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ANALYSIS OF OSTEOARTHRITIS ON APPENDICULAR JOINT SURFACES IN KNOWN AGE AND SEX SAMPLES FROM THE TERRY AND SPITALFIELDS COLLECTIONS

by

MICHELLE L. WEBB

Under the Direction of Frank L'Engle Williams

ABSTRACT

Arthritis is one of the most common manifestations of aging and is the single largest cause of disability in the UK, US, Australia, and Canada among people age 30 years and older. Osteoarthritis of appendicular joint surfaces exhibits alterations of bony tissue in and around the joint surface. The degree to which osteoarthritis of articular surfaces occurs as a function of age and sex can be resolved with cemetery populations of known individuals, such as the Terry (19-20th century) and Spitalfields (17-18th century) collections upon which I report (n = 322; 162 males and 160 females). Using the five point scoring system 0-4 of lipping from the Chicago Standards Guide I ask whether (1) age has an influence on the accumulation of OA; (2) sex differences are present in patterns of OA; and (3) population origin is responsible for explaining intensity of OA.

INDEX WORDS: Osteoarthritis, Terry, Spitalfields, Cemetery, Lipping, Porosity, Eburnation, Osteophyte, Knee, Shoulder, Elbow, Hip

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MICHELLE L. WEBB

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

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in the College of Arts and Sciences

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Michelle Lynn Webb
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by

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May 2010

DEDICATION

This thesis is dedicated to the memory of my maternal grandmother, June W. Ramundo. Her complete belief in my ability to be the best at what I do and succeed at any task put before me has been an inspiration to me throughout my education and life. Grandmom, you are my hero and while you were not able to see the completion of this work, I know you are watching from somewhere and are still cheering me on.

This work would also not have been possible without the support, love and guidance of my husband Eddy and my partner David. The daily affirmations and total support they have provided me in my journey towards this life's work has been invaluable.

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1 INTRODUCTION

Arthritis is one of the most common manifestations of aging and is considered by the medical community as the largest cause of disability in aging Western societies (Turner et al., 2007). Osteoarthritis is the single largest cause of disability in the United Kingdom, the United States, Australia, and Canada among people age 30 years and older (Turner et al., 2007, Felson et al., 2000, Busija et al., 2007 and Hootman, 2006). Some of the common beliefs about the development of osteoarthritis in the general population include weight, age, occupation, and sports participation as a youth. Numerous causes of osteoarthritis are studied in the medical communities although they are more comprehensive. When researching osteoarthritis, both medical and anthropological research should influence the focus in understanding the bioculturally-impacted elements of osteoarthritis in skeletal populations.

Throughout this study, I will attempt to explore what osteoarthritis is, how it manifests in living human populations and use that as a guide to help understand how the skeletal evidence of osteoarthritis can be explained in known populations. The two populations used in this research are the Terry and Spitalfields Collections. Both collections are of known age and sex, lived in urban environments, and can be used to help understand, more specifically, some of the possible impacts of osteoarthritis on them.

When I began my research on osteoarthritis, I hypothesized there would be a strong occupational and social component, with more difficult work and living conditions producing less healthy individuals. I surmised that quantity as well as severity of osteoarthritis in the appendicular skeleton would relate to these two factors. In addition to work and health, I believed the sex of the individual would also be a prime determinant of both the development and severity of osteoarthritis. My initial hypotheses included the question that men who worked at strenuous jobs would develop osteoarthritis earlier in life and in the lower limbs, whereas women would show more upper body osteoarthritis at younger ages and more generalized osteoarthritis as they aged based on a different type of work as well as hormonal impact. I did not initially consider the impact of weight or genetics in my initial analytical framework nor did I consider comparing the women or men of one collection to the other. Over the course of my investigation of both collections, I expanded my analysis to include the possible impact of weight on the lower body of women (impact of multiple pregnancies and general placement of body fat in women). This directed me to compare women and men in one collection to their sexual counterparts in the other. This expansion of my initial hypotheses allowed me to further elucidate the difference between collection as well as the possible similarities between sexes regardless of collection.

The Terry Collection consisted of a generally lower socioeconomic class of people than that of the Spitalfields Collection. These individuals were from institutions throughout the St. Louis area as well as those who were not claimed by family or friends or had their bodies donated to science. Even though we know who they are and what their ages at death were, as well as some general data on weight, height, and sometimes occupations, the lives of these people is often unclear. By comparison, the people of Spitalfields are relatively well known. For some individuals, we know their familial relations, information about diet, occupations, housing, living conditions as well as sex and age at death. Unlike Terry, the people of Spitalfields were middle to upper middle class individuals with more highly skilled jobs and better diets and lifestyles, despite the difference in the time periods of each population (Spitalfields lived from the 1700 to 1800's, and Terry lived from the 1800 to 1900's). Even with this difference in temporal space, the people of Spitalfields had a better-lived experience, even with poorer medical care. These two populations are ideal for understanding the larger implications of understanding both the etiology and impact of osteoarthritis in past and current populations due to the amount of discreet data known about each group. Unlike unknown skeletal populations where individuals past age 50 are lumped into one category (Old Adult), these collections can help me better understand the impact of age, stress and sex on osteoarthritis as well as similarities and differences between the two collections.

My initial objectives when starting this research was identifying the key features and what are the most likely contributors related to osteoarthritis in these skeletal populations. While age is a factor in other studies, these two known populations can demonstrate in what decade of life osteoarthritis began, which sex showed a higher rate of progression and which joints were most affected. I also compare the two cemetery populations by sex, age and joint to determine if any differences are manifested, where they are found and which groups exhibit greater extremes of osteoarthritis than others. In addition, this review of the data using the Chicago Standards guide allowed for an opportunity to evaluate whether the methods used to analyze skeletal metrics are reliable when known people are measured. My secondary objective was to determine if some positive correlation between osteoarthritis and type of occupation as well as the possible impact of social class might be discernable (when comparing the lower social class individuals of Terry with the middle class workers of Spitalfields). I also hypothesize that despite class differences, the access to modern medicine by those of the Terry Collection may show a decrease in osteoarthritis compared to that of Spitalfields.

In the following pages, I will provide a general overview of osteoarthritis, the prevailing theories that were the foundation of my research, a background of the populations studied as well as analysis and discussion of the results.

1.1 Osteoarthritis – an overview

The terms Osteoarthritis (OA) and Degenerative Joint Disease (DJD) are used synonymously in the literature of both the anthropological and medical communities although DJD can sometimes be used more broadly to discuss other types of arthritis (Haq et al., 2008, Klaus et al., 2009). Both of these terms ultimately discuss a set of specific degenerative changes to joint surfaces in the human body. This use, however, has received some criticism from a small, vocal group of anthropologists (Weiss and Jurmain, 2007). The first question that needs to be answered is, what is osteoarthritis and why is it important to understand this degenerative disease?

Osteoarthritis is a chronic degenerative disorder of multiple etiologies, which involves the loss of articular cartilage, bone growth at the margins of joints and alteration or destruction of the cartilage and synovial fluid membrane (the fluid pocket found between the joint surfaces) (Lieverse et al, 2007, Mahajan et al., 2005, Kalichman et al., 2002). Despite medical interventions in nutrition, current medical therapies or physical treatments, there is no cure for osteoarthritis (Buckwalter et al., 2004). Osteoarthritis is second only to osteoporosis as a leading cause of musculoskeletal morbidity in elderly people (50+) and is the most common form of musculoskeletal disease in the world (Kalichman et al., 2002, Brooks et al., 2002). The deterioration commonly affects both load bearing joints as well as the hands and the temporal-mandibular joint but can be found between any joint surfaces in the body. Currently, osteoarthritis has a worldwide distribution, and is commonly encountered in the archaeological record exhibiting global evidence of this disease (Haq et al., 2008, Cope et al., 2005). Common symptoms of osteoarthritis are pain and stiffness, although people can have the disease and be asymptomatic (Sarzi-Puttini et al., 2005). Other symptoms include decline of function and use of the affected joint that can be quite painful and severe in large joints (e.g., weight bearing joints) requiring total joint replacement (Mounach et al., 2007). In anthropology, the four general features identified as osteoarthritis are: hypertrophy of the joint margins (lipping), osteophytes (small buttons of bone found on the joint surface), porosity (a series of pin-sized or larger holes on the joint surface) and eburnation (bone-on-bone contact resulting in polishing and/or grooves in the joint surface) (Lieverse et al, 2007).

Osteoarthritis is generally classified into two types – primary and secondary. Primary osteoarthritis can be either localized (specific to a few areas) or generalized (found all over the body) and is usually linked to the process of aging (Haq, 2003). Secondary osteoarthritis, however, is more often associated with some sort of trauma, specific disease, or infection (e.g., septic arthritis) and is not often reviewed by anthropologists in the context of generalized osteoarthritis, as its etiology is understood (Mahajan et al., 2005).

A number of factors are cited as causes of the development of osteoarthritis. The identified causes include: age, trauma, weight, genetic predisposition, sex, and mechanical/occupational stress (Cope et al., 2005, Felson, 1996, Lieverse et al., 2007, Brown et al., 2008, Jurmain, 1977, Jurmain, 1980, Jurmain, 1991, Klaus et al., 2009, Ruff, 1992). Felson and colleagues (2000) also cite soft tissue laxity (ligaments and muscles) as a possible factor in the development of osteoarthritis in load bearing joints, suggesting that weak soft tissue support of the joint could cause displacement or rotation of the joint surface, aggravating the area. It is generally suggested that age shows a positive correlation with the onset and severity of osteoarthritis and is the most common and well-documented cause of this cumulative deteriorating condition (Knusel et al., 1997, Lieverse et al., 2007, Brown et al., 2008, Jurmain, 1980, Jurmain, 1977, Klaus et al., 2009). Before age 50, men show greater overall evidence of osteoarthritis than women (with hip osteoarthritis being most frequent). After age 50, women exhibit more hand, foot and knee osteoarthritis than men (Felson et al., 2000). Obesity is generally seen by the medical community as another key aggravating factor of knee osteoarthritis and is the strongest modifiable risk factor in living people and could have affected in skeletal populations as well, and in particular, some of the people at Spitalfields (Haq et al., 2003, Sarzi-Puttini et al., 2005, Felson et al., 2000, Hunter et al., 2002, Felson, 1996, Molleson et al., 1993).

There is much debate in the anthropological community about the ability to understand the impacts of occupation and stress and its relation to the development of osteoarthritis. Despite this conflict, it is included in most analyses (Weiss and Jurmain, 2007). The discipline is noticeably divided on this issue, with some scientists switching sides back and forth on this subject over the years, moving from a position that environmental stress was a “primary focus of the onset of OA” to stating that “osteoarthritis not an ideal indicator of the overall level of activity" (cf., Jurmain 1977, 1980, 1991; Weiss and Jurmain, 2007 and Jurmain, 1999).

Within the medical community, stress and occupational impacts are a primary focus of many investigations and it is strongly suggested that occupations involving repetitive tasks and/or heavy joint loading (or overloading), there is a higher prevalence of osteoarthritis (Felson et al., 2000). Many studies identify occupations that osteoarthritis impacts, citing specific joints (farming and hip osteoarthritis, knee osteoarthritis and playing football or occupations that require heavy lifting, kneeling or squatting, elbow and shoulder osteoarthritis and baseball pitchers or house cleaners) (Rossignol et al., 2005, Holmberg et al., 2003, Hunter et al., 2002, Kumar and Kumar, 2008, Nordander et al., 2007, Mazoue and Andrews, 2004). Despite the medical community's admission that the causes of osteoarthritis are still poorly understood, there is a clear consensus that this degenerative condition does have an occupational component.

It is even more difficult to identify what is and is not the cause of osteoarthritis in historic and prehistoric populations. Even with these limitations, many skeletal studies evaluate osteoarthritis to better understand the health and well being of a group and perhaps glean some insights into both their work and personal lives based on the frequency, severity and distribution of osteoarthritis. The advantage that anthropology has over the medical community is that we are able to examine the entire joint, minus any flesh or cartilage, giving us a complete view from all angles, whereas rheumatologists are only able to view joints via radiograph or laparoscopic camera. Understanding the causes of osteoarthritis is considered a vital, if controversial, method to better understand how physical labor and culture impacts individuals.

1.2 Study of osteoarthritis by the anthropology and medical communities

Osteoarthritis has been extensively studied by anthropologists and the medical community. Entire journals are dedicated in the clinical setting (e.g., *Arthritis & Rheumatism, Joint Bone Spine, Annals of Rheumatic Diseases*, etc.). In some instances anthropologists contribute articles to these journals to bring both paleopathological skeletal studies together with clinical research, giving a cross disciplined approach (Rogers et al., 2004).

Many studies involve the impact of treatment options and how they can create an improved quality of life (Felson et al., 2000, Sarzi-Puttini et al., 2005, Mahajan et al., 2005). Others focus on the impact of occupation from different activities (sport participation, certain types of work) on the development of osteoarthritis (Rossignol et al., 2005, Holmberg et al., 2003, Hunter et al., 2002, Kumar and Kumar, 2008, Nordander et al., 2007, Mazoue and Andrews, 2004). This research can be divided by sex as well (Nordander et al., 2008). Many of these studies can and should influence anthropology in terms of understanding the biocultural-impacts of osteoarthritis on skeletal populations.

In anthropology, the study of osteoarthritis is often connected to larger skeletal evaluations of lifestyle in populations. In the case of the larger skeletal evaluation, osteoarthritis is often used in the assessment of a deterioration of the lifeways of peoples before and after an event. In the case of some studies, European contact is the factor used to understand if life and health improved or deteriorated (Klaus et al., 2009, Larsen 1981). Osteoarthritis is one of the key factors in making these assessments of general health and stress placed on the indigenous people (Klaus et al., 2009). Often, this same method is applied to studying behavioral shifts over time (e.g., with shifts to agriculture) or patterns of heavy labor at the location by observing the severity of joint deterioration (Klaus et al., 2009, Cope et al., 2005, Lieverse et al., 2007, Jurmain, 1991).

It is not uncommon for studies to compare multiple populations who lived in a similar time period or to look at different social classes within a single population to determine the impact of hard labor on different groups/classes (Ortner, 1968, Jurmain, 1991, Knusel, 1997). Other studies focus less on specific groups but more on the impact of aging of certain joints. Experimental works are being conducted with cadavers to understand the biomechanical implications of osteoarthritis in the human body (Stevens and Vidarstdottir, 2008, Brown et al., 2008, Kalichman, et al, 2002).

In addition, some studies focus on how sex and occupational stress affect the development of osteoarthritis (e.g., Slaus, 2000). Much of the literature and studies being done include osteoarthritis in some way when they are discussing stress, lifestyle and morbidity in skeletal populations. This regular inclusion of osteoarthritis in studies where the primary focus may be on other forms of morbidity suggests that it is believed to be a strong indicator of the health of an individual and/or population despite some objections as to its value. It is clear that while age is a well-known indicator in the development of osteoarthritis, many of the studies conducted by medical practitioners also focus on the impact of stress and workload elucidate the lifestyle and health implications that osteoarthritis can have on a group than that of age alone (Rossignol et al., 2005, Holmberg et al., 2003, Hunter et al., 2002, Kumar and Kumar 2008, Nordander et al., 2007, Mazoue and Andrews, 2004).

1.3 Rheumatoid arthritis and its relation to osteoarthritis

Rheumatoid arthritis (RA) is a chronic, autoimmune, and inflammatory arthritis of unknown etiology that can result in joint damage, deformation and possible disability (Lequerre et al., 2009). Most people recognize the visible features of this form of arthritis due to the deformation of the joints (most visible are the hands). However, it can and does affect other joints and areas of the body and symptoms range from fatigue, myalgia, weight loss and depression. The current medical consensus for the pathogenesis of RA includes a genetic vulnerability to an environmental, possibly viral, trigger, leading to autoimmune inflammation that leads to joint destruction (Devlin, 2009). More women than men suffer from this type of arthritis and the general age of onset is between 50 and 70 years of age, although it can occur at any life cycle stage (Devlin, 2009).

Little is written about rheumatoid arthritis in anthropological journals and minimal study has been done. This type of arthritis does not appear to affect the joint until the advanced stages of the disease when deformation begins to occur. With this in mind and understanding the median age of most skeletal populations is younger than aged 50, evidence of this problem in the skeletal record is limited. In addition, the autoimmune component of this disease in skeletal populations may be difficult to assess deriving from diet, health or work on complicating the understanding of how biocultural factors impinge rheumatoid arthritis. This particular disease seems to have no correlation at this time to osteoarthritis.

1.4 Osteoporosis and its relation to osteoarthritis

Unlike rheumatoid arthritis, osteoporosis has been extensively investigated (Armelagos, 1969, Mays, 2000, Mays et al., 2006, Mays, 2006, Mead, 2008) and is probably the most obvious type of arthritis found in the archaeological record second only to osteoarthritis. Osteoporosis is characterized by abnormalities in the amount and architectural arrangement of bone tissue leading to impaired skeletal strength and increased susceptibility to fracture risk (Melton et al., 1992). Generally, osteoporosis is found in greater frequency in women due to the hormonal changes of menopause, which causes accelerated bone loss (Brickley, 2002).

While osteoporosis is found in both sexes and bone loss generally increases as people age, it is generally not associated with osteoarthritis (Mays et al., 2006, Agarwal and Grynpas, 2009). Individuals who suffer from osteoporosis historically share similar occurrence patterns with contemporary populations and a possible genetic component in the cause of osteoporosis may account for this consistency (Mays, 1996, Mays, 2006, Mays et al., 2006). Since osteopenia/osteoporosis (evidenced by bone loss) is generally not found in a subject that suffers from osteoarthritis (evidenced by additional bone growth) they are not generally discussed within the same individual.

1.5 Conclusion

Osteoarthritis is extensively analyzed in the anthropological community to assess the lifeways of skeletal populations through time. While age is the clearest indicator of the amount and severity of osteoarthritis one might find on a skeleton, it is more often used in conjunction with other indicators of stress (e.g., cribal orbitalia, dental hypoplasias, rickets, etc.) to identify the impacts of stress and workload had on the body throughout an individual's life. Although stress/workload severity and type are topics for much debate, there may be a way to measure occupational impact in living humans, by studying the skeletons of historic and prehistoric groups. The preponderance of data from the medical community on the impact of occupation and mechanical loading stress (from obesity and occupation) suggests that there is a positive correlation between the development of osteoarthritis and the lifestyle and work lives of the studied groups.

1.6 Theoretical Framework

1.7 Life History Theory and how it pertains to osteoarthritis

Life history theory is a generalized theory, originally (and more often) used in the evolutionary and developmental biological communities to interpret the adaptive value of different survival strategies in animals of all kinds. The primary focus of life history theory is on the beginning of life, birth, parental investment, period of juvenility, and fertility and growth (Worthman and Kuzara, 2005). The immediate connection to osteoarthritis does not occur until one analyzes elements of this theory such as the grandmother hypothesis (Worthman and Kuzara, 2005, Hawkes et al., 2006). As life history theory helps interpret the value of longevity in human life cycles, it also gives hints to the energetic trade-offs needed to have longer lives. Chronic conditions, such as osteoarthritis, do not generally affect the young (under age 40) nearly as much as individuals who are above 40. The payment for long life in humans and slow aging in women and men after age 40 may be the onset of slow chronic degenerative conditions such as osteoarthritis. When we begin to look at the longevity of humans when compared to other primates (chimpanzees in particular) the energetic trade-offs for longer living become relevant to the development of osteoarthritis.

In general, life history theory attempts to place the phenotypic variation of species in the context of their evolutionary fitness (Worthman and Kuzara, 2005). The idea is that understanding these variations will generate a species-specific set of traits and characteristics that explain its life course (Worthman and Kuzara, 2005). In humans, this leads to an animal of large size that has a period of childhood (slow development) and adolescence (much more rapid development and sexual maturation relative to childhood), which incorporates an extended period of growth (Wells and Stock, 2007, Kaplan et al., 2000). Humans have the longest life span of all primates averaging 85 years with the next longest-lived primate, the orangutan, living 58.7 years (Robson et al., 2008). This increased human lifespan is only applicable to the 20th century and less so to archaeological populations.

Humans have the shortest interbirth interval of any other ape but live longer and females have the potential for latest age at last birth of ~47 years among some hunter-gatherer societies (Robson et al., 2008). Due to technology and complex social structures, humans have decreased the interbirth interval even to as short as 2 years or less in some farming communities (the shortest interbirth interval of all apes), compared with a 5.46-year interval in chimpanzees, 6.25 in bonobos, 4.40 in gorillas and 7.0 in orangutans (Kaplan et al., 2000, Bogin, 2001; Wells and Stock, 2007; Strassmann and Gillespie, 2001; Robson et al., 2006).

In addition, because of increased longevity, human women undergo menopause and live well past the age of reproduction (Bogin, 2001). It is speculated that only human women undergo this change of life but there is a suggestion that a species of whales do as well (Bogin, 2001). This post-reproductive stage in humans suggests that these women may act to help benefit their younger kin in raising subsequent generations, often called the grandmother hypothesis (Hawkes et al., 2006). Because post-menopausal (>50) women age very slowly compared to other primates, this idea of provisioning their offspring and grand-offspring shows some evolutionary value. With human senescence spanning multiple decades, a more vigorous post-menopausal life would be possible. Degenerative conditions, such as osteoarthritis, would become more prominent as the body deteriorates from continued wear over the course of the lifetime. The additional duties of rearing and/or provisioning grandchildren and children could also create more opportunities for accumulation of osteoarthritis via stress and wear and tear on the skeleton that the body cannot repair.

Human ages at first birth are much later than their primate cousins, averaging at 19.5 years (20th century average) compared to 13.3 in chimpanzees and 15 years in orangutans (Robson et al., 2006). In modern industrial societies, wealthier people raise fewer children than do poorer people, a trend that is becoming more noticeable in developing nations (Kaplan, 1996, Wells and Stock, 2007). Even with this change in subsistence economy, humans still outperform their primate cousins in number of offspring per lifetime (Robson et al., 2006). This late age at first birth may be explained as a result of the time needed to acquire skills for survival without provisioning from parents as well as allowing for brain complexity to complete its development throughout childhood and adolescence (van Schaik et al., 2006). With such an expensive, large, and complex brain, the longevity of humans makes sense when understanding this length of development and maturation time of their cognitive skills as well as the role of older adults in supporting their children and grandchildren (van Schaik et al., 2006).

So the question remains, how does life history theory explain the onset of osteoarthritis? Due to the factors listed above that allow for longer life spans in both hunter/gatherer and early farmers, technology and cultural adaptations and developments have played a key role in the slow shift towards longer lives. Since age is the most definitive factor in the development of osteoarthritis, chronic conditions like osteoarthritis do not generally appear in humans until they reach old age, therefore, are not affected by natural selection (Knusel et al., 1997, Lieverse et al., 2007, Brown et al., 2008, Jurmain, 1980, Jurmain, 1977, Klaus et al, 2009).

Aging, also called senescence, is defined as the time when the body cannot adapt to changes in the environment as well as it had been previously able and problems begin to accumulate over time (Bogin, 2001). Chronic illnesses tend to manifest as a result of a collection of stresses that happened earlier in life (Loustaunau and Sobo, 1997). The onset of osteoarthritis as seen through the lens of life history theory could be viewed as the trade-off for longevity. Longer life allows for an accumulation of mechanical and health stresses as well as general use of the bones in the body. At some point, the systems that keep the collective damage at bay begin to fail and accumulated damage manifests. Osteoarthritis is one of the chronic conditions of extreme longevity. In addition, the changes in hormones as we age (in both men and women) could also have a noticeable impact on how much damage is repaired over the course of longer lives. With bone turnover in males and females diverging later in life (post menopausal bone changes in women in particular slows), understanding this is important for interpretation of stress and energetic trade offs.

1.8 Stress theory and osteoarthritis

Stress theory differs from life history theory in that it focuses on impacts of reaching the limits of one's ability to adapt to environmental impacts (Goodman et al., 1988). Many things can cause biological stressors in an individual and a population. Some more commonly reviewed and well documented stressors found in the archaeological record are diet, disease, power (or lack thereof), poverty, parasitic infestations, repetitive task injury, occupational hazards, violence, socioeconomic class, shifts in diet type and living environment (Klaus and Tam, 2009, Papathaunasiou, 2005, Mosothwane and Steyn, 2009, DeLeon, 2007, Saunders and Hoppa, 1993, Leatherman and Goodman, 1997, Goodman et al., 1988, Armelagos, 2003, Armelagos and Harper, 2005, Armelagos, 2004, Boyden 2004).

Stress theory helps explains how living conditions and diet impacts health. The difference between stress theory and life history theory is that the focus is less on the reasons humans developed the way they did and more on the mechanism by which the body wears out, or wears out more easily. With stress theory, there are multiple impacts on the body over the course of its lifetime that affects other health problems (e.g., dental caries, repetitive motion injuries, poor diet, obesity). It makes sense that the stressors on the physiology of the individual experiencing them would also impact a disease that is degenerative in nature. What is not clear, however, is which of these stress incidences contribute to cumulative degenerative disease. Many studies include osteoarthritis as a component of impacts of lifestyle on the health and general wellbeing of the skeletal population they are studying. However, there is much debate in the anthropological community about the ability to understand the impacts of occupation and stress and its relation to the development of osteoarthritis (Weiss and Jurmain, 2007). There is a clear division among anthropologists that discuss this very common degenerative condition. No scientist can get definitive occupations from observing osteoarthritis in skeletal populations (although some types of osteoarthritis such as squatting facets can tell us what activity was performed by the body), the idea that any occupational impacts can be understood is under debate (Weiss and Jurmain, 2007, Dlamini and Morris, 2005). While specific jobs may not be able to be determined, strenuous working lives can leave markers on the bones via development of osteoarthritis. If I could understand the cause of osteoarthritis more clearly, the use of the stress theory would more adequately address the impacts on the body that could cause the onset or intensity of osteoarthritic development to increase.

1.9 Impact of sex, class, and occupational differences and osteoarthritis

Much of the impact of stress in the human body has been outlined. However, sex, class and occupation are three key areas that likely affect the health and well being of populations being studied and osteoarthritis is one of the components measured.

Sex can be discussed in two ways in relation to osteoarthritis, as a hormonal component and in gendered division of labor (Klaus and Tam, 2009). It is not uncommon for populations to be divided by sex to examine what impacts different environmental factors have on women versus men. In the case of my study, I use biological sex as a way to compare women from Terry to women from Spitalfields as well as women to men within the same collections. By looking at women or men in one collection versus the other, I can understand more about the affects of age and sex on the development of osteoarthritis. These same things can be said for the men as well. When comparing both cemeteries, I also observe the results of possible work lives and dietary influence on the general health of the two populations. While there is a genetic component linking sex to osteoarthritis, it is often not the sole focus of studies, nor is it the sole focus of this analysis.

Socioeconomic class is often used to understand how lack of availability to resources can control a group. Often those who have no socioeconomic power (e.g., access to money, resources or even health care) are the targets of study by anthropologists. In specific, the Terry Collection falls into those “without”, or in this case, of lower socioeconomic class, suffering from poverty and with little access to adequate medical care (Leatherman and Goodman, 1997). Class is not always clearly defined in the archaeological record. It is possible to look at diet, dental health, attempts at medical interventions, and general skeletal health to make assessments about classes in unknown populations. However, I am rarely 100% certain that our assessments are accurate. Due to a lack of clear documentation and data on the persons I am assessing, I can only guess as to what their social standing was or was not. Despite these restrictions, it is often the subject of study and can be found in studies comparing different time periods of occupation or with pre- and post contact and how osteoarthritis is impacted by it (Papathanasiou, 2005, Nagaoka et al., 2006, Klaus et al., 2009). Occupational/work-related differences are considered most often alongside socioeconomic status. While specific occupations are infrequently discussed, the generalities of hard work, repetitive motions indicative of certain types of work and general beliefs about the impact of hard work are assessed and osteoarthritis is generally the indicator of this mechanical form of stress (Papathanasiou, 2005, Mosothwane and Steyn, 2009).

Occupation-based diseases are endemic in the literature. Diseases such as clay-shovellers fracture, housemaid's knee, sweeper's cancer, stonemason's disease, and repetitive strain injury are just a short list of occupation-based diseases and disorders (Knusel et al., 1996, Boyden, 2004). Occupation and activity related osteoarthritis is a vast and controversial avenue of study in anthropology at this time. It is not unreasonable to suggest that activity and perhaps occupation undertaken over several decades of life would shape the joints of the body, and as a result, affect the severity of osteoarthritis.

While there is substantial body of literature on life history theory regarding the development and fertility of human beings, there is less about aging and death and even fewer about the brunt of environment on the adult human. Stress theory explains the impacts of diet and disease, class, activity, and occupation are the strongest indicators of the possible environmental and social factors of osteoarthritis outside of the component of age.

1.9.1 Hypotheses and experimental protocols

There were several reasons why these two collections were chosen over others. The three primary reasons were as follows: both populations were from urban centers, both age and sex were known, and additional data was know about occupation in some instances.

When comparing the two collections to one another, it was important to understand what sort of environment that they were living in. There has been extensive study of rural communities but the focus of my research is aimed toward city dwellers (which probably also include migrants from rural to urban areas). Since both populations were primarily living in city environments they would be more easily comparable despite the difference in time between the two.

The individuals in both collections were also chosen because both their sex and age were known. This knowledge has several advantages. It first allows for less time trying to accurately assess age and sex, allowing for a greater quantity of individuals to be analyzed. With a correct age at death known, I could more easily separate individuals by decade rather than by using more general age groups (e.g., 20-35, 36-50, 50+). There is decreasing accuracy in estimating skeletal age over 40 years, which is exactly the window when osteoarthritis begins (Lovejoy et al., 1985, Steele and Bramblett, 1988, Buikstra and Ubelaker, 1994).

With more specific ability to compare individuals by age at death, it is easier to more accurately assess its impact on the onset of osteoarthritis. The benefit of known sex also allows for the ability to compare similarities and differences both between sexes within and between populations. Additionally, individuals with more robust (for women) or more gracile (for men) skeletons or those with less clearly distinguishable sexual characteristics are able to be included with confidence.

Finally, additional data is known about each group (e.g., occupation, stature, weight at time of death, cause of death). I also hypothesize that despite class differences, the access to modern medicine by those individuals of the Terry Collection may show a decrease in osteoarthritis compared to that of Spitalfields.

2 EXPERIMENT

2.1 Materials and Methods

2.1.1 Description of the research locations populations and data collection

Data collection was performed on 322 total individuals (162 males and 160 females) in the laboratory space at the Smithsonian Institution (Washington D.C.) and Natural History Museum (London) with permission from Dr. David Hunt and Dr. Margaret Clegg respectively. These collections were selected due to the sex as well as age at death being known, allowing for more accurate and specific analysis. This was undertaken over the course of 10 days (five at the Smithsonian Institution and five at the London Natural History Museum) during the month of May 2009. Data was recorded in Microsoft Excel 2007 and archival data was provided in pdf, xls and hard copy for both collections. Digital photos were taken of both samples, with permission from the Smithsonian Institution and London Natural History Museums using a Canon Digital Rebel XTi camera.

2.1.2 The Terry collection

The Robert J. Terry Collection is comprised of skeletal remains from individuals who lived in and around the city of St. Louis, Missouri who died between 1910 (when this iteration of the collection was formally started) until the completion of the collection in 1967 (Hunt and Albanese, 2005). During the time of acquisition, two scientists were involved in obtaining specimens for, collecting data on and managing the collection, Robert Terry and Mildred Trotter. The original location of the Terry Collection was at Washington University in St. Louis, Missouri (Hunt and Albanese, 2005). In 1967, after Mildred Trotter retired, the collection was moved to the Smithsonian Institution and is now under the curation of Dr. David Hunt, Collections Manager, Division of Physical Anthropology, National Museum of Natural History.

What is remarkable about the Terry Collection is that identifying and demographic information is documented for all individuals including age at death, sex, name, occupation, weight and often cause of death. The location of what part of the country the individuals lived was also known. Individual's age at death ranged from 14-102 years with the majority falling into the 20-80 year age range (Hunt and Albanese, 2005). The mean age at death for women is 58 years old and mean for men is 53 (Hunt and Albanese, 2005). In the collection, the range of years at birth of individuals studied for this research span from 1828 to 1919 with deaths ranging from 1910 to 1966. The entire collection's age ranges at birth and death differ from the subsection of those selected for review[1] (Hunt and Albanese, 2005). Unlike the Spitalfields cohort, the Terry

[1] Per Hunt and Albanese (2005) range of years at birth span from 1828 to 1943 with deaths ranging from 1910 to 1967

Collection was assembled for the purposes of anatomical and skeletal analysis and the individuals were brought to Terry and Trotter often without overly detailed backgrounds or the ease or ability to track down family history or data on the lives of the decedent. While this collection is remarkable, the lack of data on the lived experience of the individuals in the Terry Collection can make it difficult to make more than the most general assessments about their personal lives.

During the course of amassing the collection, there was a heavy demographic skewing towards adult males (likely due to the nature of how the individuals came into the collection) (Hunt and Albanese, 2005). Margaret Trotter, the second contributor to the collection, focused her time on adding women to the collection to balance the amount of total women in comparison to the men. The number of men in the collection totaled 950 and women totaled 658 when additions stopped in the 1960's (Hunt and Albanese, 2005).

The demographic group of the Terry Collection was primarily gained from institutional morgues and St. Louis hospitals, with a small percentage of individuals coming from other institutions around the state of Missouri (Hunt and Albanese 2005). Another key feature of the Terry Collection is that the majority of the individuals collected were of a lower socioeconomic class who were not claimed by relatives and would have been buried at the expense of the state so one can assume the lives of these individuals was not terribly easy, diets may have been poor and individuals may have had other chronic illnesses that would have impacted their overall health and well-being. While little is known about the details of their daily life, much more is available about the end of it than is known about those of Christ's Church Spitalfields.

2.1.3 The Spitalfields collection

Unlike the people that populate the Terry Collection, those at Christ's Church Spitalfields were buried with the upmost care by their relatives (and some notable expense). In the collection, the range of years at birth of individuals analyzed for this research span from 1646 to 1814 with deaths ranging from 1729 to 1852. Christ Church Spitalfields exists today as an Anglican church still in operation in East London. It is located at the corner of Fornier and Commercial Streets in the London borough of Tower Hamlets within a short walk of the Aldgate East tube stop.

The entire collection age ranges at birth and death differ slightly from those selected for review[2]. The crypt burials at Spitalfields were extensive with over 1,000 interments (Molleson et al., 1993). Among the individuals sampled, the range of years at birth of this collection span from 1646 to 1844 with deaths including the first interment of Susannah Hull in 1732 to William Louis Moinier Leschalles in 1852 (Molleson et al., 1993). With burial expenses running as high as 200+ pounds in the late 1700 and early 1800's for a crypt burial, those who were privileged enough to be buried there and not the connecting churchyard were obviously cared for and remembered by their families who had the means to cover those expenses at the time of their death, or at least funeral expenses had already been paid for by the deceased (Molleson et al., 1993). The birth of the oldest members of the Terry Collection overlaps with the deaths of the latest members of the Spitalfields Collection so they are not contemporary collections per se, however, the overlap is not temporally significant to the study. The mean age of the

[2] Per Molleson, the complete range of years at birth of this collection span from 1646 to 1844 with deaths ranging from 1732 to 1852.

women buried at Spitalfields in the sample is 64 years and the mean for men is 60 years.

Unlike the Terry Collection, the residents of Spitalfields were of middle to upper middle class and had lifestyles and careers to fit their social standing with more access to healthy foods and health care of the period (Molleson et al., 1993). While Spitalfields did have potential access to more resources, the types of health care and ideas about balanced diets differed, sometimes dramatically, from that of those living at the time of the Terry Collection (Molleson et al., 1993). Even within the Spitalfields group, there is evidence of economic decline in the 19th century portion of the collection, with dietary deficiencies becoming more evident (Molleson et al., 1993). Even with this decline, the people of Spitalfields were successful enough life to be interred under the church so while perhaps not as well off financially as their predecessors, were still likely solidly middle class as obesity appears to have been an issue based on the amount of adipocere left in many coffins and shown in paintings of some of those buried there (Molleson et al., 1993).

The diet of the earlier portion of the sample appears rich in animal proteins and fats as well as a fair portion of fruits, vegetables and cereal crops (Molleson et al., 1993). This variety decreases in the 19th century portion of the sample, suggesting a decline in access to a more variable, but not necessarily unhealthy, diet (Molleson et al., 1993). During the primary period that the crypt was in operation, Spitalfields (then a suburb East of London) was the center of the silk industry in England (Molleson et al., 1993). Many of the families buried in Spitalfields participated in the silk industry and were of Huguenot ancestry (French Protestants) who had fled religious persecution in

France. Spitalfields silks and other textiles were highly valued by not only wealthy English, but the Crown as well, described as a variety of "lustrings, velvets, brocades, satins, very strong silks known as paduasoys, watered silks, black and coloured mantuas, ducapes, watered tabies, and stuffs of mingled silk and cotton-all of the highest excellence" (Cockburn et al., 1911). In addition to these residents, other city notables were also found buried in the crypt, including barristers, members of parliament and a former mayor of London (Molleson et al., 1993).

Much more is know about the life, health and daily work of those buried at Christ's Church and while not all individuals are positively identified, 387 are known with the range of age at death spreading from stillbirth to 92 years of age (Molleson et al., 1993). One of the most fascinating aspects of the Spitalfields Collection is the named sample. At least 129 related people were recovered resulting in a total of 245 related pairs with most of these families being of Huguenot origin and heavily involved in the silk industry, as mentioned above (Molleson et al., 1993). In my sample, 56 individuals bore the same surname as another individual in the collection and some were more prevalent (Pontardent 3, Lemaistre 6, Mesman 4, Curtis 6, and Hull 3). Of the families in my study, nine family names have confirmed lineages (Gamage, Mesman, Lemaistre, Merzeau, Thistleton, Jourdan, Giles, Julien and Pontardent). My study includes one brother and sister pair (2461 and 2142), one mother and son pair (2561 and 2577), father and son pair (2537 and 2468) as well members of the family groups listed above (Molleson et al., 1993). While I was not aware of this fact at the time of study, this leaves an opportunity to revisit this collection and observe not only familial physiological traits, but perhaps better understand if there is an impact in family lines for the prevalence and age at onset of osteoarthritis.

Occupations are also known from the Spitalfields sample. The vast majority of those buried in the crypt worked in the silk industry (39.6%), 14% from food retail and manufacturing, 15.6% were involved in different building trades, and the remaining occupations known range from MP, lawyers, surgeons and brush makers and bird breeders (Molleson et al., 1993).

The diversity of location of life for those buried in the crypt at Spitalfields covers large potions of London and beyond. At time of death, 38.5% of the named individuals lived in the parish of Spitalfields with 38.9% living in the nearby parishes of Bethnal Green, Whitechapel, Shoreditch, Bishopsgate, Miles End, Stepney, 21.7% in other London parishes with the remaining 1.3% from outside of London (Molleson et al., 1993).

Like Terry, we know the name, age at death, sex, and often the occupation of 387 individuals buried in the crypt, of which 162 were used in this research.

2.1.4 Data collection, scoring, measurements and methods

Data collection was completed in two ways, visual analysis and measurements, using a digital spreading caliper. Visual analysis was conducted on the shoulder, elbow, knee and hip joints (16 total surfaces) for three pathological features of osteoarthritis. The selected joint surfaces were the glenoid fossa of the scapula and the proximal humerus for the shoulder, the distal humerus and the proximal ulna for the elbow, the acetabulum of the innominate and the proximal femur for the hip and the distal femur and proximal tibia for the knee. Left femoral head sizes as well as left femoral midshaft measurements were taken using a digital spreading caliper. My initial training for visual observation of osteoarthritis was learned in the forensic anthropology class of my undergraduate university with additional instruction from Dawn Cobb, Osteologist at the Illinois State Museum. Further training on understanding how to visually identify and score osteoarthritis and handle femoral and femoral midshaft measurements was provided by Dr. Frank L'Engle Williams, Georgia State University. Dr. David Hunt, Collections Manager, Division of Physical Anthropology, National Museum of Natural History provided additional guidance into how to observe and understand the presence of osteoarthritis of the acetabulum using Buikstra and Ubelaker's (1994) data collection standards.

Femoral head diameter measurements were taken to compare the actual measurement of the individual (of known sex) against the guide for sex provided by Bass (2005) which identifies individuals whose maximum femoral head measurement is >45cm as male and <45cm as female. Those individuals who from 45-46cm are normally considered indeterminate, but in this study, this distinction was not needed, as sex was known on all specimens (Steele and Bramblett, 1988).

Mediolateral diameter of the midshaft of the femur measurement was taken using a spreading caliper to estimate body mass of the individuals studied as not all those chosen had a weight given at or near time of death (Bass, 2005).

Minimum criteria for inclusion in the study were as follows: Adults over the age of 20 years with at least one observable joint surface and known sex and age at time of death. No adults with unknown sex or age at death or commingled remains were included. Joint surfaces were considered present when >25% of the joint was visible and undamaged by decay and/or storage.

Individuals in the Terry and Spitalfields Collections were selected because of known sex and age. A complete breakdown of age by sex and decade for each collection, as well as the age by decade for both collections (not divided by sex) can be found in Tables 2.1-2.3.

Table 2.1 Age of Individuals in Terry Collection (n=80 females, n=80 males)

Sex	20-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100+	Grand Total
Females	3	6	11	13	18	12	11	6	80
Males	3	10	6	20	24	14	3	0	80
Total	**6**	**16**	**17**	**33**	**42**	**26**	**14**	**6**	**160**

Table 2.2 Age of Individuals in Spitalfields Collection (n= 80 females, n=82 males)

Sex	20-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100+	Grand Total
Females	6	5	11	20	17	14	7	0	80
Males	4	12	8	17	24	13	2	2	82
Total	**10**	**17**	**19**	**37**	**41**	**27**	**9**	**2**	**162**

Table 2.3 Age of Both Collections by Decade

Sex	20-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100+	Grand Total
Total	6	33	36	70	83	53	23	8	322

Fragmented joints observed with >75% missing joint surface, manifesting excessive fragmentation to effectively analyze and absent joints were scored as missing data. All available joints that were analyzed for pathologies but had no identifiable features were listed as 0.1. Sub-adults were excluded due to lack of complete bone fusion and extremely low instance of arthritic development.

In my visual analysis of both the Terry and Spitalfields Collections for the symptoms of osteoarthritis, I looked for the presence or absence and severity of four aspects of arthritic development: lipping, osteophytes, porosity and eburnation. The four types of development that were identified were lipping on the joint (a sharp edge along the joint surface, usually along a normal edge of bone), porosity (the appearance of what look like pinholes on the joint surface), osteophytes (an often rounded button shaped piece of additional bone growth in the joint area), and eburnation (bone on bone polish, often accompanied by grooves in the joint surface which follows the loss of the protective joint cartilage). Each type of pathology was analyzed using the Standards Guide categories created by Buikstra and Ubelaker (1994) listed in Tables 2.4 to 2.7 below. These differences in severity often represent sequential stages in osteoarthritis pathenogenesis.

Table 2.4 Lipping

0.1	null	1.1	2.1	3.1	4.1
No presence	No joint	Barely discernable	Sharp ridge, sometimes curled with spicules (irregular outgrowths of bone also called bone spurs)	Extensive spicule development	Ankylosis (bones of the joint have fused)

Table 2.5 Porosity

0.1	null	1.1	2.1	3.1
No presence	No joint	Pinpoint	Coalesced	Pinpoint and Coalesced

Table 2.6 Osteophyte

0.1	null	1.1	2.1
No presence	No joint	Barely discernable	Clearly visible

Table 2.7 Eburnation

0.1	null	1.1	2.1	3.1
No presence	No joint	Barely discernable	Polish only	Polish with groove(s)

Numbering was modified slightly to include 0.1 (no presence) and null (absent or fragmented) to avoid zeros in the statistical analysis software. The addition of 0.1 to all whole numbers compensated for the initial 0.1. Collection was coded (1 for Terry Collection and 2 for Spitalfields) as well as sex (1 for females and 2 for males). When coding for pathology, lipping was given the prefix L, porosity was given the prefix P, osteophytes were given the prefix O and eburnation, E. These prefixes were combined with the abbreviations for the joint (e.g., EHP would define eburnation on the proximal humerus). A complete listing of codes can be found in Table 2.8.

Table 2.8 Code Definitions

Code	Definition
E	Eburnation
P	Porosity
O	Osteophyte
L	Lipping
HP	Humerus Proximal
HD	Humerus Distal
U	Ulna
S	Scapula
A	Acetabulum
FP	Femur Proximal
FD	Femur Distal
T	Tibia
FH	Femoral Head
FMSH	Femoral Midshaft
L	Left
R	Right
Sex (1)	Female
Sex (2)	Male
Collection (1)	Terry
Collection (2)	Spitalfields
ID Number (e.g., 15R or 2176)	Collection ID number

3 RESULTS

3.1 General overview of the Terry and Spitalfields collections

The mean age for women of the Terry Collection is 63.85 years with a minimum age of 20 years and a maximum of 102 years. Lipping was the most prominent pathology exhibited compared to all other pathologies observed. Left femoral head measurements with a mean measurement of 42.16 mm (SD=2.9066). This average femoral head measurement is within the parameters for sex (female) based on Steele and Bramblett (1988). Femoral midshaft mean for this collection is 25.70 mm (SD = 2.3855).

The mean age for men of the Terry Collection was 59.75 years with a minimum age of 26 years and a maximum of 86. Lipping was the most prominent pathology exhibited compared to all other pathologies. Left femoral heads on the left sides of the body show a mean of 48.84 mm (SD = 2.8485). This average femoral head measurement is also within the parameters for sex (male) based on Steele and Bramblett (1988). Femoral midshaft mean for this collection were 28.81 mm (SD = 2.1482).

The mean age for women of the Spitalfields Collection is 59.44 years with a minimum age of 23 and a maximum of 89. Lipping was again the most prominent pathology exhibited compared to all other pathologies. Femoral heads on the left side of the body show a mean of 40.78 mm (SD = 2.4582). This is within the parameters for females (Steele and Bramblett, 1988). The femoral midshaft mean for this collection is 25.88 mm (SD = 1.9609).

The mean age for men of the Spitalfields Collection is 57.56 years with a minimum age of 21 and a maximum of 92. Lipping was also the most prominent pathology exhibited compared to all other pathologies. The femoral heads on the left sides of the body show a mean of 47.05 mm (SD = 2.9710). This falls into the parameters for their sex (male). The femoral midshaft mean for this collection is 28.12 mm (SD = 2.4604).

When comparing mean ages, the women of Terry lived longer than the women of Spitalfields and the men of both collection by as much as 6.29 years when compared to the men of Spitalfields and as little as 4.1 years compared to the women of Spitalfields. When comparing women in each collection, Terry women lived longer by 4.41 years but this was not statistically significant (p=0.069). Since only individuals aged 20 and older were included in the study, the ages at death do not include adolescent and children who did not reach adulthood, which impacts a complete understanding of the entire life expectancy of these populations. It is possible, however, that the higher mean is due to the skewing effect of several long lived individual females in the Terry Collection (102 is the oldest female versus the oldest male being 92 years in the Spitalfields Collection). Even considering some possible skewing towards older women (which may have been a result of the collection methods employed by Trotter in Terry), the average age does not differ significantly (p=0.069).

While the average femoral head measurements of all collections fell within Steele and Bramblett's (1988) parameters for identifying sex, the individuals in the Terry Collection had larger femoral head measurements than their counterparts at Spitalfields. This is possibly due to a generally larger and more robust population at Terry or a particularly diminutive group at Spitalfields, however, the averages, again, are not separated more than 1.79 mm for men and 1.38 for women.

Thus far, when comparing the descriptive statistics for Terry and Spitalfields, the Terry Collection appears larger and longer-lived. However, when comparing the means of the femoral midshafts, the women of Spitalfields show slight robusticity over those of the Terry Collection but it was not significant (p=0.631). While the difference is slight (0.18 mm when comparing means), it is the first time the smaller group of women in Spitalfields shows a more robust average. The Terry men again show more robust midshaft measurements than their Spitalfields counterparts (0.69 mm when comparing means).

When pathologies were grouped and with no distinction for sex or collection, lipping stood out at the most prominent pathology exhibited by all persons (with means above 1). Osteophytes in the tibia of the women of Terry showed a mean of above 1. Porosity of the acetabulum in women of Spitalfields and Terry were the only other area with a mean above 1. See Tables 3.1 to 3.5 in the Appendices for more comprehensive detail.

3.2 **Understanding significance based on sex** (Independent T-Test)

I performed an Independent Sample T-Test with sex as the grouping variable for each pathology independently (Table 3.6). The following locations and pathologies showed statistical significance. Eburnation was statistically significant in the tibia and distal femora with women's means higher than men's. Porosity was significant in the proximal humerii, tibiae, proximal and distal femora as well as the acetabulum. In all of these instances, women's means were higher than those of their male counterparts. Osteophytes were statistically significant in the proximal humerii, scapulae, tibiae and proximal and distal femora. Again, women's means were higher than those of the men. Lipping was statistically significantly different for the tibiae, and distal femora only with women's means again higher than the males. Finally, the midshaft of the femur as well as the femoral head also were statistically significant with male means higher than those of their female counterparts.

3.3 **Significance based on collection** (Independent T-Test)

In addition to sex, I performed an Independent Sample T-Test with Collection as the grouping variable for each pathology (Table 3.7). The following locations and pathologies showed statistical significance. Eburnation was statistically significant in the distal femora with Terry means higher than Spitalfields. Porosity was significant in the proximal and distal femora. In both, Terry means were higher than those of Spitalfields. Osteophytes were statistically significant in the proximal and distal humerii, ulnae, scapulae, and distal femora. Terry means were higher than those of Spitalfields. Lipping was statistically significant in the distal humerii, ulnae, scapulae and proximal and distal femora with Terry means again higher than Spitalfields. Finally, the femoral heads were statistically significant with Terry means higher than those of their Spitalfields counterparts.

3.4 **Significance based on sex and collection** (Independent T-Test)

In addition to both sex and collection, I performed an Independent Sample T-Test with cases delineated by sex with collection as the grouping variable for each pathology (Table 3.8). The following locations and pathologies showed statistical significance when comparing females of Terry with those of Spitalfields. Porosity was significant in the distal femur with Terry means higher than those of Spitalfields. Osteophytes were statistically significant in the proximal humerii, ulnae, proximal and distal femora as well as the acetabulum. Terry means were higher than those of Spitalfields. Lipping was statistically significant in the distal humerii, scapulae and proximal femora with Terry means higher than Spitalfields. Finally, the femoral heads were statistically significant with Terry means higher than those of their Spitalfields counterparts.

A second Independent T-Test was performed with males as the case, and collection as the grouping variable for each pathology (Table 3.9). The following locations and pathologies showed statistical significance when comparing males of Terry with those of Spitalfields. Porosity was significant in the ulnae with Terry and Spitalfields. Osteophytes were statistically significant in the distal humerii, ulnae, and tibiae. Terry means were higher than those of Spitalfields in the humerii and ulnae but Spitalfields means were higher than those of Terry in the tibiae. Lipping was statistically significant in the ulnae with Terry means higher than Spitalfields. Finally, the femoral heads were statistically significant with Terry means higher than those of their Spitalfields counterparts.

3.5 ANCOVA and the rate of degeneration

I performed an ANCOVA (Table 3.10) on the joint surfaces based on pathology and sex to determine if the rate of degeneration of the joint is or is not significantly different between males and females. In my first comparison of the slopes of males and females, the only areas that were not significantly different between the sexes were in the following pathologies and areas: lipping of the proximal humerii, scapulae, proximal and distal femora, acetabulum, and femoral head midshaft measurements with women showing a greater rate of deterioration over males. Porosity, eburnation and osteophytes were not presenting with enough frequency to analyze. When I compared the Y intercepts of these joints with the confidence intervals of the other group, I found that only lipping of the proximal humerii and femora, lipping of the acetabulum and femoral head and midshaft measurements still showed no difference between sexes.

I performed an ANCOVA (Table 3.11) on the joint surfaces between females from both collections to determine if the rate of degeneration of the joint is or is not significantly different between females in Terry versus Spitalfields. In my first comparison of the slopes of females, the only areas that were not significantly different between the collections were in the following pathologies and areas: lipping of the proximal humerii, scapulae, tibiae, distal femora, and acetabulum, as well as femoral head and midshaft measurements. Spitalfields women showed greater rates of deterioration than Terry with the exception of the distal humerus, and ulna. Porosity, eburnation and osteophytes were not presenting with enough frequency to analyze. When I compared the Y intercepts of these joints with the confidence intervals of the other group, I found that only lipping of the proximal humerii, tibiae, distal femur, femoral head and midshaft measurements still showed no significant difference between women of either collection.

I also performed an ANCOVA (Table 3.12) on the joint surfaces between males from both collections to determine if the rate of degeneration of the joint is or is not significantly different between males in Terry versus Spitalfields. In my first comparison of the slopes of males, the only areas that were not significantly different between the collections were in the following pathologies and areas: lipping of the proximal humerii, scapulae, tibiae and proximal and distal femora, acetabulum as well as femoral he and midshaft measurements showed no significant difference. Terry men showed greater degrees of deterioration over Spitalfields in all areas except the scapula. When I compared the Y intercepts of these joints with the confidence intervals of the other group, I found that only lipping of the proximal humerii, scapulae, proximal and distal femora and femoral head and midshaft measurements still showed no significant difference between men of either collection.

3.6 Discussion

Understanding the foundations of both collections helped me to better analyze the impact of age, sex, and possibly occupation on my data. Considering that more than 100 years of medical care and technology separated these collections, the mean age at death was not significantly different. Since only individuals aged 20 and older were included in the study, the ages at death do not include adolescent and children who did not reach adulthood, which affects a complete understanding of the entire life expectancy of these populations. Terry women had the oldest average age at death of any group in the collections. This is likely due to some very old women in the Terry Collection. Of the 8 total individuals aged 91 and above, 6 were women of Terry, which would skew the age at death up slightly. However, even without those women, the mean ages at death for the collection ranged between 63.85 (Terry women) and 57.56 (Spitalfields men) were not significant (p=0.069) (Hunt and Albanese, 2005). With such a narrow range of ages at death, these collections could be compared more reliably. One aspect of the mean ages at death I found interesting was the lack of a substantial difference of age at death between both groups considering their distance from one another temporally. I had initially expected that the Spitalfields people, having lived in the 1700's and 1800's would have had a substantially lower mean age at death than those of Terry. With substandard dental and medical care, less access to clean water and greater impact of infectious diseases during the time these people lived, it seemed more likely to find a lower mean age at death. While Terry people were, on average, longer lived, the amount of difference was not significant, causing me to reconsider the affect of the better overall lifestyles of the people of Spitalfields when compared to those of Terry.

While the Terry people were on average longer lived, the nature of where they came from (asylums, institutions, unclaimed bodies) suggests that the lives they led were not as secure as those of Spitalfields. The people of Terry had may not have had access to more modern medical and dental care (if not use of them), less exposure to infectious diseases compared to those of Spitalfields and better access to clean water, but these differences did not greatly increase the lifespan of the people of Terry (Hunt and Albanese, 2005). This is likely due to the poor nature of the lives of these forgotten people. It is possible that many of the individuals in the collection spent time living on and off the streets prior to and after living in the institutions in which many died (Hunt and Albanese, 2005). Unlike Spitalfields, they did not likely have any family support or interactions, or access, at times, to more modern medical and dental care.

Lipping was the most prominent pathology of all four groups studied. The preponderance of this particular condition suggests that it is a valuable and measurable osteological reaction to stress at the joint. Based on the response of bone to remodel where there is weakness (such as when a break occurs), the amount of lipping on the bones, and the frequency in which the margins showed this pathology suggest that this particular bony growth may have been an attempt by the body to strengthen a weak joint (Felson et al., 2000). If soft tissue damage occurred at the joint (e.g., ligament tears or aggravations, muscle damage), the structure that keeps the joint held in place would allow for lateral movement in hinge joints (knee and elbow) and possible slight dislocation of ball and socket joints (hip and shoulder). This extra movement would encourage the bone to compensate for the loss of stability by building bone. The greater amount of bone that accumulates, the more movement can be restricted the increased likely that pain can be present. Jurmain (1999) believes that any pathology save eburnation should not be used to determine the presence of arthritis. I wholeheartedly disagree. Eburnation occurs when there is severe joint impingement including the loss of protective cartilage and bone-on-bone rubbing. I only found one instance of eburnation in the elbow of one individual and some in the shoulder. The vast majority of eburnation found was in the hip and knee with women showing more knee eburnation than men. This may be due to the sexual dimorphism in humans. The different in pressure points on the knee joint due to wider hips in women may load the lateral tibial condyle more than it would in men who have narrower hips. While this angulation may have been a factor, I did not, during my examination, record which areas of the tibial condyles in men and women were affected by this pathology. The pressure of load bearing is greater in these joints resulting in a breakdown of cartilage under the pressure of a lifetime of weight bearing. If eburnation were readily found in all of the joint surfaces observed, perhaps there might greater evidence to remove the other three pathologies listed as osteoarthritis. However, with so little evidence of eburnation compared to lipping, I see no reason to eliminate lipping, osteophytes or porosity in favor of this one, not regularly seen, pathology to determine the presence or absence of arthritis in the body. The presence of lipping as a primary pathology further reinforces its value in assessing arthritic development in the aging human skeleton.

When femoral head measurements were compared, women and men fell within the parameters for their sexes based on Steele and Bramblett (1988). The women of Spitalfields had significantly smaller femoral head measurements than those of Terry, suggesting that they were smaller in size. When comparing the men of Terry to those of

Spitalfields, the same differences were noted, with Terry femoral heads averaging significantly larger than those of Spitalfields. Again, this suggests that the men of Spitalfields were generally smaller than those of Terry. Considering the difference in time period and the slow increase in size of people as we move towards modernity, it is not surprising that generally larger and taller group of individuals exist in the Terry Collection than in Spitalfields. Separately, the people of Terry likely came from a more diverse ethnic background than those of Spitalfields and that variety of body shape and size dependent upon biological origins might have also played a factor in the difference.

When comparing femoral midshaft measurements, there are some differences suggesting Terry individuals were larger than the people of Spitalfields. In this instance, the women of Spitalfields showed a significantly larger midshaft measurement compared to the women of Terry. This more robust midshaft may suggest that even with the smaller statures, the women of Spitalfields may have been heavier than the women of Terry. Molleson and colleagues (1993) cite a marked propensity for obesity in the people of Spitalfields based on a high percentage of crypts with adipocere still present as well as paintings of the people showing many heavier people. Despite this, the men of Spitalfields had significantly smaller midshaft measurement, suggesting they were small compared to Terry males.

When comparing the sexes to one another, I found that in every instance of pathology, females showed more statistically significant types and severity than the men. Eburnation, the rubbing of bone-on-bone, was found to be significant in the tibiae and distal femora. This difference may suggest a greater degree of repetitive motion that destroyed the cartilage of women more often than in men.   Porosity was found to be significantly different in on the proximal humerii, tibiae, as well as the proximal and distal femora and acetabulum. Women again showed more porosity in these areas over men. It is likely that there is a hormonal component affecting the amount of porosity in women. However, when porosity was found in many individuals, it was often accompanied by eburnation. This porosity may be a result of the cortical bone wearing away, exposing the trabecular bone underneath. With porosity being found primarily in the lower joints, it is also possible that there is some sort of weight bearing component to this particular pathology.

Osteophytes (buttons of bone in the joint surface) were found significantly more often in women than in men and were located in the proximal humerii, scapulae, tibiae and proximal and distal femora. The only joint surfaces that did not show significant osteophytes production were the acetabulum and ulna. As osteophytes are thus by far the most generalized pathology affecting the most observed joint surfaces, it is possible that these are sex-limited phenomena.

Lipping was significant by sex (with women again exhibiting higher means than men) in the knee joints. This may suggest that in women are more likely to develop lower body osteoarthritis than men, perhaps due to the extra weight burden of child bearing over multiple births and/or a higher work burden. This may also be a component of sex due to menopause as well. Typically, post-menopause is associated with an increase in osteopenia and osteoporosis but whether these are related to osteoarthritis remains essentially unknown (Haq, 2003).

I then compared the collections against one another (all of the people of Terry versus all of the people of Spitalfields). When comparing the two collections, the Terry

Collection showed more evidence of osteoarthritis than the people of Spitalfields. This may suggest, that the people of the Terry Collection, when considered as whole, were in worse physical condition than those of Spitalfields. This may be due to poorer diet, a less steady and stable way of life less-skilled, heavier impact labor jobs.

When eburnation was observed, the distal femur was the only area that showed significant development, suggesting perhaps some heavy load bearing activities (e.g, lifting heavy objects from a squatting position). Porosity was evident in both the proximal and distal femora, again suggesting more lower body impact, perhaps due to weight or heavy load bearing. Similar to the observation by sex, osteophytes are found in most joints, with only the proximal humerii and acetabulum not showing any statistically significant difference suggesting that this pathology may not be impacted by sex or collection. Lipping showed significance in all observed joints save the proximal humerii and acetabula. This generalized condition when comparing collections reinforces the volume and severity of lipping over the span of both groups and suggests that lipping in the elbows, some parts of the shoulder girdle, hips and knees could be either the generalized bony response or evidence of a more difficult life.

I next compared the women of each collection to the other. This analysis allowed me to look at how women were either alike or not. With the exception of eburnation, where no group showed a difference, the women of Terry showed statistically significantly greater amounts of all other pathologies than those of Spitalfields. Porosity was only significant in the distal femur of Terry women, suggesting perhaps some impact of weight or load bearing. Osteophytes were significant in all joints of Terry women with the exception of the distal humerii and scapulae over that of Spitalfields. Lipping again, was significantly greater in Terry women for the distal humerii, scapulae and proximal femora. The locations of this arthritic impact could suggest heavy upper body use (with shoulder and elbow impacted) and generalized hip impacts, possibly due to age and perhaps the impact of childbirth on the skeletons of women. Since Terry again showed significantly more than those of Spitalfields, I can surmise that these women did not have as easy a life as their counterparts. In addition, the higher age at death of Terry may skew these women slightly higher due to longer lives, more impact of wear and tear, and hormonal shifts.

When comparing the men of Terry and Spitalfields, both eburnation and porosity, showed any difference between the two groups. It is only when osteophytes and lipping are examined that a significant difference between the two groups of men are present. Osteophytes were less generalized in men than in women but still were significant in the elbow and knee with Terry men only showing a higher significance in the knee. This may suggest that the men of Terry had more loading damage to their knees than those of Spitalfields men who were primarily weavers and master weavers. This occupation involves a large amount of repetitive motion of the elbow (but not the knee) moving the shuttlecock back and forth through the loom (Molleson et al., 1993).

When lipping is considered, only the ulna is significantly different with Terry men having a greater mean. This joint surface may again suggest repetitive motion of this joint in both groups, with Terry men showing a slightly significant increase in this pathology.

When observing rates of degeneration between females and males, I expected that females would show greater rates of degeneration at older ages than males. I found that there were significant differences between males and females in most joints and pathologies with the following areas not showing any notable difference: porosity of the scapulae, lipping of the proximal humerii and femora, lipping of the acetabulum and femoral head and midshaft measurements. This suggests that sex or gendered labor is a factor in the rate of degeneration of joints between men and women for most of the studied areas. It is interesting that lipping was the only area that did not show much difference, particularly in the lower limbs. This may suggest that in the hip joints, sex does not play a role in the rate of degeneration. It is possible that activity is more likely to be the cause of the degeneration of these joint surfaces. When comparing the sexes in this manner, I surmised that some of the lower body differences may be present due to childbirth in women (which results in heavy load bearing of successive children as well as hormonal changes affecting the bones), but that was not evident based on this analysis. Also, the lack of difference in significance of the proximal humerii may also suggest an activity based problem, and not one of sex.

When examining females of both collections, I found that only osteophytes of the distal femur, lipping of the proximal humerii, tibiae, distal femur, and femoral head and midshaft measurements showed no significant difference between women of either collection. This again may suggest that activity plays a stronger role in the degeneration of the hip and knee joints in women than the impact of hormones in females as they age

When examining the males of both collections, I found that only lipping of the proximal humerii, scapulae, proximal and distal femora, and femoral head and midshaft measurements still showed no significant difference between men of either collection. Once again, I found that the hip, knee and shoulder joints were not different between men of either collection. This lack of distinction in these joint surfaces between all reviews of men and women (either together or separately) suggest that something else besides sex may play a part in the development of osteoarthritis in these joints. I suggest that general daily activities in these two groups, both males and females, such as walking and using the shoulders regularly to do many basic activities eliminated the ability to assess different rates of deterioration between the same sexes of each collection and between men and women.

After reviewing all of the data from my analyses I found that the people of Terry, despite my original beliefs that access to better health care and fewer environmental insults suffered more and more severe osteoarthritis than those of Spitalfields. I found that the women of both collections had their hips and knees impacted more often than other joints suggesting that like modern women, these joints may have been affected by hormonal components as well as the possible impacts of weight and child bearing (Felson et al., 2000). When analyzing the men, I did not see as much location specific joints affected but a more generalized osteoarthritis that is also what is seen in modern people (Felson et al., 2000, Haq, 2003). This may suggest that there is a stronger hormonal component for certain joints based on sex (women showing more specific joint impact than men after age 50). I also observed that some of the differences between men and women suggest some gender specific activities may also have impacted the more generalized features of osteoarthritis shown in the joints.

Overall, my initial hypothesis that the people of Spitalfields, due to their older temporal location, would have shown more evidence of osteoarthritis was incorrect. As I studied my data, it became clear that the opposite was true. This suggests that less strenuous occupational opportunities for the people of Spitalfields may have been a factor in the development of osteoarthritis.

I discovered several limitations when completing my analysis that have impeded my ability to more accurately and consistently assess osteoarthritis. Since osteoarthritis only impacts adults, and rarely children or adolescents, I am unable to collect a comprehensive study of arthritic development from youth to advanced old age. In addition, while using the Chicago Standards Guide (1994), I found that the clearly defined grades became highly subjective when I entered the field and began working with individuals. Although these standards assist the anthropological community in coming to a closer consensus when comparing one data set to another, the choice of what grade to place an individual joint surface into is highly subjective. Intermediate pathological development can sometimes cause consternation to the researcher (e.g., when a joint surface is balanced between two grades, only one must be selected). Taphonomic bias also restricted my ability to compare these two collections as evenly as possible. While both groups have known age and sex, the manner in which they skeletonized was markedly different. The Terry Collection was macerated and did not spend any time either in earth or coffin and was not impacted by the problems of decomposition. The individuals of Spitalfields were buried in a crypt environment in lead coffins. The effects of invasion by mold, insects, coffin liquor and undecomposed adipocere resulted in a more fragmented skeletal material. It is possible that Spitalfields suffered just as much from osteoarthritis as their counterparts in Terry, however, with many joints damaged and/or missing, it makes one to one comparison more difficult.

A further limitation in understanding the lived experience of the people in both collections is that there is no direct relationship between severity of osteoarthritis and symptoms. It is possible that what I see on the knee of an individual that appears severe and debilitating, may not have been accurate as some individuals with osteoarthritis may only have slight joint impingement (limited ability to flex the joint) or may be asymptomatic (Sarzi-Puttini et al., 2005). When one cannot speak with the individuals in question, it is difficult to understand what restrictions on movement or endurance they may have had, if any based on the severity of the pathology alone.

4 CONCLUSIONS

When I began my research on osteoarthritis, I felt there would be a strong occupational and social component, with more difficult work and living conditions producing less healthy individuals. Based on my initial understanding of the two collections, I felt that Terry would have shown better health despite some of their social disadvantages. After analysis, this supposition was found to be incorrect. Even with access to potentially better medical care, the people of Terry showed more general and severe amounts of osteoarthritis regardless of sex than those of Spitalfields. This difference gives me reason to consider the possibility that environment, work life, and diet play a decidedly larger role in the development of osteoarthritis than can be accounted for with age alone. However, with no lived experience to review, I can only make limited statements about the impact of lifestyle. Even though the people of Spitalfields lived in the heart of the Industrial Revolution in East London, their diets, work environments, as well as familial and social support outweighed their lack of modern medical care when the development of osteoarthritis is considered. This conclusion provides a foundation for more in depth and extensive analysis of the people of these two collections to further understand the overall health of these groups beyond osteoarthritis.

When comparing the sexes, my initial hypothesis was that the men would (earlier in life) show greater amounts of generalized osteoarthritis than their female counterparts who would show mostly upper body osteoarthritis. The men of both collections did show more generalized osteoarthritis than their female counterparts. The men of Terry showed more osteoarthritis but they did not present with any regularity in any significant part of the body, suggesting that in men, sex was not a primary factor in arthritic development. In this instance, the women showed more specific evidence of osteoarthritis in the lower body, not the upper as I had originally surmised. As mentioned earlier, this may be due to a genetic component (impact of body mass placement and child birth) and less with occupation related development.

While I was not able to discern if any specific occupation types showed more evidence of osteoarthritis than another, the general occupation types (skilled versus unskilled) did provide insight into the impact of labor on the severity and placement of osteoarthritis in the skeletons of both populations. Further analysis with occupations (if known) included may offer a view into what could progress into a more detailed analysis of occupation-based markers in these two groups.

Finally, I was able to successfully test the reliability of the standards used to discern sex based on femoral head measures with consistent success. Even when considering the difference in robusticity of the two groups (Terry men and women were decidedly larger than the individuals represented by Spitalfields), the measurements taken were within the boundaries of males and females with few outliers. This review of the metrics allows further confidence that when observing groups separated by large spans of temporal space, it is possible to reliably and consistently discern males and females regardless of stature.

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6 TABLES

3.1 Descriptive Statistics: Collection = Terry and Sex = Female

	N	Minimum	Maximum	Mean	Std. Deviation
Age	80	20.0	102.0	63.850	18.4398
EHP	78	0	2.1	0.138	0.2519
EHD	79	0	0	0.100	0.0000
EU	80	0	0	0.100	0.0000
ES	80	0	1.6	0.150	0.2590
ET	80	0	3.1	0.238	0.5092
EFP	76	0	1.1	0.126	0.1611
EFD	80	0	3.1	0.400	0.7230
EA	80	0	1.1	0.113	0.1118
PHP	78	0	1.1	0.158	0.1971
PHD	79	0	1.6	0.138	0.2084
PU	80	0	.6	0.119	0.0956
PS	80	0	1.1	0.163	0.2160
PT	80	0	3.1	0.275	0.5343
PFP	77	0	1.6	0.230	0.3183
PFD	78	0	2.6	0.286	0.4566
PA	80	0	3.1	1.225	1.1009
OHP	78	0	2.1	0.388	0.5840
OHD	79	0	2.1	0.404	0.6476
OU	80	0	2.1	0.381	0.4894
OS	80	0	2.1	0.675	0.6986
OT	80	0	2.1	1.006	0.9416
OFP	77	0	2.1	0.613	0.7299
OFD	80	0	2.1	0.988	0.8418
OA	78	0	2.1	0.683	0.7036
LHP	78	0	3.1	1.529	0.7329
LHD	79	0	3.1	1.397	0.6771
LU	79	0	3.1	1.784	0.7389
LS	79	0	3.1	1.638	0.8388
LT	79	0	3.1	1.416	0.9877
LFP	78	0	3.1	1.453	0.6351
LFD	80	0	3.1	1.744	0.9008
LA	79	0	3.1	1.581	0.7656
FHL	73	37.5	55.8	42.156	2.9066
FMSHL	75	21.3	32.6	25.696	2.3855
Valid N (listwise)	65				

3.2 Descriptive Statistics: Collection = Terry and Sex = Male

	N	Minimum	Maximum	Mean	Std. Deviation
Age	80	26.0	86.0	59.750	14.1757
EHP	80	0	0	0.100	0.0000
EHD	80	0	0	0.100	0.0000
EU	79	0	0	0.100	0.0000
ES	78	0	1.6	0.119	0.1698
ET	79	0	3.1	0.157	0.3754
EFP	80	0	1.1	0.113	0.1118
EFD	80	0	3.1	0.188	0.4039
EA	79	0	1.1	0.113	0.1125
PHP	79	0	0	0.100	0.0000
PHD	80	0	1.1	0.113	0.1118
PU	78	0	0	0.100	0.0000
PS	79	0	2.1	0.157	0.2654
PT	79	0	3.1	0.151	0.3544
PFP	80	0	2.1	0.163	0.3016
PFD	80	0	2.6	0.175	0.3477
PA	78	0	3.1	0.985	0.6975
OHP	80	0	2.1	0.169	0.2949
OHD	80	0	2.1	0.556	0.7256
OU	79	0	2.1	0.284	0.4749
OS	79	0	2.1	0.353	0.4862
OT	79	0	2.1	0.505	0.6702
OFP	80	0	2.1	0.306	0.5494
OFD	80	0	2.1	0.331	0.5734
OA	79	0	2.1	0.353	0.4927
LHP	80	0	3.1	1.081	0.6910
LHD	80	0	3.1	1.337	0.7794
LU	80	0	3.1	1.969	0.8025
LS	80	0	2.6	1.287	0.7688
LT	80	0	2.6	0.847	0.6399
LFP	80	0	2.6	1.231	0.7280
LFD	79	0	3.1	1.226	0.6708
LA	78	0	3.1	1.254	0.8386
FHL	79	44.2	63.3	48.843	2.8485
FMSHL	79	24.0	35.8	28.814	2.1482
Valid N (listwise)	70				

3.3 Descriptive Statistics: Collection = Spitalfields and Sex = Female

	N	Minimum	Maximum	Mean	Std. Deviation
Age	80	23.0	89.0	59.437	16.3489
EHP	52	0	0	0.100	0.0000
EHD	65	0	0	0.100	0.0000
EU	63	0	1.1	0.116	0.1260
ES	50	0	1.6	0.160	0.2969
ET	57	0	3.1	0.232	0.5865
EFP	68	0	2.1	0.129	0.2425
EFD	60	0	3.1	0.233	0.5031
EA	73	0	1.6	0.121	0.1756
PHP	51	0	0.6	0.120	0.0980
PHD	65	0	0	0.100	0.0000
PU	63	0	0	0.100	0.0000
PS	54	0	1.1	0.202	0.2639
PT	56	0	2.1	0.243	0.4125
PFP	68	0	1.6	0.159	0.2207
PFD	60	0	1.1	0.158	0.1862
PA	76	0	3.1	1.159	0.6830
OHP	52	0	1.1	0.119	0.1387
OHD	65	0	2.1	0.246	0.4213
OU	64	0	2.1	0.202	0.3902
OS	53	0	2.1	0.317	0.4548
OT	57	0	2.1	0.907	0.8439
OFP	67	0	2.1	0.339	0.5797
OFD	60	0	2.1	0.467	0.6369
OA	76	0	2.1	0.304	0.5045
LHP	52	0	3.1	1.302	0.6437
LHD	65	0	2.6	1.046	0.5457
LU	64	.6	3.1	1.694	0.5626
LS	54	0	3.1	1.072	0.7032
LT	54	0	3.1	1.205	0.6927
LFP	68	0	3.1	1.181	0.5898
LFD	62	0	3.1	1.463	0.8157
LA	76	0	3.1	1.330	0.8384
FHL	70	36.1	48.4	40.783	2.4582
FMSHL	65	21.0	30.3	25.875	1.9609
Valid N (listwise)	24				

3.4 Descriptive Statistics: Collection = Spitalfields and Sex = Male

	N	Minimum	Maximum	Mean	Std. Deviation
Age	82	21.0	92.0	57.561	15.9103
EHP	59	0	0	0.100	0.0000
EHD	65	0	2.1	0.131	0.2481
EU	62	0	0	0.100	0.0000
ES	53	0	0	0.100	0.0000
ET	62	0	0	0.100	0.0000
EFP	68	0	0	0.100	0.0000
EFD	66	0	0.6	0.108	0.0615
EA	72	0	0	0.100	0.0000
PHP	53	0	0.6	0.109	0.0687
PHD	65	0	0	0.100	0.0000
PU	62	0	0	0.100	0.0000
PS	60	0	0.6	0.108	0.0645
PT	62	0	1.1	0.132	0.1781
PFP	69	0	0.6	0.107	0.0602
PFD	68	0	0.6	0.115	0.0851
PA	73	0	3.1	0.867	0.4571
OHP	59	0	1.1	0.134	0.1825
OHD	65	0	2.1	0.223	0.3753
OU	62	0	1.1	0.116	0.1270
OS	61	0	2.1	0.264	0.4539
OT	62	0	2.1	0.866	0.8718
OFP	68	0	2.1	0.306	0.4750
OFD	65	0	2.1	0.262	0.5086
OA	70	0	2.1	0.507	0.6931
LHP	59	0	2.6	1.108	0.5685
LHD	65	0	3.1	1.185	0.5418
LU	62	0	3.1	1.689	0.6435
LS	59	0	3.1	1.253	0.7727
LT	59	0	3.1	0.963	0.5445
LFP	68	0	3.1	1.151	0.6297
LFD	66	0	3.1	1.092	0.6878
LA	73	0	3.1	1.436	0.6925
FHL	71	39.3	52.8	47.046	2.9710
FMSHL	74	20.8	33.8	28.124	2.4604
Valid N (listwise)	25				

3.5 Descriptive Statistics – By Pathology and Location

	N	Minimum	Maximum	Mean	Std. Deviation
EHP	269	0	2.1	0.111	0.1361
EHD	289	0	2.1	0.107	0.1176
EU	284	0	1.1	0.104	0.0593
ES	261	0	1.6	0.133	0.2146
ET	278	0	3.1	0.183	0.4316
EFP	292	0	2.1	0.117	0.1541
EFD	286	0	3.1	0.238	0.5054
EA	304	0	1.6	0.112	0.1179
PHP	261	0	1.1	0.123	0.1219
PHD	289	0	1.6	0.114	0.1242
PU	283	0	0.6	0.105	0.0513
PS	273	0	2.1	0.157	0.2217
PT	277	0	3.1	0.201	0.4023
PFP	294	0	2.1	0.166	0.2544
PFD	286	0	2.6	0.187	0.3207
PA	307	0	3.1	1.063	0.7866
OHP	269	0	2.1	0.215	0.3836
OHD	289	0	2.1	0.370	0.5891
OU	285	0	2.1	0.256	0.4188
OS	273	0	2.1	0.421	0.5678
OT	278	0	2.1	0.812	0.8550
OFP	292	0	2.1	0.395	0.6054
OFD	285	0	2.1	0.528	0.7201
OA	303	0	2.1	0.461	0.6199
LHP	269	0	3.1	1.260	0.6928
LHD	289	0	3.1	1.254	0.6638
LU	285	0	3.1	1.795	0.7082
LS	272	0	3.1	1.339	0.8012
0	277	0	3.1	1.109	0.7796
LFP	294	0	3.1	1.260	0.6583
LFD	287	0	3.1	1.391	0.8126
LA	306	0	3.1	1.401	0.7931
FHL	293	36.1	63.3	44.816	4.3657
FMSHL	293	20.8	35.8	27.190	2.6313
Valid N (listwise)	183				

3.6 Independent T-Test significant results (Constant = Sex 1 Female, 2 Male)

Pathology	Joint Surface	Significance	Mean Female	Mean Male
Eburnation	Tibia	0.046	0.235	0.132
	Femur (distal)	0.003	0.329	0.151
Porosity	Humerus (proximal)	0.010	0.143	0.104
	Tibia	0.013	0.262	0.143
	Femur (proximal)	0.044	0.197	0.137
	Femur (distal)	0.028	0.230	0.147
	Acetabulum	0.003	1.193	0.928
Osteophyte	Humerus (proximal)	0.007	0.281	0.154
	Scapula	0.001	0.532	0.314
	Tibia	0.003	0.965	0.664
	Femur (proximal)	0.011	0.485	0.306
	Femur (distal)	0.000	0.764	0.300
Lipping	Tibia	0.000	1.328	0.898
	Femur (distal)	0.000	1.621	1.165
Head Measurement	Femur (left)	0.000	41.484	47.993
Midshaft Diameter	Femur (left)	0.000	25.779	28.480

3.7 Independent T-Test significant results (Constant = Collection: 1 Terry, 2 Spitalfields)

Pathology	Joint Surface	Significance	Mean Terry	Mean Spitalfields
Eburnation	Femur (distal)	0.036	0.294	0.167
Porosity	Femur (proximal)	0.035	0.196	0.133
	Femur (distal)	0.013	0.230	0.135
Osteophyte	Humerus (proximal)	0.001	0.277	0.127
	Humerus (distal)	0.000	0.481	0.235
	Ulna	0.000	0.333	0.160
	Scapula	0.001	0.515	0.289
	Femur (distal)	0.000	0.659	0.360
Lipping	Humerus (distal)	0.001	1.367	1.115
	Ulna	0.028	1.877	1.691
	Scapula	0.003	1.462	1.166
	Femur (proximal)	0.023	1.341	1.166
	Femur (distal)	0.026	1.486	1.272
Head Measurement	Femur (left)	0.001	45.632	45.937

3.8 Independent T Test significant results (Constant = Female)

Pathology	Joint Surface	Significance	Mean Terry	Mean Spitalfields
Eburnation	Humerus (distal)	0.000	0.100	0.100
Porosity	Femur (distal)	0.044	0.286	0.158
Osteophyte	Humerus (proximal)	0.001	0.388	0.119
	Ulna	0.001	0.381	0.202
	Femur (proximal)	0.015	0.613	0.339
	Femur (distal)	0.000	0.987	0.467
	Acetabulum	0.000	0.683	0.304
Lipping	Humerus (distal)	0.001	1.397	1.046
	Scapula	0.000	1.638	1.072
	Femur (proximal)	0.009	1.453	1.182
Femur Head Left		0.003	42.156	40.783

3.9 Independent T Test significant results (Constant = Male)

Pathology	Joint Surface	Significance	Mean Terry	Mean Spitalfields
Eburnation	Humerus (proximal)	0.000	0.100	0.100
	Ulna	0.000	0.100	0.100
Porosity	Ulna	0.000	0.100	0.100
Osteophyte	Humerus (distal)	0.001	0.556	0.223
	Ulna	0.008	0.284	0.116
	Tibia	0.006	0.505	0.866
Lipping	Ulna	0.026	1.969	1.689
Femur Head Left		0.000	48.843	47.046

3.10 Linear Regression Table: Sex = 1 Male, 2 Female, Independent Variable, Dependent Variable = Joints and Lipping

Variable Name	Sex	Slope	Slope CI Low	Slope CI High	SE Slope	Y Intercept	Y Intercept CI Low	Y Intercept CI High	SE Y Intercept
LHP	1	0.015	-0.0144	0.0444	0.003	0.528	-0.51	1.56	0.206
LHD	1	0.003	-0.0029	0.0089	0.003	1.081	-1.04	3.20	0.918
LU	1	0.009	-0.0086	0.0266	0.003	1.165	-1.12	3.45	0.199
LS	1	0.022	-0.0211	0.0651	0.004	0.035	-0.03	0.10	0.232
LT	1	0.023	-0.0211	0.0651	0.004	-0.101	0.10	-0.30	0.246
LFP	1	0.008	-0.0077	0.0237	0.003	0.820	-0.79	2.43	0.188
LFD	1	0.017	-0.0202	0.0622	0.004	0.583	-0.56	1.73	0.252
LA	1	0.017	-0.0202	0.0622	0.004	0.394	-0.38	1.17	0.226
FHL	1	0.043	-0.0413	0.1273	0.013	38.888	-37.33	115.11	0.826
FMSHL	1	0.024	-0.0230	0.01273	0.011	24.306	-23.33	71.95	0.664
LHP	2	0.016	-0.0154	0.0474	0.003	0.150	-0.14	0.44	0.211
LHD	2	0.008	-0.0077	0.237	0.004	0.784	-0.75	2.32	0.231
LU	2	0.021	-0.0202	0.0622	0.004	0.637	-0.61	1.89	0.233
LS	2	0.026	-0.0250	0.0770	0.004	-0.256	0.25	-0.76	0.242
LT	2	0.008	-0.0077	0.0237	0.003	0.453	-0.43	1.34	0.196
LFP	2	0.007	-0.0067	0.0207	0.004	0.756	-0.73	2.24	0.230
LFD	2	0.012	-0.0115	0.0355	0.004	0.464	-0.45	1.37	0.224
LA	2	0.018	-0.0173	0.0533	0.004	0.304	-0.45	0.90	0.239
FHL	2	0.047	-0.0451	0.1391	0.016	45.251	-43.44	133.94	0.956
FMSHL	2	0.049	-0.0471	0.1450	0.012	25.590	-24.57	75.75	0.715

3.11 Linear Regression Table Sex: Female, Collection 1 = Terry 2 = Spitalfields Age = Independent Variable, Dependent Variable = Joints and Lipping

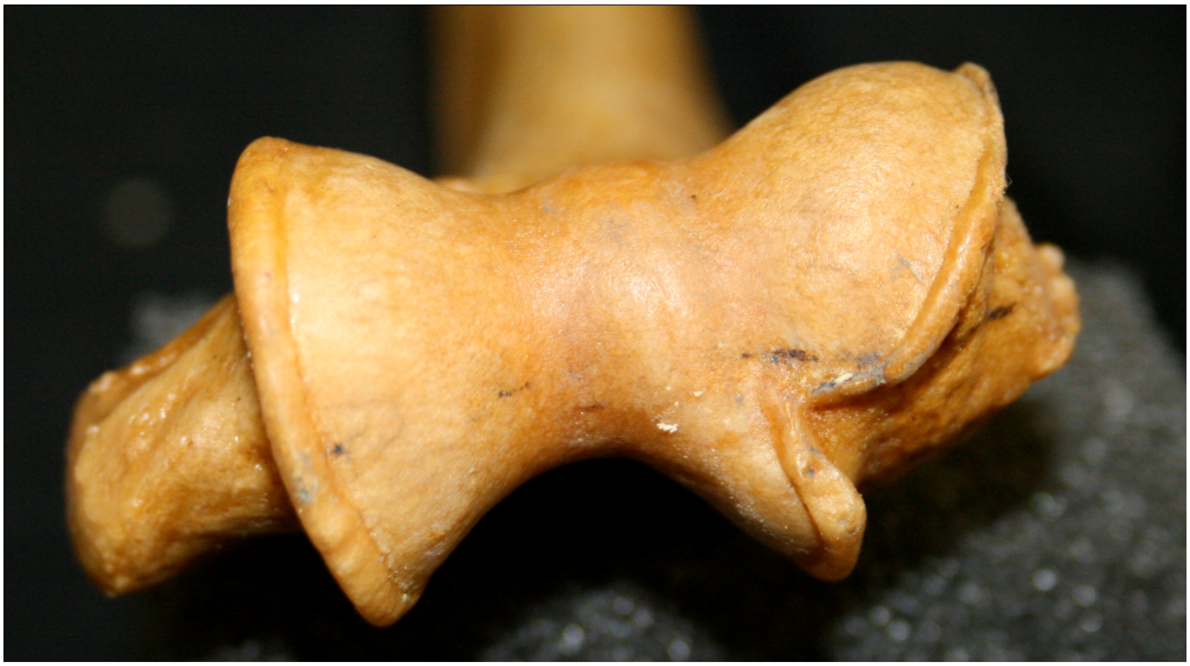
Variable Name	Collection	Slope	Slope CI Low	Slope CI High	SE (Slope)	Y Intercept	Y Intercept CI Low	Y Intercept CI High	SE Y Intercept
LHP	1	0.012	-0.0115	0.0355	0.004	0.766	-0.7354	2.27	0.288
LHD	1	0.002	-0.0019	0.0059	0.004	1.248	-1.20	3.69	0.227
LU	1	0.011	-0.0106	0.0326	0.004	1.081	-1.04	3.20	0.290
LS	1	0.017	-0.0202	0.622	0.005	0.581	-0.56	1.72	0.319
LT	1	0.025	-0.0240	0.0740	0.006	-0.200	-0.19	0.59	0.372
LFP	1	0.006	-0.0058	0.0178	0.004	1.039	-1.00	3.08	0.257
LFD	1	0.015	-0.0144	0.0444	0.005	0.789	-0.76	2.34	0.350
LA	1	0.011	-0.0106	0.0326	0.005	0.890	-0.85	2.63	0.303
FHL	1	0.044	-0.0422	0.1302	0.018	39.446	-37.87	116.76	1.180
FMSHL	1	0.021	-0.0202	0.0622	0.015	24.411	-23.43	72.26	0.987
LHP	2	0.018	-0.0173	0.0533	0.005	0.246	-0.24	0.73	0.284
LHD	2	0.00003217	-0.000030883	0.000095223	0.004	1.046	-1.00	3.10	0.264
LU	2	0.006	-0.0058	0.0178	0.004	1.326	-1.27	3.92	0.268
LS	2	0.028	-0.0269	0.0829	0.005	-0.568	0.55	-1.68	0.280
LT	2	0.019	-0.0182	0.0562	0.005	0.103	-0.10	0.30	0.310
LFP	2	0.008	-0.0077	0.0237	0.005	0.684	-0.66	2.02	0.278
LFD	2	0.018	-0.0173	0,0533	0.006	0.423	-0.41	1.25	0.379
LA	2	0.025	-0.0240	0.0740	0.005	-0.145	0.14	-0.43	0.335
FHL	2	0.032	-0.0307	0.0947	0.019	38.933	-38.34	118.20	1.125
FMSHL	2	0.032	-0.0307	0.0947	0.015	23.985	-23.03	71.00	0.889

3.12 Linear Regression Table Sex = Male, Collection 1 = Terry, 2 = Spitalfields Age = Independent Variable, Dependent Variable = Joints and Lipping

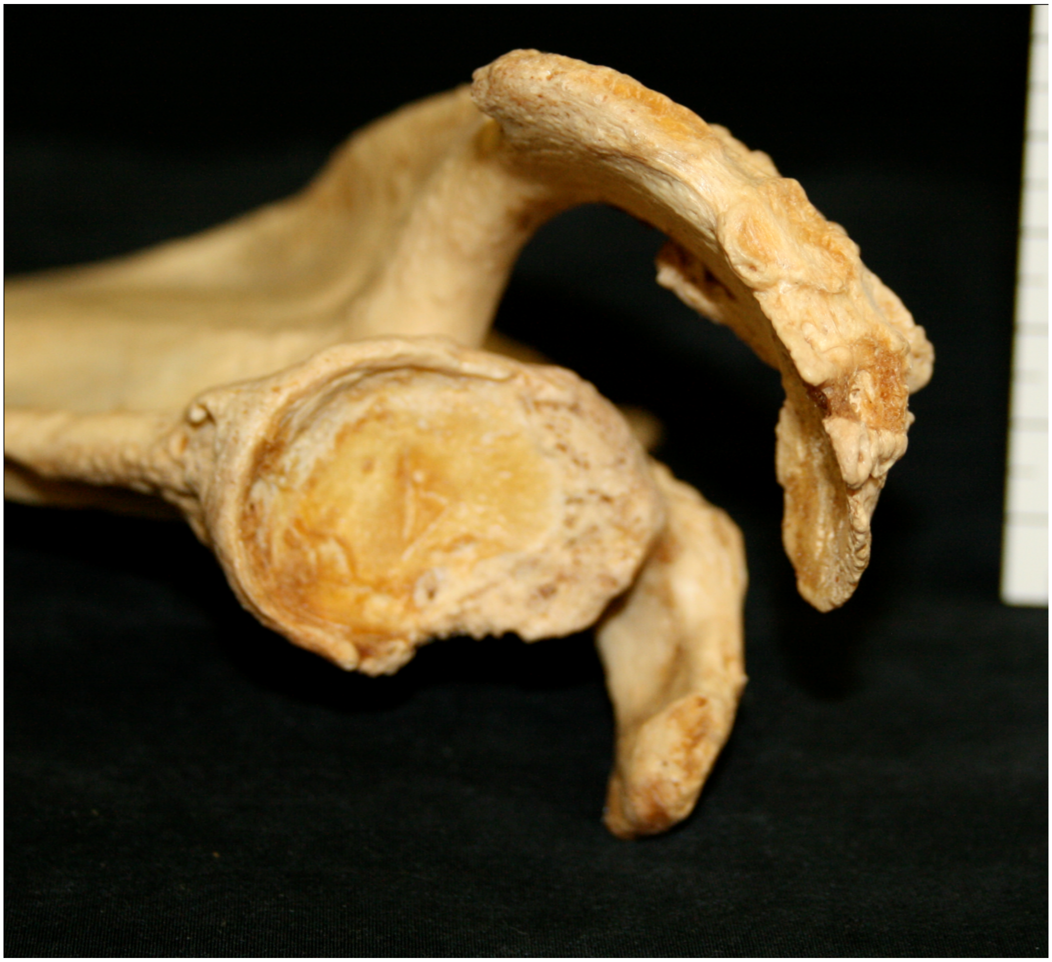
Variable Name	Collection	Slope	Slope CI Low	Slope CI High	SE (Slope)	Y Intercept	Y Intercept CI Low	Y Intercept CI High	SE Y Intercept
LHP	1	0.020	-0.0192	0.0592	0.005	-0.103	-23.03	-0.30	0.310
LHD	1	0.015	-0.0144	0.0444	0.006	0.456	-0.44	1.35	0.368
LU	1	0.027	-0.0259	0.0799	0.006	0.336	-0.32	0.99	0.345
LS	1	0.022	-0.0211	0.0651	0.006	-0.023	0.02	-0.07	0.345
LT	1	0.011	-0.0106	0.0326	0.005	0.183	-0.18	0.54	0.304
LFP	1	0.013	-0.0125	0.0385	0.006	0.427	-0.41	1.26	0.345
LFD	1	0.018	-0.0173	0.0533	0.005	0.137	-0.13	0.41	0.303
LA	1	0.021	-0.0202	0.0622	0.006	0.032	-0.03	0.09	0.388
FHL	1	0.034	-0.0326	0.1006	0.022	46.830	-44.96	138.62	1.378
FMSHL	1	0.040	-0.0384	0.1184	0.017	26.415	-25.36	78.19	1.016
LHP	2	0.012	-0.0115	0.0355	0.005	0.419	-0.40	1.24	0.280
LHD	2	0.001	-0.001	0.003	0.004	1.125	-1.08	3.33	0.262
LU	2	0.012	-0.0115	0.0355	0.005	1.018	-0.98	3.01	0.298
LS	2	0.031	-0.0298	0.0918	0.006	-0.544	0.52	-1.61	0.336
LT	2	0.005	-0.0048	0.0148	0.004	0.656	-0.63	1.94	0.246
LFP	2	0.001	-0.001	0.003	0.005	1.088	-1.04	3.22	0.302
LFD	2	0.005	-0.0048	0.0148	0.00	0.815	-0.78	2.41	0.329
LA	2	0.018	-0.0173	0.0533	0.005	0.446	-0.43	1.32	0.284
FHL	2	0.047	-0.0451	0.1391	0.021	44.382	-42.61	131.37	1.255
FMSHL	2	0.054	-0.0518	0.1598	0.017	25.019	-24.02	74.06	1.007

7 FIGURES

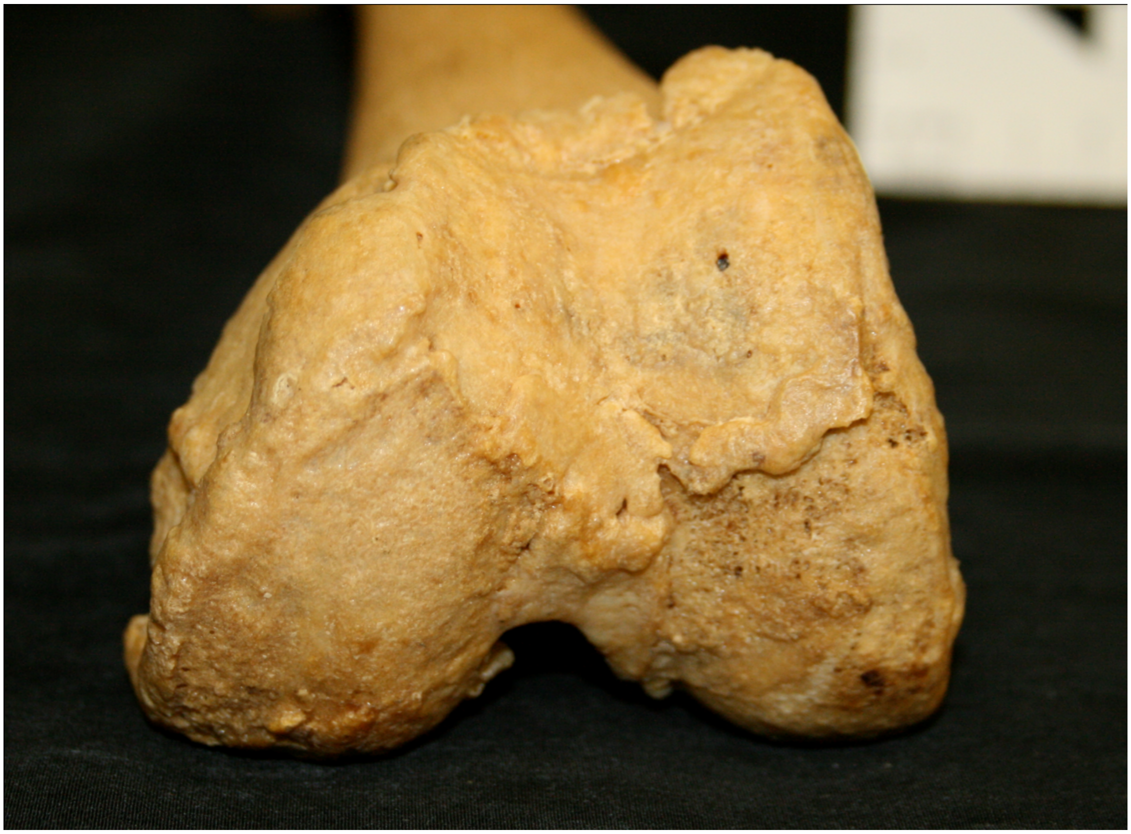
7.1 Terry Collection – Distal Humerus – Grade 3



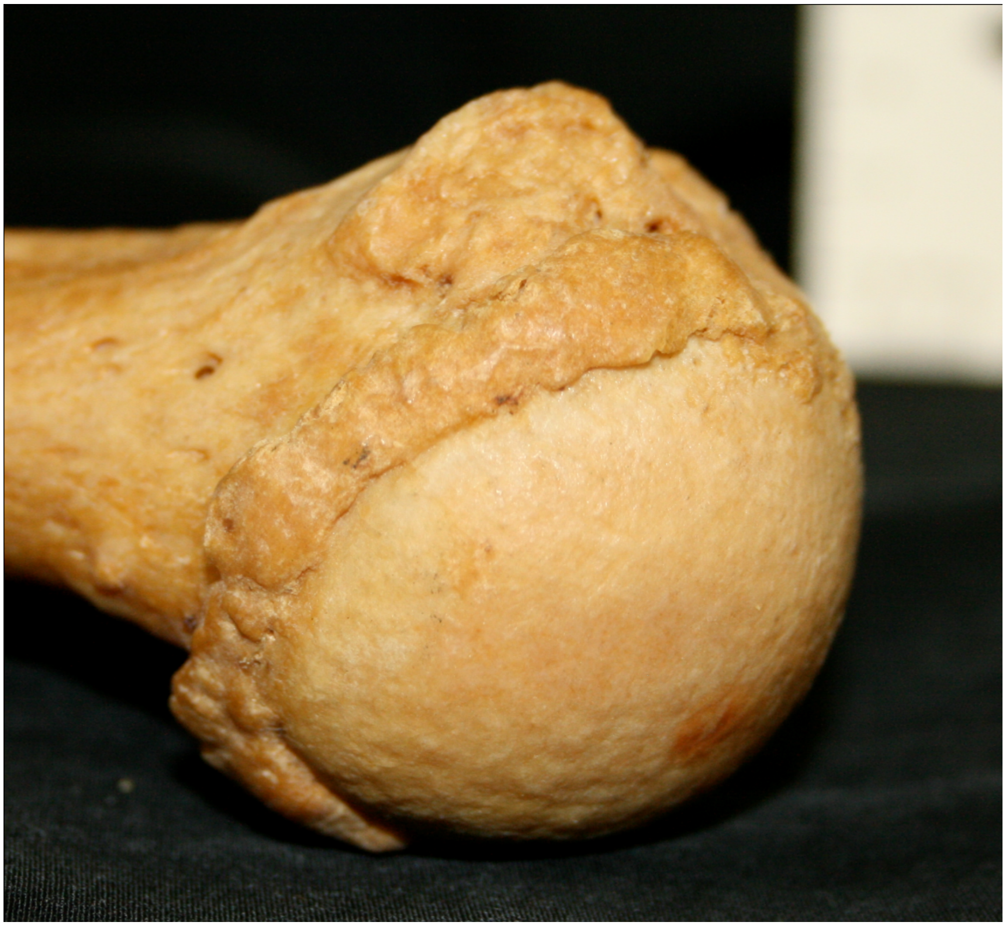
7.2 Terry Collection – Scapula – Grade 3



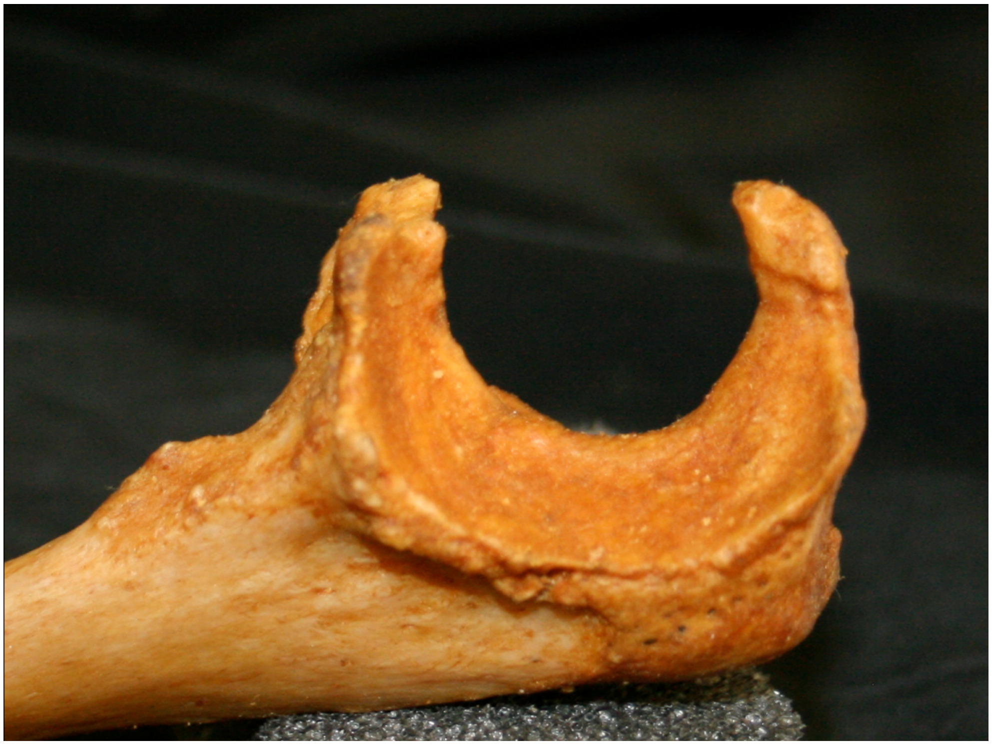
7.3 Terry Collection – Distal Femur – Grade 3



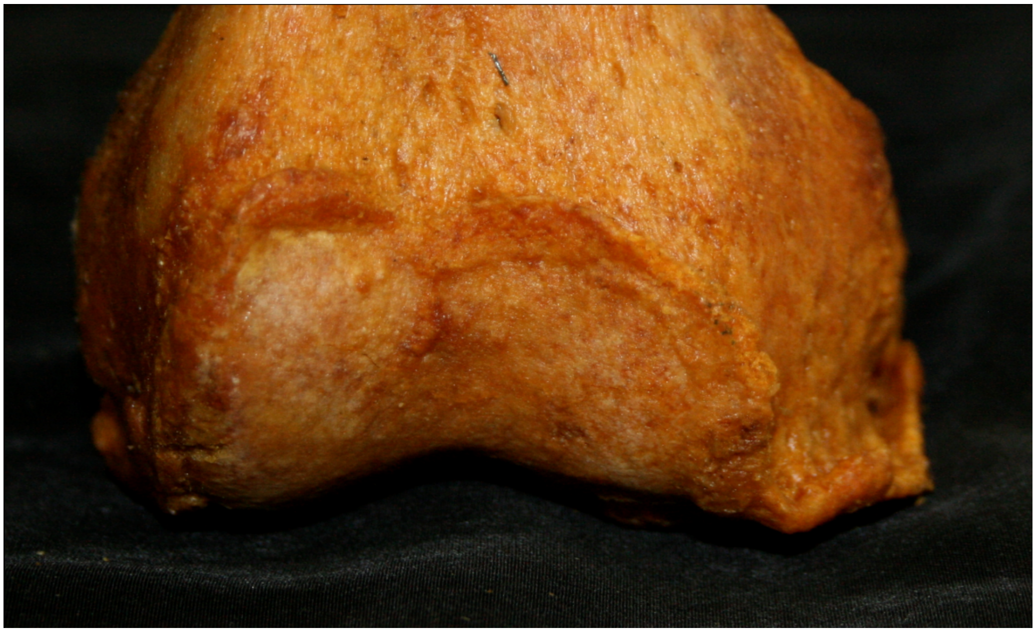
7.4 Terry Collection – Proximal Humerus – Grade 3



7.5 Terry Collection – Proximal Ulna – Grade 3



7.6 Terry Collection – Distal Femur – Grade 2



7.7 Terry Collection – Left Scapula – Grade 2

7.8 Terry Collection – Distal Femur – Grade 1