   21.5  | 71.7%
                      +---------+---------+
                   1  |     6   |     1   |     7
                      |    3.5  |    3.5  | 11.7%
                      +---------+---------+
                   2  |     7   |     3   |    10
                      |    5.0  |    5.0  | 16.7%
                      +---------+---------+
              Column       30        30        60
               Total    50.0%     50.0%    100.0%
      Chi-Square                    Value             DF                Significance
--------------------            ----------           ----               ------------
Pearson                            7.05515             2                   .02938
Likelihood Ratio                   7.50581             2                   .02345
Mantel-Haenszel test for           4.76853             1                   .02898
      linear association
Minimum Expected Frequency -      3.500
Cells with Expected Frequency < 5 -      2 OF      6 ( 33.3%)
SEX:             2 (FEMALE)
CLAV4   by   POPAFF
                       POPAFF        Page 1 of 1
               Count  |
             Exp Val  |
                      |                   Row
                      |        1|        2| Total
CLAV4        ---------+---------+---------+
                   0  |    25   |    22   |    47
                      |   23.5  |   23.5  | 78.3%
                      +---------+---------+
                   1  |     3   |     0   |     3
                      |    1.5  |    1.5  |  5.0%
                      +---------+---------+
                   2  |     2   |     8   |    10
                      |    5.0  |    5.0  | 16.7%
                      +---------+---------+
              Column       30        30        60
               Total    50.0%     50.0%    100.0%
```

```
     Chi-Square                     Value          DF           Significance
  --------------------           -----------      ----          -----------
Pearson                           6.79149          2               .03352
Likelihood Ratio                  8.20540          2               .01653
Mantel-Haenszel test for          2.33008          1               .12690
linear association
Minimum Expected Frequency -    1.500
Cells with Expected Frequency < 5 -      2 OF     6 ( 33.3%)
RADIUS2   by   POPAFF
                    POPAFF          Page 1 of 1
             Count |
           Exp Val |
                   |                  Row
                   |        1|       2| Total
RADIUS2     --------+--------+--------+
               0   |    24   |    30  |    54
                   |  27.0   |  27.0  |  90.0%
                   +--------+--------+
               1   |     3   |     0  |     3
                   |   1.5   |   1.5  |   5.0%
                   +--------+--------+
               2   |     3   |     0  |     3
                   |   1.5   |   1.5  |   5.0%
                   +--------+--------+
            Column      30        30       60
             Total    50.0%     50.0%   100.0%
     Chi-Square                     Value          DF           Significance
  --------------------           -----------      ----          -----------
Pearson                           6.66667          2               .03567
Likelihood Ratio                  8.98581          2               .01119
Mantel-Haenszel test for          5.83516          1               .01571
      linear association
Minimum Expected Frequency -    1.500
Cells with Expected Frequency < 5 -      4 OF     6 ( 66.7%)
POPAFF:             1 (BLACK)
FEMUR4   by   SEX
                    SEX             Page 1 of 1
             Count |
           Exp Val |
                   |                  Row
                   |        1|       2| Total
FEMUR4      --------+--------+--------+
               0   |    19   |    28  |    47
                   |  23.5   |  23.5  |  78.3%
                   +--------+--------+
               1   |     2   |     0  |     2
                   |   1.0   |   1.0  |   3.3%
                   +--------+--------+
               2   |     9   |     2  |    11
                   |   5.5   |   5.5  |  18.3%
                   +--------+--------+
            Column      30        30       60
             Total    50.0%     50.0%   100.0%

Mantel-Haenszel test for          6.91575          1               .00854
      linear association
Minimum Expected Frequency -    1.000
```

```
      Chi-Square                      Value          DF               Significance
--------------------               ----------       ----              -----------
Pearson                             8.17795          2                  .01676
Likelihood Ratio                    9.32486          2                  .00944 Cells
with Expected Frequency < 5 -       2 OF       6 ( 33.3%)
HUMERUS4  by  SEX
                     SEX           Page 1 of 1
             Count  |
           Exp Val  |
                    |                  Row
                    |       1|        2| Total
HUMERUS4    --------+--------+--------+
                 0  |   15   |   28   |   43
                    |  21.5  |  21.5  | 71.7%
                    +--------+--------+
                 1  |    5   |    1   |    6
                    |   3.0  |   3.0  | 10.0%
                    +--------+--------+
                 2  |    7   |    1   |    8
                    |   4.0  |   4.0  | 13.3%
                    +--------+--------+
                 3  |    1   |    0   |    1
                    |    .5  |    .5  |  1.7%
                    +--------+--------+
                 4  |    2   |    0   |    2
                    |   1.0  |   1.0  |  3.3%
                    +--------+--------+
            Column      30       30       60
             Total    50.0%    50.0%   100.0%
      Chi-Square                      Value          DF               Significance
--------------------               ----------       ----              -----------
Pearson                            14.09690          4                  .00699
Likelihood Ratio                   16.12435          4                  .00286
Mantel-Haenszel test for           11.78061          1                  .00060
      linear association
Minimum Expected Frequency -        .500
Cells with Expected Frequency < 5 -      8 OF    10 ( 80.0%)
```

```
POPAFF:            2 (WHITE)
CLAV2  by   SEX
                   SEX           Page 1 of 1
           Count  |
           Exp Val |
                   |                   Row
                   |        1|        2| Total
CLAV2      --------+--------+--------+
              0    |   15   |   24   |   39
                   |  19.5  |  19.5  | 65.0%
                   +--------+--------+
              1    |    5   |    3   |    8
                   |   4.0  |   4.0  | 13.3%
                   +--------+--------+
              2    |    3   |    3   |    6
                   |   3.0  |   3.0  | 10.0%
                   +--------+--------+
              3    |    4   |    0   |    4
                   |   2.0  |   2.0  |  6.7%
                   +--------+--------+
              4    |    3   |    0   |    3
                   |   1.5  |   1.5  |  5.0%
                   +--------+--------+
           Column      30       30       60            Total   50.0%   50.0%
100.0%
     Chi-Square                Value          DF          Significance
--------------------        -----------      ----         ------------
Pearson                       9.57692          4              .04819
Likelihood Ratio             12.30517          4              .01522
Mantel-Haenszel test for      7.93869          1              .00484
linear association
Minimum Expected Frequency -   1.500
Cells with Expected Frequency < 5 -     8 OF    10 ( 80.0%)
FEMUR4  by  SEX
                   SEX           Page 1 of 1
           Count  |
           Exp Val |
                   |                   Row
                   |        1|        2| Total
FEMUR4     --------+--------+--------+
              0    |   21   |   26   |   47
                   |  23.5  |  23.5  | 78.3%
                   +--------+--------+
              1    |    0   |    3   |    3
                   |   1.5  |   1.5  |  5.0%
                   +--------+--------+
              2    |    9   |    1   |   10
                   |   5.0  |   5.0  | 16.7%
                   +--------+--------+
           Column      30       30       60
            Total   50.0%    50.0%   100.0%
```

```
     Chi-Square                      Value            DF              Significance
--------------------              -----------        ----             -----------
Pearson                             9.93191            2                 .00697
Likelihood Ratio                   12.05309            2                 .00241
Mantel-Haenszel test for            4.86153            1                 .02746
      linear association
Minimum Expected Frequency -      1.500
Cells with Expected Frequency < 5 -      2 OF      6 ( 33.3%)
ULNA3  by  SEX
                          SEX          Page 1 of 1
                  Count  |
                  Exp Val |
                         |              Row
                         |      1|      2| Total
ULNA3             --------+-------+-------+
                     0   |   21   |   27   |   48
                         |  24.0  |  24.0  | 80.0%
                         +--------+--------+
                     1   |    0   |    1   |    1
                         |   .5   |   .5   |  1.7%
                         +--------+--------+
                     2   |    9   |    2   |   11
                         |   5.5  |   5.5  | 18.3%
                         +--------+--------+
                  Column     30       30       60
                   Total   50.0%    50.0%   100.0%
     Chi-Square                      Value            DF              Significance
--------------------              -----------        ----             -----------
Pearson                             6.20455            2                 .04495
Likelihood Ratio                    6.95643            2                 .03086
Mantel-Haenszel test for            4.59281            1                 .03211
      linear association
Minimum Expected Frequency -       .500
Cells with Expected Frequency < 5 -      2 OF      6 ( 33.3%)
```

DISCRIMINANT ANALYSIS

```
POPAFF:         1 (BLACK)
On groups defined by SEX
                              Summary Table
        Action      Vars  Wilks'
Step Entered Removed  in    Lambda    Sig.   Label
  1  HUMERUS4          1    .80033   .0003
  2  FEMUR4            2    .73535   .0002
  3  HUMERUS5          3    .66716   .0000

POPAFF:         2 (WHITE)
On groups defined by SEX
                             Summary Table
        Action      Vars  Wilks'
Step Entered Removed  in    Lambda    Sig.   Label
  1  CLAV2             1    .86545   .0039
  2  FEMUR4            2    .77958   .0008
```

```
POPAFF:          1 (BLACK)
On groups defined by SEX
List of the 3 variables used..
Variable  Label
--------  ----------------------------------------
FEMUR4
HUMERUS4
HUMERUS5
Classification results -
                          No. of    Predicted Group Membership
   Actual Group            Cases           1           2
--------------------  ------    --------    --------
Group        1             30          20          10
                                       66.7%       33.3%
Group        2             30           2          28
                                        6.7%       93.3%
Percent of "grouped" cases correctly classified:  80.00%

POPAFF:          2 (WHITE)
On groups defined by SEX
Analysis number.. 1
List of the 2 variables used..
Variable  Label
--------  ----------------------------------------
CLAV2
FEMUR4
Classification results -
                          No. of    Predicted Group Membership
   Actual Group            Cases           1           2
--------------------  ------    --------    --------
Group        1             30          17          13
                                       56.7%       43.3%
Group        2             30           6          24
                                       20.0%       80.0%
Percent of "grouped" cases correctly classified:  68.33%

SEX:          1 (MALE)
On groups defined by POPAFF
                                  Summary Table
         Action      Vars  Wilks'
Step Entered Removed   in    Lambda    Sig.  Label
  1  ULNA1              1    .91918   .0277
  2  FEMUR2             2    .84964   .0096
  3  HUMERUS1           3    .79381   .0045

SEX:          2 (FEMALE)
On groups defined by POPAFF
                                Summary Table
         Action      Vars  Wilks'
Step Entered Removed   in    Lambda    Sig.  Label
  1  RADIUS2            1    .90110   .0144
  2  TIBIA1             2    .83339   .0055
```

```
SEX:          1 (MALE)
Analysis number.. 1
List of the 3 variables used..
Variable  Label
--------  ----------------------------------------
FEMUR2
HUMERUS1
ULNA1
Classification results -
                     No. of    Predicted Group Membership
   Actual Group       Cases          1           2
--------------------  ------   --------    --------
Group       1           30          16          14
                                  53.3%       46.7%
Group       2           30           3          27
                                  10.0%       90.0%
Percent of "grouped" cases correctly classified:  71.67%

SEX:          2 (FEMALE)
On groups defined by POPAFF
Analysis number.. 1
List of the 2 variables used..
Variable  Label
--------  ----------------------------------------
RADIUS2
TIBIA1
Classification results -
                     No. of    Predicted Group Membership
   Actual Group       Cases          1           2
--------------------  ------   --------    --------
Group       1           30          15          15
                                  50.0%       50.0%
Group       2           30           4          26
                                  13.3%       86.7%
Percent of "grouped" cases correctly classified:  68.33%
```

BIBLIOGRAPHY

Adler MJ, C Van Doren, and G Ducas, eds (1969): The Negro in American History: Vol. II. Encyclopedia Britannica Educational Corp.

Aiello LC and C Dean (1990): Introduction to Human Evolutionary Anatomy. San Diego, CA, Academic Press.

Angel, JL (1975): Middle class skeletal differences. Am J. Phys Anthropol. *42:* 288.

Angel, JL (1976): Colonial to modern skeletal change in the U.S.A. Am J. Phys. Anthropol. *45:* 723-736.

Angel JL, Kelley JO, Parrington M, and S Pinter (1987): Life stresses of the free black community as represented by the First African Baptist Church, Philadelphia, 1823-1841. Am. J. Phys. Anthropol. *74:* 213-229.

Bass WM (1987): Human Osteology: A Laboratory and Field Manual, 3rd ed. Columbia, MO, Missouri Archaeological Society.

Bridges PS (1990): Osteological correlates of weapon use. In Buikstra JE (ed): A Life in Science: Papers in Honor of J. Lawrence Angel. Center for American Archaeology Scientific Papers Number 6.

Bridges PS (1991): Skeletal evidence of changes in subsistence activities between the Archaic and Mississippian time periods in Northwestern Alabama. In Powell ML, Bridges PS and AMW Mires (eds): What mean these bones?: Studies in Southeastern bioarchaeology. Tuscaloosa, University of Alabama Press, pp. 89-101.

Cobb WM (1932): Human archives. Ph.D. dissertation, Department of Anatomy, Case Western Reserve University.

Dutour O (1986): Enthesopathies (lesions of muscular insertions) as indicators of the activities of Neolithic Saharan populations. Am. J. Phys. Anthropol. *71(2):* 221-224.

Helmbold LR (1988): Downward occupational mobility during the Great Depression: Urban black and white working class women. Labor Hist. *29(2):* 135-172.

Kennedy KAR (1983): Morphological variations in ulnar supinator crests and fossae as identifying markers of occupational stress. J Forensic Sci. *28(4)* 871-876.

Kennedy KAR (1989) Skeletal markers of occupational stress. In Iscan MY and KAR Kennedy (eds): Reconstruction of Life from the Skeleton. New York, Alan R. Liss, Inc., pp. 129-160.

Larsen CS and CB Ruff (1991) Biomechanical adaptation and behavior on the prehistoric Georgia coast. In Powell ML, Bridges SB and AMW Mires (eds): What mean these bones?: Studies in Southeastern bioarchaeology. Tuscaloosa, University of Alabama Press, pp. 102-113.

Larsen CS and CB Ruff (1994) The stresses of conquest in Spanish Florida: Structural adaptation and change before and after contact. In Larsen CS and GR Milner (eds): In the Wake of Contact. New York, Wiley-Liss, Inc., pp. 21-34.

Luttgens K, Deutsch H, and N Hamilton (1992): Kinesiology: Scientific Basis of Human Motion, 8th ed. Madison, WI, Wm C. Brown Communications, Inc.

Lynch HR (1973): The Black Urban Condition: A documentary history, 1866-1971. New York, Thomas Y. Crowell Co.

Merbs CF (1983): Patterns of Activity-Induced Pathology in a Canadian Inuit Population. Ottawa, National Museums of Canada.

Mintz G and A Fraga (1973): Severe osteoarthritis of the elbow in foundry workers. Arch. Environ. Health. *27:* 78-80.

Morton MJ (1985): Seduced and abandoned in an American city: Cleveland and its fallen women, 1869-1936. J. Urban Hist. *11(4):* 443-469.

Newman DK (1976): The black American worker. In Smythe MM (ed): The Black American Reference Book. Englewood Cliffs, NJ, Prentice-Hall, Inc.

Ortner DJ (1968): Description and classification of degenerative bone changes in the distal joint surfaces of the humerus. Am. J. Phys. Anthropol. *28:* 139-156.

Ortner DJ and WGJ Putschar (1985): Identification of Pathological Conditions in Human Skeletal Remains. Washington D.C., Smithsonian Institution Press.

Owsley DW, Orser CE, Mann RW, Moore-Jansen PH and RL Montgomery (1987): Demography and pathology of an urban slave population from New Orleans. Am. J. Phys. Anthropol. *74:* 185-197.

Parrington M and DG Roberts (1990): Demographic, cultural, and bioanthropological aspects of a nineteenth century free black population in Philadelphia, Pennsylvania. In Buikstra JE (ed): A Life in Science: Papers in honor of J. Lawrence Angel. Center for American Archeology, Scientific Papers 6.

Phillips KL (1996): "But it is a fine place to make money": Migration and African American families in Cleveland, 1915-1929. J. Soc. Hist. *30(2):* 391-413.

Rathbun TA (1987): Health and disease at a South Carolina Plantation: 1840-1870. Am. J. Phys. Anthropol. *74:* 239-253.

Roberts CA (1995): The Archaeology of Disease. Ithaca, New York, Cornell University Press.

Roberts MR (1997): The application of skeletal stress markers to cases of personal identification. Paper presented to the Montana Academy of Sciences, Social Sciences Section, Billings, Montana.

Rose JC and LG Santeford (1985): Chapter 5: Burial descriptions. In JC Rose (ed): Gone to a Better Land: A Biohistory of a Rural Black Cemetery in the Post-Reconstruction South. Arkansas Archeological Survey Research Series Number 25.

Ruff CB (1992) Biomechanical analyses of archaeological human skeletal samples. In Saunders SR and MA Katzenberg (eds): Skeletal Biology of Past Peoples: Research Methods. New York, Wiley-Liss, Inc.

Steele DG and CA Bramblett (1988): The Anatomy and Biology of the Human Skeleton. College Station, Texas A&M University Press.

Stewart TD (1958): The rate of development of vertebral osteoarthritis in American whites and its significance in skeletal age identification. Leech *28:* 14-151.

Stirland A (1988): Diagnosis of occupationally related paleopathology: Can it be done? In Ortner DJ and AC Aufderheide (eds): Human Paleopathology: Current syntheses and future options, pp. 40-47.

Taeuber KE and AF Taeuber (1976): The black population in the United States. In Smythe MM (ed): The Black American Reference Book. Englewood Cliffs, NJ, Prentice-Hall, Inc.

Todd, TW (1923): Cranial capacity and linear dimensions, in white and negro. Am. J. Phys. Anthropol. 6 *(2):* 97-191.

Ubelaker DH (1979): Skeletal evidence for kneeling in prehistoric Ecuador. Am. J. Phys. Anthropol. *51:* 679-686.

Walker E (1976): The black woman: Selected list of black women of achievement. In Smythe MM (ed): The Black American Reference Book. Englewood Cliffs, NJ, Prentice-Hall, Inc.

White T (1991): Human Osteology. San Diego, Academic Press, Inc.