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Wear and tear in the rich and poor: A study of socioeconomic status and osteoarthritis in the post-medieval population of Eindhoven, The Netherlands.

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Kiki Gaarthuis

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Sources:

1. Map of Eindhoven by Jacob van Deventer around 1560 https://www.eindhovenfotos.nl/1/kaart_eindhoven_1560.html
2. Drawing of the St. Catharinakerk and its graveyard in 1738 by Jan de Beijer. Melssen, J., 2013. De Geschiedenis van de Catharinakerk: een kort overzicht, in N. Arts (ed.), *Een Knekelveld maakt geschiedenis: Het archeologisch onderzoek van het koor en het grafveld van de middeleeuwse Catharinakerk in Eindhoven, circa 1200-1850.* Utrecht: Stichting Matrijs, 27-32.
3. Picture of an osteoarthritic femoral head. ©Kiki Gaarthuis

Wear and tear in the rich and poor

A study of socioeconomic status and osteoarthritis in the post-medieval population of Eindhoven, The Netherlands

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Master Thesis Archaeological Science (1084VTSY)

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1. Introduction

As individuals living in a society, our activities, diet, and health are influenced by our socioeconomic position in said society (Miszkiewicz et al. 2019, 3). Socioeconomic status (SES) can be defined as; "A measure of one's combined economic and social status. It is often measured as a combination of education, income and occupation" (Baker 2014, 1). Socioeconomic status can affect individuals in such a way that it affects entire lives, as it can determine access to health care, resources, and level of activity (Miszkiewicz et al. 2019, 3). Those from the lower socioeconomical strata are often associated with a weaker "health", lack of access to healthcare, nutritional deficiency, poor hygiene and living circumstances and strenuous labour. Whereas those from the higher socioeconomical strata are associated with, less strenuous labour, better health, adequate access to health care and nutritional resources and good living circumstances. Because physical activity includes all bodily motion and activities, it is very broad and thus very difficult to define. Next to this, the anthropology of labour often focusses on how the modern conceptions of labour influences social inequality (Kasmir and Carbonella 2008). Yet, the modern conception is more than likely not applicable to older societies, therefore it is important to mention how archaeologist address labour and physical activity. One approach often used by archaeologists is that of processes involving production and exchange. Other topics covered by archaeologists include craft specialization and elite control of labour. In general labour is often associated with economic arrangements, but it should rather be associated as a social phenomenon. This is because labour is highly routinized, it includes actions that are performed day in day out, and it is a social and bodily experience. This highlights the importance of labour as a lived experience in the daily life of an individual. Therefore, bioarchaeologists use the archaeological context, examine the human skeleton for osteoarthritis or other markers of activity, to assess activity and to discover whether any differences in the lived experience are present (DeWitte et al. 2016, 241-242; Palmer and Waters-Rist 2019, 304; Schrader 2018, 38-39).

In the past few decades multiple different methods have been used and developed to reconstruct activity patterns by studying activity markers. Entheseal changes, changes to the normal surface structure of a bone at the point of muscle tendons and ligament attachment sites, is one of the markers often used to reconstruct activity (for example see Havelkova et al. (2011) or Palmer et al. (2016)). A second marker that can be used to reconstruct activity patterns, is the analysis of fracture patterns, which present in different shapes and different levels of healing (for example see Larsen (1997) (Henderson 2013, 492; Alioto 2015, 110-111). Another marker is osteoarthritis (OA), which has been extensively used in the past and present to study activity patterns in osteological as well as clinical settings. As a result of harsher forms of manual labour, osteoarthritis worsens, thus allowing bioarchaeologists to study the prevalence and severity of osteoarthritis in relation among others to sex, age, and socioeconomic status (Schrader 2018, 55). Other markers which can be indicative of activity are squatting facets, Schmorl's nodes, cross-sectional geometry, and even dental wear patterns (Jurmain et al. 2012, 531-534).

In this thesis, the sole activity marker which will be studied is osteoarthritis. Osteoarthritis has been chosen for this master's thesis, because of its large clinical presence and widespread use within bioarchaeology. Next to this, osteoarthritis is also thought to reflect the level of strenuous manual labour the best among the markers of activity.

1.1 Research problem

For thousands of years social inequality has played a part in human society and has affected the way history and societies have shaped. Because socioeconomic inequality is very prevalent in past and modern day societies, it is important to understand how it can affect the health of individuals and populations. Historical sources can provide information on socioeconomic inequalities in past populations; however, it must be noted that most of these historical sources are biased. The occupation at death, for example, might have been listed by family members, rather than documents provided by the individual previous to death. Next to this, the name of an occupation often oversimplifies the actual tasks that were performed and their biomechanical implications. Moreover, while historical sources can provide fruitful information, it often only globally describes the differences in health between distinct socioeconomical strata and thus lacks specificity. Therefore, it is nearly impossible to correctly assess the impact of socioeconomical status by solely using historical sources. Fortunately, bioarchaeological methods allow one to study the human skeleton an provide more definitive answers addressing how socioeconomic status can affect the health of individuals and populations (Cardoso 2018, 151-155). As previously mentioned, it is known from historical as well as bioarchaeological sources, that in many populations low socioeconomic strata are accompanied with more strenuous labour and a negative effect on health and living conditions (DeWitte et al. 2016, 241-242; Palmer and Waters-Rist 2019, 304). Therefore, it is clear that socioeconomic inequality could influence the level of intensity and type of activity one participated in during one's lifetime.

The indicator of activity, osteoarthritis, has previously been used to study socioeconomic inequality in archaeological populations, yet it is not a topic that is often covered by bioarchaeologists. One of these few studies is by Palmer et al. (2016), in which osteoarthritis and entheseal changes were examined for the collection from the post-Medieval Dutch site of Middenbeemster. The objective of this study was to discover whether activity differed by socioeconomic status and/or sex by using osteoarthritis and entheseal changes. Surprisingly, this study did not find any apparent differences in activity markers related to socioeconomic status. However, according to the authors, this might have been caused by a lack of 'elite' individuals or social differentiation (Palmer et al. 2016).

Beyond the study by Palmer et al. (2016), no other studies have been done on comparing differences in prevalence and levels of osteoarthritis between socioeconomical classes in the Netherlands. Often, when socioeconomic differences are studied in bioarchaeology, two geographically differing populations are used, which might yield inconsistent results. Therefore, this thesis will use the post-Medieval skeletal collection from Eindhoven, which consists of individuals belonging to two differing groups, those who were buried inside of the church and those who were buried in the northern cemetery outside of the church. A burial inside of a church meant that one was in closer proximity to God, while being buried outside meant that one was farther away from God. According to the bible the northern door of a church symbolises heathens, plagues, and sinners, additionally the northern face of a church is also often described as the 'cold side' (Alberdinkh-Thijm 1858, 92-93). Therefore, the cemetery towards the north of a church is often associated with individuals of low to middle socioeconomic status.

Moreover, this collection has not been extensively researched and thus provides a great opportunity to deepen our knowledge on socioeconomic status differences. Hence, this thesis will provide an important unbiased contribution to the understanding of how socioeconomic status and the lived experience are embodied in an archaeological population from the Netherlands.

1.2 Research Questions

The following primary research question has been posed:

- How are differences in socioeconomical status and strenuous labour embodied in the post-medieval population of Eindhoven, The Netherlands?

To gain a more in-depth understanding of the subject, the following sub-questions have been formulated:

1. What are the differences in prevalence and severity of osteoarthritis between the sexes of the lower socioeconomic status population of Eindhoven?
2. What are the differences in prevalence and severity of osteoarthritis between the sexes of the high socioeconomic status population of Eindhoven?
3. What are the differences in prevalence and severity of osteoarthritis between the sexes of the high and lower socioeconomic status populations of Eindhoven?
4. What are the synovial joints most commonly affected in the high and low socioeconomic status populations of Eindhoven and what can this tell us about activity?

1.3 Approach

In order to answer the questions on whether socioeconomic status affected the prevalence and severity of osteoarthritis, the skeletal collection from the St. Catharinakerk in Eindhoven will be studied. Yet, it is important to note that the church from which the skeletal material derives from is the Medieval St. Catharinakerk, which had been demolished in 1860, and is not the current St. Catharinakerk.

In total the skeletal remains of 65 individuals were selected for analysis, of which the general biological profile of the individuals from Eindhoven had been established by Steffen Baetsen and Leonie Weterings-Korthorst. As osteoarthritis is a degenerative disease it is greatly influenced by the passage of time and thus, age. Therefore, non-adults have been excluded from this study, since the chance of them having developed osteoarthritis is close to zero. All of the individuals selected for this research have been scored by the author of this thesis according to Buikstra and Ubelaker (1994). The data derived from this analysis has correspondingly been statistically analysed by the author, has led to an opinionated discussion and at the end has led to a conclusion. This will in the end contribute to a better understanding of the differences in prevalence of osteoarthritis between low and high socioeconomic strata in the post-medieval city of Eindhoven and in The Netherlands.

1.4 Thesis Outline

Following this initial introduction, a background chapter on all aspects of osteoarthritis ranging from terminology to aetiology will be provided. The next chapter will provide more insight into the materials that have been used for this thesis, this will include information about the socioeconomic and historical background of the city of Eindhoven and information on the excavation that was performed in order to retrieve said materials. After this, the methods that have been used for this thesis will be elaborated on in chapter four. The fifth chapter will be used to show the results that have been obtained during this research, and thus will reveal the outcomes of all of the different comparisons. Following the presentation of the results, the latter will be elaborately discussed in the sixth chapter. The final chapter will provide answers to the main research question and the sub-questions, will draw a conclusion, and will provide some suggestions for future research.

2. Osteoarthritis

Osteoarthritis, a condition causing the degeneration of joints and surrounding soft tissue, is the most prevalent disease in past and current society (Haq et al. 2003; Schrader 2018, 56; Weiss 2017, 69). The Encyclopaedia Britannica defines osteoarthritis as follows:

“Osteoarthritis, also called osteoarthrosis or degenerative joint disease, disorder of the joints characterized by progressive deterioration of the articular cartilage or of the entire joint, including the articular cartilage, the synovium (joint lining), the ligaments, and the subchondral bone (bone beneath the cartilage). Osteoarthritis is the most common joint disease, although estimates of incidence and prevalence vary across different regions of the world and among different populations. The disease may be asymptomatic, especially in the early years of its onset. As it progresses, however, pain, stiffness, and a limitation in movement may develop. Common sites of discomfort are the vertebrae, knees, and hips—joints that bear much of the weight of the body. The cause of osteoarthritis is not completely understood.” (www.britannica.com).

It is estimated that today 9.6% of men and 18.0% of women over the age of 65 are affected by symptomatic osteoarthritis, worldwide (Tanna et al. 2013, 6). Next to this, osteoarthritis is also among the most common identified pathological conditions in skeletal collections, therefore making it likely to be just as present in the past world as it is now (Weiss and Jurmain 2007, 437). Even though osteoarthritis is highly prevalent in society, many aspects of this disease are still debated among clinical professionals and academics (Schrader 2018, 56; Weiss 2017, 69). Therefore, to give better insight into osteoarthritis, this chapter will discuss among others the history, terminology, characteristics, and aetiology of osteoarthritis. This chapter will also dive deeper into the relationship between socioeconomical status and osteoarthritis as well as osteoarchaeological research that has been performed previously into osteoarthritis.

2.1 History and terminology

Osteoarthritis is a disease that has plagued humanity for many centuries, as numerous historical accounts suggest. However, these historical sources regarded all types of arthritis as expressions of gout, from the classic period until 250 years ago gout was used as a scapegoat for all rheumatic symptoms (Dequeker and Luyten 2008, 5). In an 1816 publication, William Heberden formulated a remark on the distinction between gout and rheumatism: “The disease called chronical rheumatism, which often passes under the general name of rheumatism and is sometimes supposed to be the gout, is in reality a very different distemper from the genuine gout and from the acute rheumatism, and ought to be carefully distinguished from both.” (Dobson et al. 2018, 1003). However, Heberden had already separated rheumatism from gout in 1782. This signifies one of the first initiatives to make a distinction within the degenerative joint diseases. The term osteoarthritis is speculated to have originated in the 1850s and was coined by the German orthopaedic surgeon Richard von Volkmann, who differentiated between all three major types of arthritis. Yet, von Volkmann’s publication was largely overlooked during its own time due to another study, Charcot and Trastour in 1853, being more popular. Charcot and Trastour synthesized that rheumatoid arthritis and osteoarthritis were different grades of the same condition ‘arthritis deformans’. This term remained the preferred term up till the mid 20th century, after which OA was widely recognised as a distinctive entity (Dobson et al. 2018, 1004). Next to the old term ‘arthritis deformans’, many different terms have been utilised to describe this disease, which confuses both amateurs as well as professionals. Terms utilised to describe this disease in the past include osteoarthrosis, osteoarthritis, degenerative joint disease, hypertrophic arthritis, chronic articular rheumatism, nodular rheumatism, and senile arthritis (Dobson et al. 2018, 1004; Roberts and Manchester 2010, 133). However, for this thesis the use of the term osteoarthritis is preferred, because research has shown that osteoarthritis is an inflammatory disease and the suffix -itis refers to an inflammation, thus justifying the use of the -itis suffix (Weiss 2017, 70-71).

2.2 Characteristics of Osteoarthritis

As mentioned in the introduction of this chapter osteoarthritis is a pathological condition which affects the joints (Haq et al. 2003; Schrader 2018, 56; Weiss 2017, 69). The type of joints osteoarthritis occurs in are the so called diarthrodial joints, better known as synovial joints (Weiss 2017, 71). Synovial joints are composed of the articulating ends of two bones, a layer of cartilage of varying thickness (1-7 millimetres) lining the bone, a capsule lined by synovium on the inside and a layer of fibrous tissues varying in thickness on the outside, ligaments, tendons, and muscles. The synovium’s

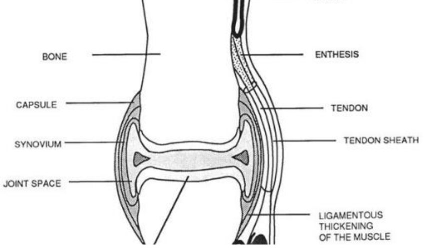

Figure 1: The structure of a synovial joint. (Waldron 2009, 26).

function is to secrete synovial fluid, which lubricates the joint-surface and removes any debris or micro-organism resulting from the wear and tear of the joint (Arden et al. 2008, 5; Waldron 2009, 24-26). During one's lifetime cartilage continues to repair itself, which continues to make the joint function properly (Weiss 2017, 72; Arden et al. 2008, 6). However, this changes when the damage done to the joint outpaces the repair, thus initiating osteoarthritis. Osteoarthritis not only affects the cartilage, it affects the entire joint, the condition also causes subchondral bone (the thin layer cortical bone on the articular surface directly below the cartilage) thickening, synovial fluid and capsule inflammation, degenerative changes of ligaments and osteophyte formation (Weiss 2017, 73).

Three stages can be defined within the process of the breakdown of the articular cartilage in osteoarthritis. The first stage entails the enzymatic breakdown of the cartilage in the joint, whereby the metabolism of the chondrocytes (cartilage-producing cells) is affected, leading to the production of enzymes that further break down the articular cartilage. After this stage, fibrillation (twitching) of the cartilage takes place horizontally as well as vertically. This process of fibrillation causes the erosion of the articular cartilage surface, which in turn lead to the discharge of collagen and proteoglycan (one of the components of cartilage) into the joint cavity. In reaction to the damage a temporary process of chondrocytes multiplying and synthesising more cartilage and proteoglycan is started. Following this, the cartilage becomes soft and begins to show more signs of tearing. However, the release of the collagen and proteoglycan commences the third stage of the cartilage breakdown. During this stage the synovial membrane responds with an inflammatory reaction, which leads to the production of inflammatory cytokines, these can either directly destroy the cartilage or diffuse into it (Goldring and Otero 2014, 471-472; Man and Mologhianu 2014; Martel-Pelletier 2004, 31; Waldron 2009, 27; Weiss 2017, 72). Accompanying the inflammation in the joint the synovium starts producing a protein that stimulates the formation of blood vessels, thus more blood vessels are shaped (Waldron 2009, 27).

Figure 2: An example of moderate lipping, in the right femoral head of individual number 2828. Source: Kiki Gaarthuis.

This process of the breakdown of the cartilage eventually results into changes in the articulating bone, in an attempt of the bone to remodel. These bone changes are what physical anthropologists depend on for the diagnosis of osteoarthritis in a skeleton, with the absence of living tissue. Osteophytic growth also known by the term 'lipping', is the formation of new bone on or around the margins of the surface of the affected joint and is one of these identifiable bone changes. These bony spurs grow in order to maintain stability and reduce further damage in the affected joint. Furthermore, osteophytic growths are the most common feature of osteoarthritis and the easiest feature to identify osteoarthritis (Waldron 2009, 27; Weiss 2017, 73-74; Schrader 2018, 57; Arden et al. 2008, 6). However, it is important to note that the formation of osteophytes might be a response to osteoarthritis rather than a part of the expression of the condition itself (Ortner 2003, 547).

Another feature of osteoarthritis that expresses itself in the skeleton is porosity of the joint surface. The porosity of the joint surface is characterised by microscopic and macroscopic pitting of the joint surface, of which the size and severity increases as the condition progresses. However, in the clinical field this feature is not used to diagnose osteoarthritis, thus raising scepticism on whether to use porosity as a diagnostic feature of osteoarthritis. Moreover, multiple studies (Rothschild 1997; Woods 1995; Weiss and Jurmain 2007; Weiss 2017) have suggested that this porosity might be the result of vascular invasion in an attempt to nourish the deteriorating cartilage. Therefore, physical anthropologists should be cautious when interpretating the severity of porosity in osteoarthritis.

Figure 3: An example of porosity in the acromial end of the left clavicle of individual number 844. Source: Kiki Gaarthuis.

One of the most recognisable pathogenic characteristics of osteoarthritis is eburnation, which gives the bone a smoothly polished appearance similar to ivory or porcelain. Eburnation develops as a result of bone rubbing on other bone in the absence of articular cartilage. Sometimes grooves are present on the eburnated surface as a result of the hinge-like movement of the joint, such as the knee joint, or the presence of debris between the articulating surfaces (Weiss 2017, 74; Ortner 2003, 548; Waldron 2009, 27-28). Eburnation is sometimes used by physical anthropologists as the single feature to determine the presence of osteoarthritis, yet clinical researchers have been able to diagnose osteoarthritis without the presence of eburnation, by using radiographs and magnetic resonance imaging. Therefore, the likelihood of osteoarthritis being underreported would be many times greater if it would be used as the only indicator. Because of this, eburnation is foremost used as an indicator of the severity of osteoarthritis rather than an indicator of whether osteoarthritis is present or absent (Weiss 2017, 74-77). All of the aforementioned changes in the bone can lead to changes in the shape and contour of a joint, mostly in widening and flattening of the joint (Waldron 2009, 27).

Figure 4: An example of moderate eburnation on the distal articular surface of the right distal radius of individual number 2586, because eburnation is difficult to capture on camera the affected area has been encircled in red. Source: Kiki Gaarthuis.

Despite osteoarthritis being able to be determined by only a few characteristics, its diagnosis is not standardised within the medical world or anthropology. This lack of standardisation makes it almost impossible to compare studies to each other, even if the same methodology is used. While using the same methods, one researcher could consider a trait of osteoarthritis absent or more severe than another researcher, thus creating interobserver error rates. Therefore, almost all research into osteoarthritis is biased on the pathological variation of this condition (Weiss 2017, 78).

2.3 Aetiology of Osteoarthritis

Bioarchaeologists have mainly focussed on the effects of mechanical loading (activity) and ageing as the main causations of osteoarthritis over the past decades (Weiss and Jurmain 2007, 439). Aside from that, the aetiology of osteoarthritis can be divided into two main groups primary or 'systemic' osteoarthritis and secondary or 'local' osteoarthritis. One can refer to primary osteoarthritis when there is no obvious direct cause, this is the most common type of osteoarthritis and is the focus of most bioarchaeological research. Hence, for this type of osteoarthritis it cannot exactly be pinpointed by looking at the joint what has caused the osteoarthritis, thus its aetiology is more likely to be multifactorial. Secondary osteoarthritis is when osteoarthritis occurs after an initial insult to the joint. This type of osteoarthritis may occur following trauma to a joint or as the result of another joint disease such as rheumatoid arthritis or a different condition such as Legge-Perthes disease (Waldron 2009, 29; Arden et al. 2008, 10; Ortner 2003, 546-547; Schrader 2018, 56). Because this thesis is focussed on class differences the main aetiology that will be discussed are activity patterns. However, first all the other aetiologies will be discussed.

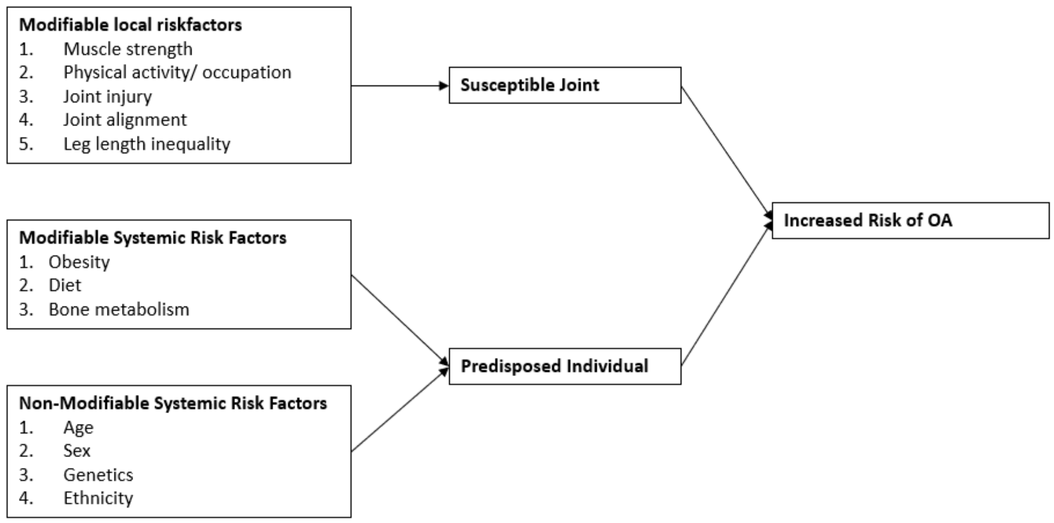

Figure 5: Possible risk factors associated with the susceptibility and predisposition to osteoarthritis. (Adapted from: Johnson and Hunter 2014, 7).

2.3.1 Age

The most prevalent non-activity related cause of osteoarthritis is considered to be age (Weiss 2017, 86). The general assumption is that it is uncommon for individuals below the age of 40 to present with osteoarthritis, however after that age the incidence and prevalence increases considerably (Waldron 2009, 31). Contemporary data from Sarzi-Puttini et al. (2005) shows that 60% of males and 70% of females over the age of 65 are affected by osteoarthritis, while data from WHO shows that more than 30% of adults between the ages of 45 and 64 years of age are affected by osteoarthritis (Myszka et al. 2020, 2358). This increase in the prevalence and incidence of osteoarthritis might be caused by the inability of the old joints to repair the damaged cartilage. During the process of ageing the synthesisation of growth hormone is reduced and these are thought to play a role in the turnover of cartilage. Thus, as the joint ages, it loses its ability to repair the cartilage and eventually succumbs to the strain that has accumulated over the years. Next to this, changes in activity and fitness levels occur with age. Due to a decrease in activity and fitness muscle strength is affected negatively, when muscle strength is reduced or diminished more pressure is put onto the joint, more specifically on the cartilage (Arden et al. 2008, 10-11). Multiple archaeological and clinical studies also indicate the effect age has on the formation and prevalence of osteoarthritis (e.g., Anderson et al. 2010; Verzijl et al. 2003; Baetsen et al. 1997; Calce et al. 2018).

2.3.2 Sex

Besides age, sex can also influence the incidence and prevalence of osteoarthritis. Osteoarthritis affects men and women almost equally until the age of 55, after which women are more commonly affected (Arden et al. 2008, 11). In general, women have a 50% higher risk of developing osteoarthritis (Buckwalter and Lappin 2000; Jones et al. 2000). The increase in risk of developing osteoarthritis in elder women could be explained by the menopause. Following the menopause women experience a drop in oestrogen levels, which can result in an increased risk of developing osteoarthritis (Busija et al. 2010, 762-753). While oestrogen replacement studies do support the hypothesis that oestrogen replacement therapy after menopause decreases the development and progression of osteoarthritis, the association between oestrogen levels and the risk of osteoarthritis does not seem to be consistent (Herndon 2004, 500; Busija et al. 2010, 753). Besides this, women also appear to have thinner cartilage compared to men (Otterness and Eckstein 2007, 670). Thus, in all circumstances women are more prone to the development of osteoarthritis compared to men (Weiss 2017, 89).

2.3.3 Genetics

Over the years it has also come to light, that genes also play a part in the development of osteoarthritis. Familial and twin studies have been performed to discover whether genes can influence the progress of this disease. Studies like these, have determined that genes do influence the formation of osteoarthritis, differences in genotype account for 50% of the heritability of osteoarthritis (Weiss and Jurmain 2007, 439). Yet, the upper-limb joints seem to be affected less by heritability than the knee joint and the vertebral column, for example the heritability of hand osteoarthritis being 39% (Weiss 2017, 92). A gene that can be linked with osteoarthritis is COL2A1, which is a gene that codes for type II procollagen. Mutations in this gene have been shown to lead to early-onset systemic osteoarthritis. Chromosomal linkage studies have also shown an association of disruptions in some chromosomes (2q, 9q, 11q and 16q) with the formation of osteoarthritis (Spector and MacGregor 2003, 40; Weiss 2017, 92). The inflammatory response of an individual has also been proven to be controlled by genes, multiple variants of genes encoding for proteins and cytokines that are responsible for inflammation have been reported to be related to osteoarthritis (Valdes and Spector 2008, 592). However, it is likely that other genes influencing body weight, joint shape and muscle strength also play an important part in the formation, development, and incidence of osteoarthritis (Arden et al. 2008, 11).

2.3.4 Body Mass Index (BMI)

Clinical studies have concluded that the body mass index correlates significantly with the risk of developing osteoarthritis (Berenbaum and Sellam 2008, 667). Accordingly, individuals who are heavier or obese have a greater chance to develop more severe osteoarthritis compared to lighter individuals (Weiss and Jurmain 2007, 441). Not only does obesity influence the formation and development of osteoarthritis in the weight-bearing joints (the knee and hip), but also in the non-weight-bearing joints (such as the fingers) (Berenbaum and Sellam 2008, 667). Being overweight or obese causes the joint to experience more stress on the weight-bearing joints, with each increase of 1 kilo above the BMI of 27 increasing the risk of developing osteoarthritis with 15%, and as a result of that the rate of osteoarthritis hastens (Arden et al. 2008, 14; Berenbaum and Sellam 2008, 667). The knees, as the major weight-bearing joints, are affected the most by increased weight.

Besides the theory of increased mechanical loading of the joints, a metabolic theory has also been proposed. This metabolic theory proposes that local hormones and biological mediators such as leptins and adipokines which are related to obesity, influence the development of osteoarthritis (Myszka et al. 2020, 2358; Abramson and Attur 2009, 2). However, osteological studies on past populations by Weiss (2005, 2006) contradict the results of current clinical studies. These studies show greater osteoarthritis scores in smaller and lighter individuals than larger and overweight individuals. This might either indicate that a higher BMI might be more of a modern problem and the consequences thereof influence clinical literature and studies or that bioarchaeological estimates of BMI are incorrect. Therefore, the influences of body mass on osteoarthritis might not be as significant in pre-modern populations (Weiss and Jurmain 2007, 441-442).

2.3.5 Activity

Osteoarthritis is often looked at, by clinicians as well as osteoarchaeologists, in an attempt to recreate activity patterns (Weiss 2017, 78). The reason behind this is that, as Waldron (2009) states, "joints that do not move, do not develop osteoarthritis", thus making movement a sine qua non for the formation of osteoarthritis (Waldron 2009, 28). Moreover, in past studies it has also been attempted to trace the occupation back from the distribution of osteoarthritis in the skeleton, with some endeavours being successful. Yet, it is important to keep in mind that no form of osteoarthritis is limited or unique to one occupational group, as well as that an increased risk of osteoarthritis at a particular site does not mean that many individuals within a certain occupational group develop it (Waldron 2012, 519-520). Anthropological and clinical studies have shown that excessive activity could lead to the development of osteoarthritis (Molnar et al. 2011, 284). Palmer et al. (2016) shows that the prevalence of osteoarthritis in the shoulder and elbow in the rural population of Middenbeemster is higher than that of other contemporaneous Dutch populations, indicating that the population of Middenbeemster engaged in strenuous activities. According to in vitro research excessive loads on the joint have a negative influence on the joint, including damage to the collagen, cell death and inflammation. Next to that, lab studies have also managed to successfully produce osteophytes while applying mechanical stress (Weiss 2017, 78; Guilak 2011; Sandell and Aigner 2001).

2.4 Osteoarthritis and socioeconomic status an overview of past research

As mentioned in the introduction of this thesis, socioeconomic status can have a large impact on the living circumstances, health, and activity patterns (Baker 2014, 1). Therefore, it is also possible that ones socioeconomical status can influence one's susceptibility to osteoarthritis. Multiple studies have shown a correlation between osteoarthritis and status. In the study by Webb et al. (2009), of a low status skeletal population from the Medieval and post Medieval graveyard of St peter-Le-Bailey in Oxford a high prevalence of osteoarthritis was found. They also found that the males were, apart from the hip, only affected in the upper body, which according to Webb et al. (2009) might be the result of intense activity from a young age in these particular individuals. Moreover, while osteoarthritis was highly prevalent in the individuals from Oxford, joint diseases generally associated with higher status such as DISH and gout were nearly absent (Webb et al. 2009, 149). More comparative research by Rando (2016) of the Eastgate

Square cemetery site in Chichester yielded some interesting results. It was discovered for this sample that the pattern of osteoarthritis did not differ between the high status and low status males, while the females did show differences in osteoarthritis patterns. This led them to hypothesize that high and low socioeconomic males were exposed to similar levels and amount of activity, and that higher status females were probably less subjected to activity than lower class females (Rando 2016, 82). A Dutch study on the skeletons from a cloister cemetery in Dordrecht dating between 1275 and 1572 AD showed a low prevalence of osteoarthritis (Maat et al. 1998). The highest prevalence of osteoarthritis was 12% in the hip joint, while the lowest amount was 3% in the big toe. These results led Maat et al. (1998) to conclude that this part of the population of Dordrecht must have been of a high socioeconomic status, who performed minimal physical labour (Maat et al. 1998, 22-24)

The above-mentioned studies suggest that the labour intensity, which is affected by socioeconomic status, influences the prevalence of osteoarthritis in archaeological collections. However, while the studies mentioned in the above are archaeological studies, most studies on this topic have been performed on modern day populations, not archaeological. Consequently, the field of archaeology is still lacking information on the effects of socioeconomical status on osteoarthritis, especially in the Netherlands.

3. Materials

The skeletal collection used for this thesis originates from post-medieval Eindhoven, which is a city located in the southern part of the Netherlands. To give a better insight on the living circumstances of the individuals from this collection the historical context of the city, which includes the economical situation of Eindhoven during the ages, and the past of the St. Catharinakerk will be provided. Additionally, information on how the excavation proceeded and, on the sample, will be given as well.

Figure 6: The location of Eindhoven within the Netherlands. (Source: https://d-maps.com/carte.php?num_car=4121&lang=en).

3.1 Eindhoven, the historical context of a city

Eindhoven is a city located in the province of Noord-Brabant in the southern part of the Netherlands. The exact date of emergence of this settlement cannot be determined with complete certainty, yet it is clear from archaeological research that there was human activity in the region of Eindhoven before the Middle Ages (Smits 1887, 1; Peynenburg and Tops 1961, 1-2). It is said that Eindhoven arose as a part of Woensel at the end of the 7th century A.D. or the beginning of the 8th century AD. Due to its advantageous position between the rivers the Dommel and Gender, Eindhoven quickly rose to become a prosperous trade centre. This development caused Eindhoven to separate from Woensel and receive city rights from Hendrik I, Duke of Brabant in 1232 (Peynenburg and Tops 1961, 2-6). The newly obtained city rights permitted the city to organise a weekly market, which was beneficial to its approximately 1420 inhabitants, who among other things crafted linen, sheets, hats, and shoes (Smits 1887, 6, 19). In 1390 the city was relieved from provincial taxes, which meant that the trade ware of merchants deriving from ships from the river Schelde was not halted anymore. Accordingly, the wealth, prosperity, and the number of inhabitants of the city grew, in 1435 the population of Eindhoven rose to 1800 inhabitants (Smits 1887, 19). During the 15th century AD five different guilds were established in the city of Eindhoven, because of the upcoming wealth and trade. These five guilds were the shoemakers and tanner's guild, the smiths, bakers and pedlar's guild, the brewers, wine sellers and butcher's guild, the linen-weavers and -sellers and leathercrafters guild, and the draper's guild (Lintsen and Thoben 2009, 32).

Though, the development and welfare of Eindhoven became diminished due the occurrence of many wars and various other conflicts at the end of the 15th century and during the entirety of the 16th century. In 1486, after houses having been destroyed, plundered and many inhabitants having either been arrested or killed, soldiers led by the count of Aremberg set fire to the city, causing among others the destruction of the city hall and its archives. Misfortune occurred once again in July of 1543, Eindhoven was yet again attacked and plundered, this time by the troops of the Duke of Guelders. Shortly after this attack the plague broke out in Eindhoven, causing even more death and destruction in the city (Peynenburg and Tops 1961, 9-11). Ten years after this, the city was set to ashes once again, due to a city fire in the night of January 2nd, 1554. This fire affected 150 homes, which meant that approximately three quarters of the entire city was destroyed (van Schagen 2020, 34). These unfortunate events lead to a severe decrease in the number of inhabitants and welfare of Eindhoven. This lasted until 1581, when the inhabitants of Eindhoven experienced a new surge of prosperity, resulting in a steep increase of the number of inhabitants of the city, which rose to 2138 individuals. During the Eighty Years' War (1568-1648) Eindhoven was in total conquered ten times by the Dutch States army and the Spanish royal army, every invasion leaving behind a path of death and destruction. During the sieges on Eindhoven the inhabitants also had to deal with an ongoing famine, which elevated the food prices to absurdity and resulted in a further decline of the population number to approximately 800 inhabitants (Smits 1887, 25-63). Consecutively, after the Twelve Years' Truce ended in 1621 the financial situation in Eindhoven worsened even more. Because the very little number of artisans, who were left with few resources and did not own any land, had to raise the taxes for the city. Next to this, many of the 150 houses in the city were uninhabited due to inhabitants fleeing the city and of houses that were inhabited, 25 were inhabited by individuals who were exempt from taxation because of their low socioeconomic status. During these unruly years, the privileged right of organising a weekly market in Eindhoven was disputed. This was problematic, because Eindhoven did not have a peasant class, there were no arable lands and barely any vegetable gardens inside the walls and was dependent on provision from its direct surroundings (van Schagen 2020, 46-47). Following the peace treaty of Munster on January 30th, 1648, Eindhoven became a part of the Republic of the Seven United Netherlands. However, this did not lead to a true peace for Eindhoven, Roman Catholicism was forbidden, and higher taxes were imposed on the city by the Republic (Peynenburg and Tops 1961, 18). Yet, wealth and prosperity did in general increase in The Netherlands for the higher class as well as for the middle and lower class (van Schagen 2020, 47).

However, the peace treaty of 1648 did not prevent Eindhoven from being sieged and occupied during the following century. In June of 1672 Eindhoven was forced to yield its provisions to the French army and was occupied by the French a month later. The French occupied Eindhoven for one and a half year and left the city in an even worse economical situation than the city previously was. During this period in time, most of the inhabitants of Eindhoven were part of the bourgeoisie. Ten years later, Eindhoven was once again occupied by the French, this time the occupation lasted for three years. However, successive to the peace the prices of foodstuffs rose to such an extent that a famine almost ensued. This dire situation mainly affected the poor, resulting in an increase in poverty, beggars, and vagrants in the city. In the following decades Eindhoven was repeatedly attacked by the French and Austrians, as well as suffering under multiple epidemics due to bad hygienic conditions in the streets of the city. During the 18th century, a general increase of paupers took place in Eindhoven and its surrounding villages and towns. This came hand in hand with the dwindling linen industry, during this period the number of looms decreased from 1100 to barely 100, because of foreign competition. In 1793 during the French revolution, Eindhoven once again came into the possession of the French (Peynenburg and Tops 1961, 46-58; van Schagen 2020, 50-56). Between 1790 and 1794, Eindhoven was inhabited by 1785 individuals, 1243 middle and high status individuals and 542 low status individuals (van Schagen 2020, 58). While after the French occupation taxes were increased and living conditions worsened. This led to an increase of the low socioeconomic class, at the end of the 18th century of the 2300 inhabitants approximately 1000 individuals were considered to be of the lower class (Peynenburg and Tops 1961, 59-62). In 1798 it was decided to abolish the guilds, reasoned by that the rules they imposed on the working class were standing in the way of the development of a healthy economy in the city (van Schagen 2020, 63). On February the 5th 1814, Eindhoven had officially accepted to be a part of the Kingdom of The Netherlands under King Willem I, henceforth Eindhoven was not considered to be occupied territory and could focus on its future (Peynenburg and Tops 1961, 94). Soon after 1815, the industrial revolution took hold of Eindhoven, which resulted in the flourishing of many industries. However, many of its inhabitants lack perspective, looking back at the desolate situation of the city last centuries. Resulting in every member of each household, even small children, putting in maximum effort to survive the costs of daily life, yet the wages one received remained low and the food prices high (van Schagen 2020, 72).

All in all, Eindhoven was the victim of misfortune for many centuries, with many of its poorer inhabitants suffering the consequences of war, disease, and famine. Next to this, the thriving city of Eindhoven as we currently know it, came in to being in the late 19th century and 20th century, which is important for visualising the past urban environment of the city.

3.2 The history of the St. Catharinakerk

The skeletal population sample that has been studied for this thesis derives from the St. Catharinakerk (St. Catherine's church), hence it is important to gain more knowledge of its history in order to get more familiar with the individuals who would have lived in Eindhoven. Similar to the foundation date of the city of Eindhoven, it is unknown when exactly its first church was built. However, it has been proposed that the first inhabitants used to worship in the parochial church of Woensel, approximately 2 kilometres from Eindhoven. Next to this, it is known that until the 14th century AD there was one pastor presiding over the parish of Woensel and Eindhoven. The earliest record of a church in Eindhoven in literary sources dates to 1340 (Melssen 2013, 27-29). It is also unknown when Eindhoven became a parish of its own, but the split most likely occurred between 1380 and 1390 when the holy Catharina of Alexandria was chosen as the patron saint of the church (Peynenburg and Tops 1961, 25). In 1399 the St. Catharinakerk was elevated to the status of a collegiate church by the Bishop of Liège (Melssen 2013, 28).

Figure 7: The St. Catharinakerk on a coloured sketch of Isaac van Ostade. (van Schagen 2020, 15).

During the siege of 1486, the church could not escape plundering and like many other buildings was heavily damaged by fire. This led to the construction of a new church building in 1489, which only measured 50 metres by 25 metres (Peynenburg and Tops 1961, 25). From historical sources it is known that the church was under construction or repaired in the years 1437, 1489, 1529, 1610, 1611, 1614, 1750, 1771, 1798-1810, 1823, 1830 until its destruction in 1860. Through the years, the church has served multiple purposes, for instance for burial (until 1794), public notices, storage, and other purposes. Most of the times when a part was added to the church or when it was repaired, it was a result one of the many misfortunes that impacted the city. In 1526, the spire collapsed onto the roof of the church, as a result of a heavy storm (Smits 1887, 22). However, this was not the only instance when the church was damaged, in 1486, 1554 and 1566 the church damaged by fire, it was looted in 1543 and in 1566 statues and altars were destroyed due to the iconoclasm.

Following the end of the Eighty years' war in 1648, the church that once was Roman Catholic permanently fell into the hands of the Reformed Protestants (Melssen 2013, 30). In 1794, the church was confiscated by the French, constructed bread ovens in the church, in order to supply their regiments. In the course of constructing and the use of the ovens by the French, the nave of the church largely collapsed when a column was torn down and as a result of this a small fire started. During the French occupation, the church functioned as a bakery, a storage facility for the French army, housing for the poor and maybe even as a law court. In 1809 after a visit from Louis Bonaparte, the Roman Catholic faith was reinstalled and practised in the St. Catharinakerk once again from 1810 onwards. It must be noted that while the Protestants used the church and condemned the Roman Catholic faith for 161 years, the Catholics were allowed to bury their deceased inside the church and on the premises of the graveyard outside the church (Peynenburg and Tops 1961, 124-125).

Before the old St. Catharinakerk was destroyed in 1860, it was completely surrounded by a brick wall. The first record of the use of a graveyard next to the church dates to as early as 1416 AD. Yet, it was not solely used as a graveyard, during its existence it was also used as a meeting place, playground and at the end of the 18th when the graveyard became severely neglected it was even used as a garbage dump, animal pasture and latrine. Archival data sheds light on how expensive it was to be buried inside the church and the lesser costs to be buried outside of the church. Between the years 1637 and 1640, the standard price for a burial inside the church was 14 stuivers (fl. 0.70) for an adult and 7 stuivers (fl. 0.45) for a child, while the half of those prices had to be paid to be buried in the graveyard outside of the church (Melssen 2013, 31-32). After the protestants were in charge of the church in 1648, the prices changed drastically, the new prices became 6.30 guilders to be buried inside the church for an adult and the half that price for a child, while the price to be buried on the graveyard changed to 1.50 guilders (www.catharinakerkhof.nl). These price differences indicate that there would have been a socioeconomical distinction between the individuals who were buried inside the church and outside the church.

3.3 Burials outside and inside of the church

In the Early Medieval period, the first Christians in Western Europe were accustomed to burying their dead in open yards. Yet, from the 9th century AD clergymen were pressured into allowing burials inside the church. For example, in 813 the city council of Mainz permitted senior clergy, royalty and other high status individuals to be interred inside its church. This eventually led to more individuals wanting to be buried inside the church and thus becoming a standard procedure for individuals who could afford it from the 13th century AD onwards. Moreover, within a church some locations were considered to be more sacred than others (O'Sullivan 2013, 271). A burial near the high altar on the most eastern side of a church or near the shrine of a saint were considered the most desirable locations (Daniell 1998, 86). While burials anywhere in a church denoted a certain degree of wealth, there was a distinct social hierarchy within the church. This often involved a decreasing hierarchy from the eastern part to the western part of the church and the separation of the tombs of the gentry and aristocracy from the less wealthy (O'Sullivan 2013, 271-272). Thus, it was more desirable to be buried inside a church than to be buried in a graveyard outside a church, as it signified the degree of an individuals' socioeconomic standing.

In general, individuals from a middle and low socioeconomic status could only afford to be interred in the graveyard outside the church. However, within the graveyard outside the church some locations were preferred over others as well (Veselka and Klomp 2019, 139). In the post-medieval period, a burial on the "sunny" southern side outside of the church was preferred over the "cold" northern side (van Oosten 2018, 155). The northern side of the church was considered to be the breeding ground of darkness, sin, minorities and sin. This is complemented by the biblical view that the northern door of the church is related to pagans, sinners, and plagues (Alberdinkh Thijm 1858, 92-93). Hence, individuals who possessed enough money preferred a burial in the southern graveyard, leaving only the poorest individuals and outsiders to be buried in the northern graveyard. Therefore, it is most likely that individuals buried inside the St. Catharinakerk were of a higher socioeconomical status than the individuals buried in the graveyard outside of the church. Yet, the status of these individuals cannot be confirmed with certainty, due to the lack of archival documents stating specific occupations.

3.4 The excavation of the old St. Catharinakerk (2005-2006)

Following the excavation of trial trenches in 2002, a larger scale excavation, which was expected to last one-and-a-half year was planned to start in 2005. The entire excavation consisted of a single trench, spanning over a surface of approximately 340 m^2 (Nollen 2013, 38-39). All of the features in this excavation were measured in with the help of a laser spirit level, eventually there were 19 levels (vlakken) ranging between 15.35 and 17.20 meters above NAP (Normaal Amsterdams Peil, the Dutch water level system) (Nollen 2013, 40).

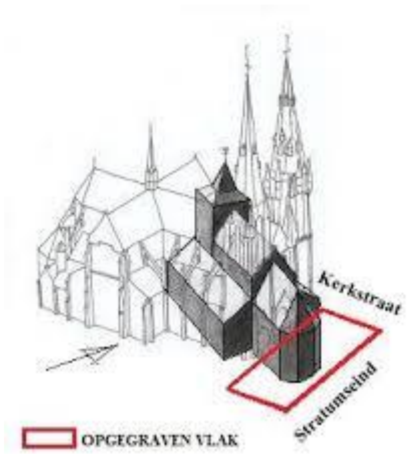

Figure 8: The location of the old and new St. Catharinakerk, the part which has been excavated is in red. https://www.opdenrosheuvel.nl/pdf-regio/Eindhoven,%20op%20voorspraak%20van%20de%20Heilige%20Catharina%20v%201.0.pdf

During the excavation 752 primary burials as well as many secondary burials were discovered. The skeletons that were excavated during this excavation were buried in four different parts of the inside of the church and church's graveyard, the choir, the second choir, the southern graveyard, and the northern graveyard. The burials were dated accordingly to the artifacts, optically stimulated luminescence dating (OSL), the Harris matrix and C14-dating, which led to a division of four distinct periods, 1200-1350, 1350-1500, 1500-1650 and 1650-1850. Nearly all of the burials that were dated, dated between 1650-1850 (162 burials), which might have been the result of the population growth in Eindhoven after 1650. Due to the increasing size of the population after 1650, the pressure on the graveyard increased and as a result only wealthy individuals would have been able to afford a burial inside the church. The most crowded burial spot was graveyard to the north of the church, resulting in the excavation of 293 individuals (Nollen 2013, 117-118). During the excavation most skeletons were found to have been buried with their head positioned in the west and their feet in the east, according to Christian burial rituals (Nollen 2013, 122). The skeletons were over all reasonably well preserved, yet this differed per time period in which the individuals were buried (Baetsen and Weterings- Korthorst 2013, 160-161).

Figure 9: The excavation from above. ©Laurens Mulkens 2007.

3.4 Selected sample

At Leiden University, 287 skeletons of the entire number of 752 excavated primary burials were available for analysis. In this thesis, the differences in prevalence and severity of OA between the sexes and ages of different socioeconomical groups will be researched. Non-adult individuals were deselected for this thesis, because OA does not commonly affect non-adults and the sex of non-adults cannot be macroscopically determined (White and Folkens 2005). Additionally, for this thesis the vertebral column will not be studied, because the joints between vertebrae are not synovial (Jurmain and Kilgore 1995, 445).

Next to this, in order to create a more accurate picture of the differences between the socioeconomical groups in Eindhoven, timeframes which are more socioeconomically cohesive have been selected (1500-1650 and 1650-1850). Furthermore, the individuals selected for this thesis were required to at least be 50% complete. As a result of the selection measures, 65 skeletons were deemed suitable for analysis. Moreover, due to the limited sample size the individuals from the northern and southern graveyard were combined, as well as the individuals from the choir and the second choir. Among these selected individuals, 48 were dated between 1650 and 1850, and 17 were dated between 1500 and 1650. More extensive information on the skeletal sample is provided for in tables 1 and 2.

Table 1: The distribution of sex per time period for both sites.

Burial site	1500-1600		1650-1850		Total
	Male	Female	Male	Female	
Inside the church	4	0	5	4	13
Outside the church	9	4	21	18	52
Total	13	4	26	22	65

Table 2: The distribution of sex per time period for each age group.

Age-at-death	1500-1650		1650-1850		Total
	Male	Female	Male	Female	
20-29	3	1	5	3	12
30-39	2	1	3	2	8
40-49	2	2	7	5	16
50-59	4	0	8	7	19
60-69	2	0	3	5	10
Total	13	4	26	22	65

4. Methods

In this chapter the methods used to obtain information from the skeletal sample population from Eindhoven will be discussed. During and after the excavation the skeletal remains were analysed by Steffen Baetsen and Leonie Weterings-Korthorst. Therefore, the methods used by Steffen Baetsen and Leonie Weterings-Korthorst to estimate sex and age-at-death will be described. Next to this the methods used by the author to obtain the data on the prevalence and severity of osteoarthritis and the statistical methods used to analyse this data will also be discussed.

4.1 Sex

The sex of the skeletons from Eindhoven has been estimated by using the morphological features of the pelvis and the cranium. Steffen Baetsen and Leonie Weterings-Korthorst scored these features according to the method of the *Workshop of European Anthropologists* (Baetsen and Weterings-Korthorst 2013, 154). In this method certain traits of the pelvis and skull are scored based on the degree of sexualisation. These traits are scored in five categories: hyperfeminine (-2), feminine (-1), indeterminate (0), masculine (+1) and hypermasculine (+2) (WEA 1980, 517-525). During the estimation of sex if an individual had a total score between -2 and -0.75 or +0.75 and +2 the individual was estimated to be female or male, when an individual scored between -0.75 and -0.5 or +0.5 and +0.75 the individual was estimated to be a probable female or male and when an individual scored between -0.1 and +0.1 the sex was estimated to be indeterminate. Because sex estimations from the pelvis are more accurate than those from the skull, the estimations from the pelvis were prioritized. In the case that the results from the different traits opposed each other, a metrical sex estimation method was used to help estimate the sex. The maximum length of the humerus and femur and the diameter of the diaphysis of the femur and tibia were measured and accordingly the sex was estimated by using the method developed by Steward (1979) (Baetsen and Weterings-Korthorst 2013, 154-155). However, the method proposed by the WEA is mostly only used for skeletal remains in The Netherlands. Internationally, other methods such as the method proposed by Buikstra and Ubelaker (1994) and Phenice (1969) are more commonly used to estimate sex.

4.2 Age-at-death

During the analysis of the skeletons from Eindhoven, Baetsen and Weterings-Korthorst (2013) used four different methods to estimate the age-at-death. The first method used to estimate the age-at-death of an individual was the method by Ascádi and Nemeskéri (1970). This method, also called the complex method, uses a combination of the following indicators of age: the degeneration of the pubic symphysis (pubic bone), the spongiosum (spongy bone) of the femur, spongiosum of the humerus and closure of the cranial sutures. The second method that was used for age estimation is by Lovejoy et al. (1985), for this method the changes to the auricular surface of the ilium are scored and the individual is grouped in one of the eight different age groups. The next method that was used is the method by Işcan et al. (1984, 1985), this method considers the degenerative changes to the sternal end of the fourth rib. Lastly, the method by Hermann et al. (1990) was used to estimate age by looking at the level of cranial suture obliteration.

The age estimates resulting from the complex method were considered before the others. However, this method is only accurate if three or four of the age indicators were able to be scored. When only two or three age indicators were present, the other methods were used to round the complex method up or down to determine a fitting age group. When the complex method resulted in an age that deviated to much and the other methods were not able to be used, the individual was not assigned to an age group. A method based on dental attrition by Maat (1998 and 2002) was also used when it was impossible to use the complex method (Baetsen and Weterings-Korthorst 2013, 154-156). The adult individuals were categorised into five different age groups: 20-29, 30-39, 40-49, 50-59 and 60-69 (Baetsen and Weterings-Korthorst 2013, 167).

4.3 Osteoarthritis

The prevalence of osteoarthritis in this skeletal sample has been macroscopically analysed by the author of this thesis. The surfaces of the joints were analysed and scored on the three main abnormalities associated with osteoarthritis, lipping (osteophytic growth), porosity and eburnation. The deformation of the joint contour was also taken into account, yet it was not specifically used to determine the severity of osteoarthritis (Roberts and Manchester 2010, 135-138). Eburnation is generally looked upon as the most reliable indicator and sometimes even as the only reliable indicator of osteoarthritis. Waldron and Rogers (1991) also mention that if eburnation is not present at least two of the other indicators of osteoarthritis need to be present on the joint surface (Waldron and Rogers 1991, 49). This has been partially implemented by the author, see table 3. Over the years, multiple different methods to assess osteoarthritis have been developed (Larsen et al. 1995; Klaus et al. 2009; Lieverse et al. 2007; Rogers and Waldron 1995; Öberg et al. 1971; Jurmain 1990; Weiss 2006; Buikstra and Ubelaker 1994; Steckel et al. 2006). Thus, a standardised method for the scoring of osteoarthritis is still lacking in the current bioarchaeological community. This includes a lack of specification of the elements of the joint systems that are analysed. For this thesis, the following joints, and the skeletal elements that the joint is comprised of, have been described:

Acromio-clavicular joint: comprising of the articular surface of the acromial end of the clavicle and the articular surface of the acromion.

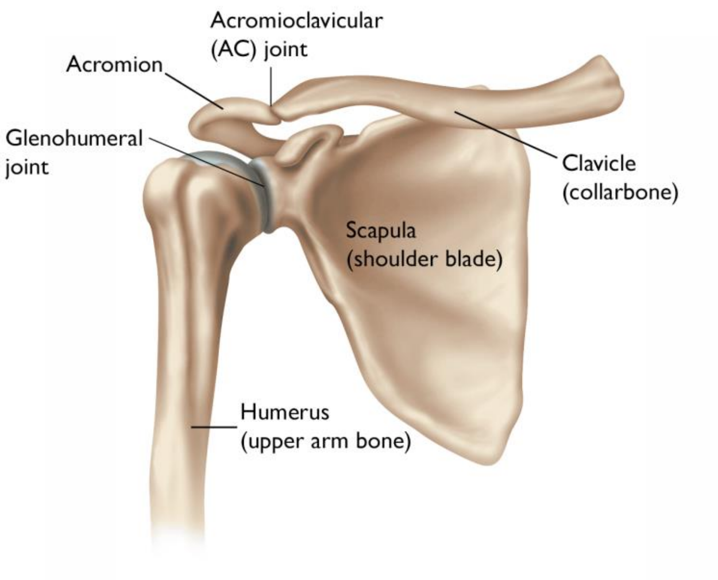

Figure 10: The location of the acromioclavicular and glenohumeral joint in the shoulder.
https://orthoinfo.aaos.org/en/diseases--conditions/arthritis-of-the-shoulder

Gleno-humeral joint: comprising of the articular surface of the glenoid cavity and the humeral head.

Radio-humeral joint: comprising of the capitulum and the radial head.

Ulna-humeral joint: comprising of the trochlea, trochlear notch, olecranon, and coronoid process.

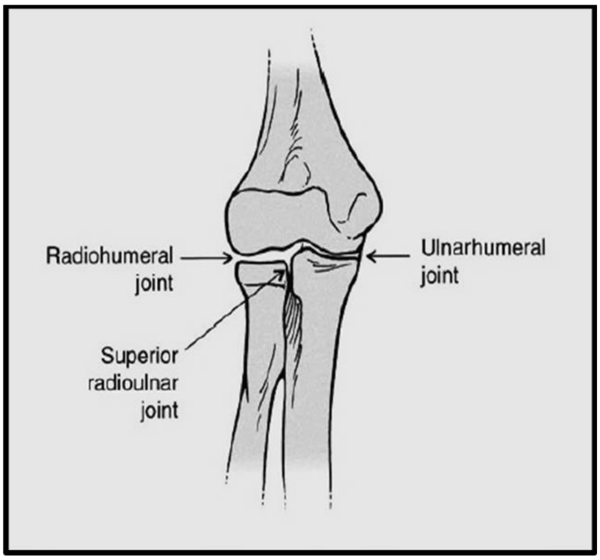

Figure 11: The joints of the elbow. (Lafta Mossa 2018).

Radio-ulnar joints: comprising of the radial head and radial notch on the proximal side and the medial and distal aspect of the ulna and the ulnar notch of the radius on the distal side

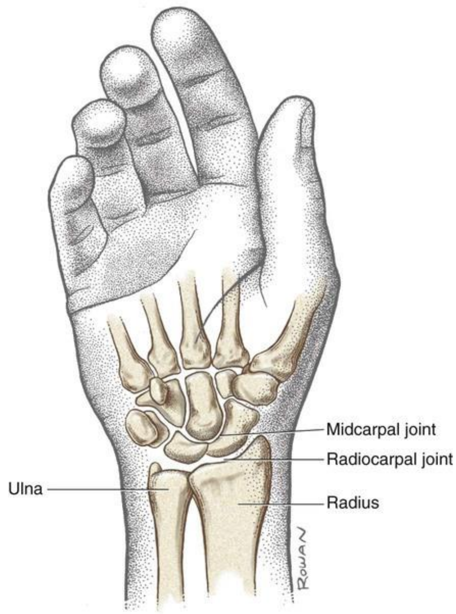

Figure 12: The location of the radiocarpal joint. https://standardofcare.com/wrist/

Radio-carpal joint: comprising of the distal radial articular surface, the lunate, and the scaphoid.

Acetabulo-femoral joint: comprising of the acetabulum and the femoral head.

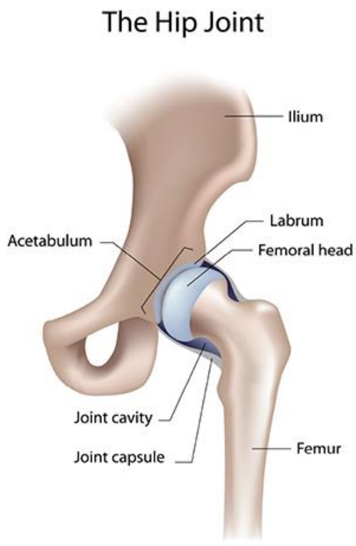

Figure 13: The acetabulo-femoral joint in the hip. https://keepingmewell.com/services/what-is-physiotherapy/self-help/hip-pain/

Tibio-femoral joint: comprising of the medial and lateral condyles of the femur and the medial and lateral epicondyles of the tibia.

Patello-femoral joint: comprising of the patellar surface of the femur and the medial and lateral articular surfaces of the patella.

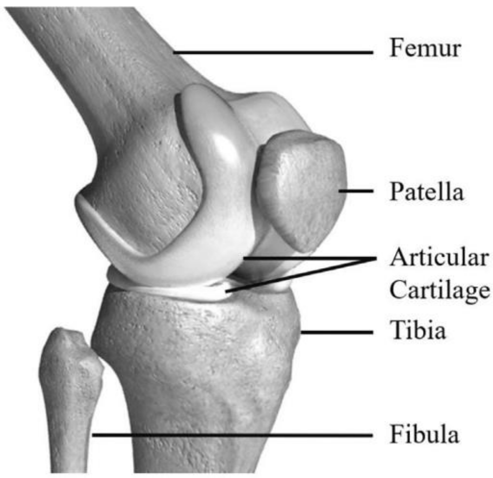

Figure 14: The knee joint. (Kohkar et al. 2020).

Tibio-fibular joint: consisting of the superior fibular articular facet of the tibia and the proximal fibular articular surface of the fibula.

Talo-crural joint: consisting of the distal malleolar articular surface of the fibula, the medial malleolus of the tibia and the trochlea of the talus.

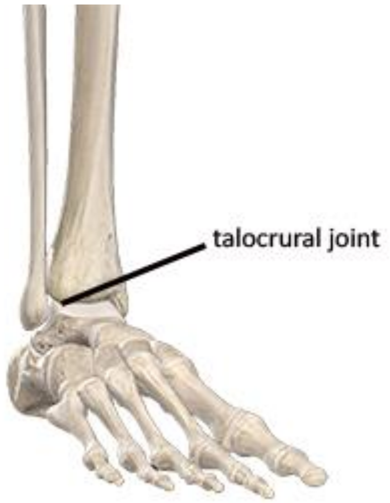

Figure 15: The location of the talocrural joint. https://www.academyofclinicalmassage.com/ankle-structure-and-mechanics/

For this thesis the choice was made to exclude the vertebrae, the small joints in the hands and the feet. The vertebrae were excluded from this study because the joints between the vertebrae are not synovial joints (Jurmain and Kilgore 1995, 445). The small joints in the hands and the feet were excluded because they are often missing, and its osteoarthritis is often easily confused with rheumatic arthritis.

This thesis will use only one of the previously mentioned methods, namely Buikstra and Ubelaker (1994), this has been done to increase the accuracy of the outcomes of the analysis. The method proposed by Buikstra and Ubelaker scores the severity/prevalence of lipping, porosity, and eburnation separately, which increases the accuracy of the results and allows for eventual backtracking of the results (Schrader 2018, 70-71). Buikstra and Ubelaker (1994) assess osteoarthritis as follows:

Lipping: degree

1) Barely discernible
2) Sharp ridge, sometimes curled with spicules
3) Extensive spicule formation
4) Ankylosis

Lipping: Extent of circumference affected by most severe expression

1) <1/3
2) 1/3-2/3
3) >2/3

Surface porosity: Degree

1) Pinpoint
2) Coalesced
3) Both pinpoint and coalesced present

Porosity: Extent of surface affected

1) <1/3
2) 1/3-2/3
3) >2/3

Eburnation: Degree

1) Barely discernible
2) Polish only
3) Polish with grooves

Eburnation: Extent of surface affected

1) <1/3
2) 1/3-2/3
3) >2/3

In the scoring method developed by Buikstra and Ubelaker (1994) two different criteria are applied per trait, yet, for this research the two different criteria per trait will be combined. Next to this, the fourth degree of lipping, ankylosis, will be eliminated. In addition to this a score of 0 will be added, which represents the absence of any signs of osteoarthritis. During the initial collecting of the data, a score of 4 had been given when an element was present but damaged and thus not suited for scoring, and a score of 5 had been given when an element was not present. After all data had been collected the lipping, porosity and eburnation scores were combined and given a score ranging from 0 to 3, according to table 3. This was done to make the data interpretable for the statistical analysis.

Table 3: The scoring system, as applied in this study.

Osteoarthritis	
0	Absence of osteoarthritis
1	Mild Lipping and porosity, moderate lipping without porosity or severe porosity without lipping
2	Moderate lipping and moderate porosity or severe lipping and mild porosity
3	eburnation present

4.4 Data Analysis

In order to be able to correctly statistically analyse the data obtained from scoring the skeletal remains on osteoarthritis, a excel data sheet had been made. This excel data sheet the data on sex, age-at-death, location, and severity of osteoarthritis on the basis on the three traits for each bone was entered. The program used to perform the statistical analysis for this thesis is IBM SPSS 26. To be able to analyse the data In IBM SPSS 26 the data had been transformed into numerical values (see table 4).

Table 4: The numerical values assigned to the age-at-death groups, sites, and sexes

Age-at-death		Site	
1	20-29	1	inside
2	30-39	2	outside
3	40-49	Sex	
4	50-59	1	Male
5	60-69	2	Female

To establish whether there are significant differences in the severity and prevalence of osteoarthritis between and within the two skeletal samples, the mean osteoarthritis scores have been compared against each other. The type of statistical testing that has been used for this is the ANCOVA test also known as Analysis of Covariance. ANCOVA is a general linear model to compare means, this test needs a dependent variable (measurements/scores), an independent variable (categorical values/groups) and a covariate. ANCOVA controls the influence of a covariate, in this study it is age-at-death, which reduces the within-group error variance and eliminates the confounds (Field 2015, 575-576).

In order to accept or reject a null-hypothesis, the p-value (probability-value) needs to be determined. This value indicates whether there is a statistically significant difference between the means of the groups compared to each other. The boundary often set for the p-value is at the α level of 0.05, when the p-value is greater than the α level the null-hypothesis can be accepted and the result is deemed statistically insignificant, when the p-value is less or equal to the α level the null-hypothesis should be rejected, and the result is deemed statistically significant. However, for this thesis an α level of 0.1 will be used, not an α level of 0.05. This has been done because most research in physical anthropology is not well suited for the use of statistical significance, as in most studies one deals with small sample sizes. The p-value can severely differ depending on the sample size used, in a small sample a large effect can still result in bigger p-values, while in a large sample a small effect can still result in a small p-value. Therefore, by increasing the α level to 0.1 one partially makes up for the less accurate perspective an α level of 0.05 creates (Valeggia and Fernández-Duque 2021, 193). The results of the statistical analysis will be displayed in the next chapter, whereas the results will be interpreted and discussed in chapter six.

5. Results

In this chapter, the data on osteoarthritis deriving from the population samples from inside and outside the St. Catharinakerk in Eindhoven will be thoroughly analysed. The two population samples will first be analysed separately, regarding the prevalence of osteoarthritis in the population and the differences between the sexes. This will be followed by another subchapter comparing the individuals from inside and outside the church to each other. The separate analysis of the two population will provide an insight on the differences between a population of the same socioeconomical background, resulting in a better understanding of the data before the populations are compared to each other.

5.1 Results cemetery outside of the St. Catharinakerk

The lower socioeconomic status sample population consists of 52 individuals, of these individuals 27 individuals were affected by osteoarthritis, meaning these individuals either presented with a certain degree of lipping and porosity or eburnation on at least one of the studied elements. This indicates that 51.92% of the sample population was affected by osteoarthritis. The skeletal element most commonly affected within the lower socioeconomic status population, is the acromial end of the left clavicle with a prevalence of 40%. While the acromial end of the left clavicle is the most affected element, multiple elements are not affected at all, such as the distal epiphysis of the humerus, left scaphoid, the distal epiphysis of the left tibia, the proximal fibula, and the talus. When adding all of the number of affected individuals and dividing this by the total number of individuals, osteoarthritis seems to be more prevalent in the right side (8.38%) than in the left side (8.04%). Other percentages on the prevalence of osteoarthritis in the analysed skeletal elements are visible in table 5.

Table 5: The prevalence of osteoarthritis among the sample population buried outside of the St. Catharinakerk per analysed skeletal element.

outside	OA					
	Left			Right		
	N total	N affected	%	N total	N affected	%
Acromial end clavicle	35	14	40%	37	9	24.3%
Acromion	29	8	27.6%	36	9	25%
Glenoid fossa	45	2	4.4%	43	3	7%
Humeral head	44	5	11.4%	44	7	15.9%
Distal humerus	45	0	0%	46	0	0%
Proximal ulna	49	3	6.1%	48	2	4.2%
Distal ulna	42	2	4.8%	37	2	5.4%
Proximal radius	46	1	2.2%	43	1	2.3%
Distal radius	43	2	4.7%	43	0	0%
Scaphoid	41	0	0%	41	1	2.4%
Lunate	40	2	5%	43	4	9.3%
Acetabulum	50	6	12%	48	10	20.8%
Femoral head	48	4	8.3%	50	4	8%
Distal Femur	45	1	2.2%	45	1	2.2%
Patella	40	4	10%	42	3	7.1%
Proximal Tibia	42	1	2.4%	46	2	4.4%
Distal Tibia	42	0	0%	46	1	2.2%
Proximal Fibula	18	0	0%	21	0	0%
Distal Fibula	34	1	2.9%	36	1	2.8%
Talus	37	0	0%	37	0	0%

5.1.1 Sex

To obtain a complete picture of how osteoarthritis affects a population, sex must be considered. Therefore, the mean osteoarthritis scores of males and females have been compared against each other, as well as the prevalence of osteoarthritis in the analysed skeletal elements. In the skeletal population buried outside the church 17 of the 30 males (56.67%) and 10 of the 22 females (45.45%) were affected by osteoarthritis. From tables 6 and 7, it is visible that the element which is affected the most in both males and females, is the left acromial end of the clavicle. Among the lower limbs the prevalence of osteoarthritis stands out in both sexes, with percentages being higher than other elements in that certain region.

Table 6: The prevalence of osteoarthritis among the males of the sample population buried outside of the St. Catharinakerk per analysed element.

Outside Males	OA					
	Left			Right		
	N total	N affected	%	N total	N affected	%
Acromial end clavicle	25	11	44%	22	6	27.3%
Acromion	23	8	34.8%	24	7	29.2%
Glenoid fossa	28	2	7.1%	27	3	11.1%
Humeral head	27	4	14.8%	26	4	15.4%
Distal humerus	27	0	0%	26	0	0%
Proximal ulna	28	1	3.6%	27	2	7.4%
Distal ulna	25	2	8%	24	1	4.2%
Proximal radius	27	0	0%	25	1	4%
Distal radius	25	1	4%	25	0	0%
Scaphoid	23	0	0%	23	1	4.4%
Lunate	22	1	4.6%	24	3	12.5%
Acetabulum	30	3	10%	28	6	21.4%
Femoral head	27	2	7.4%	30	0	0%
Distal Femur	24	0	0%	26	0	0%
Patella	23	1	4.4%	22	1	4.6%
Proximal Tibia	24	0	0%	26	1	3.9%
Distal Tibia	24	0	0%	26	1	3.9%
Proximal Fibula	9	0	0%	13	0	0%
Distal Fibula	20	0	0%	19	1	5.3%
Talus	20	0	0%	20	0	0%

Table 7: The prevalence of osteoarthritis among the females of the sample population buried outside of the St. Catharinakerk per analysed element.

Outside Females	OA					
	Left			Right		
	N total	N affected	%	N total	N affected	%
Acromial end clavicle	10	3	30%	15	3	20%
Acromion	6	0	0%	12	2	16.7%
Glenoid fossa	17	0	0%	16	0	0%
Humeral head	17	1	5.9%	18	3	16.7%
Distal humerus	18	0	0%	20	0	0%
Proximal ulna	21	2	9.5%	21	0	0%
Distal ulna	17	0	0%	13	1	7.7%
Proximal radius	19	1	5.3%	18	0	0%
Distal radius	18	1	5.6%	18	0	0%
Scaphoid	18	0	0%	18	0	0%
Lunate	18	1	5.6%	19	1	5.3%
Acetabulum	20	3	15%	20	4	20%
Femoral head	21	2	9.5%	20	4	20%
Distal Femur	21	1	4.8%	19	1	5.3%
Patella	17	3	17.7%	20	2	10%
Proximal Tibia	18	1	5.6%	20	1	5%
Distal Tibia	18	0	0%	20	0	0%
Proximal Fibula	9	0	0%	8	0	0%
Distal Fibula	14	1	7.1%	17	0	0%
Talus	17	0	0%	17	0	0%

However, while these percentages do provide more insight in which elements are more affected by osteoarthritis, it does not account for the severity of the disease. The mean of the osteoarthritis scores per element gives a better insight into the severity of osteoarthritis in all of the analysed elements. To analyse the differences in mean scores, the statistic testing method ANCOVA has been used. When looking at the mean scores for osteoarthritis (see table 8) for the males and females of this sample, it is evident that the highest mean score among the elements is that of the female right femoral head (mean = 0.55). This high of a mean score was not observed for the male right femoral head (mean = 0.00). Thus, suggesting that this difference might be of statistical significance, which it is ($F(1,47) = 6.08$, p= 0.017) (see table 9). The element which resulted in the highest mean for the males is the right acromion (mean = 0.54), yet when comparing this to the female right acromion it did not result in a statistically significant result ($F(1,33) = 2.18$, p= 0.149). The other element of which the comparison between the sexes did yield a statistically significant result is the left acromion ($F(1,26) = 3.096$, p= 0.090).

Table 8: The mean osteoarthritis score per skeletal element, sex, and side. N= total number of individuals available for analysis.

Outside	Right Female			Left Female			Right Male			Left Male		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Acromial end clavicle	15	0.20	0.414	10	0.30	0.483	22	0.36	0.727	25	0.52	0.714
Acromion	12	0.17	0.389	6	0.00	-	24	0.54	0.977	23	0.39	0.538
Glenoid fossa	16	0.00	-	17	0.00	-	27	0.11	0.320	28	0.07	0.262
Humeral head	18	0.17	0.383	17	0.18	0.728	26	0.15	0.368	27	0.15	0.362
Distal humerus	20	0.00	-	18	0.00	-	26	0.00	-	27	0.00	-
Proximal ulna	21	0.00	-	21	0.19	0.680	27	0.07	0.267	28	0.11	0.567
Distal ulna	13	0.23	0.832	17	0.00	-	24	0.13	0.612	25	0.20	0.707
Proximal radius	18	0.00	-	19	0.16	0.688	25	0.04	0.200	27	0.00	-
Distal radius	18	0.00	-	18	0.06	0.236	25	0.00	-	25	0.12	0.600
Scaphoid	18	0.00	-	18	0.00	-	23	0.13	0.626	23	0.00	-
Lunate	19	0.05	0.229	18	0.06	0.236	24	0.13	0.336	22	0.05	0.213
Acetabulum	20	0.40	0.940	20	0.20	0.523	28	0.21	0.418	30	0.13	0.434
Femoral head	20	0.55	1.146	21	0.19	0.680	30	0.00	-	27	0.15	0.602
Distal Femur	19	0.16	0.688	21	0.05	0.218	26	0.00	-	24	0.00	-
Patella	20	0.20	0.696	17	0.18	0.393	22	0.05	0.213	23	0.04	0.209
Proximal Tibia	20	0.05	0.224	18	0.06	0.236	26	0.04	0.196	24	0.00	-
Distal Tibia	20	0.00	-	18	0.00	-	26	0.04	0.196	24	0.00	-
Proximal Fibula	8	0.00	-	9	0.00	-	13	0.00	-	9	0.00	-
Distal Fibula	17	0.00	-	14	0.07	0.267	19	0.16	0.688	20	0.00	-
Talus	17	0.00	-	17	0.00	-	20	0.00	-	20	0.00	-

Table 9: The number of analysed individuals, the F-values and p-values for each analysed element when comparing the mean osteoarthritis scores of the males and females from outside of the St. Catharinakerk to each other.

outside	Left			Right		
	N	F	P-value	N	F	P-value
Acromial end clavicle	35	2.552	0.120	37	1.493	0.230
Acromion	29	3.096	0.090	36	2.180	0.149
Glenoid fossa	45	1.766	0.191	43	2.437	0.126
Humeral head	44	0.075	0.785	44	0.030	0.863
Distal humerus	45	-	-	46	-	-
Proximal ulna	49	0.155	0.696	48	2.032	0.161
Distal ulna	42	2.341	0.134	37	0.080	0.779
Proximal radius	46	2.235	0.142	43	1.111	0.298
Distal radius	43	0.365	0.549	43	-	-
Scaphoid	41	-	-	41	1.426	0.240
Lunate	40	0.007	0.952	43	1.001	0.323
Acetabulum	50	0.140	0.710	48	0.466	0.498
Femoral head	48	0.027	0.870	50	6.079	0.017
Distal Femur	45	1.152	0.289	45	1.350	0.252
Patella	40	1.109	0.299	42	1.263	0.268
Proximal Tibia	42	1.374	0.248	46	0.300	0.862
Distal Tibia	42	-	-	46	1.107	0.299
Proximal Fibula	18	-	-	21	-	-
Distal Fibula	34	1.366	0.251	36	0.616	0.438
Talus	37	-	-	37	-	-

5.2 Inside the church

This sample consist of 13 individuals, of which 5 were affected by osteoarthritis on at least one of the studied elements, which means that 38.46% of the sample population was affected by osteoarthritis. Before discussing more in-depth information on this sample, it must be mentioned that because of the small size of this sample the results might not be an accurate representation of the population. The skeletal element affected the most in this sample is the right acromial end of the clavicle with a prevalence of 40%. Elements showing surprisingly high percentages are the left distal radius and the right scaphoid, both presenting with a prevalence of 20%. While these elements are more often affected by osteoarthritis, elements such as the humeral head and distal tibia are not at all affected by osteoarthritis. Moreover, the side more commonly affected in this sample is the right side (5.64%), the left side shows a prevalence of 5.58%. The remaining percentages and numbers on the prevalence of osteoarthritis within this sample are visible in table 10.

Table 10: The prevalence of osteoarthritis among the sample population buried inside of the St. Catharinakerk per analysed skeletal element

inside	OA					
	Left			Right		
	N total	N affected	%	N total	N affected	%
Acromial end clavicle	8	2	25%	5	2	40%
Acromion	8	1	12.5%	8	0	0%
Glenoid fossa	11	0	0%	12	0	0%
Humeral head	13	0	0%	12	0	0%
Distal humerus	11	0	0%	13	0	0%
Proximal ulna	12	0	0%	12	0	0%
Distal ulna	10	1	10%	13	0	0%
Proximal radius	10	0	0%	10	0	0%
Distal radius	10	2	20%	11	1	9.1%
Scaphoid	10	1	10%	5	1	20%
Lunate	6	0	0%	10	1	10%
Acetabulum	12	1	8.3%	13	1	7.7%
Femoral head	11	0	0%	11	1	9.1%
Distal Femur	10	0	0%	10	1	10%
Patella	10	1	10%	10	1	10%
Proximal Tibia	12	2	16.7%	9	1	11.1%
Distal Tibia	11	0	0%	10	0	0%
Proximal Fibula	5	0	0%	3	0	0%
Distal Fibula	8	0	0%	9	1	11.1%
Talus	9	0	0%	9	0	0%

5.2.1 Sex

This sample consists of 9 males and 4 females, of which 3 (33.33%) males and 2 (50%) females were affected by osteoarthritis. This results in a total of 5 out of 13 (38.46%) individuals being affected. The skeletal element which is most affected in the male sample is the right scaphoid and, in the females, it is the left proximal tibia (see tables 11 and 12). However due to the small sample size these results must be approached with caution.

Table 11: The prevalence of osteoarthritis among the males of the sample population buried inside of the St. Catharinakerk per analysed element.

Inside Males	OA					
	Left			Right		
	N total	N affected	%	N total	N affected	%
Acromial end clavicle	4	0	0%	1	0	0%
Acromion	4	0	0%	4	0	0%
Glenoid fossa	7	0	0%	8	0	0%
Humeral head	9	0	0%	9	0	0%
Distal humerus	7	0	0%	9	0	0%
Proximal ulna	8	0	0%	8	0	0%
Distal ulna	7	1	14.3%	7	0	0%
Proximal radius	7	0	0%	9	0	0%
Distal radius	8	2	25%	8	1	12.5%
Scaphoid	9	1	11.1%	2	1	50%
Lunate	4	0	0%	7	1	14.3%
Acetabulum	7	1	14.3%	9	0	0%
Femoral head	9	0	0%	7	1	14.3%
Distal Femur	9	0	0%	7	0	0%
Patella	7	0	0%	7	0	0%
Proximal Tibia	9	0	0%	7	0	0%
Distal Tibia	8	0	0%	7	0	0%
Proximal Fibula	3	0	0%	2	0	0%
Distal Fibula	6	0	0%	6	0	0%
Talus	7	0	0%	6	0	0%

Table 12: The prevalence of osteoarthritis among the females of the sample population buried inside of the St. Catharinakerk per analysed element.

Inside Females	OA					
	Left			Right		
	N total	N affected	%	N total	N affected	%
Acromial end clavicle	4	2	50%	4	2	50%
Acromion	4	1	25%	4	0	0%
Glenoid fossa	4	0	0%	4	0	0%
Humeral head	4	0	0%	3	0	0%
Distal humerus	4	0	0%	4	0	0%
Proximal ulna	4	0	0%	4	0	0%
Distal ulna	3	0	0%	3	0	0%
Proximal radius	3	0	0%	4	0	0%
Distal radius	2	0	0%	3	0	0%
Scaphoid	1	0	0%	3	0	0%
Lunate	2	0	0%	3	0	0%
Acetabulum	4	0	0%	4	1	25%
Femoral head	2	0	0%	4	0	0%
Distal Femur	1	0	0%	3	1	33.3%
Patella	3	1	33.3%	3	1	33.3%
Proximal Tibia	3	2	66.7%	2	1	50%
Distal Tibia	3	0	0%	3	0	0%
Proximal Fibula	2	0	0%	1	0	0%
Distal Fibula	2	0	0%	3	1	33.3%
Talus	3	0	0%	3	0	0%

When looking at the mean scores of osteoarthritis in this sample (see table 13) for the males and females of this sample, the greatest mean between the sexes is that of the male right scaphoid (mean= 1.5). The greatest mean in the female sample is that of the left proximal tibia (mean= 0.67). However, when statistically comparing the means of these two elements between the sexes, it did not result in a statistically significant result (see table 14). Elements of which the statistical comparison did result in statistical significance are the left acromial end of the clavicle ($F(1,5) = 6.499$, p= 0.051), the right acromial end of the clavicle ($F(1,5)= 6.499$, p= 0.051) and the left proximal tibia ($F(1,9)= 11.390$, p= 0.008). All of the other comparisons did not yield statistically significant results.

Table 13: The mean osteoarthritis score per skeletal element, sex, and side. N= total number of individuals available for analysis

Inside	Right Female			Left Female			Right Male			Left Male		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Acromial end clavicle	4	0.50	0.577	4	0.50	0.577	1	0.00	-	4	0.00	-
Acromion	4	0.00	-	4	0.25	0.500	4	0.00	-	4	0.00	-
Glenoid fossa	4	0.00	-	4	0.00	-	8	0.00	-	7	0.00	-
Humeral head	4	0.00	-	4	0.00	-	9	0.00	-	9	0.00	-
Distal humerus	4	0.00	-	4	0.00	-	9	0.00	-	7	0.00	-
Proximal ulna	4	0.00	-	4	0.00	-	8	0.00	-	9	0.00	-
Distal ulna	3	0.00	-	3	0.00	-	7	0.00	-	7	0.43	1.134
Proximal radius	4	0.00	-	3	0.00	-	9	0.00	-	7	0.00	-
Distal radius	3	0.00	-	2	0.00	-	8	0.38	1.061	8	0.75	1.389
Scaphoid	3	0.00	-	1	0.00	-	2	1.5	2.121	9	0.33	1.000
Lunate	3	0.00	-	2	0.00	-	7	0.43	1.134	4	0.00	-
Acetabulum	4	0.25	0.500	4	0.00	-	9	0.00	-	8	0.13	0.354
Femoral head	4	0.00	-	2	0.00	-	7	0.14	0.378	9	0.00	-
Distal Femur	3	0.33	0.577	1	0.00	-	7	0.00	-	9	0.00	-
Patella	3	0.33	0.577	3	0.33	0.577	7	0.00	-	7	0.00	-
Proximal Tibia	2	0.50	0.707	2	0.67	0.577	7	0.00	-	9	0.00	-
Distal Tibia	3	0.00	-	3	0.00	-	7	0.00	-	8	0.00	-
Proximal Fibula	1	0.00	-	2	0.00	-	2	0.00	-	3	0.00	-
Distal Fibula	3	0.33	0.577	2	0.00	-	6	0.00	-	6	0.00	-
Talus	2	0.00	-	2	0.00	-	6	0.00	-	7	0.00	-

Table 14: The number of analysed individuals, the F-values and p-values for each analysed element when comparing the mean osteoarthritis scores of the males and females from inside of the St. Catharinakerk to each other.

inside	Left			Right		
	N	F	P-value	N	F	P-value
Acromial end clavicle	8	6.499	0.051	5	1.052	0.051
Acromion	8	2.105	0.206	8	-	-
Glenoid fossa	11	-	-	12	-	-
Humeral head	13	-	-	12	-	-
Distal humerus	11	-	-	13	-	-
Proximal ulna	12	-	-	12	-	-
Distal ulna	10	0.220	0.654	13	-	-
Proximal radius	10	-	-	10	-	-
Distal radius	10	0.258	0.627	11	0.214	0.656
Scaphoid	10	0.102	0.758	5	1.600	0.333
Lunate	6	-	-	10	0.227	0.648
Acetabulum	12	0.397	0.544	13	3.558	0.890
Femoral head	11	-	-	11	0.450	0.521
Distal Femur	10	-	-	10	1.757	0.227
Patella	10	1.690	0.235	10	1.757	0.227
Proximal Tibia	12	11.390	0.008	9	3.559	0.108
Distal Tibia	11	-	-	10	-	-
Proximal Fibula	5	-	-	3	-	-
Distal Fibula	8	-	-	9	1.397	0.282
Talus	9	-	-	9	-	-

5.3 Inside versus outside

In order to answer the research questions, the skeletal sample populations from inside and outside the church needed to be compared to each other. The mean scores in table 15 show that within the sample from outside the church the mean score of the left acromial end of the clavicle is the highest among all elements. For the sample population from inside the church the mean scores of the left distal radius and right scaphoid are the highest among the analysed elements. Furthermore, it is apparent that both populations do not show any signs of osteoarthritis in the following elements: the right and left distal humerus, left distal tibia, right and left proximal fibula, and the right and left talus. The lowest mean osteoarthritis score among the inside sample population is that of both acetabula, while that of the outside sample population is that of the right distal ulna, left distal femur, left proximal tibia and right distal tibia. The p-values were also calculated for the means, these values are also shown in table 15. The comparison of six of the elements lead to a p-value below 0.1, when comparing the sites to each other. These elements are the left acromial end of the clavicle ($F(1,40)= 3.188$, p= 0.082), right humeral head ($F(1,53)= 2.848$, p= 0.097), right distal radius ($F(1,51)= 3.584$, p= 0.064), left distal radius ($F(1,50)= 3.428$, p= 0.07), right scaphoid ($F(1,43)= 3.478$, p= 0.069) and left scaphoid ($F(1,48)= 3.804$, p= 0.057). The statistical analysis of the other skeletal elements did not lead to statistically significant results (p-value≤0.1).

Table 15: The mean and marginal mean scores for osteoarthritis of the inside and outside population per skeletal element, where N is the number of individuals that were available for analysis. Together with the p-values for the comparison of the means between the sites. The numbers in bold signify the highest mean scores in both populations.

Entire sample	Inside			Outside			P-value
	N	Mean	Marginal Mean	N	Mean	Marginal Mean	
Right acromial end clavicle	5	0.40	0.311	37	0.30	0.309	0.996
Left acromial end clavicle	8	0.25	0.089	35	**0.46**	0.494	0.082
Right acromion	8	0.00	-0.042	36	0.42	0.426	0.136
Left acromion	8	0.13	0.084	29	0.31	0.322	0.261
Right glenoid fossa	12	0.00	-0.009	43	0.07	0.072	0.299
Left glenoid fossa	11	0.00	-0.013	45	0.21	0.048	0.352
Right humeral head	12	0.00	-0.020	44	0.16	0.165	0.097
Left humeral head	13	0.00	-0.064	44	0.16	0.068	0.105
Right distal humerus	13	0.00	0.000	46	0.00	0.000	-
Left distal humerus	11	0.00	0.000	45	0.00	0.000	-
Right proximal ulna	12	0.00	-0.010	48	0.04	0.044	0.371
Left proximal ulna	12	0.00	-0.017	49	0.14	0.147	0.378
Right distal ulna	10	0.00	-0.007	43	0.02	0.025	0.463
Left distal ulna	10	0.00	0.049	46	0.07	0.054	0.972
Right proximal radius	13	0.00	-0.034	37	0.16	0.171	0.359
Left proximal radius	10	0.30	0.216	42	0.12	0.139	0.736
Right distal radius	11	0.27	0.264	43	0.00	0.002	0.064
Left distal radius	10	**0.60**	0.560	43	0.09	0.102	0.070
Right scaphoid	5	**0.60**	0.595	41	0.07	0.074	0.069
Left scaphoid	10	0.30	0.295	41	0.00	0.001	0.057
Right lunate	10	0.30	0.284	43	0.09	0.097	0.275
Left lunate	6	0.00	-0.015	40	0.05	0.052	0.470
Right acetabulum	13	0.08	0.004	48	0.29	0.311	0.123
Left acetabulum	12	0.08	0.050	50	0.16	0.168	0.421
Right femoral head	11	0.09	0.025	50	0.22	0.235	0.386
Left femoral head	11	0.00	-0.012	48	0.17	0.084	0.360
Right distal femur	10	0.10	0.087	45	0.07	0.070	0.916
Left distal femur	10	0.00	0.000	45	0.02	0.022	0.651
Right patella	10	0.10	0.119	42	0.12	0.115	0.981
Left patella	10	0.10	0.029	40	0.10	0.118	0.423
Right proximal tibia	9	0.11	0.099	46	0.04	0.046	0.549
Left proximal tibia	12	0.17	0.156	42	0.02	0.027	0.104
Right distal tibia	10	0.00	-0.011	46	0.02	0.024	0.477
Left distal tibia	11	0.00	0.000	42	0.00	0.000	-
Right proximal fibula	3	0.00	0.000	21	0.00	0.000	-
Left proximal fibula	5	0.00	0.000	18	0.00	0.000	-
Right distal fibula	9	0.11	0.137	36	0.08	0.077	0.750
Left distal fibula	8	0.00	-0.003	34	0.03	0.030	0.609
Right talus	9	0.00	0.000	37	0.00	0.000	-
Left talus	9	0.00	0.000	37	0.00	0.000	-

5.3.1. Sex inside versus outside

Due to the small sample size of the population buried inside of the church, only the males of each site could be compared to each other, as the female population from inside the church consists only of four individuals. The total amount of male individuals is 39, 30 from the sample population buried outside of the church and 9 from the sample population buried inside the church. 17 Of the 30 males buried outside of the church were affected by osteoarthritis (56.67%), while 3 of the 9 males buried inside the church were affected (30%). Table 16 shows the mean osteoarthritis scores of the males of both sides per analysed element, as well as the p-value when comparing the sites and when controlling for the covariate age. What is apparent from this table, is that the males from inside the almost do not show any sign of osteoarthritis in the upper limbs. Moreover, it seems that the males from inside the church in general show lesser signs of osteoarthritis. The highest mean score observed in the male population from inside the church is that of the right scaphoid (mean= 1.5), however this is based only on the analysis of two individuals. The second highest mean score is that of the left distal radius (mean= 0.75), which is more reliant as it is based on the analysis of eight individuals. The highest mean among the males from outside of the church is that of the right acromion (mean= 0.54). The comparison of the mean scores of the two sites has led to three of the elements being statistically significant. These three elements are: the right humeral head ($F(1,32) = 3.086$, $p= 0.089$), right scaphoid ($F(1,22)= 6.376$, $p= 0.19$) and right acetabulum ($F(1,34)= 5.809$, $p= 0.022$). In the next chapter, the possible explanation for these statistically significant mean scores of these elements will be discussed as well as those for the other results.

Table 16: The mean and marginal mean scores for osteoarthritis of the male population found inside and outside the church per skeletal element, where N is the number of individuals that were available for analysis. Together with the p-values for the comparison of the mean osteoarthritis scores between the sites. The numbers in bold signify the highest means for the males in both populations.

Males	Inside			Outside			P-value
	N	Mean	Marginal Mean	N	Mean	Marginal Mean	
Right acromial end clavicle	1	0.00	-0.201	22	0.36	0.153	0.455
Left acromial end clavicle	4	0.00	-0.337	25	0.52	0.574	0.12
Right acromion	4	0.00	-0.083	24	**0.54**	0.556	0.227
Left acromion	4	0.00	-0.101	23	0.39	0.409	0.111
Right glenoid fossa	8	0.00	-0.031	27	0.11	0.120	0.219
Left glenoid fossa	7	0.00	0.035	28	0.07	0.045	0.274
Right humeral head	9	0.00	-0.057	26	0.15	0.063	0.089
Left humeral head	9	0.00	-0.072	27	0.15	0.172	0.62
Right distal humerus	9	0.00	0.000	26	0.00	0.000	-
Left distal humerus	7	0.00	0.000	27	0.00	0.000	-
Right proximal ulna	8	0.00	-0.027	27	0.07	0.082	0.274
Left Proximal ulna	8	0.00	-0.100	28	0.11	0.136	0.262
Right Distal ulna	9	0.00	-0.087	24	0.13	0.150	0.322
Left distal ulna	7	0.43	0.200	25	0.20	0.264	0.861
Right proximal radius	7	0.00	-0.022	25	0.04	0.048	0.339
Left proximal radius	7	0.00	0.000	27	0.00	0.000	-
Right distal radius	8	0.38	0.360	25	0.00	0.005	0.130
Left distal radius	8	0.75	0.649	25	0.12	0.152	0.2
Right scaphoid	2	**1.50**	1.445	23	0.13	0.135	0.019
Left scaphoid	9	0.33	0.321	23	0.00	0.005	0.169
Right lunate	7	0.43	0.373	24	0.13	0.141	0.385
Left lunate	4	0.00	-0.070	22	0.05	0.058	0.257
Right acetabulum	9	0.00	-0.091	28	0.21	0.244	0.022
Left acetabulum	8	0.13	0.084	30	0.13	0.144	0.735
Right femoral head	7	0.14	0.141	30	0.00	0.000	0.54
Left femoral head	9	0.00	-0.041	27	0.15	0.162	0.354
Right distal femur	7	0.00	0.000	26	0.00	0.000	-
Left distal femur	9	0.00	0.000	24	0.00	0.000	-
Right patella	7	0.00	-0.031	22	0.05	0.055	0.338
Left patella	7	0.00	-0.270	23	0.04	0.052	0.373
Right proximal tibia	7	0.00	-0.004	26	0.04	0.040	0.590
Left proximal tibia	9	0.00	0.000	24	0.00	0.000	-
Right distal tibia	7	0.00	-0.022	26	0.04	0.044	0.412
Left distal tibia	8	0.00	0.000	24	0.00	0.000	-
Right proximal fibula	2	0.00	0.000	13	0.00	0.000	-
Left proximal fibula	3	0.00	0.000	9	0.00	0.000	-
Right distal fibula	6	0.00	0.048	19	0.16	0.143	0.760
Left distal fibula	6	0.00	0.000	20	0.00	0.000	-
Right talus	6	0.00	0.000	20	0.00	0.000	-
Left Talus	7	0.00	0.000	20	0.00	0.000	-

6. Discussion

The main objective of this thesis has been to research whether socioeconomic status has an impact on the development of osteoarthritis. In order to come to a conclusion and answer the objective, the results of the statistical analysis have to be interpreted and discussed. Therefore, this chapter will elaborate on the results deriving from the analysis and will provide insights on these results. First of all, the results from the previous chapter will be interpreted, discussed and compared to other studies. Secondly, the general relation of socioeconomic status and activity in this sample population will be discussed as well as its effectiveness. After this, the limitations of osteoarchaeological research will be discussed in the form of the osteological paradox and the bone former conundrum.

6.1 The lower status population of Eindhoven

It is immediately clear from the results of the analysis, that the acromial end of the clavicle and the acromion are among the elements that are most commonly affected by osteoarthritis in this sample. Therefore, the acromioclavicular joint (a part of the shoulder, which assists in abduction and flexion of the shoulder) is the joint which shows the highest prevalence of osteoarthritis in the lower status population of Eindhoven (Wong and Kiel 2018). This could be an indication of physical strain on the acromioclavicular joint, possibly caused by strenuous labour. However, a study on the prevalence, stages, and severity of osteoarthritis in modern cadavers by Petersson (1983), found that the degradation of the acromioclavicular joint is a gradual process normally associated with ageing. Therefore, the sample population used for this study has been controlled for age during the statistical analysis. Yet, the prevalence of osteoarthritis in the acromioclavicular joint in this population is quite high and comparable to the results of Palmer et al. (2016). The results of Palmer et al. (2016) show the following percentages, left clavicle 37.93%, right clavicle 54.55%, left acromion 26.67% and right acromion 28.13%. The population buried outside the St. Catharinakerk in Eindhoven shows the following percentages, left clavicle 40%, right clavicle 24.3%, left acromion 27.6% and right acromion 25%. Palmer et al. (2016) argue that the individuals from Middenbeemster must have engaged in more strenuous labour activities, because it shows a higher prevalence compared to other contemporaneous Dutch populations. The other contemporaneous Dutch populations the data from Middenbeemster was compared to the urban post medieval high status population from the Sint-Laurenskerk in Alkmaar and the urban medieval population from the city of Dordrecht (Palmer et al. 2016, 83).

The skeletal population from Alkmaar dating between the 18th and 19th century only showed a percentage of 2% on the prevalence of osteoarthritis in the shoulder, which is remarkably lower than that of the Eindhoven population (Baetsen 2001, 17, 62). The study by Baetsen 2001 does not divide the shoulder in the different elements it exists of, hence the comparison to the percentage of the shoulder. Moreover, this study does also not mention the method used to score osteoarthritis in the population of Alkmaar (Baetsen 2001, 17, 62).

The skeletal population from Dordrecht dating between 1275 and 1572 AD showed a prevalence of 8% for osteoarthritis in the shoulder. The low prevalence of osteoarthritis among other aspects led Maat et al. (1998) to conclude that their sample population was of high socioeconomic status. Yet, this study also does not mention the method used to score osteoarthritis in this population (Maat et al. 1998, 7, 45). A study by Waldron (1991) on osteoarthritis in the post medieval middle class skeletal population from Christ Church, Spitalfields, London resulted in percentages higher than those of the populations from Alkmaar and Dordrecht. The following percentages are derived from the data presented in Waldron (1991), the prevalence of osteoarthritis in the left acromioclavicular joint is 13.31% and that of the right 14.02% (Waldron 1991; Mays 2012, 485). However, Waldron (1991) did use a scoring method different from the method used for this thesis.

Nevertheless, the studies of the skeletal populations of Alkmaar, Dordrecht and Spitalfields all show higher percentages of osteoarthritis within their sample population. Therefore, the likelihood that the skeletal sample population buried outside the church in Eindhoven belongs to a lower socioeconomical status group increases, as the prevalence of osteoarthritis is higher than that of middle and higher status populations. A possible explanation for this might be that the lower status individuals from Eindhoven might have been subjected to intense labour from a young age onwards, which often results in a greater prevalence of osteoarthritis in the upper body (Webb et al. 2009, 149).

The second most commonly affected element within this population is the acetabulum, with the prevalence of osteoarthritis in the left acetabulum being 12% and in the right acetabulum being 20.83%. This does not come as a surprise, as the hip joint is one of the major weight-bearing joints in the human body. These scores are relatively high compared to the hip osteoarthritis percentage of urban high status population of Alkmaar, where the prevalence of hip osteoarthritis is 9% (Baetsen 2001, 62). Other contemporaneous Dutch skeletal populations show higher percentages related to osteoarthritis in the hip. The skeletal population of the Sint Janskerkhof in 'S-Hertogenbosch dating between 1450 and 1830/1858 AD showed a prevalence of 28% for osteoarthritis of the hip (Maat et al. 2002). Yet, Maat et al. (2002) did not use Buikstra and Ubelaker (1994), instead they used Rogers and Waldron (1995). Next to this population, the previously mentioned population from Dordrecht showed a prevalence of 25% for osteoarthritis of the hip (Maat et al. 1998, 31). This might indicate that the lower status individuals from Eindhoven presents with a normal ratio of hip osteoarthritis within its own population.

6.1.1 Sex

The males and females buried outside of the St. Catharinakerk in Eindhoven show remarkably similar percentages for the prevalence of osteoarthritis. The only differences that can be noticed between the sexes are the percentages for the acromion, patella, and femoral head. Both sexes show the highest percentages for osteoarthritis in the acromial ends of the clavicle, males (L= 44%, R= 27.3%) and females (L= 30%, R= 20%). When looking at the mean osteoarthritis scores of both sexes it is clear that the mean for both acromia of the males is substantially greater than that of the female. Yet, only the comparison of the mean scores of the left acromion between the sexes is statistically significant. This indicates that the mean score of the left acromion of the males is statistically higher (mean= 0.39) than that of the females. Another skeletal element, of which the comparison of the mean scores between the sexes resulted in a statistically significant result, is the right femoral head. This indicates that the mean score of the right femoral head of the females is statistically higher (mean= 0.55) than that of the males. However, how can these differences be explained?

The most likely explanation for this is possibly the gendered division of labour, which is often put forward to explain differences similar to the ones in this research. Like other Dutch urban communities, the men and women from Eindhoven would have likely both been employed in urban industries. Yet, females would have been more likely to work from home or have entered household service (Saers et al. 2017). In this classic view of gendered labour division men would perform the more physical strenuous tasks, while women would perform less strenuous tasks (Palmer et al. 2016, 79). This might explain why the lower socioeconomical status men from Eindhoven show a significant greater mean osteoarthritis score for the left acromion when compared to the females of the same sample.

However, this does not entirely explain why the females show a significant greater mean osteoarthritis score for the right femoral head. There are multiple reasons why females can have more severe osteoarthritis in the hip. In the 1996 study by Kaprio et al. it was discovered that the heritability of osteoarthritis is greater in females in comparison to males. Next to this, females can also experience an increased risk for osteoarthritis after menopause, questioning the possible role of oestrogen. Other disparities between the sexes might be caused by bone strength, alignment, ligament laxity, pregnancy, and neuromuscular strength (Johnson and Hunter 2014, 7). Therefore, it could be that these differences were also present within the genetic make-up of the lower socioeconomical status females from Eindhoven, leading to them experiencing hip osteoarthritis more frequently and severely than the males from this population.

6.2 The high status population of Eindhoven

The skeletal element that is affected most commonly within the sample population that was buried inside the church is the acromial end of the clavicle, with two of the eight (20%) individuals being affected on the left and two out of five (40%) on the right. Thus, showing similar results to the population buried in the cemetery outside of the St. Catharinakerk. However, this sample is of a very limited size, as has been mentioned previously. Therefore, it leaves the interpretation of these results with a lot of speculation on what the results would have been. Hence, these results can simply be interpreted as being similar to that of the lower socioeconomical status population or could be interpreted as something else. Some would possibly still want to argue that the higher status population would show a lesser prevalence of osteoarthritis than the lower status population. However, for the sake of this thesis the interpretations will solely be made for the data that is available and not for what could have been, but some suggestions will be made.

When looking at the prevalence of osteoarthritis in the acromial end of the clavicle in this higher status population it is likely that multiple high status individuals suffered from osteoarthritis in the shoulder. Yet, because of the small sample size, when comparing the prevalence of OA is to other sites in The Netherlands it does not show similarity in percentages.

The skeletal population of the beguines in Breda dating between 1267 and 1530 AD show that 15.2% of the population displayed signs of osteoarthritis in the acromioclavicular joint. Yet, the authors do not mention the method used to score osteoarthritis for this population (Rijpma and Maat 2005, 11). While this is still a higher prevalence than the previously mentioned populations from Alkmaar and Dordrecht showed, the high status population in this study still shows a greater percentage. In Rijpma and Maat (2005) the relatively high percentage is explained by that the Beguines would have been vigorously scrubbing the floors and thus performing strenuous repetitive labour (Rijpma and Maat 2005, 11). However, this is most likely not the reason why the high status Eindhoven individuals would have developed osteoarthritis in the acromioclavicular joint. The high prevalence of osteoarthritis in the acromioclavicular joint could maybe be explained by gender labour differentiation, this will be discussed later on.

Other elements that show a high prevalence of osteoarthritis within this sample are the distal epiphysis of the radius and the scaphoid. Both of these elements of the individuals buried within the St. Catharinakerk presented with percentages between 9% and 20% on both the right and left side. In the right distal epiphysis of the radius one out of 11 individuals were affected and in the left two out ten individuals were affected. One individual was bilaterally severely affected by osteoarthritis (see appendix 1 and 3, and figure 4) and showed moderate eburnation on the joint.

Modern studies suggest that osteoarthritis in the wrist is mainly caused by trauma, metabolic diseases, or inflammatory joint diseases (Laulan et al. 2015, 52). A fracture in the wrist or of the radius can result in misalignment of the bones and accordingly result in the development of osteoarthritis (Weiss and Rodner 2007, 725). However, this can be excluded as the cause of osteoarthritis in these two individuals, as no signs of a fracture have been observed.

Yet, the high percentages of osteoarthritis in the wrist among the high status individuals of Eindhoven is more likely to be explained by activities more often associated with the ‘elite’. It is generally known that the literacy amongst the upper classes was greater, hence many of the upper class individuals were able to write. The high status individuals would have written for business purposes and leisure, thus using the wrist more frequently. The repetitive motions associated with the writing of letters and other items could have led to the inflammation of the wrist joint, which over time would have resulted in the development of osteoarthritis (Schoemaker 2018, 74; Descatha et al. 2020, 174; Waldron 2019).

However, when comparing the percentages of wrist osteoarthritis of the high status population of Eindhoven to another post medieval high status Dutch population, the percentages of the high status population from Eindhoven are remarkably higher. In the afore mentioned high status population from Alkmaar only 2% of 103 individuals were affected by osteoarthritis in the wrist (Baetsen 2001, 62).

6.2.1 Sex

Opposite to the lower status individuals from Eindhoven, the high status individuals from Eindhoven do not show a similarity in prevalence of osteoarthritis between the sexes. One of the main discrepancies is that the males do not show any signs of osteoarthritis in the acromioclavicular joint, whereas the females do. Furthermore, while the males seem to be affected the most in the wrists and hip, the females are affected the most in the acromioclavicular joint and knee. The highest percentage amongst the males are those of the distal epiphysis of the radius (L= 25%, R= 12.5%). The highest percentage amongst the females are those of the proximal tibia (L= 66.67%, R= 50%), note that the female population only counts four individuals. These differences in elements that are affected by osteoarthritis are also noticeable in the mean scores of all the scores elements. From table 13 it is visible how big the differences in some elements are when comparing the mean scores of the sexes to each other. Both female acromial ends of the clavicula show a mean score of 0.50, while the males show a mean score of 0.00. When compared, these differences were determined to be of statistical significance, because the p-values for the comparison of the mean scores for the left and right acromial end of the clavicle were smaller than 0.1. Next to this element, the mean scores for the proximal tibia of the females are also substantially higher than those of the males. For the females the mean osteoarthritis score of the right proximal tibia is 0.50 and that of the left is 0.67, while those of the males again both are 0.00.

However, only when comparing the mean osteoarthritis scores of the left proximal tibia did the difference between the means result in a statistically significant result. It is important to mention that the comparison of the mean scores of the right proximal tibia almost resulted in a statistically significant result (p-value= 0.108). All of the other comparisons of mean osteoarthritis scores of skeletal elements did not provide results that are of statistical significance. Moreover, from the tables of this particular population it is clear that many of the analysed elements were not at all affected. The majority of the analysed elements of the upper limbs were not affected, as well as lesser elements of the lower limbs. All in all, when comparing the high status males to the high status females it is apparent that the females suffered significantly more from osteoarthritis in the acromial end of the clavicle or the acromioclavicular joint and the left proximal tibia or knee. Yet, this should be approached with a certain degree of caution due to the limited sample size of this population.

Even though the acromioclavicular joint has a relatively small articular surface area, it can withstand substantial forces during an individuals' lifetime. Clinical studies have documented arthritic changes in the acromioclavicular joint in 93% of individuals over 30 years old and approximately 100% in individuals over 50 years old (see Stein et al. 2001 and Tauber 2016) (Candela et al 2021, 2). Because of its common occurrence in modern day society Candela et al. (2021) attempted to assess the role genetics in the development of acromioclavicular osteoarthritis. In their studies of 50 pairs of identical twins aged between 50 and 75 years old were analysed. To prevent inaccurate results twin pairs with a history of trauma related injuries to the joint, rheumatoid diseases or other autoimmune diseases were excluded from the study. Since the beginning of cadaveric studies last century, genetics and an anatomical basis have been proposed to be the main causational factors for acromioclavicular osteoarthritis. Different degrees of damage to the joint would be influenced by the shape of the joint, repetitive movement thereof and morphological joint variations. The heritability index created in the study of Candela et al. (2021) shows that genetic factors only slightly influence the development of osteoarthritis in the acromioclavicular joint, merely accounting for 20%. Therefore, they conclude that environmental factors, such as activity, sports, and comorbidities, have a greater impact on the development of osteoarthritis in the acromioclavicular joint (Candela et al. 2021). Furthermore, McLean et al. (2018) suggest that the development of primary osteoarthritis is the result of the transmission of high axial loads through the small articular surface. This study also mentions the risk factors leading to secondary acromioclavicular osteoarthritis: "occupational heavy lifting, manual work, repetitive micro-trauma (weightlifting, swimming, basketball), inflammatory arthropathies, septic arthritis, instability and traumatic injury" (McLean et al 2018, 2). Therefore, the emphasis on how acromioclavicular osteoarthritis develops lies on activity. This would implicate that the high status males from Eindhoven did not perform any repetitive tasks or labour. Yet, this might have been different in their lived experience. On the other side this suggests that the high status females from Eindhoven did perform repetitive tasks. Not much is known about the roles high status females played in Eindhoven itself. However, it is known that in general during the Dutch Golden Age Dutch females were involved in the trade and the business of their husbands, in contrast to the uprising ideal of high status women staying at home and taking care of the household (Kloek 1998, 223). Nonetheless, the most likely explanation for this significant outcome for the acromial ends of the clavicula is the small sample size.

Knee osteoarthritis is very common within current society and past societies. Current clinical studies find osteoarthritis of the knee to be more prevalent in females than in males. One of these studies is a study by Felson et al. (1987), which investigated the prevalence of knee osteoarthritis in elderly subjects. This study found a slight difference in prevalence of radiographic changes of osteoarthritis between females and males, the changes in females were slightly higher. It was also discovered that significantly more females presented with symptomatic osteoarthritis than males (Felson et al. 1987). The reason why females tend to show a higher prevalence of osteoarthritis, like the high status females of Eindhoven, has not been well researched. The cause of this difference in prevalence of knee osteoarthritis between males and females is most likely to be multifactorial. Anatomic differences are one of these factors, narrower femora and differences in tibial condylar size could be the cause. Yet, the volume of cartilage in the knee may play a more important role, because it has been discovered that females have a significantly smaller tibial and patellar cartilage volume. Next to this, it also appears that females have different knee mechanics compared to males, which might result in more abnormal biomechanical stress being put on the knee joint (Hame and Alexander 2013, 182-183). Therefore, it is likely that the high status females of Eindhoven were more affected by osteoarthritis in the left proximal tibia due to mechanical differences of the body. This indicates that the high status females probably would have been performing different tasks than the high status males from Eindhoven. Yet, the most probable explanation for this significant result is once again the limited sample size of the high status population.

6.3 Comparison of the Low and High status population from Eindhoven

In order to study whether socioeconomic status makes a difference when it comes to the prevalence and severity of osteoarthritis in Eindhoven, the two sample population have been compared to each other. What is apparent from the prevalence percentages is that surprisingly both high and lower status populations show that the acromial end of the clavicle is the most commonly affected element in this study. The comparison of the percentages also shows that overall, the lower status individuals are affected by osteoarthritis in more of the elements. Showing that when looking at the complete picture the high status population is generally less affected by osteoarthritis. Though the high status individuals are affected in some other elements where the lower status individuals are barely affected at all. This concerns the distal radii and the scaphoid-bones, which are when solely observing the percentages more affected by osteoarthritis. Yet are the same patterns also visible when looking at the mean osteoarthritis scores of both scores?

The highest mean score among the population who were buried inside the church are those of the left distal radius and that of the right scaphoid (both mean scores = 0.6). On the other hand, the highest mean score among the population who were buried in the cemetery outside of the church was that of the left acromial end of the clavicle (mean = 0.46). The statistical analysis of the differences between the mean osteoarthritis scores of both sites resulted in six statistically significant results. This concerns the following skeletal elements: the left acromial end of the clavicle, right humeral head, right and left distal radii, and the right and left scaphoid-bones. This means that all of the elements showed a p-value≤0.1, yet if the more conventional p-value≤0.05 would have been used none of the comparisons would have yielded a statistically significant result.

The elements of which the mean osteoarthritis scores are significantly higher for the lower status population when compared to the mean scores of the high status population are the left acromial end of the clavicle and the right humeral head. This suggests that lower status individuals were more severely affected in the shoulder. Thus, automatically leading to the suggestion that the lower status individuals from Eindhoven would have engaged in more strenuous labour than their high status counterparts.

In the current clinical field acromioclavicular joint is known to be one of the most common locations affected by osteoarthritis (Waldron 2019, 725). Osteoarthritis in the acromioclavicular joint, as mentioned previously, can occur due to age or trauma. It has been suggested that especially repetitive microtrauma can lead to the development of osteoarthritis and is a common occurrence in modern day weightlifters as well as in basketball players and swimmers. Therefore, in clinical settings it is often advised to avoid repetitive pushing, lifting, throwing and overhead work (Mall et al. 2013, 2686). Moreover, the risks of developing osteoarthritis in the acromioclavicular joint are greatly increased when repetitive tasks are performed at shoulder level (Henderson et al. 2013, 206). The possibility that the lower status individuals from Eindhoven engaged in repetitive strenuous lifting is supported by the statistically significant result of the right humeral head. Glenohumeral osteoarthritis can also be caused by excessive mechanical loading of the joint (Ibounig et al. 2021, 445). This supports the assumption that the occupations of /lower status individuals were involved repetitive labour of a certain degree. Combining this with the statistically significant results it is clear that the lower status individuals from Eindhoven did experience more strenuous and repetitive labour, when it comes to labour involving heavy lifting and performing tasks keeping their arms at shoulder height, compared to their high status neighbours. However, what undermines this is that it would be logical when performing such repetitive tasks involving the upper limbs, osteoarthritis would also develop in the elbow. As osteoarthritis in the elbow has been proven to correlate with strenuous manual labour (Stanley 1994). Yet barely any individual from the lower status population shows signs of osteoarthritis in the elements involved in the elbow joint. Furthermore, the comparison of the mean scores of the elements involved in this joint did not lead to a significant result.

The elements of which the mean osteoarthritis scores are significantly higher for the high status population when compared to the mean scores of the lower status population are the distal radii and the scaphoid-bones. This would indicate that the high status individuals engaged in an activity that required them to use their wrists extensively. In turn, suggesting that the high status individuals participated in a different kind of repetitive strenuous activity than the lower status individuals.

As previously mentioned, modern studies suggest that wrist osteoarthritis is mainly caused by trauma, metabolic diseases, or inflammatory joint diseases (Laulan et al 2015, 52). It is even said that radiocarpal osteoarthritis is relatively uncommon within modern Western societies and is most often caused by trauma (Roberts et al. 2006, 208). Especially in bilateral cases, is osteoarthritis of the wrist caused by mechanical, micro traumatic stress (Pálfi and Dutour 1996, 44). The clinically most common form of wrist osteoarthritis is scapholunate advanced collapse (SLAC), which causes the development of osteoarthritis in the wrist due to articular alignment problems between the radius, scaphoid, and lunate (Watson and Ballet 1984, 358). SLAC develops as a result of a traumatic injury to the wrist, which usually involves a fall on an outstretched hand. Accordingly, such a fall can result in a fracture of the scaphoid or the attenuation or rupture of the scapholunate interosseous ligament (SLIL). The rupture of this ligament allows the scaphoid to rotate, leaving more space between the scaphoid and lunate, and thus permanently altering the mechanics of the radiocarpal joint (Roberts et al. 2006, 217). This indicates that the high status population would have been more prone to receiving trauma to the wrist. Combining this with the violent past of Eindhoven, it could very well be that the high status population were more easily involved in military conflicts. Because of their possible greater involvement in military matters, the high status individuals might have more easily sustained trauma to the wrist. The trauma of the wrist could have possibly been the result of falling during combat or the wrong handling of a sword. However, this does not necessarily mean that the lower status population participated less or were less affected by military conflicts in Eindhoven. Moreover, this cannot be concluded with certainty because of the limited sample size and no archival research has been done to reconstruct the lives of these individuals. It could also be suggested that the microtrauma causing osteoarthritis in the wrist might be the result of too much pressure on the joint by positioning it wrongfully. However, it remains more likely that the high prevalence of osteoarthritis in the wrists of the high status population is the result of activity patterns differing from those of the lower status population.

While the high status population seems to be less affected by osteoarthritis in general, there also seem to be some similarities between the high and lower status populations, regarding which elements are not at all affected by osteoarthritis. Both of the populations from Eindhoven are not affected by osteoarthritis in the distal humeri, the left distal tibia, the proximal fibulae and the tali. This would imply that both high and lower status populations did not engage in repetitive and strenuous activities associated with the joint complexes to which these elements belong, the elbow, knee, and ankle.

6.3.1 Sex

Due to the limited sample size of the high status population buried within the church, not enough female individuals were present to be compared to the lower status females buried outside of the church. Hence, only the males of both populations could be compared against each other. In general, by looking at the tables displaying the percentages of males affected by osteoarthritis (see tables 6 and 11), it is evident that the skeletons the lower status males are overall more affected by osteoarthritis than the high status males. In general, among the lower status males 17 out 0f 30 are affected (56.67%), while among the high status males three out of nine are affected (30%). The ratios of prevalence between the high and lower status males, corresponds with the ratios found in the study by Marklein and Crews (2022). In this study the frailty of different socioeconomic groups from post-medieval London are compared to each other, by studying this it was discovered that the prevalence for the low status males from London is 31.4% and for the high status males from London is 20.02% (Marklein and Crews 2022, 43).

The percentages of the separate elements of the male populations from Eindhoven, show that the lower status males are more affected by osteoarthritis in the shoulder as well as in the lower limbs. The only elements in which the high status males seem to be more affected are the distal ulna, distal radii, and the scaphoid-bones. The highest percentage among the lower status males is that of the left acromial end of the clavicle (44%), while that of the high status males is that of the right scaphoid (50%). However, for the high status males the percentage of the left distal radius is more representative (25%), because the percentage of the right scaphoid is based on only two individuals. Hence, when putting these greatest percentages next to each other it is visible that highest percentage of the lower status males is quite a bit higher compared the same of the high status males.

The element which is the highest among the prevalence percentages of the lower status males, is not the highest among the mean scores of the same male population. The highest mean score among the lower status males is that of the right acromion (mean= 0.54), which indicates that while being less commonly affected by osteoarthritis it was more severely affected. Amidst the mean scores of the high status males the right scaphoid (mean = 1.5) and the left distal radius (mean = 0.75) yet again presented the highest scores. This indicates that these elements were the most commonly and severely affected by osteoarthritis among the high status males of Eindhoven. The comparison of the mean score of the right acromion between the male populations did not result in a result of statistical significance. The comparison of the mean scores of three other elements did obtain a statistically significant result. These are comparisons of the mean scores of the right humeral head, right scaphoid, and the right acetabulum. This indicates that the mean scores of the right humeral head and right acetabulum of the lower status males are significantly higher than the mean scores for those elements of the high status males. This subsequently also indicates that the mean score of the right scaphoid of the high status males is significantly higher than that of the lower status males. Nonetheless, the importance and relevance of the mean score of the high status males' scaphoid being statistically higher can probably be neglected, because of the aforementioned small sample size of the right scaphoid. Hence, further onwards only the significance of the significant results of the right humeral head and the right acetabulum will be discussed.

Hip osteoarthritis is in the modern world one of the most common locations for osteoarthritis, yet it is less commonly affected than the knee joint (Arden and Nevitt 2006, 8). Secondary to the knee joint the hip joint is one of the major weight-bearing joints in the human body (Lespasio et al. 2018). Hip osteoarthritis seems to have been more prevalent in past populations than modern populations. This is evident from the study by Baetsen et al. (1997), who from studying a skeletal population from Alkmaar determined that hip osteoarthritis was more prevalent in past population than knee osteoarthritis. Baetsen et al. (1997) also suggest that the repetitive use of the hip joint over an extended period of time, for example in a specific occupation, might lead to the development of osteoarthritis (Baetsen et al. 1997, 630). Rossignol et al. (2005) studied a 2003 survey of French osteoarthritis patients in order to identify occupations with excess prevalence of hand, hip or knee osteoarthritis and compared these occupations regarding biomechanical stress and the severity of osteoarthritis (Rossignol et al. 2005, 772). This study discovered that the prevalence of osteoarthritis in the hip is greatly influenced by the performance of tasks that include carrying or lifting of heavy objects and the repetition thereof (Rossignol et al. 2005, 774). In archaeological populations such comparisons cannot be made most of the time, due to a lack of information on the specific occupations of individuals. Next to this, specific occupations cannot be linked to particular osteoarthritis patterns, as an individual might have had multiple different occupations during once's lifetime (Mays 2012, 491). The statistically significant result of the comparison of the mean scores of the right acetabulum, thus supports that the lower status males engaged in the carrying or lifting of heavy objects, resulting in a higher prevalence and severity of osteoarthritis in the hip. Therefore, the assumption can be made about the lower status males from Eindhoven that they were very likely to be subjected to heavier labour involving the hip joint than their rich counterparts. Hence, these results also support the assumption that lower status individuals engaged in more activity/labour in their lived experienced than high status individuals, who would not have needed to engage in such activities. Another factor which might account for the significant higher mean score of osteoarthritis of the hip in the lower status males is body mass. Individuals of lower socioeconomical status would have had less access to good nutrition and would have been more exposed to disease than high status individuals (Robb et al. 2001, 213). Thus, it is likely that the body mass of the poor would have been lower than that of the rich. A study by Weiss (2006) on the correlation of body mass and osteoarthritis discovered that individuals with a lower body mass showed a greater hip osteoarthritis than individuals with a higher body mass. Therefore, the environmental factors the lower males were exposed to dispositioned them to be more prone to developing hip osteoarthritis.

As previously lead out, the humeral head is part of the glenohumeral joint and thus the shoulder. Currently, degenerative changes related to osteoarthritis account for approximately 17% of shoulder pain complaints by patients. These changes in the glenohumeral joint are often brought on by great mechanical stress on normal cartilage or normal mechanical stress on weakened cartilage (Ibounig et al. 2021, 442). Therefore, it is very likely that the lower status males from Eindhoven were engaged in activities that greatly strained the cartilage in the joint and thus setting a chain in action that results in the development of osteoarthritis.

6.4 Socioeconomic status differences and activity

Are any distinguishable differences visible between populations of high and lower socioeconomical status by using osteoarthritis as a marker of physical activity? And is osteoarthritis an effective marker for physical activities? These are some of the questions this thesis aimed to answer. Differences in the prevalence and severity between the two socioeconomically differing populations of Eindhoven were visible from the statistical analysis. These differences make it seem quite likely that the two socioeconomical classes experienced differing levels of physical activity. The high status population was more subjected to osteoarthritis of the wrist joint, whereas the lower status individuals were affected more severely in the shoulder and the hip. The lower status individuals overall engaged in more repetitive and strenuous activities than the high status individuals.

It is very likely that the lower status individuals were members of one of the five guilds established during the Middle Ages in Eindhoven. These are known to have been the following: the shoemaker and tanners guild, the smiths, bakers and peddler's guild, the brewers, wine sellers and butcher's guild, linen weavers/sellers, fur and leather crafters guild, and the clothing sellers and wool weavers, -fuller, -dyers, -shearers and -sellers guild. It is likely that there were other professions in which individuals engaged, but not much is known about the specifics of those. The study of archival data would shed more light into this subject, but this has not yet been extensively done. Next to this, while archival data would provide more insight into the occupations of individuals, it would not be known who of those individuals would have been buried inside or outside of the St. Catharinakerk. However, this would have meant that the individuals of Eindhoven engaged in differing occupations, which results in a display of complex variation of osteoarthritis within the skeletal remains. The exact reason why the high socioeconomic status individuals show such a high osteoarthritis score in the wrist largely remains unclear. Two of the individuals from this sample S2586 and S2817 presented with severe osteoarthritis of the wrist, respectively presenting bilateral and unilateral cases of osteoarthritis. However, it is likely that the cause of osteoarthritis in this case is trauma instead of activity, and thus it does not necessarily represent an activity pattern in the high status population.

Following the results of this thesis, much can be discussed about the usefulness of osteoarthritis as a marker of activity. Sixty-five skeletons were analysed for osteoarthritis, which provided useful information on the socioeconomical differentiation within post-medieval Eindhoven. The study of osteoarthritis has strengthened the assumption that the lower status individuals of Eindhoven lived a life filled with more strenuous activities compared to the high status individuals of the same city. This corresponds with the general assumption and the narrative of historical documentation, that low status individuals had a tougher life than high status individuals. Osteoarthritis was also useful to distinguish the different impacts of activity on different joint complexes. Showing that some joints are more vulnerable on a biomechanical level than other joints. The methodological aspect of this thesis has also proven to be useful in the study of using osteoarthritis as a marker of activity. The scoring method developed by Buikstra and Ubelaker (1994) was proven to be effective as well as the controlling for age during the statistical analysis by using ANCOVA. In general, it is known that the severity of osteoarthritis is greatly affected by age, thus by controlling for age the results became more reliable and more likely the result of other aetiological factors. These other aetiological factors are likely to be activity and occupation related, but this cannot be determined with certainty because of the multifactorial aetiology of osteoarthritis.

6.5 Limitations

Many bioarchaeological studies rely on small skeletal samples and recognise the limitations posed by the small size, yet also acknowledge the insights it can provide and the usefulness of the data (for instance: Domett and O'Reilly 2009; Henderson and Nikita 2016; Stodder and Palkovich, 2012; Tornberg and Jacobsson, 2018). Therefore, the main pitfall of using samples of a small size, is that it might not accurately represent the population that a study is attempting to reconstruct (Cheverko et al. 2020, 2). This is one of the main limitations of this study, because the high status population sample is of a very limited size. Yet, other phenomena can also cause the interpretation of results to be approached with caution.

6.5.1 The osteological paradox

During osteological research one always needs to keep the osteological paradox in account. The osteological paradox is based on three problems, demographic nonstationarity, selective mortality and hidden heterogeneity in risks. Demographic nonstationarity refers to that fertility has a greater effect on the age-at-death distribution of a nonstationary population than it is affected by mortality (Wood et al. 1992, 344). In essence, selective mortality entails that bioarchaeologists can only study the individuals who deceased at a certain age, and not all individuals who might have been at risk of decease or death at a certain age. Therefore, the prevalence of a disease is almost always overestimated in osteological studies (Wood et al. 1992, 344). This inevitably also includes this thesis, because this thesis deals with a selected sample of the deceased population of post medieval Eindhoven. Hidden heterogeneity in risks refers to that a sample population is made up of an unknown mix of individuals with varying frailty or susceptibility to disease and death (Wood et al. 1992, 344-345; Cohen et al. 1994; DeWitte and Stojanowski 2015). Hence, the results of this sample population were interpreted with a certain degree of caution. Moreover, the 350 year time fame is certainly not expected to be very homogenous in social, political, economical, and natural environment, which is another reason why this has also been approached with caution. While selective mortality is the aspect of the osteological paradox that is most easily identifiable for this study, the other to aspects equally have been taken into account.

6.5.2 The bone former conundrum

A relatively unknown factor which also needs to be taken into account while studying osteoarthritis, is the so-called bone former conundrum. One of the first studies to discuss this conundrum is the study by Rogers et al. (1997), who state that some individuals are intrinsically more prone to form bone at joint margins and entheses compared to other individuals. The most common types of bone growth in the human skeleton are osteophyte and enthesophyte formation, the first being strongly related with osteoarthritis (Brandt 1999, 334; Hardcastle et al, 2014, 2430). These bone growths are often formed as a result of biomechanical stress and multiple other factors. According to Rogers et al. (1997) the difference in ability to form bone in response to stress might be the reason for an observed variation in bone formation, rather than the differences in the experience of stress (Rogers et al. 1997, 85, 90). In relation to osteoarthritis, this can thus be interpreted as that some individuals are more prone to osteoarthritis, because of their tendency to form more bone in response to mechanical stress. It is not certain how many bone formers are present in society, but Waldron (2009) suggests that it might be as high as a fifth of the entire population (Waldron 2009, 72). This hypothesis of bone formers being present in populations has been criticised (Felson and Neogi 2004), but it has also received some support by for example Myszka et al. (2020). However, as more and more bioarchaeological research is being done on osteoarthritis, more differing opinions will be put forward and expand on the large amount of research that has already been performed.

7. Conclusion

The main aim of this thesis has been to establish how socioeconomical status and strenuous labour are embodied in the post-medieval population of Eindhoven in the Netherlands. This has been studied by looking at the differences in prevalence and severity of osteoarthritis of the individuals from this city. The skeletal population of Eindhoven was accordingly divided into two groups, a high socioeconomical status population and a middle to lower socioeconomical status population. This division has been made according to where the individuals were buried, the high status individuals had been buried inside of the St. Catharinakerk, while the middle to lower status individuals were buried in the cemeteries north and south outside of the church. The study of osteoarthritis provides a glimpse into the lived experience of individuals from differing socioeconomical classes, yet does not allow for definite conclusions to be drawn.

The main research question posed in the introduction of this thesis was as follows:

How are differences in socioeconomical status and strenuous labour embodied in the post-medieval population of Eindhoven, The Netherlands?

To help answer this question four sub questions were formulated:

1. What are the differences in prevalence and severity of osteoarthritis between the sexes of the lower socioeconomical status population of Eindhoven?
2. What are the differences in prevalence and severity of osteoarthritis between the sexes of the high socioeconomical status population of Eindhoven?
3. What are the differences in prevalence and severity of osteoarthritis between the sexes of the high and lower socioeconomical status populations of Eindhoven?
4. What are the synovial joint most commonly affected in the high and lower socioeconomical status populations of Eindhoven and what can this tell us about activity?

The statistical analysis of the raw data with ANCOVA, provided answers to these questions. Within the populations of both socioeconomical classes differences between the two sexes were discovered. The statistical comparison of the mean osteoarthritis scores for the lower socioeconomic status males and females resulted in two significant results, the higher mean of the males for the left acromion and the higher mean score of the females for the right femoral head. This could indicate that the lower class population males and females engaged in different repetitive strenuous activities, thus suggesting the possible presence of a gendered division of labour in Eindhoven. The statistical comparison of the mean osteoarthritis scores for the high socioeconomic status males and females also resulted in two significant results, the higher mean score of the males for the left acromial end of the clavicle and the higher mean score of the females for the left proximal tibia. This would indicate that within the high status population males and females engaged in different activities. However, due to the limited sample size nothing can be concluded from this with great confidence.

The same problem was encountered when the sexes of the high and lower status populations were compared to each other, as the female sample of the high status population was not big enough to result in a useful comparison. Hence, only the males of the high and lower status populations could be compared to each other. The statistical comparison of the mean osteoarthritis scores of the males of both populations resulted in three significant results. Whereas the lower status males showed higher mean scores for the right humeral head and right acetabulum, the high status males showed a higher mean for the right scaphoid. However, the significant result of the high status males was dismissed as not reliable, due to it being based on the scores of two individuals. This suggests that the right humeral head and right acetabulum were likely to be subjected to strenuous labour. Therefore, these two significant results indicate that the lower status males at least to some extent engaged in more repetitive and strenuous activities/labour than the high status males from Eindhoven.

In the entire population from Eindhoven the element that is most commonly affected by osteoarthritis seems to be the acromial end of the clavicle, which is a component of the acromioclavicular joint in the shoulder. When looking at both socioeconomical classes separately, it is clear that the joint most commonly and severely affected within the high status population is the wrist, while the most commonly and severely affected joint within the lower status population is the shoulder. This reinforces the idea that the lower status population was likely to be engaged in repetitive and strenuous activities, such as lifting, pulling, and holding heavy items, which resulted in the overloading of the shoulder joint. However, no clear explanation can be found as to why the high socioeconomic status individuals show such a high prevalence of osteoarthritis in the wrist joint. Due to the multifactorial aetiology of osteoarthritis, it is difficult to specifically pinpoint the cause of this. Therefore, it could for example be speculated that it is the result of military engagements, yet this only leaves room for speculation and mystery. Yet, the most likely explanation might be that the high status individuals were subjected to a large amount of writing and thus exposing the wrist to frequent repetitive movements, causing osteoarthritis to develop.

The answers to the sub-questions make it possible to formulate an answer to the main research question of this thesis. From the research on the post-medieval population of Eindhoven it is clear that strenuous labour was embodied differently among the socioeconomical classes. The lower status individuals were affected more in different locations of the body by osteoarthritis and have likely engaged in more strenuous activities than the high status individuals of post-medieval Eindhoven. However, the high status population of Eindhoven was not exempt from suffering from osteoarthritis, thus likely also having engaged in some form of strenuous activities. Therefore, it is possible that there are differences in the level of development of osteoarthritis between different socioeconomical classes, even though these differences might be minimal.

7.1 Future research

This research has answered many questions, but it perhaps has also left some questions unanswered or formed new questions which are left to be answered. To answer these questions more research on differing topics should be conducted in the future. The possibilities for future research thus need to be discussed.

7.1.1 The Eindhoven collection

At first glance, it could be thought that the Eindhoven collection provides an outstanding opportunity to study differences between socioeconomic classes. Yet, due to the limited availability of skeletal remains of the higher class, this becomes very difficult but not impossible. Therefore, for this collection it would be more useful and scientifically reliable if the entire population or solely the middle to lower socioeconomical status population would be studied, to be compared to other Dutch populations. Next to this, it would be interesting to see how the osteoarthritis scores of the population from Eindhoven compare statistically to those of other urban cities in the Netherlands, preferably from the southern part of the country. This would help identify whether the middle to lower status population of Eindhoven has abnormal high prevalence of osteoarthritis or not. In future research it will also be necessary to compare the prevalence and severity of osteoarthritis with that of other skeletal markers of activity. These other skeletal markers of activity would include entheseal changes, squatting facets (a marker on the talus or tibia) and os acromiale (an unfused secondary ossification centre of the acromion). It would be interesting to see whether the entheseal changes of the bones would be as severe as the osteoarthritis for the same skeletal element. This would help more accurately predict the motions the individuals would have performed when engaging in strenuous activities. Besides this, it would also be helpful if a possible relation between osteoarthritis and stature or bone length would be studied, especially when looking at the weight bearing joints. Differences in cortical bone thickness could also be studied in relation to bone length and osteoarthritis.

Another aspect of the Eindhoven collection which would be very interesting to research, if possible, is to compare the DNA samples of this population to DNA of living individuals for kinship analysis. This would allow researchers to figure out, through genealogical research, who these individuals were and to retrieve their name. Accordingly, when a name is known their occupation could be discovered from the archives of Eindhoven, which could possibly contribute to an explanation for certain activity patterns within the population of Eindhoven. Moreover, this could also confirm or deny the socioeconomical status given to an individual in this study.

Lastly, this population would also benefit if other pathologies commonly used to study the differences in socioeconomical status between different classes, to discover how big the differences really were between the poor and the rich in Eindhoven.

7.1.2 Future research into osteoarthritis

One of the problems most commonly encountered when studying the prevalence of osteoarthritis in skeletal remains, is the lack of a standardized method. Therefore, it would be highly useful if in the future a standardized method would be developed and applied for the scoring of osteoarthritis. This would benefit the entire bioarchaeological world, as it would make the comparisons between sites more reliable and more trustworthy. However, this method should be adjustable to different levels, a more detailed and complex version suited for those who want to study each articular facet in depth and a simplified version for researchers who compare multiple markers to each other. When this standardized method is put into use, it might also be necessary to revaluate older studies using other methods and re-examine the skeletal remains. Another problem which is often encountered in the study of osteoarthritis is the aetiology because the aetiology of osteoarthritis is multifactorial. Therefore, more research would need to go into the impact of different aetiological factors on development of osteoarthritis. This would include more DNA research in living individuals as well as skeletal remains, to for example determine whether osteoarthritis could possibly by partially inheritable. This would also be relevant for living populations, as osteoarthritis is one of the most common conditions around the world.

Additionally, it would be favourable if research would be done on how weight affects the development of osteoarthritis in modern populations, to assess the role of weight-bearing joints. Furthermore, for future research on socioeconomical status differences, in order to come to a less disputable result a bigger sample is needed. The size of the sample ideally would consist of several hundred skeletons from a single rural or urban town or city and would consist of high, middle, and low socioeconomic status individuals. In ideal research, the occupations of these skeletal populations would be known and would be able to be compared to each other. In addition to this, to completely reconstruct the activity patterns of individuals from differing classes all markers and other things that could possibly influence activity should be studied. However, it is likely that only a few of the outlined suggestions on the ideal research will be able to be adapted due to the extensiveness of it.

A problem which occurred during the research for this thesis is the lack or academic articles on the relation between osteoarthritis and socioeconomical status in the post-medieval period in Europe. Therefore, the study of this possible relation will need to be popularised and encouraged within the scientific community. Additionally, in order to make this research more reliable osteoarthritis should be assessed by multiple researchers to reduce the inter- and intra-observer variability.

Abstract

As individuals living in a society, our activities, diet, and health are influenced by our socioeconomic position in said society. This amongst others means that our socioeconomic standings play a large part in our social and bodily experience, therefore also in the level and kind of labour we are involved in. Labour is often highly routinised, as certain actions and movements are performed day in day out. Therefore, labour is an important aspect of ones 'lived experience'. Osteoarthritis, a condition causing the degeneration of synovial joints and surrounding soft tissue, is the most prevalent disease in past and current societies. It is also the most frequently used marker for establishing and examining activity patterns within archaeological populations. The aim of this study is to figure out how differences in socioeconomic status and strenuous labour are embodied in a post medieval Dutch city. In order to answer this, this study analyses the severity and prevalence of osteoarthritis in two skeletal population samples of different socioeconomic status from the same city, Eindhoven. The individuals of high status were buried inside of the St. Catharinakerk, while the low status individuals were buried in the cemetery outside of this church. The high status sample consists of 13 adult individuals and the low status sample consists of 52 adult individuals. In total 40 skeletal elements have been analysed per studied individual, 20 on the left side and 20 on the right side, by using the method proposed by Buikstra and Ubelaker (1994). Following this, the scores resulting from the study of the skeletal remains were statistically analysed using ANCOVA (Analysis of Covariance). This allows to control the sample population for a covariant, in this research age-at-death was controlled for. The statistical analysis showed that the low socioeconomic status individuals were significantly more affected by osteoarthritis in the acromial end of the left clavicle and right humeral head, while the high socioeconomic status individuals were significantly more affected in the distal radii and both left and right scaphoid. The most likely explanation for this is that the low and high socioeconomic status populations engaged in different types of activities. The low socioeconomic status individuals would have likely been subjected to repetitive and strenuous activities involving the shoulder such as lifting, pulling, holding, and carrying heavy objects. Yet, while the high socioeconomic status individuals of Eindhoven probably did not engage in the same repetitive and strenuous activities as the low socioeconomic status individuals, the prevalence and severity of osteoarthritis in the wrist does indicate that they too did experience strain on joints. This would have most likely been caused by the amount of

writing the high socioeconomic status individuals had to withstand. Hence, this study concludes that osteoarthritis and thus strenuous labour is embodied differently among the high and low socioeconomic status populations of post-medieval Eindhoven.

Bibliography

Abramson, S. B. and M. Attur, 2009. Developments in the scientific understanding of osteoarthritis. *Arthritis Research and Therapy* 11, 227–235. DOI: 10.1186/ar2655

Alberdingk Thijm, J. A., 1858. *De Heilige Linie. Proeve over de oostwaardsche richting van kerk en autaar als hoofdbeginsel der kerkelijke bouwkunst*. Amsterdam: CL van Langenhuysen

Alioto, A., 2015. Controversy in skeletal biology: The use of pathological and osteological markers as evidence for activity patterns. The Hilltop Review, 8(1), 19.

Alves Cardoso, F., 2018. Lives not written in bones: discussing biographical data from identified skeletal collections, in C. Henderson and F. Alves Cardoso (Eds.), *Identified Skeletal Collections: The Testing Ground of Anthropology?* Oxford: Archeopress, 151-167. https://doi.org/10.2307/j.ctv1pdrqct.10

Anderson, A. S. and R.F. Loeser, 2010. Why is osteoarthritis an age-related disease?. *Best practice & research Clinical rheumatology*, *24*(1), 15-26. DOI: 10.1016/j.berh.2009.08.006

Arden, E., Arden, N. and D. Hunter, 2008. *Osteoarthritis*. 6th ed. Oxford; New York: Oxford University Press, 2008.

Arden, N. and M.C. Nevitt, 2006. Osteoarthritis: epidemiology. *Best practice & research Clinical rheumatology*, *20*(1), 3-25. DOI: 10.1016/j.berh.2005.09.007

Arts, N. 2013. Inleiding: Het begin van meer, in N. Arts (Ed.), *Een knekelveld maakt geschiedenis: Het archeologische onderzoek van het koor en het grafveld van de middeleeuwse Catharinakerk in Eindhoven, circa 1200-1850*. Utrecht: Stichting Matrijs, 10-22.

Ascádi, G. and J. Nemeskéri, 1970. *History of human life span and mortality.* Budapest: Akadémiai Kiadó.

Baetsen, S. and L. Weterings-Korthorst, 2013. De menselijke overblijfselen, in N. Arts (ed.), *Een Knekelveld maakt geschiedenis: Het archeologisch onderzoek van het koor en het grafveld van de middeleeuwse Catharinakerk in Eindhoven, circa 1200-1850.* Utrecht: Stichting Matrijs, 151-212.

Baetsen, S., 2001. Graven in de Grote Kerk. Het fysisch antropologisch onderzoek van de graven in de St. Laurenskerk van Alkmaar. Alkmaar: gemeente Alkmaar. (Rapporten over de Alkmaarse Monumentenzorg en Archeologie (RAMA) 8)

Baetsen, S., Bitter, P. and T.D. Bruintjes, 1997. Hip and knee osteoarthritis in an eighteenth century urban population. *International Journal of Osteoarchaeology*, *7*(6), 628-630.

Baker, E. H., 2014. Socioeconomic status, definition. The Wiley Blackwell encyclopedia of health, illness, behavior, and society, 2210-2214. https://doi.org/10.1002/9781118410868.wbehibs395

Berenbaum, F. and J. Sellam, 2008. Obesity and osteoarthritis: what are the links? *Joint Bone Spine*, *75*(6), 667-668. DOI: 10.1016/j.jbspin.2008.07.006

Brandt, K. D., 1999. Osteophytes in osteoarthritis. Clinical aspects. *Osteoarthritis and cartilage, 7(3),* 334-335. DOI: 10.1053/joca.1998.0187

Buikstra, J.E. and D. Ubelaker (eds.), 1994. *Standards for Data Collection from Human Skeletal Remains: Proceedings of a Seminar at the Field Museum of Natural History*. Fayetteville: Arkansas Archaeological Survey Press.

Buckwalter, J.A. and D.R. Lappin, 2000. The disproportionate impact of chronic arthralgia and arthritis among women. *Clinical Orthopaedics and Related Research 372*:159–68. DOI: 10.1097/00003086-200003000-00018

Busija, L., Bridgett, L., Williams, S. R. M., Osborne, R. H., Buchbinder, R., March, L. and M. Fransen, 2010. Osteoarthritis. *Best Practices & Research: Clinical Rheumatology*, 24(6), 757–768. DOI: 10.1016/j.berh.2010.11.001

Calce, S. E., Kurki, H. K., Weston, D. A. and L. Gould, 2018. The relationship of age, activity, and body size on osteoarthritis in weight-bearing skeletal regions. *International journal of paleopathology*, *22*, 45-53.

Candela, V., C. Villani, J. Preziosi Standoli, M. Scacchi and S. Gumina, 2021. AC joint osteoarthritis: The role of genetics. An MRI evaluation of asymptomatic elderly twins. *Journal of Anatomy, 238(4),* 1023-1027. DOI: 10.1111/joa.13340

Cheverko, C. M., J.R. Prince-Buitenhuys and M. Hubbe, 2020. *Theory in bioarchaeology*. Theoretical approaches in bioarchaeology. London: Routledge.

Cohen, M. N., Wood, J. W. and G.R. Milner, 1994. The osteological paradox reconsidered. *Current Anthropology, 35(5*), 629-637.

Descatha A., B.A. Evanoff, A. Leclerc and Y. Roquelaure, 2020. Occupational Determinants of Musculoskeletal Disorders. In: Bültmann U., Siegrist J. (eds) Handbook of Disability, Work and Health. Handbook Series in Occupational Health Sciences, vol 1. Springer, Cham. https://doi.org/10.1007/978-3-030-24334-0_8

Dequeker, J. and F.P. Luyten, 2008. The history of osteoarthritis-osteoarthrosis. *Annals of the rheumatic diseases*, *67*(1), 5-10. DOI: 10.1136/ard.2007.079764

DeWitte, S. N. and C.M. Stojanowski, 2015. The osteological paradox 20 years later: past perspectives, future directions. *Journal of Archaeological Research, 23(4),* 397-450. DOI 10.1 007/s 1 08 1 4-0 1 5-9084- 1

DeWitte, S.N., Hughes-Morey G., Bekvalac J. and J. Karsten, 2016. Wealth, health and frailty in industrial-era. London, Annals of Human Biology, 43:3, 241-254. DOI: 10.3109/03014460.2015.1020873

Dobson, G. P., Letson, H. L., Grant, A., McEwen, P., Hazratwala, K., Wilkinson, M. and J.L. Morris, 2018. Defining the osteoarthritis patient: back to the future. *Osteoarthritis and cartilage*, *26*(8), 1003-1007. DOI: 10.1016/j.joca.2018.04.018

Domett, K. M. and D.J. O'Reilly, 2009. Health in pre-Angkorian Cambodia: a bioarchaeological analysis of the skeletal remains from Phum Snay. *Asian Perspectives*, 56-78. DOI: 10.1353/asi.0.0016

Felson, D. T. and T. Neogi, 2004. Osteoarthritis: Is It a Disease of Cartilage or of Bone? Arthritis & Rheumatism 20, 341–344. DOI: 10.1002/art.20051

Felson, D. T., A. Naimark, J. Anderson, L. Kazis, W. Castelli and R.F. Meenan, 1987. The prevalence of knee osteoarthritis in the elderly. The Framingham Osteoarthritis Study. *Arthritis & Rheumatism: Official Journal of the American College of Rheumatology*, *30*(8), 914-918. DOI: 10.1002/art.1780300811

Field, A.P., 2015. *Discovering Statistics Using IBM SPSS Statistics: And Sex and Drugs and Rock 'n' Roll*. Thousand Oaks: Sage Publishings Ltd.

Guilak, F., 2011. Biomechanical factors in osteoarthritis. *Best practice & research Clinical rheumatology*, *25*(6), 815-823. https://doi.org/10.1016/j.berh.2011.11.013

Goldring, M. B. and M. Otero, 2011. Inflammation in osteoarthritis. *Current opinion in rheumatology, 23(5)*, 471- 478. doi:10.1097/BOR.0b013e328349c2b1

Hame, S. L. and R.A. Alexander, 2013. Knee osteoarthritis in women. *Current reviews in musculoskeletal medicine*, *6*(2), 182-187. doi: 10.1007/s12178-013-9164-0

Haq, I., Murphy, E. and J. Dacre, 2003. Osteoarthritis. *Postgrad Med J 79*, 377–383. DOI: 10.1136/pmj.79.933.377

Hardcastle, S. A., P. Dieppe, C.L. Gregson, N.K. Arden, T.D. Spector, D.J. Hart, M.H. Edwards, E.M. Dennison, C. Cooper, M. Williams, G.D. Smith and J.H. Tobias, 2014. Osteophytes, enthesophytes, and high bone mass: a bone-forming triad with potential relevance in osteoarthritis. *Arthritis & Rheumatology, 66(9)*, 2429-2439. DOI 10.1002/art.38729

Havelková, P. and S. Villotte. Enthesopathies: test of the reproducibility of the new scoring system based on current medical data. Slovenská antropológia 10, 51-57.

Henderson, C. Y. and E. Nikita, 2016. Accounting for multiple effects and the problem of small sample sizes in osteology: a case study focussing on entheseal changes. *Archaeological and Anthropological Sciences, 8(4*), 805-817. DOI: 10.1007/s12520-015-0256-1

Henderson, C., 2013. Subsistence strategy changes: the evidence of entheseal changes. Homo, 64(6), 491-508. DOI: 10.1016/j.jchb.2013.08.002

Herndon, J. H., 2004. Osteoarthritis in women after menopause. *Menopause*, *11*(5), 499-501. DOI: 10.1097/01.gme.0000135244.19596.30

Herrmann, B., G. Grupe, S. Hummel, H. Piepenbrink and H. Schutkowski, 1990. *Prähistorische Anthropologie : Leitfaden der Feld- und Labormethoden*. Berlin: Springer-Verlag.

Ibounig, T., T. Simons, A. Launonen and M. Paavola, 2021. Glenohumeral osteoarthritis: an overview of etiology and diagnostics. *Scandinavian Journal of Surgery*, *110*(3), 441-451. https://doi.org/10.1177/1457496920935018

Işcan, M.Y., S.R. Loth and P. Miller-Shaivitz, 1984. Age estimation from the ribs by phase analysis: White males. *Journal of Forensic Sciences* 29, 1094-1104.

Işcan, M.Y., S.R. Loth and P. Miller-Shaivitz, 1985. Age estimation from the ribs by phase analysis: White females. *Journal of Forensic Sciences* 30, 853-863.

Johnson, V. L. and D.J. Hunter, 2014. The epidemiology of osteoarthritis. *Best practice & research Clinical rheumatology*, *28*(1), 5-15. DOI: 10.1016/j.berh.2014.01.004

Jones, G., Glisson, M., Hynes, K. and F. Cicuttini, 2000. Sex and site differences in cartilage development: a possible explanation for variations in knee osteoarthritis in later life. *Arthritis Rheum 43*:2543–9. DOI: 10.1002/1529-0131(200011)43:11<2543::AID-ANR23>3.0.CO;2-K

Jurmain, R. D. and L. Kilgore, 1995. Skeletal evidence of osteoarthritis: a palaeopathological perspective. *Annals of the rheumatic diseases*, *54*(6), 443. https://dx.doi.org/10.1136%2Fard.54.6.443

Jurmain, R. D., Cardoso, F. A., Henderson, C. and S. Villotte, 2012. Bioarchaeology's Holy Grail: The reconstruction of activity. In A. L. Grauer (Ed.), A companion to paleopathology (pp. 531– 552). Oxford, UK: Wiley-Blackwell.

Jurmain, R.D., 1990. Paleoepidemiology of a Central California prehistoric population from CA-ALA-329: II. Degenerative disease. American Journal of Physical Anthropology 83(1), 83-94. DOI: 10.1002/ajpa.1330830110

Kaprio, J., U.M. Kujala, L. Peltonen and M. Koskenvuo, 1996. Genetic liability to osteoarthritis may be greater in women than men. *Bmj*, *313*(7051), 232. DOI: 10.1136/bmj.313.7051.232

Kasmir, S. and A. Carbonella, 2008. Dispossession and the anthropology of labor. *Critique of Anthropology*, *28(1)*, 5-25. https://doi.org/10.1177/0308275X07086555

Khokhar, R., M. Kaur, S. Sofat and D. Chouhan, 2020. Review of automated segmentation approaches for knee images. IET Image Processing. 15. 10.1049/ipr2.12045.

Klaus, H., C.S. Larsen and M.E. Tam, 2009. Economic intensification and degenerative joint disease: Life and labor on the postcontact North Coast of Peru. *American Journal of Physical Anthropology, 139(2)*, 204–221. DOI: 10.1002/ajpa.20973

Kloek, E., 1998. 'Een nieuw studieveld'. Vrouwengeschiedenis, interdisciplinariteit en de Nederlandse zeventiende eeuw. *De Zeventiende eeuw*, 14(2), 218.

Lafta Mossa, H. A., 2018. Analysis of Upper Body Biomechanics and Control in Manual Wheelchair Users. Cardiff: Cardiff university.

Larsen, C. S., 1997. *Bioarcheology: Interpreting Behavior from the Human Skeleton*. New York: Cambridge University Press.

Larsen, C. S., C.B. Ruff and R.L. Kelly, 1995. Structural analysis of the Stillwater postcranial human remains: Behavioral implications of articular joint pathology and long bone diaphyseal morphology, in C. S. Larsen and R. L. Kelly (Eds.), *Bioarchaeology of the Stillwater marsh: Prehistoric human adaptation in the Western Great Basin*. New York, NY: American Museum of Natural History, 107-133.

Laulan, J., E. Marteau and G. Bacle, 2015. Wrist osteoarthritis. *Orthopaedics & Traumatology: surgery & research, 101(1),* S1-S9. https://doi.org/10.1016/j.otsr.2014.06.025

Lieverse, A. R., W.A. Weber, V.I. Bazaliiskiy, O.I. Goriunova and N.A. Savel'ev, 2007. Osteoarthritis in Siberia's Cis-Baikal: Skeletal indicators of hunter-gatherer adaptation and cultural change. *American Journal of Physical Anthropology, 132(1)*, 1–16. DOI: 10.1002/ajpa.20479

Lintsen, H.W. and P. Thoben, 2009. *De canon van Eindhoven*. 's-Hertogenbosch: Heinen.

Lovejoy, C.O., R.S. Meindl, T.R. Pryzbeck and R.P. Mensforth, 1985. Chronological metamorphosis of the auricular surface of the ilium: a new method for the determination of age at death. American Journal of Physical Anthropology 68, 15-28. https://doi.org/10.1002/ajpa.1330680103

Maat, G.J.R., Mastwijk, R.W. and H. Sarfatij, 1998. *Een fysisch anthropologisch onderzoek van begravenen bij het Minderbroedersklooster te Dordrecht, circa 1275-1572 AD.* Amersfoort: Rijksdienst voor het Oudheidkundig Bodemonderzoek.

Maat, G.J.R., R.W. Mastwijk and M. Jonker, 2002. *Citizens buried in the 'Sint Janskerkhof' of the 'Sint Jans' cathedral of 's-Hertogenbosch in the Netherlands ca 1450 and 1830-1858 AD*. Leiden: Barge's Anthropologica 8.

Mall, N. A., E. Foley, P.N. Chalmers, B.J. Cole, A.A. Romeo and B.R. Bach Jr, 2013. Degenerative joint disease of the acromioclavicular joint: a review. *The American journal of sports medicine*, *41*(11), 2684-2692. DOI: 10.1177/0363546513485359

Marklein, K. E. and D.E. Crews, 2022. Highs and lows of frailty: skeletal frailty differentials among socioeconomic groups in Postmedieval London. *Archaeological and Anthropological Sciences*, *14*(3), 1-22.

Martel-Pelletier, J., 2004. Pathophysiology of osteoarthritis. *Osteoarthritis and cartilage, 12*, 31-33. https://doi.org/10.1016/j.joca.2003.10.002

Mays, S., 2012. An investigation of age-related changes at the acetabulum in 18th–19th century AD adult skeletons from Christ Church Spitalfields, London. *American journal of physical anthropology*, *149*(4), 485-492. DOI: 10.1002/ajpa.22146

McLean, M., K. Hoban, R. Gupta, A. Gibson, A.J. Brooksbank, U.G. Fazzi, A. Arthur, D. Martin, P.J. Jenkins and N.L. Millar, 2019. The epidemiology of acromioclavicular joint excision. *Journal of Orthopaedic Surgery*, 27, 1-6. https://doi.org/10.1177/2309499018816521

Melssen, J., 2013. De Geschiedenis van de Catharinakerk: een kort overzicht, in N. Arts (ed.), *Een Knekelveld maakt geschiedenis: Het archeologisch onderzoek van het koor en het grafveld van de middeleeuwse Catharinakerk in Eindhoven, circa 1200-1850.* Utrecht: Stichting Matrijs, 27-32.

Miszkiewicz, J. J., 2019. Medieval English Social Inequality and Bone Health: What Lessons are There to be Learnt for the Living. *Bone Health.* Singapore: Springer, 3-15. https://doi.org/10.1007/978-981-13-7256-8_1

Molnar, P., Ahlstrom, T. P., and I. Leden, 2011. Osteoarthritis and activity—An analysis of the relationship between eburnation, musculoskeletal stress markers (MSM) and age in two Neolithic hunter-gatherer populations from Gotland, Sweden. *International Journal of Osteoarchaeology, 21(3),* 283–291. DOI: 10.1002/oa.1131

Man, G. S. and G. Mologhianu, 2014. Osteoarthritis pathogenesis–a complex process that involves the entire joint. *Journal of medicine and life*, 7(1), 37-41.

Myszka, A., Krenz-Niedbała, M., Tomczyk, J. and M. Zalewska, 2020. Osteoarthritis: A problematic disease in past human populations. A dependence between entheseal changes, body size, age, sex, and osteoarthritic changes development. *The Anatomical Record*, *303*(9), 2357-2371. DOI: 10.1002/ar.24316

Nollen, J. 2013. Het Grafritueel, in N. Arts (Ed.), *Een knekelveld maakt geschiedenis: Het archeologische onderzoek van het koor en het grafveld van de middeleeuwse Catharinakerk in Eindhoven, circa 1200-1850*. Utrecht: Stichting Matrijs, 117-150.

Nollen, J., 2013. Het archeologisch onderzoek van 2005 en 2006, in N. Arts (ed.), *Een Knekelveld maakt geschiedenis: Het archeologisch onderzoek van het koor en het grafveld* *van de middeleeuwse Catharinakerk in Eindhoven, circa 1200-1850.* Utrecht: Stichting Matrijs, 38-49.

Öberg, T., G.E. Carlsson and C. Fajers, 1971. The Temporomandibular Joint: A Morphologic Study on A Human Autopsy Material. Acta Odontologica Sandinavica 29(3), 349-384. DOI: 10.3109/00016357109026526

Ortner, D., 2003. *Identification of pathological skeletons in human skeletal remains (2nd ed.).* New York, NY: Academic Press.

O'Sullivan, D., 2013. Burial of the Christian Dead in the Later Middle Ages, in L. Nilsson Stutz and S. Tarlow (eds.), *The Oxford Handbook of the Archaeology of Death and Burial*. Oxford: Oxford University Press, 259-280. https://doi.org/10.1093/oxfordhb/9780199569069.013.0015

Otterness, I. G. and F. Eckstein, 2007. Women have thinner cartilage and smaller joint surfaces than men after adjustment for body height and weight. *Osteoarthritis and cartilage, 15(6),* 666-672. DOI: 10.1016/j.joca.2006.12.003

Pálfi, G. and O. Dutour, 1996. Activity-induced skeletal markers in historical anthropological material. *International Journal of Anthropology*, *11*(1), 41-55. https://doi.org/10.1007/BF02442202

Palmer, J. L., & Waters-Rist, A. L. (2019). Acts of life: Assessing entheseal change as an indicator of social differentiation in postmedieval Aalst (Belgium). International Journal of Osteoarchaeology, 29(2), 303-313. DOI: 10.1002/oa.2740

Palmer, J. L., Hoogland, M. H. and A.L. Waters-Rist, 2016. Activity reconstruction of post-medieval Dutch rural villagers from upper limb osteoarthritis and entheseal changes. *International Journal of Osteoarchaeology*, *26*(1), 78-92. DOI: 10.1002/oa.2397

Peijnenburg, J. and A.J.J.H. Tops, 1961. *Bouwstoffen tot de geschiedenis van Eindhoven*.

Petersson, C. J., 1983. Degeneration of the acromioclavicular joint; a morphological study. Acta Orthopaedica Scandinavica 54, 434-438. DOI: 10.3109/17453678308996597

Phenice, T.W., 1969. A newly developed visual method of sexing the os pubis. American Journal of Physical Anthropology 30, 297–302. https://doi.org/10.1002/ajpa.1330300214

Rando, C., 2016. The human remains collections at the UCL Institute of Archaeology: Recent acquisitions from Eastgate Square, Chichester, Sussex. *Archaeology International 19*, 79-83. DOI: http://dx.doi.org/10.5334/ai.1914

Rijpma, F. E. and G.J.R. Maat, 2005. A physical anthropological research of the beguines of Breda 1267 to 1530 AD. *Barge's Anthropologica*, Leiden University Medical Center.

Robb, J., R. Bigazzi, L. Lazzarini, C. Scarsini and F. Sonego, 2001. Social "status" and biological "status": A comparison of grave goods and skeletal indicators from Pontecagnano. American Journal of Physical Anthropology: The Official Publication of the American Association of Physical Anthropologists, 115(3), 213-222. https://doi.org/10.1002/ajpa.1076

Roberts, A. M., K. Robson-Brown, J.H. Musgrave and I. Leslie, 2006. A case of bilateral scapholunate advanced collapse in a Romano-British skeleton from Ancaster. *International Journal of Osteoarchaeology*, *16*(3), 208-220. DOI:10.1002/oa.817

Roberts, C. and K. Manchester, 2010. *The Archaeology of Disease*. Gloucestershire: The History Press

Rogers, J. and T. Waldron, 1995. *A field guide to joint disease in archaeology*. West Sussex, UK: Wiley

Rogers, J., L. Shepstone and P. Dieppe, 1997. Bone formers: osteophyte and enthesophyte formation are positively associated. *Annals of the Rheumatic Diseases* 56, 85–90. doi: 10.1136/ard.56.2.85

Rossignol, M., A. Leclerc, F.A. Allaert, S. Rozenberg, J.P. Valat, B. Avouac, P. Coste, E. Litvak and P. Hilliquin, 2005. Primary osteoarthritis of hip, knee, and hand in relation to occupational exposure. Occupational and Environmental Medicine (London, England), 62(11), 772–777. https://doi.org/10.1136/oem.2005.020057

Rothschild, B. M., 1997. Porosity: A curiosity without diagnostic significance. *American Journal of Physical Anthropology,* 104(4), 529–533. http://dx.doi.org/10.1002/(SICI)1096-8644(199712)104:4<529::AID-AJPA7>3.0.CO;2-M

Saers, J., M.L. Hoogland, R.V. Rijn, R. Schats, A.E. van der Merwe and A.L. Waters-Rist, 2017. Habitual activity in pre-industrial rural and urban Dutch populations: A study of lower limb cross-sectional geometry. *Bioarchaeology International*, *1*(3-4), 1-17. doi:10.5744/bi.2017.1006

Sandell, L. J. and T. Aigner, 2001. Articular cartilage and changes in arthritis: cell biology of osteoarthritis. *Arthritis Research & Therapy*, *3*(2), 1-7. DOI: 10.1186/ar148

Sarzi-Puttini, P., Atzeni, F., Fumagalli, M., Capsoni, F. and M Carrabba, 2005. Osteoarthritis of the spine. *Seminars in Arthritis and Rheumatism*, 34(6), 38–43.

Schoemaker, B. O., 2018. *Gewijd der jeugd voor taal en deugd. Het onderwijs in de Nederlandse taal op de lagere school, 1750-1850*. Leiden: Leiden University.

Schrader, S., 2019. *Activity, Diet and Social Practise: addressing everyday life in human skeletal remains*. Springer International Publishing. Doi:10.1007/978-3-030-02544-1.

Smits, F.N., 1887. *Beknopte geschiedenis van Eindhoven (eerste deel)*. Eindhoven

Spector, T. D. and A. MacGregor, 2004. Risk factors for osteoarthritis: Genetics. *Osteoarthritis and Cartilage*, 12, S39–S44. DOI: 10.1016/j.joca.2003.09.005

Stanley, D., 1994. Prevalence and etiology of symptomatic elbow osteoarthritis. *Journal of shoulder and elbow surgery*, *3*(6), 386-389. DOI: 10.1016/S1058-2746(09)80024-4

Steckel, R. H., C.S. Larsen, P.W. Sciulli, and P.L. Walker, 2006. *The global history of health project: Data collection codebook*. Columbus, OH: The Ohio State University.

Stein, B. E. S., J.M. Wiater, H.C. Pfaff, L.U. Bigliani and W.N. Levine, 2001. Detection of acromioclavicular joint pathology in asymptomatic shoulders with magnetic resonance imaging. *Journal of Shoulder and Elbow Surgery,* 10(3), 204-208. DOI: 10.1067/mse.2001.113498

Stewart, T.D., 1979. *Essentials of forensic anthropology*. Springfield: Charles C. Thomas.

Stodder, A. L. W. and A.M. Palkovich (Eds.), 2012. *The bioarchaeology of individuals.* Gainesville: University Press of Florida, 1-10.

Tanna, S., Wittenauer, R., Smith, L. and K. Aden, 2013. Background Paper 6.12 Osteoarthritis. *Priority Medicines for Europe and the World "A Public Health Approach Innovation." WHO*.

Tauber, M., 2016. Diseases of the acromioclavicular joint. *Orthopade*, 45, 555–568. https://doi.org/10.1007/s00132-016-3269-2

Tornberg, A. and L. Jacobsson, 2018. Care and consequences of traumatic brain injury in Neolithic Sweden: A case study of ante mortem skull trauma and brain injury addressed through the bioarchaeology of care. *International journal of osteoarchaeology, 28(2*), 188-198. https://doi.org/10.1002/oa.2646

Valdes, A. M. and T.D. Spector, 2008. The contribution of genes to osteoarthritis. *Medical Clinics of North America*, 93(3), 45–66. DOI: 10.1016/j.rdc.2008.04.008

Valeggia, C and E. Fernandez-Duque, 2021. Moving biological anthropology research beyond p. *American Journal of Biological Anthropology*. 177. 10.1002/ajpa.24444.

van Oosten, R., 2019. The cursed side: A folk belief evidenced by documentary records in ‘s-Hertogenbosch (1782–1858), in R. Van Oosten, R. Schats & K. Fast, *Osteoarchaeology in Historical Context. Cemetery Research from the Low Countries*. Leiden: Sidestone Press (Urban Graveyard proceedings 3), 155-165.

Verzijl, N., Bank, R. A., TeKoppele, J. M. and J. DeGroot, 2003. Ageing and osteoarthritis: a different perspective. *Current opinion in rheumatology*, *15*(5), 616-622. DOI: 10.1097/00002281-200309000-00016

Veselka, B. and M. Klomp, 2019. Taking sides: An osteoarchaeological analysis of human skeletal remains from the south and north sides of St. Andrew’s Church (Andreaskerk) in Hattem, the Netherlands, in R.M.R. van Oosten, R. Schats, and K. Fast (eds.), *Urban graveyards: Archaeological perspectives from the Low Countries*. Leiden: Sidestone Press (Urban Graveyard proceedings 3), 139-153.

W.E.A. (Workshop of European Anthropologists), 1980. Recommendations for age and sex diagnosis of skeletons. *Journal of Human Evolution 9,* 517-549.

Waldron, T. and J. Rogers, 1991. Inter-observer variation in coding osteoarthritis in human skeletal remains. International Journal of Osteoarchaeology 1, 49-56. https://doi.org/10.1002/oa.1390010107

Waldron, T., 2009. *Paleopathology.* Cambridge, UK: Cambridge University Press.

Waldron, T., 2012. Joint disease, in A. L. Grauer (ed.), *A companion to paleopathology*. Chichester, UK: Wiley-Blackwell, 513-530.

Waldron, T., 2019. Joint Disease, in J.E. Buikstra (eds.), *Ortner's Identification of Pathological Conditions in Human Skeletal Remains (Third Edition)*. Academic Press, 719-748. https://doi.org/10.1016/B978-0-12-809738-0.00020-X.

Watson, H. K. and F.L. Ballet, 1984. The SLAC wrist: scapholunate advanced collapse pattern of degenerative arthritis. *The Journal of hand surgery*, *9*(3), 358-365. DOI: 10.1016/s0363-5023(84)80223-3

Webb, H., A. Norton, L. Loe, J. Munby, C. Poole, I. Scott and R. Shaffrey, 2009. The medieval and post-medieval graveyard of St Peter-le-Bailey at Bonn Square, Oxford. *Oxoniensia*, *74*, 137-180.

Weiss E., 2005. Understanding osteoarthritis patterns: an examination of aggregate osteoarthritis. *Journal of Paleopathology 16*: 88–98.

Weiss, E. and R. Jurmain, 2007. Osteoarthritis revisited: A contemporary review of aetiology. *International Journal of Osteoarchaeology*, 17(5), 437–450. https://doi.org/10.1002/oa.889

Weiss, E., 2006. Osteoarthritis and Body Mass. Journal of Archaeological Science 33(5), 690-695. DOI: 10.1016/j.jas.2005.10.003

Weiss, E., 2017. *Reading the Bones: Activity, Biology, and Culture*. Gainesville: University Press of Florida.

Weiss, K. E. and C.M. Rodner, 2007. Osteoarthritis of the wrist. *The Journal of hand surgery*, *32*(5), 725-746. DOI: 10.1016/j.jhsa.2007.02.003

White, T. D. and P.A. Folkens, 2005. *The human bone manual*. Elsevier.

Wong, M. and J. Kiel, 2018. *Anatomy, Shoulder and Upper Limb, Acromioclavicular Joint.* Treasure Island: StatPearls Publishing.

Wood, J.W, G.R. Milner, H.C. Harpending, K.M. Weiss, M.N. Cohen, L.E. Eisenberg, D.L. Hutchinson, R. Jankauskas, G. Česnys, M.A. Katzenberg, J.R. Lukacs, J.W. McGrath, E. Abella Roth, D.H. Ubelaker and R.G. Wilkinson, 1992. *The Osteological Paradox: Problems of Inferring Prehistoric Health from Skeletal Samples*. Current Anthropology 33(4), 343-370. https://doi.org/10.1086/204084

Woods, R. J., 1995. Biomechanics of osteoarthritis of the knee. Unpublished Ph.D. dissertation, The Ohio State University, Columbus, OH.

List of Webpages

https://www.catharinakerkhof.nl/historie accessed on 7 January 2022

https://www.britannica.com/science/osteoarthritis accessed on 15 May 2022

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Appendix 1

The osteoarthritis scores of the high socioeconomic status population from Eindhoven per analysed individual.

Findnumber	561	844	3677	2586	2827	1387	3388	2817	1981	1790	2195	1477	1341
Site	1	1	1	1	1	1	1	1	1	1	1	1	1
Sex	1	2	1	1	1	1	1	1	1	2	2	1	2
Age	4	5	4	4	5	2	4	4	3	4	1	4	4
acromial end clavicle Right	-	1	-	-	-	-	0	-	-	0	0	-	1
acromial end clavicle left	-	1	0	-	0	-	0	0	-	0	0	-	1
acromion right	0	0	0	-	-	0	-	-	-	0	0	0	0
acromion left	0	1	0	-	-	-	0	0	-	0	0	-	0
glenoid fossa right	0	0	0	0	-	0	0	0	0	0	0	0	0
glenoid fossa left	0	0	0	-	0	0	0	0	0	0	0	-	0
prox. Humerus right	0	-	0	0	0	0	0	0	0	0	0	0	0
prox humerus left	0	0	0	0	0	0	0	0	0	0	0	0	0
dist humerus right	0	0	0	0	0	0	0	0	0	0	0	0	0
dist humerus left	0	0	0	-	0	0	0	0	0	0	0	-	0
prox ulna right	0	0	0	0	0	0	0	0	0	0	0	-	0
prox ulna left	0	0	0	0	0	0	0	0	0	0	0	-	0
prox radius right	0	0	0	0	0	0	0	0	0	0	0	0	0
prox radius left	0	0	0	0	0	-	0	0	-	-	0	0	0
dist ulna right	-	-	0	0	0	0	0	0	0	0	0	-	0
dist ulna left	0	-	0	0	-	-	0	3	0	0	0	0	0
dist radius right	0	-	0	3	0	0	0	0	0	0	0	-	0
dist radius left	0	-	0	3	0	0	0	3	-	-	0	0	0
prox scaphoid right	-	-	-	3	-	0	-	-	-	0	0	-	0
prox scaphoid left	0	-	0	3	0	0	0	0	0	-	-	0	0
prox lunate right	0	-	0	3	-	0	0	0	0	0	0	-	0
prox lunate left	-	-	0	-	0	-	0	-	0	-	0	-	0
acetabulum right	0	1	0	0	0	0	0	0	0	0	0	0	0
acetabulum left	0	0	1	0	0	0	0	0	0	0	0	-	0
prox femur right	-	0	1	0	0	0	0	0	-	0	0	0	0
prox femur left	0	0	0	0	0	0	0	0	0	-	0	0	-
dist femur right	-	1	0	0	0	0	0	0	-	0	-	0	0
dist femur left	0	0	0	0	0	0	0	0	0	-	-	0	-
Patella right	-	1	0	0	0	0	0	0	-	0	-	0	0
Patella left	-	1	0	0	0	-	0	0	0	0	-	0	0
prox tibia right	-	1	0	0	0	0	0	0	-	-	-	0	0
prox tibia left	0	1	0	0	0	0	0	0	0	0	-	0	1
dist tibia right	0	0	0	0	0	0	0	-	-	0	-	0	0
dist tibia left	0	0	0	0	0	0	0	-	0	0	-	0	0
prox fibula right	-	-	-	-	0	0	-	-	-	-	-	-	0
prox fibula left	-	-	-	-	0	0	-	-	0	0	-	-	0
dist fibula right	0	1	0	0	0	0	0	-	-	0	-	-	0
dist fibula left	0	-	-	0	0	0	0	-	0	0	-	-	0
prox talus right	0	0	0	0	0	0	0	-	-	0	-	-	0
prox talus left	0	0	0	0	0	0	0	-	0	0	-	-	-

Appendix 2

The osteoarthritis scores of the low socioeconomic status population from Eindhoven per analysed individual.

Findnumber	2040	1430	2765	2232	3142	2538	3536	2010	2050	3421	2828	481	2038	3640	3513	3088	1196	2834
Site	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Sex	2	1	1	2	2	1	1	1	1	1	2	1	1	1	1	2	1	1
Age	3	4	2	4	5	3	5	2	3	5	3	5	1	2	3	3	3	3
acromial end clavicle Right	1	1	0	-	1	-	0	0	0	-	0	-	0	0	-	0	0	0
acromial end clavicle left	0	-	0	-	1	1	0	0	0	1	-	1	0	0	-	0	0	1
acromion right	0	-	0	-	1	0	0	3	0	2	0	-	0	0	-	-	-	1
acromion left	-	-	0	-	0	0	0	0	0	1	-	1	0	-	-	-	-	0
glenoid fossa right	0	0	0	0	0	0	0	1	0	0	0	-	0	0	-	0	0	0
glenoid fossa left	0	-	0	0	0	0	0	0	0	0	-	0	0	0	-	0	0	0
prox. Humerus right	1	0	0	1	0	1	0	1	0	1	1	-	0	0	-	0	-	0
prox humerus left	-	0	0	0	3	0	1	1	0	0	-	0	0	0	-	0	0	0
dist humerus right	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	-	0
dist humerus left	-	0	0	0	0	0	0	-	0	0	-	0	0	0	0	0	0	0
prox ulna right	0	0	0	0	0	1	0	0	-	1	0	0	0	0	0	0	0	0
prox ulna left	0	0	0	0	1	0	0	-	0	3	0	0	0	0	0	0	0	0
prox radius right	0	1	0	0	0	0	-	0	-	0	0	-	0	0	0	0	0	0
prox radius left	0	0	0	0	0	0	0	-	0	0	-	0	0	0	0	0	0	0
dist ulna right	3	-	0	-	0	0	0	-	0	3	-	0	0	0	0	0	0	0
dist ulna left	0	0	0	-	0	-	0	0	0	3	0	-	0	-	0	0	0	0
dist radius right	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	0	0
dist radius left	1	3	0	0	0	0	0	-	0	0	-	-	0	0	0	0	0	0
prox scaphoid right	0	-	0	-	0	0	3	0	0	0	0	-	0	0	0	-	0	0
prox scaphoid left	0	-	0	0	0	0	-	0	0	0	0	0	0	0	0	0	-	0
prox lunate right	1	-	-	0	0	0	1	1	-	1	-	0	0	0	0	0	0	0
prox lunate left	1	-	0	0	0	0	-	0	0	1	0	0	0	-	0	-	0	0
acetabulum right	1	1	0	1	0	0	0	1	-	0	3	1	0	0	0	0	0	0
acetabulum left	2	2	0	-	1	0	0	1	0	0	1	0	0	0	0	0	0	0
prox femur right	2	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
prox femur left	3	0	-	0	0	0	-	1	0	0	1	0	0	0	0	0	0	0
dist femur right	3	0	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0
dist femur left	1	0	-	0	0	0	-	-	0	0	0	0	0	0	0	0	0	0
Patella right	0	1	-	0	1	0	-	-	0	0	0	-	0	0	0	0	0	0
Patella left	1	1	-	0	1	0	-	-	0	0	0	0	-	0	0	0	0	0
prox tibia right	1	0	0	0	0	0	-	-	0	0	0	0	0	0	0	0	0	1
prox tibia left	1	-	-	0	0	0	-	-	0	0	0	0	0	0	0	-	0	0
dist tibia right	0	1	0	0	0	0	-	-	-	0	0	0	0	0	0	0	0	0
dist tibia left	0	0	-	0	0	0	-	-	0	0	0	-	0	0	0	0	0	0
prox fibula right	0	-	0	-	0	-	-	-	0	0	-	-	0	-	-	-	-	-
prox fibula left	-	-	-	-	0	-	-	-	0	-	-	0	-	-	0	0	-	-
dist fibula right	0	0	3	0	0	0	-	-	-	0	-	-	0	0	-	0	0	0
dist fibula left	1	-	-	0	0	0	-	0	-	0	-	-	0	0	-	0	0	0
prox talus right	0	0	-	-	0	0	-	-	-	0	0	0	0	0	0	0	0	0
prox talus left	0	-	-	0	0	0	-	-	-	0	0	0	0	-	-	0	0	0

Findnumber	1692	2921	2766	2601	3864	3470	2108	2603	2165	3817	1603	1886	2596	1190	3150	1223	2762
Site	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Sex	2	1	1	1	2	1	1	2	2	1	1	1	1	2	2	1	1
Age	3	4	4	3	1	1	1	1	4	1	5	4	3	2	1	2	1
acromial end clavicle Right	-	-	1	3	0	-	0	-	0	0	0	-	0	0	0	1	0
acromial end clavicle left	-	1	3	1	-	0	0	0	1	-	1	1	0	-	0	1	0
acromion right	-	0	1	1	0	0	0	-	0	0	0	-	0	0	0	3	0
acromion left	-	1	1	0	0	0	0	0	-	-	0	1	0	-	-	2	0
glenoid fossa right	-	1	1	0	0	0	0	-	0	0	0	-	0	0	0	0	0
glenoid fossa left	0	1	1	0	0	0	0	0	0	0	0	0	0	-	0	0	0
prox. Humerus right	-	0	1	0	0	0	0	-	0	0	0	0	0	0	0	0	0
prox humerus left	0	1	1	0	0	0	0	0	0	0	-	0	0	-	0	0	0
dist humerus right	-	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0
dist humerus left	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0
prox ulna right	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0
prox ulna left	0	0	0	0	3	0	0	0	0	0	-	0	0	0	0	0	0
prox radius right	0	0	0	0	0	0	0	-	0	-	0	0	0	0	0	0	0
prox radius left	0	0	0	0	3	0	0	0	0	0	-	0	0	0	0	0	0
dist ulna right	-	0	0	0	-	0	0	-	-	-	0	0	-	0	0	0	0
dist ulna left	-	0	2	0	0	0	0	0	0	0	-	0	0	0	0	0	0
dist radius right	0	0	0	0	-	0	0	-	0	0	0	-	0	0	0	0	0
dist radius left	-	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0
prox scaphoid right	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
prox scaphoid left	-	0	-	0	-	0	0	0	0	0	0	0	0	0	0	0	-
prox lunate right	-	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0
prox lunate left	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	-
acetabulum right	0	1	1	0	0	0	0	0	0	0	0	-	0	0	0	0	0
acetabulum left	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
prox femur right	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
prox femur left	0	3	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0
dist femur right	0	0	0	0	0	0	0	0	-	-	0	0	0	0	0	0	0
dist femur left	0	0	-	0	0	0	0	0	0	0	0	0	0	-	0	0	0
Patella right	0	0	0	0	3	0	0	0	0	-	-	0	0	0	0	0	0
Patella left	0	0	-	0	0	0	0	0	0	0	0	0	0	0	-	0	0
prox tibia right	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0
prox tibia left	0	0	-	0	0	0	0	0	0	0	0	0	0	0	-	-	0
dist tibia right	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0
dist tibia left	0	0	-	0	0	0	0	0	0	0	0	0	0	0	-	0	-
prox fibula right	0	0	0	-	-	0	0	0	-	-	-	-	-	-	-	-	0
prox fibula left	0	-	-	0	-	-	-	0	0	-	-	-	-	0	-	-	0
dist fibula right	-	0	0	-	0	0	0	-	0	-	0	0	0	0	-	-	0
dist fibula left	-	0	-	0	0	0	0	0	0	-	0	0	0	0	-	-	0
prox talus right	0	0	0	0	0	0	0	-	0	-	0	0	-	0	-	-	0
prox talus left	-	0	-	0	0	0	0	0	0	0	0	0	-	0	-	0	0

Findnumber	2885	1911	3463	3105	2220	2577	2876	2331	3530	3284	1429	2148	3289	1212	2162	2332	1563
Site	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Sex	1	2	1	1	2	1	2	2	2	2	2	1	2	2	2	2	1
Age	3	4	3	1	5	1	2	5	5	3	4	4	3	3	4	2	1
acromial end clavicle Right	1	0	0	-	1	0	0	-	0	0	-	1	-	0	0	-	0
acromial end clavicle left	1	-	0	0	1	0	-	-	0	-	-	-	-	-	0	0	-
acromion right	2	1	-	0	0	0	0	-	0	-	-	0	-	0	-	-	0
acromion left	1	-	0	1	0	0	-	-	0	-	-	-	-	0	-	-	-
glenoid fossa right	0	0	0	0	0	0	0	-	0	0	-	0	-	0	0	-	0
glenoid fossa left	0	-	0	0	0	0	0	0	0	0	-	0	-	0	0	0	0
prox. Humerus right	0	0	0	0	0	0	0	0	0	0	-	-	0	0	0	-	0
prox humerus left	0	-	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0
dist humerus right	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	-	0
dist humerus left	0	-	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0
prox ulna right	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	-	0
prox ulna left	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
prox radius right	0	0	0	-	0	0	0	-	0	-	0	0	0	0	0	-	0
prox radius left	0	-	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0
dist ulna right	0	0	0	-	0	0	0	-	-	0	0	-	0	0	0	-	0
dist ulna left	-	-	0	0	0	0	0	-	0	0	0	0	-	0	0	0	0
dist radius right	0	0	0	-	0	0	0	-	0	0	0	0	0	0	0	-	0
dist radius left	0	-	0	0	0	-	0	0	0	0	0	-	-	0	0	0	0
prox scaphoid right	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	-	0
prox scaphoid left	0	-	0	0	0	-	0	0	0	0	0	-	-	0	0	0	0
prox lunate right	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	-	0
prox lunate left	0	-	0	0	0	-	0	0	0	0	0	-	-	0	0	0	0
acetabulum right	0	0	0	0	-	0	0	0	0	0	3	1	0	0	0	-	0
acetabulum left	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0
prox femur right	0	0	0	0	3	0	0	-	0	0	3	0	0	0	0	-	0
prox femur left	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0
dist femur right	-	0	0	0	0	0	0	-	0	0	0	0	0	0	0	-	0
dist femur left	0	0	0	0	0	-	0	0	0	0	0	-	0	0	0	0	0
Patella right	-	0	0	-	0	0	0	-	0	0	0	0	0	0	0	-	0
Patella left	0	-	0	-	0	0	0	1	0	0	-	-	-	0	0	-	0
prox tibia right	-	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0
prox tibia left	0	-	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0
dist tibia right	-	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0
dist tibia left	0	-	0	0	0	0	-	-	0	0	0	0	0	0	0	0	0
prox fibula right	-	0	0	0	-	0	-	-	-	0	-	-	0	-	-	0	0
prox fibula left	-	-	0	0	-	0	-	-	-	0	0	-	-	-	-	0	0
dist fibula right	-	0	0	-	0	-	0	-	0	0	0	0	0	0	0	0	0
dist fibula left	0	-	0	0	-	0	-	-	0	0	-	-	0	0	0	0	0
prox talus right	-	-	0	-	0	-	0	-	0	0	0	0	0	0	0	0	0
prox talus left	0	-	0	-	0	0	-	-	0	0	0	0	0	0	0	0	0

Appendix 3

The raw data of the high socioeconomic status population from Eindhoven.

Findnumber		561	844	3677	2586	1341	1387	3388	2817	1981	1790	2195	1477
Site		inside (K)	inside(K)	inside(K)	inside(2K)	inside(K)	inside(K)	inside(2K)	inside(2K)	inside(2K)	inside(K)	inside(2K)	inside(2K)
dating		1650-1850	1650-1850	1500-1650	1650-1850	1650-1850	1650-1850	1500-1650	1500-1650	1650-1850	1650-1850	1650-1850	1500-1650
Sex		M	F	M	M	F	M	M	M	M	F	PF	M
Age		50-59	60-69	50-59	50-59	50-59	30-39	50-59	50-59	40-49	50-59	20-29	50-59
	lipping	-	1	-	-	1	-	0	-	-	0	0	-
	porosity	-	1,2	-	-	3	-	1	-	-	1	0	-
acromial end clavicle Right	eburnation	-	0	-	-	9	-	0	-	-	0	0	-
	lipping	-	1	0	-	1	-	0	0	-	0	0	-
	porosity	-	3	1	-	3	-	1	0	-	2	0	-
acromial end clavicle left	eburnation	-	0	0	-	0	-	0	0	-	0	0	-
	lipping	0	0	0	-	1	0	-	-	-	0	0	0
	porosity	0	1	0	-	0	0	-	-	-	0	0	0
acromion right	eburnation	0	0	0	-	0	0	-	-	-	0	0	0
	lipping	0	2	0	-	0	-	0	0	-	0	0	-
	porosity	0	1	1	-	0	-	1	2	-	0	0	-
acromion left	eburnation	0	0	0	-	0	-	0	0	-	0	0	-
	lipping	0	0	0	0	1	0	0	0	0	1	0	0
	porosity	0	1	0	0	0	0	0	0	0	0	0	0
glenoid fossa right	eburnation	0	0	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	-	0	0	0	0	0	0	0	-
	porosity	0	1	0	-	0	0	0	0	0	0	0	-
glenoid fossa left	eburnation	0	0	0	-	0	0	0	0	0	0	0	-
	lipping	0	-	0	0	0	0	0	0	0	0	0	0
	porosity	0	-	1	0	0	0	0	0	0	0	0	0
prox. Humerus right	eburnation	0	-	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0	0	0
	porosity	0	1	0	0	0	0	0	0	0	0	0	0
prox humerus left	eburnation	0	0	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	1	1	0	0
	porosity	0	0	0	0	0	0	0	0	0	0	0	0
dist humerus right	eburnation	0	0	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	-	0	0	0	0	0	0	0	-
	porosity	0	0	0	-	0	0	0	0	0	0	0	-
dist humerus left	eburnation	0	0	0	-	0	0	0	0	0	0	0	-
	lipping	0	0	0	0	0	0	0	0	0	0	0	-
	porosity	0	1	0	0	1	0	0	0	0	0	0	-
prox ulna right	eburnation	0	0	0	0	0	0	0	0	0	0	0	-
	lipping	1	0	0	0	0	0	0	0	0	0	0	-
	porosity	0	1	0	0	0	0	0	0	0	0	0	-
prox ulna left	eburnation	0	0	0	0	0	0	0	0	0	0	0	-
	lipping	0	0	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0	0	0
prox radius right	eburnation	0	0	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	-	0	0	-	-	0	0
	porosity	0	0	0	0	0	-	0	0	-	-	0	0
prox radius left	eburnation	0	0	0	0	0	-	0	0	-	-	0	0
	lipping	-	-	0	0	1	0	0	1	0	0	0	-
	porosity	-	-	0	1	0	0	0	0	0	0	0	-
dist ulna right	eburnation	-	-	0	0	0	0	0	0	0	0	0	-
	lipping	0	-	0	0	0	-	0	1	0	0	0	0
	porosity	0	-	0	0	0	-	0	2,1	0	0	0	0
dist ulna left	eburnation	0	-	0	0	0	-	0	3	0	0	0	0
	lipping	0	-	0	2	0	0	0	0	0	0	0	-
	porosity	0	-	0	2	0	0	0	0	0	0	0	-
dist radius right	eburnation	0	-	0	2	0	0	0	0	0	0	0	-
	lipping	0	-	0	2	0	0	1	1	-	-	0	0
	porosity	0	-	1	3,1	0	0	0	2,1	-	-	0	0
dist radius left	eburnation	0	-	0	2	0	0	0	1	-	-	0	0
	lipping	-	-	-	2	0	0	-	-	-	0	0	-
	porosity	-	-	-	3,2	0	0	-	-	-	0	0	-
prox scaphoid right	eburnation	-	-	-	3	0	0	-	-	-	0	0	-
	lipping	1	-	0	1	1	0	0	0	0	-	-	1
	porosity	0	-	0	2	0	0	0	0	0	-	-	0
prox scaphoid left	eburnation	0	-	0	2	0	0	0	0	0	-	-	0
	lipping	1	-	0	2	0	0	0	0	1	0	0	-
	porosity	0	-	0	1	0	0	0	0	0	0	0	-
prox lunate right	eburnation	0	-	0	1	0	0	0	0	0	0	0	-
	lipping	-	-	0	-	0	-	0	-	0	-	0	-
	porosity	-	-	0	-	0	-	0	-	0	-	0	-
prox lunate left	eburnation	-	-	0	-	0	-	0	-	0	-	0	-

Findnumber		561	844	3677	2586	1341	1387	3388	2817	1981	1790	2195	1477
	lipping	0	1	1	1	1	0	0	0	0	0	0	0
	porosity	0	1	0	0	0	0	0	0	0	0	0	0
acetabulum right	eburnation	0	0	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	1	1	0	0	0	0	0	0	0	-
	porosity	0	1	1	0	0	0	0	0	1	0	0	-
acetabulum left	eburnation	0	0	0	0	0	0	0	0	0	0	0	-
	lipping	-	0	1	0	0	0	0	0	-	0	0	0
	porosity	-	1	1	0	0	0	0	0	-	0	0	0
prox femur right	eburnation	-	0	0	0	0	0	0	0	-	0	0	0
	lipping	0	0	1	0	-	0	0	0	0	-	0	0
	porosity	0	2,1	0	0	-	0	0	0	0	-	0	0
prox femur left	eburnation	0	0	0	0	-	0	0	0	0	-	0	0
	lipping	-	1	0	0	1,2	0	0	0	-	0	-	0
	porosity	-	1	0	0	0	0	0	0	-	0	-	0
dist femur right	eburnation	-	0	0	0	0	0	0	0	-	0	-	0
	lipping	1	0	0	0	-	0	0	0	0	-	-	0
	porosity	0	1	0	0	-	0	0	0	0	-	-	0
dist femur left	eburnation	0	0	0	0	-	0	0	0	0	-	-	0
	lipping	-	1	0	0	1,2	0	0	0	-	1	-	0
	porosity	-	2,1	0	0	0	0	0	0	-	0	-	0
Patella right	eburnation	-	0	0	0	0	0	0	0	-	0	-	0
	lipping	-	1	0	0	1	-	0	0	0	1	-	0
	porosity	-	2,1	0	0	0	-	0	0	0	0	-	0
Patella Left	eburnation	-	0	0	0	0	-	0	0	0	0	-	0
	lipping	-	1	0	0	1	0	0	0	-	-	-	0
	porosity	-	1	0	0	0	0	0	0	-	-	-	0
prox tibia right	eburnation	-	0	0	0	0	0	0	0	-	-	-	0
	lipping	1	1	0	0	1	0	0	0	0	1	-	0
	porosity	0	1	0	0	1	0	0	0	0	0	-	0
prox tibia left	eburnation	0	0	0	0	0	0	0	0	0	0	-	0
	lipping	1	0	0	0	0	0	0	-	-	0	-	0
	porosity	0	1	0	0	0	0	0	-	-	0	-	0
dist tibia right	eburnation	0	0	0	0	0	0	0	-	-	0	-	0
	lipping	1	1	0	0	0	0	0	-	0	0	-	0
	porosity	0	0	0	0	0	0	0	-	0	0	-	0
dist tibia left	eburnation	0	0	0	0	0	0	0	-	0	0	-	0
	lipping	-	-	-	-	0	0	-	-	-	-	-	-
	porosity	-	-	-	-	0	0	-	-	-	-	-	-
prox fibula right	eburnation	-	-	-	-	0	0	-	-	-	-	-	-
	lipping	-	-	-	-	0	0	-	-	0	0	-	-
	porosity	-	-	-	-	0	0	-	-	0	0	-	-
prox fibula left	eburnation	-	-	-	-	0	0	-	-	0	0	-	-
	lipping	0	0	0	0	0	0	0	-	-	0	-	-
	porosity	0	3,1	0	0	0	0	0	-	-	0	-	-
dist fibula right	eburnation	0	0	0	0	0	0	0	-	-	0	-	-
	lipping	0	-	-	0	0	0	0	-	0	1	-	-
	porosity	0	-	-	0	0	0	0	-	0	0	-	-
dist fibula left	eburnation	0	-	-	0	0	0	0	-	0	0	-	-
	lipping	1	0	0	0	0	0	0	-	-	0	-	-
	porosity	0	0	0	0	0	0	0	-	-	0	-	-
prox talus right	eburnation	0	0	0	0	0	0	0	-	-	0	-	-
	lipping	1	0	0	0	-	0	0	-	0	0	-	-
	porosity	0	1	0	0	-	0	0	-	0	0	-	-
prox talus left	eburnation	0	0	0	0	-	0	0	-	0	0	-	-

Appendix 4

Raw data of the low socioeconomic status individuals buried in the cemetery to the South the St. Catharinakerk.

Findnumber		2765	2232	3142	3536	3640	3513	3088	1692	2766	3864
Site		outside (Z)	outside (Z)	outside(Z)	outside(Z)	outside(Z)	outside(Z)	outside(z)	outside(Z)	outside(Z)	outside(Z)
dating		1500-1650	1650-1850	1650-1850	1500-1650	1500-1650	1650-1850	1650-1850	1500-1650	1650-1850	1500-1650
Sex		M	F	F	M	M	M	F	PF	M	PF
Age		30-39	50-59	60-69	60-69	30-39	40-49	40-49	40-49	50-59	20-29
	lipping	0	-	0	0	0	-	0	-	1	0
	porosity	2,3	-	3	2	2	-	1	-	3	1
acromial end clavicle Right	eburnation	0	-	0	0	0	-	0	-	0	0
	lipping	0	-	0	0	0	-	0	-	1	-
	porosity	2	-	3	2	1	-	1	-	2	-
acromial end clavicle left	eburnation	0	-	0	0	0	-	0	-	1	-
	lipping	0	-	1	0	0	-	-	-	1	0
	porosity	0	-	1	0	1	-	-	-	1	1
acromion right	eburnation	0	-	0	0	0	-	-	-	0	0
	lipping	0	-	0	0	-	-	-	-	1	0
	porosity	0	-	2	0	-	-	-	-	3	0
acromion left	eburnation	0	-	0	0	-	-	-	-	0	0
	lipping	0	1	0	0	0	-	1	-	1	0
	porosity	0	0	0	1	0	-	0	-	1	0
glenoid fossa right	eburnation	0	0	0	0	0	-	0	-	0	0
	lipping	0	0	0	0	0	-	0	0	1	0
	porosity	0	0	0	1	0	-	0	0	1	0
glenoid fossa left	eburnation	0	0	0	0	0	-	0	0	0	0
	lipping	0	1	0	0	0	-	0	-	1	0
	porosity	1	1	0	2	1	-	1	-	1	1
prox. Humerus right	eburnation	0	0	0	0	0	-	0	-	0	0
	lipping	0	0	0	0	0	-	0	0	1	0
	porosity	1	1	0	1,3	1	-	0	1	1	0
prox humerus left	eburnation	0	0	1	0	0	-	0	0	0	0
	lipping	0	0	0	0	0	1	0	-	0	0
	porosity	0	0	0	1,2	0	0	0	-	1	1
dist humerus right	eburnation	0	0	0	0	0	0	0	-	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	1	0	0	0	0	1	1
dist humerus left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	1	0	0	0	0	0	0	0
	porosity	0	0	0	0	1	1	0	1	0	0
prox ulna right	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	1	0	0	0	0	0	1	0
	porosity	0	0	1	0	0	0	0	1	0	1
prox ulna left	eburnation	0	0	0	0	0	0	0	0	0	1
	lipping	0	0	0	-	0	0	0	0	0	0
	porosity	0	0	0	-	0	0	0	0	0	0
prox radius right	eburnation	0	0	0	-	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	2,1	0	0	0	0	0	0	0	1
prox radius left	eburnation	0	0	0	0	0	0	0	0	0	1
	lipping	0	-	0	0	0	0	0	-	0	-
	porosity	1	-	0	1	0	1	1	-	1	-
dist ulna right	eburnation	0	-	0	0	0	0	0	-	0	-
	lipping	0	-	0	0	-	0	0	-	2	0
	porosity	0	-	0	1	-	0	1	-	2,1	1
dist ulna left	eburnation	0	-	0	0	-	0	0	-	0	0
	lipping	0	0	0	-	0	0	0	0	0	-
	porosity	0	1	0	-	0	0	0	0	1	-
dist radius right	eburnation	0	0	0	-	0	0	0	0	0	-
	lipping	0	0	0	0	0	0	0	-	0	0
	porosity	0	0	0	0	0	0	0	-	0	0
dist radius left	eburnation	0	0	0	0	0	0	0	-	0	0
	lipping	0	-	0	0	0	0	-	-	0	0
	porosity	0	-	0	0	0	0	-	-	0	0
prox scaphoid right	eburnation	0	-	0	1	0	0	-	-	0	0
	lipping	0	0	0	-	0	0	0	-	-	-
	porosity	0	0	0	-	0	0	0	-	-	-
prox scaphoid left	eburnation	0	0	0	-	0	0	0	-	-	-
	lipping	-	0	0	1,3	0	0	0	-	1	0
	porosity	-	1	0	1	0	0	0	-	0	0
prox lunate right	eburnation	-	0	0	0	0	0	0	-	0	0
	lipping	0	0	0	-	-	0	-	-	-	0
	porosity	0	1	0	-	-	0	-	-	-	1
prox lunate left	eburnation	0	0	0	-	-	0	-	-	-	0

Findnumber		2765	2232	3142	3536	3640	3513	3088	1692	2766	3864
	lipping	0	1	0	0	0	0	0	0	1	0
	porosity	0	2	1	1	0	0	1	0	2,1	0
acetabulum right	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	-	1	0	0	0	0	0	1	0
	porosity	0	-	1	1	0	1	0	0	0	0
acetabulum left	eburnation	0	-	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	1	1,2	0	1	0	0	1	0
prox femur right	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	-	0	0	-	0	0	0	0	1	0
	porosity	-	0	1	-	0	0	0	1	0	1
prox femur left	eburnation	-	0	0	-	0	0	0	0	0	0
	lipping	-	0	0	-	0	0	0	0	0	0
	porosity	-	0	0	-	0	0	0	0	0	0
dist femur right	eburnation	-	0	0	-	0	0	0	0	0	1
	lipping	-	0	0	-	0	0	0	1	-	0
	porosity	-	1	0	-	0	0	0	0	-	1
dist femur left	eburnation	-	0	0	-	0	0	0	0	-	0
	lipping	-	0	1	-	0	0	0	0	0	0
	porosity	-	0	1,2	-	0	0	0	0	0	0
Patella right	eburnation	-	0	0	-	0	0	0	0	0	1
	lipping	-	0	1	-	0	0	0	0	-	0
	porosity	-	0	1	-	0	0	0	0	-	0
Patella Left	eburnation	-	0	0	-	0	0	0	0	-	0
	lipping	0	0	0	-	0	0	0	0	0	0
	porosity	0	1	0	-	0	0	0	0	0	0
prox tibia right	eburnation	0	0	0	-	0	0	0	0	0	0
	lipping	-	0	0	-	0	0	-	0	-	0
	porosity	-	1	0	-	0	0	-	0	-	0
prox tibia left	eburnation	-	0	0	-	0	0	-	0	-	0
	lipping	0	0	0	-	0	0	0	1	0	0
	porosity	0	0	0	-	0	0	0	0	0	0
dist tibia right	eburnation	0	0	0	-	0	0	0	0	0	0
	lipping	-	0	0	-	0	0	0	0	-	0
	porosity	-	0	0	-	0	0	0	0	-	0
dist tibia left	eburnation	-	0	0	-	0	0	0	0	-	0
	lipping	0	-	0	-	-	-	-	0	0	-
	porosity	0	-	0	-	-	-	-	0	0	-
prox fibula right	eburnation	0	-	0	-	-	-	-	0	0	-
	lipping	-	-	0	-	-	0	0	0	-	-
	porosity	-	-	0	-	-	1	0	0	-	-
prox fibula left	eburnation	-	-	0	-	-	0	0	0	-	-
	lipping	0	0	0	-	0	-	0	-	1	0
	porosity	0	0	0	-	0	-	0	-	0	0
dist fibula right	eburnation	1	0	0	-	0	-	0	-	0	0
	lipping	-	0	0	-	0	-	0	-	-	0
	porosity	-	1	0	-	0	-	0	-	-	0
dist fibula left	eburnation	-	0	0	-	0	-	0	-	-	0
	lipping	-	-	0	-	0	0	0	0	0	0
	porosity	-	-	0	-	0	0	0	0	0	0
prox talus right	eburnation	-	-	0	-	0	0	0	0	0	0
	lipping	-	0	0	-	-	-	0	-	-	0
	porosity	-	0	0	-	-	-	1	-	-	0
prox talus left	eburnation	-	0	0	-	-	-	0	-	-	0

Findnumber		3470	2108	2165	3150	2762	3463	3105	2220	3530	2162
Site		outside(Z)	outside(Z)	outside(Z)	outside(Z)	outside(Z)	outside(Z)	outside(Z)	outside(Z)	outside(Z)	outside(Z)
dating		1650-1850	1650-1850	1650-1850	1650-1850	1500-1650	1500-1650	1500-1650	1650-1850	1650-1850	1650-1850
Sex		PM	PM	F	F	M	M	PM	PF	F	F
Age		20-29	20-29	50-59	20-29	20-29	40-49	20-29	60-69	60-69	50-59
	lipping	-	0	0	0	0	0	-	0	0	0
	porosity	-	0	1	0	0	1	-	3	0	0
acromial end clavicle Right	eburnation	-	0	0	0	0	0	-	0	0	0
	lipping	0	0	1	1	0	0	0	0	0	0
	porosity	0	0	1,2	0	0	1	2	3	0	0
acromial end clavicle left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	-	1	0	0	-
	porosity	1,2	0	0	0	0	-	0	2	1	-
acromion right	eburnation	0	0	0	0	0	-	0	0	0	-
	lipping	0	0	-	-	0	0	1	0	0	-
	porosity	0	0	-	-	0	0	1	0	1	-
acromion left	eburnation	0	0	-	-	0	0	0	0	0	-
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0
glenoid fossa right	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0
glenoid fossa left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	1	0	0	0	0	0	0	0
prox. Humerus right	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	1	0	0	0	0	0	0	0	0
prox humerus left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0
dist humerus right	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0
dist humerus left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	-	0	0	0
	porosity	0	0	0	0	0	0	-	0	1	0
prox ulna right	eburnation	0	0	0	0	0	0	-	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	1	0	0	0	0	0	0	0	0	0
prox ulna left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	-	0	0	0
	porosity	0	0	0	0	0	0	-	0	0	0
prox radius right	eburnation	0	0	0	0	0	0	-	0	0	0
	lipping	0	0	0	0	0	0	0	0	1	0
	porosity	0	0	0	0	0	0	0	0	0	0
prox radius left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	-	0	0	0	-	0	-	0
	porosity	0	0	-	0	0	0	-	0	-	0
dist ulna right	eburnation	0	0	-	0	0	0	-	0	-	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0
dist ulna left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	-	0	0	0
	porosity	0	0	0	0	0	0	-	1	0	0
dist radius right	eburnation	0	0	0	0	0	0	-	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0
dist radius left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	-	0	-	1	0	0
	porosity	0	0	0	0	-	0	-	0	0	0
prox scaphoid right	eburnation	0	0	0	0	-	0	-	0	0	0
	lipping	0	0	0	0	-	0	0	0	0	0
	porosity	0	0	0	0	-	0	0	0	0	0
prox scaphoid left	eburnation	0	0	0	0	-	0	0	0	0	0
	lipping	0	0	0	0	0	0	-	0	0	0
	porosity	0	0	1	0	0	0	-	0	0	0
prox lunate right	eburnation	0	0	0	0	0	0	-	0	0	0
	lipping	0	0	0	0	-	0	0	1	0	0
	porosity	0	0	0	0	-	0	0	0	1	0
prox lunate left	eburnation	0	0	0	0	-	0	0	0	0	0

Findnumber		3470	2108	2165	3150	2762	3463	3105	2220	3530	2162
	lipping	0	0	0	0	0	0	0	-	0	0
	porosity	0	0	0	0	0	0	0	-	0	0
acetabulum right	eburnation	0	0	0	0	0	0	0	-	0	0
	lipping	0	0	0	0	0	0	0	1	0	0
	porosity	0	0	0	0	0	0	1	0	0	0
acetabulum left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	2	0	0
prox femur right	eburnation	0	0	0	0	0	0	0	2	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0
prox femur left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	-	0	0	0	0	0	0	0
	porosity	0	0	-	0	0	0	0	0	0	0
dist femur right	eburnation	0	0	-	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0
dist femur left	eburnation	0	0	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	0	0	-	1	0	0
	porosity	0	0	0	0	0	0	-	0	0	0
Patella right	eburnation	0	0	0	0	0	0	-	0	0	0
	lipping	0	0	0	-	0	0	-	1	0	0
	porosity	0	0	0	-	0	0	-	0	0	0
Patella Left	eburnation	0	0	0	-	0	0	-	0	0	0
	lipping	0	0	0	-	0	0	0	0	0	0
	porosity	1	0	0	-	0	0	0	0	0	0
prox tibia right	eburnation	0	0	0	-	0	0	0	0	0	0
	lipping	0	0	0	-	0	0	0	0	0	0
	porosity	0	0	0	-	0	0	0	0	0	0
prox tibia left	eburnation	0	0	0	-	0	0	0	0	0	0
	lipping	0	0	0	-	0	0	0	0	0	0
	porosity	1	0	0	-	0	0	0	0	0	0
dist tibia right	eburnation	0	0	0	-	0	0	0	0	0	0
	lipping	0	0	0	-	-	0	0	0	0	0
	porosity	0	0	0	-	-	0	0	0	0	0
dist tibia left	eburnation	0	0	0	-	-	0	0	0	0	0
	lipping	0	0	-	-	0	0	0	-	-	-
	porosity	0	0	-	-	0	0	0	-	-	-
prox fibula right	eburnation	0	0	-	-	0	0	0	-	-	-
	lipping	-	-	0	-	0	0	0	-	-	-
	porosity	-	-	1	-	0	0	0	-	-	-
prox fibula left	eburnation	-	-	0	-	0	0	0	-	-	-
	lipping	0	0	0	-	0	0	-	0	0	0
	porosity	0	0	0	-	0	0	-	0	0	0
dist fibula right	eburnation	0	0	0	-	0	0	-	0	0	0
	lipping	0	0	0	-	0	0	0	-	0	0
	porosity	0	0	0	-	0	0	0	-	0	0
dist fibula left	eburnation	0	0	0	-	0	0	0	-	0	0
	lipping	0	0	0	-	0	0	-	0	1	0
	porosity	0	0	0	-	0	0	-	0	0	0
prox talus right	eburnation	0	0	0	-	0	0	-	0	0	0
	lipping	0	0	0	-	0	0	-	1	0	0
	porosity	0	0	0	-	0	0	-	0	0	0
prox talus left	eburnation	0	0	0	-	0	0	-	0	0	0

Appendix 5

Raw data of the low socioeconomic status individuals buried in the cemetery to the North of the St. Catharinakerk.

Findnumber		2040	1430	2538	2010	2050	3421	2828	481	2038	1196	2834
Site		outside (N)	outside (N)	outside(N)	outside(N)	outside(N)	outside(N)	outside (N)	outside(N)	outside(N)	outside(N)	outside(N)
dating		1650-1850	1650-1850	1650-1850	1650-1850	1650-1850	1500-1650	1500-1650	1650-1850	1650-1850	1650-1850	1650-1850
Sex		F	M	M	M	M	M	F	PM	M	M	M
Age		40-49	50-59	40-49	30-39	40-49	60-69	40-49	60-69	20-29	40-49	40-49
	lipping	1	0	-	0	0	-	0	-	0	0	0
	porosity	2	3	-	2	1	-	1	-	0	0	1
acromial end clavicle Right	eburnation	0	0	-	0	0	-	0	-	0	0	0
	lipping	0	-	1	0	0	0	-	0	0	0	1
	porosity	2	-	2	1,2	2	3	-	3	1	1	2
acromial end clavicle left	eburnation	0	-	0	0	0	0	-	0	0	0	0
	lipping	1	-	0	0	0	2	0	-	0	-	1
	porosity	0	-	0	1	1	3	1	-	2	-	2
acromion right	eburnation	0	-	0	1	0	0	0	-	0	-	0
	lipping	-	-	1	0	0	0	-	1	0	-	0
	porosity	-	-	0	1	1	3,2	-	1	1	-	2
acromion left	eburnation	-	-	0	0	0	0	-	0	0	-	0
	lipping	1	1	1	1	0	0	0	-	0	0	0
	porosity	0	0	0	1	0	0	0	-	0	1	0
glenoid fossa right	eburnation	0	0	0	0	0	0	0	-	0	0	0
	lipping	1	-	1	1	0	0	-	0	0	0	0
	porosity	0	-	0	0	0	0	-	0	0	1	0
glenoid fossa left	eburnation	0	-	0	0	0	0	-	0	0	0	0
	lipping	1	0	1	1	0	1	1	-	0	-	0
	porosity	1	1	1	2,1	0	1	2,1	-	1	-	1
prox. Humerus right	eburnation	0	0	0	0	0	0	0	-	0	-	0
	lipping	-	0	0	1	0	0	-	0	0	0	0
	porosity	-	1	1	1	0	1	-	0	0	0	0
prox humerus left	eburnation	-	0	0	0	0	0	-	0	0	0	0
	lipping	-	0	0	-	0	1	1	0	0	-	1
	porosity	0	0	0	-	0	0	0	0	0	-	0
dist humerus right	eburnation	0	0	1	-	0	0	0	0	0	-	0
	lipping	-	0	1	-	0	1	-	0	0	0	0
	porosity	-	0	0	-	0	0	-	0	0	0	0
dist humerus left	eburnation	-	0	0	-	0	0	-	0	0	0	0
	lipping	1	0	1	0	-	1	1	0	0	0	1
	porosity	0	0	1	1	-	1	0	0	1	1	0
prox ulna right	eburnation	0	0	0	0	-	0	0	0	0	0	0
	lipping	1,2	0	1	-	0	1	0	0	0	0	0
	porosity	0	1	0	-	0	1	1	0	1	0	0
prox ulna left	eburnation	0	0	0	-	0	1	0	0	0	0	0
	lipping	1	1	0	0	-	1	0	-	0	0	0
	porosity	0	1	0	0	-	0	0	-	0	0	0
prox radius right	eburnation	0	0	0	0	-	0	0	-	0	0	0
	lipping	1	0	0	-	0	1	-	0	0	0	0
	porosity	0	0	0	-	0	0	-	0	0	0	0
prox radius left	eburnation	0	0	0	-	0	0	-	0	0	0	0
	lipping	2	-	0	-	0	2	-	0	0	0	0
	porosity	0	-	0	-	0	2	-	1	0	0	0
dist ulna right	eburnation	1	-	0	-	0	1	-	0	0	0	0
	lipping	1	0	-	0	0	1	0	-	0	0	0
	porosity	0	1	-	0	0	2,1	0	-	0	0	0
dist ulna left	eburnation	0	0	-	0	0	1	0	-	0	0	0
	lipping	1	-	0	0	0	1	0	-	0	0	0
	porosity	0	-	0	0	0	0	0	-	0	0	0
dist radius right	eburnation	0	-	0	0	0	0	0	-	0	0	0
	lipping	2	1	0	-	0	1	-	-	0	0	0
	porosity	1	1	0	-	0	0	-	-	0	0	0
dist radius left	eburnation	0	1	0	-	0	0	-	-	0	0	0
	lipping	1	-	0	0	0	0	0	-	0	0	0
	porosity	0	-	0	0	0	1	0	-	0	0	0
prox scaphoid right	eburnation	0	-	0	0	0	0	0	-	0	0	0
	lipping	0	-	0	0	0	0	0	0	0	-	0
	porosity	0	-	0	0	0	0	0	0	0	-	0
prox scaphoid left	eburnation	0	-	0	0	0	0	0	0	0	-	0
	lipping	2	-	0	1	-	1	-	0	0	0	0
	porosity	1	-	0	1	-	1	-	0	0	0	0
prox lunate right	eburnation	0	-	0	0	-	0	-	0	0	0	0
	lipping	2	-	0	0	1	1	0	0	0	0	0
	porosity	1	-	1	1	0	1	1	1	0	0	0
prox lunate left	eburnation	0	-	0	0	0	0	0	0	0	0	0

Findnumber		2040	1430	2538	2010	2050	3421	2828	481	2038	1196	2834
	lipping	2,3	1	0	1	-	0	2	1	0	0	1
	porosity	1	3,1	1	1	-	1	3	1	1	1	0
acetabulum right	eburnation	0	0	0	0	-	0	2	0	0	0	0
	lipping	3	2	0	1	1	0	2	0	0	0	1
	porosity	1	2,1	1	1	0	1	1	1	0	1	0
acetabulum left	eburnation	0	0	0	0	0	0	0	0	0	0	0
	lipping	2	0	0	0	0	0	3	0	0	0	0
	porosity	2,1	2,1	0	1	0	1	3	0	0	0	0
prox femur right	eburnation	0	0	0	0	0	0	2	0	0	0	0
	lipping	2	0	0	1	0	0	1	0	0	0	0
	porosity	2,1	1	0	1	0	1	1	0	0	0	0
prox femur left	eburnation	1	0	0	0	0	0	0	0	0	0	0
	lipping	2	0	0	0	0	0	0	0	0	0	0
	porosity	1	0	0	0	0	0	0	0	0	0	0
dist femur right	eburnation	1	0	0	0	0	0	0	0	0	0	0
	lipping	2,3	0	0	-	0	0	0	0	0	0	0
	porosity	1	0	0	-	0	0	0	0	0	0	0
dist femur left	eburnation	0	0	0	-	0	0	0	0	0	0	0
	lipping	1	1	0	-	0	0	0	-	0	0	0
	porosity	0	1	0	-	0	0	0	-	0	0	1
Patella right	eburnation	0	0	0	-	0	0	0	-	0	0	0
	lipping	2	1	0	-	0	1	0	0	-	0	0
	porosity	0	1	0	-	0	0	0	0	-	0	0
Patella Left	eburnation	0	0	0	-	0	0	0	0	-	0	0
	lipping	1	0	0	-	0	0	0	0	0	0	1
	porosity	1	1	0	-	0	0	0	0	0	0	1
prox tibia right	eburnation	0	0	0	-	0	0	0	0	0	0	0
	lipping	2	-	0	-	0	0	0	0	0	0	0
	porosity	0	-	1	-	0	0	0	0	0	0	0
prox tibia left	eburnation	0	-	0	-	0	0	0	0	0	0	0
	lipping	0	1	0	-	-	0	0	0	0	0	0
	porosity	1	1	0	-	-	0	1	0	1	1	0
dist tibia right	eburnation	0	0	0	-	-	0	0	0	0	0	0
	lipping	-	0	0	-	0	0	0	-	0	0	0
	porosity	0	0	0	-	0	0	0	-	0	1	0
dist tibia left	eburnation	0	0	0	-	0	0	0	-	0	0	0
	lipping	1	-	-	-	0	1	-	-	0	-	-
	porosity	0	-	-	-	0	0	-	-	0	-	-
prox fibula right	eburnation	0	-	-	-	0	0	-	-	0	-	-
	lipping	-	-	-	-	0	-	-	0	-	-	-
	porosity	-	-	-	-	0	-	-	0	-	-	-
prox fibula left	eburnation	-	-	-	-	0	-	-	0	-	-	-
	lipping	0	1	0	-	-	0	-	-	0	0	0
	porosity	1	0	0	-	-	0	-	-	0	0	1
dist fibula right	eburnation	0	0	0	-	-	0	-	-	0	0	0
	lipping	1	-	0	0	-	0	-	-	0	0	0
	porosity	1	-	0	0	-	0	-	-	0	0	0
dist fibula left	eburnation	0	-	0	0	-	0	-	-	0	0	0
	lipping	0	0	0	-	-	0	0	0	0	0	0
	porosity	0	0	1	-	-	0	0	0	0	0	0
prox talus right	eburnation	0	0	0	-	-	0	0	0	0	0	0
	lipping	0	-	0	-	-	0	0	0	0	0	0
	porosity	0	-	0	-	-	0	0	0	0	0	0
prox talus left	eburnation	0	-	0	-	-	0	0	0	0	0	0

Findnumber		2921	2601	2603	3817	1603	1886	2596	1190	1223	2885	1911
Site		outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)
dating		1650-1850	1650-1850	1650-1850	1650-1850	1650-1850	1650-1850	1650-1850	1650-1850	1650-1850	1500-1650	1650-1850
Sex		M	M	PF	M	M	M	M	F	M	M	F
Age		50-59	40-49	20-29	20-29	60-69	50-59	40-49	30-39	30-39	40-49	50-59
	lipping	-	1	-	0	0	-	0	0	0	1	0
	porosity	-	3,2	-	0	1	-	0	0	3	3	1
acromial end clavicle Right	eburnation	-	1	-	0	0	-	0	0	0	0	0
	lipping	1	1	0	-	0	1	0	-	1	1	-
	porosity	3	2	0	-	3,2	3	0	-	3	3	-
acromial end clavicle left	eburnation	0	0	0	-	0	0	0	-	0	0	-
	lipping	0	0	-	0	0	-	0	0	3	2	0
	porosity	2	3	-	0	1	-	0	0	3	3	3
acromion right	eburnation	0	0	-	0	0	-	0	0	3	0	0
	lipping	0	0	0	-	0	1	0	-	2	1	-
	porosity	3	2	0	-	2,1	1	0	-	3	2	-
acromion left	eburnation	0	0	0	-	0	0	0	-	0	0	-
	lipping	1	1	-	0	1	-	0	0	0	1	0
	porosity	1	0	-	0	0	-	0	0	0	0	0
glenoid fossa right	eburnation	0	0	-	0	0	-	0	0	0	0	0
	lipping	1	1	0	0	1,3	0	0	-	0	0	-
	porosity	2	0	0	0	0	0	0	-	0	0	-
glenoid fossa left	eburnation	0	0	0	0	0	0	0	-	0	0	-
	lipping	1	0	-	0	0	0	0	0	0	0	0
	porosity	0	0	-	0	0	0	0	0	0	0	0
prox. Humerus right	eburnation	0	0	-	0	0	0	0	0	0	0	0
	lipping	2	0	0	0	-	0	0	-	0	0	-
	porosity	0	0	0	0	-	0	0	-	0	0	-
prox humerus left	eburnation	0	0	0	0	-	0	0	-	0	0	-
	lipping	1	1	-	0	0	0	0	0	0	0	0
	porosity	0	0	-	0	0	0	0	0	0	0	0
dist humerus right	eburnation	0	0	-	0	0	0	0	0	0	0	0
	lipping	0	0	0	0	-	0	0	0	0	0	-
	porosity	0	0	0	0	-	0	0	0	0	0	-
dist humerus left	eburnation	0	0	0	0	-	0	0	0	0	0	-
	lipping	0	1	-	0	0	0	0	0	0	0	0
	porosity	1	0	-	0	0	0	0	0	0	0	0
prox ulna right	eburnation	0	0	-	0	0	0	0	0	0	0	0
	lipping	0	1	0	0	-	0	0	0	0	1	-
	porosity	1	0	1	0	-	0	0	0	0	0	-
prox ulna left	eburnation	0	0	0	0	-	0	0	0	0	0	-
	lipping	0	0	-	-	0	0	0	0	0	0	0
	porosity	0	0	-	-	0	0	0	0	0	0	0
prox radius right	eburnation	0	0	-	-	0	0	0	0	0	0	0
	lipping	0	0	0	0	-	0	0	0	0	1	-
	porosity	0	0	0	0	-	0	0	0	0	0	-
prox radius left	eburnation	0	0	0	0	-	0	0	0	0	0	-
	lipping	0	0	-	-	0	0	-	0	0	0	0
	porosity	0	0	-	-	0	0	-	0	0	0	0
dist ulna right	eburnation	0	0	-	-	0	0	-	0	0	0	0
	lipping	0	0	0	0	-	0	0	0	0	-	-
	porosity	0	0	0	0	-	0	0	0	0	-	-
dist ulna left	eburnation	0	0	0	0	-	0	0	0	0	-	-
	lipping	1	0	-	0	0	-	0	0	0	0	0
	porosity	0	0	-	0	0	-	0	0	0	0	0
dist radius right	eburnation	0	0	-	0	0	-	0	0	0	0	0
	lipping	0	0	0	0	-	0	0	0	0	0	-
	porosity	0	0	0	0	-	1	0	0	0	0	-
dist radius left	eburnation	0	0	0	0	-	0	0	0	0	0	-
	lipping	-	0	0	0	0	0	0	0	-	-	0
	porosity	-	0	0	0	0	0	0	0	-	-	0
prox scaphoid right	eburnation	-	0	0	0	0	0	0	0	-	-	0
	lipping	0	0	0	0	0	0	0	0	0	0	-
	porosity	0	0	0	0	0	0	0	0	0	0	-
prox scaphoid left	eburnation	0	0	0	0	0	0	0	0	0	0	-
	lipping	0	0	0	0	0	0	-	0	0	-	0
	porosity	0	0	0	0	0	0	-	0	0	-	0
prox lunate right	eburnation	0	0	0	0	0	0	-	0	0	-	0
	lipping	-	0	0	0	0	0	0	0	0	0	-
	porosity	-	0	0	0	0	0	0	0	0	0	-
prox lunate left	eburnation	-	0	0	0	0	0	0	0	0	0	-

Findnumber		2921	2601	2603	3817	1603	1886	2596	1190	1223	2885	1911
	lipping	1	0	0	0	1	-	0	0	0	0	0
	porosity	1	0	0	0	0	-	0	0	0	0	0
acetabulum right	eburnation	0	0	0	0	0	-	0	0	0	0	0
	lipping	1	0	0	0	1	0	0	0	0	0	0
	porosity	1	0	0	0	0	0	0	0	0	0	0
acetabulum left	eburnation	0	0	0	0	0	0	0	0	0	0	0
	lipping	1	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0	0
prox femur right	eburnation	0	0	0	0	0	0	0	0	0	0	0
	lipping	1	0	0	0	0	0	0	-	0	0	0
	porosity	1	0	0	0	0	0	0	-	0	0	0
prox femur left	eburnation	1	0	0	0	0	0	0	-	0	0	0
	lipping	1	0	0	-	0	0	0	0	0	-	0
	porosity	0	0	0	-	0	0	0	0	0	-	0
dist femur right	eburnation	0	0	0	-	0	0	0	0	0	-	0
	lipping	1	0	0	0	0	0	0	-	0	1	0
	porosity	0	0	0	0	0	0	0	-	0	0	0
dist femur left	eburnation	0	0	0	0	0	0	0	-	0	0	0
	lipping	0	0	0	-	-	0	0	0	0	-	0
	porosity	1	0	0	-	-	0	0	0	0	-	0
Patella right	eburnation	0	0	0	-	-	0	0	0	0	-	0
	lipping	0	0	0	0	0	0	0	0	0	0	-
	porosity	0	0	0	0	0	0	0	0	0	0	-
Patella Left	eburnation	0	0	0	0	0	0	0	0	0	0	-
	lipping	1	0	0	0	0	0	0	0	-	-	0
	porosity	0	0	0	0	0	0	0	0	-	-	0
prox tibia right	eburnation	0	0	0	0	0	0	0	0	-	-	0
	lipping	0	0	0	0	0	0	0	0	-	0	-
	porosity	0	0	0	0	0	0	0	0	-	0	-
prox tibia left	eburnation	0	0	0	0	0	0	0	0	-	0	-
	lipping	0	0	0	0	1	0	0	0	0	-	0
	porosity	0	0	0	0	0	0	0	0	0	-	0
dist tibia right	eburnation	0	0	0	0	0	0	0	0	0	-	0
	lipping	0	1	0	0	1	0	0	0	0	0	-
	porosity	0	0	0	0	0	0	0	0	0	0	-
dist tibia left	eburnation	0	0	0	0	0	0	0	0	0	0	-
	lipping	0	-	0	-	-	-	-	-	-	-	0
	porosity	0	-	0	-	-	-	-	-	-	-	0
prox fibula right	eburnation	0	-	0	-	-	-	-	-	-	-	0
	lipping	-	0	0	-	-	-	-	0	-	-	-
	porosity	-	0	0	-	-	-	-	0	-	-	-
prox fibula left	eburnation	-	0	0	-	-	-	-	0	-	-	-
	lipping	0	-	-	-	0	0	0	0	-	-	0
	porosity	0	-	-	-	0	0	0	0	-	-	0
dist fibula right	eburnation	0	-	-	-	0	0	0	0	-	-	0
	lipping	0	0	0	-	1	0	0	0	-	0	-
	porosity	0	0	0	-	0	0	0	0	-	0	-
dist fibula left	eburnation	0	0	0	-	0	0	0	0	-	0	-
	lipping	0	0	-	-	0	0	-	0	-	-	-
	porosity	0	0	-	-	0	0	-	0	-	-	-
prox talus right	eburnation	0	0	-	-	0	0	-	0	-	-	-
	lipping	0	0	0	0	1	0	-	0	0	0	-
	porosity	0	0	0	0	0	0	-	0	0	0	-
prox talus left	eburnation	0	0	0	0	0	0	-	0	0	0	-

Findnumber		2577	2876	2331	3284	1429	2148	3289	1212	2332	1563
Site		outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)	outside(N)
dating		1500-1650	1500-1650	1650-1850	1650-1850	1650-1850	1650-1850	1650-1850	1650-1850	1650-1850	1650-1850
Sex		PM	F	PF	PF	PF	PM	PF	F	F	M
Age		20-29	30-39	60-69	40-49	50-59	50-59	40-49	40-49	30-39	20-29
acromial end clavicle Right	lipping	0	0	-	0	-	1	-	0	-	0
	porosity	0	1	-	0	-	1	-	0	-	0
	eburnation	0	0	-	0	-	0	-	0	-	0
acromial end clavicle left	lipping	0	-	-	-	-	-	-	-	0	-
	porosity	0	-	-	-	-	-	-	-	0	-
	eburnation	0	-	-	-	-	-	-	-	0	-
acromion right	lipping	0	0	-	-	-	0	-	0	-	0
	porosity	0	1	-	-	-	0	-	0	-	0
	eburnation	0	0	-	-	-	0	-	0	-	0
acromion left	lipping	0	-	-	-	-	-	-	0	-	-
	porosity	0	-	-	-	-	-	-	0	-	-
	eburnation	0	-	-	-	-	-	-	0	-	-
glenoid fossa right	lipping	0	0	-	0	-	1	-	0	-	0
	porosity	0	0	-	0	-	0	-	0	-	0
	eburnation	0	0	-	0	-	0	-	0	-	0
glenoid fossa left	lipping	0	0	0	0	-	0	-	0	0	0
	porosity	0	0	0	0	-	0	-	0	0	0
	eburnation	0	0	0	0	-	0	-	0	0	0
prox. Humerus right	lipping	0	0	0	0	-	-	0	0	-	0
	porosity	0	0	0	0	-	-	0	0	-	0
	eburnation	0	0	0	0	-	-	0	0	-	0
prox humerus left	lipping	0	0	0	0	1	-	-	0	0	0
	porosity	0	0	0	0	0	-	-	0	0	0
	eburnation	0	0	0	0	0	-	-	0	0	0
dist humerus right	lipping	0	0	0	0	0	-	0	0	-	0
	porosity	0	0	0	0	0	-	0	0	-	0
	eburnation	0	0	0	0	0	-	0	0	-	0
dist humerus left	lipping	0	0	0	0	0	-	-	0	0	0
	porosity	0	0	0	0	0	-	-	0	0	0
	eburnation	0	0	0	0	0	-	-	0	0	0
prox ulna right	lipping	0	0	0	0	0	1	0	0	-	0
	porosity	0	0	0	0	0	0	0	0	-	0
	eburnation	0	0	0	0	0	0	0	0	-	0
prox ulna left	lipping	0	0	0	0	0	0	0	0	0	0
	porosity	0	0	0	0	0	0	0	0	0	0
	eburnation	0	0	0	0	0	0	0	0	0	0
prox radius right	lipping	0	0	-	-	0	0	0	0	-	0
	porosity	0	0	-	-	0	0	0	0	-	0
	eburnation	0	0	-	-	0	0	0	0	-	0
prox radius left	lipping	0	0	0	1	0	-	-	0	0	0
	porosity	0	0	0	0	0	-	-	0	0	0
	eburnation	0	0	0	0	0	-	-	0	0	0
dist ulna right	lipping	0	0	-	0	1	-	0	0	-	0
	porosity	0	1	-	0	0	-	0	0	-	0
	eburnation	0	0	-	0	0	-	0	0	-	0
dist ulna left	lipping	0	0	-	0	0	0	-	0	0	0
	porosity	0	0	-	0	0	0	-	0	0	0
	eburnation	0	0	-	0	0	0	-	0	0	0
dist radius right	lipping	0	0	-	0	0	0	0	0	-	0
	porosity	0	0	-	0	0	0	0	0	-	0
	eburnation	0	0	-	0	0	0	0	0	-	0
dist radius left	lipping	-	0	0	1	0	-	-	0	0	0
	porosity	-	0	0	0	0	-	-	0	0	0
	eburnation	-	0	0	0	0	-	-	0	0	0
prox scaphoid right	lipping	0	0	0	0	0	1	0	0	-	0
	porosity	0	0	0	0	0	0	0	0	-	0
	eburnation	0	0	0	0	0	0	0	0	-	0
prox scaphoid left	lipping	-	0	0	0	0	-	-	0	0	0
	porosity	-	0	0	0	0	-	-	0	0	0
	eburnation	-	0	0	0	0	-	-	0	0	0
prox lunate right	lipping	0	0	0	0	0	0	0	0	-	0
	porosity	0	0	0	0	0	0	0	0	-	0
	eburnation	0	0	0	0	0	0	0	0	-	0
prox lunate left	lipping	-	0	0	0	0	-	-	0	0	0
	porosity	-	0	0	1	0	-	-	0	0	0
	eburnation	-	0	0	0	0	-	-	0	0	0

Findnumber		2577	2876	2331	3284	1429	2148	3289	1212	2332	1563
	lipping	0	0	0	0	2	1	0	0	-	0
	porosity	0	0	0	0	3	1	0	0	-	0
acetabulum right	eburnation	0	0	0	0	2	0	0	0	-	0
	lipping	0	0	-	1	1	0	0	0	0	0
	porosity	0	0	-	0	0	0	0	0	0	0
acetabulum left	eburnation	0	0	-	0	0	0	0	0	0	0
	lipping	0	0	-	0	3	0	0	0	-	0
	porosity	0	0	-	0	3	0	0	0	-	0
prox femur right	eburnation	0	0	-	0	2	0	0	0	-	0
	lipping	-	0	0	0	0	0	0	0	0	0
	porosity	-	0	0	0	0	0	0	0	0	0
prox femur left	eburnation	-	0	0	0	0	0	0	0	0	0
	lipping	0	0	-	0	0	0	0	0	-	0
	porosity	0	0	-	0	0	0	0	0	-	0
dist femur right	eburnation	0	0	-	0	0	0	0	0	-	0
	lipping	-	0	0	0	0	-	0	0	0	0
	porosity	-	0	0	0	0	-	0	0	0	0
dist femur left	eburnation	-	0	0	0	0	-	0	0	0	0
	lipping	0	0	-	0	0	0	0	0	-	0
	porosity	0	0	-	0	0	0	0	0	-	0
Patella right	eburnation	0	0	-	0	0	0	0	0	-	0
	lipping	0	0	2	0	-	-	-	0	-	0
	porosity	0	0	1	0	-	-	-	0	-	0
Patella Left	eburnation	0	0	0	0	-	-	-	0	-	0
	lipping	0	0	-	0	0	0	0	0	0	0
	porosity	0	0	-	0	0	0	0	0	0	0
prox tibia right	eburnation	0	0	-	0	0	0	0	0	0	0
	lipping	0	-	1	0	0	0	0	0	0	0
	porosity	0	-	0	0	0	0	0	0	0	0
prox tibia left	eburnation	0	-	0	0	0	0	0	0	0	0
	lipping	0	0	-	0	0	0	0	0	0	0
	porosity	0	0	-	0	0	0	0	0	0	0
dist tibia right	eburnation	0	0	-	0	0	0	0	0	0	0
	lipping	0	-	-	0	0	0	0	0	0	0
	porosity	0	-	-	0	0	0	0	0	0	0
dist tibia left	eburnation	0	-	-	0	0	0	0	0	0	0
	lipping	0	-	-	0	-	-	0	-	0	0
	porosity	0	-	-	0	-	-	0	-	0	0
prox fibula right	eburnation	0	-	-	0	-	-	0	-	0	0
	lipping	0	-	-	0	0	-	-	-	0	0
	porosity	0	-	-	0	0	-	-	-	0	0
prox fibula left	eburnation	0	-	-	0	0	-	-	-	0	0
	lipping	-	0	-	0	0	0	0	0	0	0
	porosity	-	0	-	0	0	0	0	0	0	0
dist fibula right	eburnation	-	0	-	0	0	0	0	0	0	0
	lipping	0	-	-	0	-	-	0	0	0	0
	porosity	0	-	-	0	-	-	0	0	0	0
dist fibula left	eburnation	0	-	-	0	-	-	0	0	0	0
	lipping	-	0	-	0	0	0	0	0	0	0
	porosity	-	0	-	0	0	0	0	0	0	0
prox talus right	eburnation	-	0	-	0	0	0	0	0	0	0
	lipping	0	-	-	0	0	0	0	0	0	0
	porosity	0	-	-	0	0	0	0	0	0	0
prox talus left	eburnation	0	-	-	0	0	0	0	0	0	0