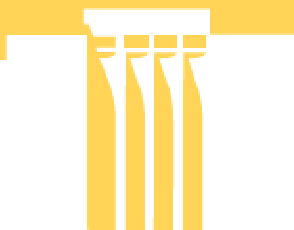

Osteoarthritis in Iceland
An archaeological study

Hildur Gestsdóttir

Dissertation towards the degree of Doctor of Philosophy
[2014]

UNIVERSITY OF ICELAND
SCHOOL OF HUMANITIES
FACULTY OF HISTORY AND PHILOSOPHY

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An archaeological study

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has declared this dissertation eligible for a defense
leading to a PhD degree in archaeology

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Abstract

Osteoarthritis has been intensively studied within the field of palaeopathology. For decades there was assumed to be a direct link between activity and the development of osteoarthritis, and this was reflected in the work which was carried out, with often very specific interpretations of occupation and activity on the basis of the diagnosis of osteoarthritis. By the 1990s it began to be more accepted within the field that the aetiology of osteoarthritis is far too multifactorial to allow for such simplistic conclusions to be drawn. This has resulted in a great reduction in the interest in the study of osteoarthritis within palaeopathology in the past few decades, as the condition appears to have somewhat lost its place within the archaeological discussion. Within the medical community, the focus has shifted in the past three decades to the genetic aetiopathogenesis of osteoarthritis. There has been a great deal of work in this field in Iceland, where the genetic link to hip, hand, and to a lesser extent knee osteoarthritis has been demonstrated, with the identification of several osteoarthritis families within the population.

The main aim of this thesis is to reclaim the study of osteoarthritis within palaeopathology using the analysis of the condition within five Icelandic skeletal populations, *kuml,* Skeljastaðir, Hofstaðir, Haffjarðarey and Reykjavík, which span the occupation of Iceland, from the earliest settlement in the late 9th century to the 19th century. The approach to this is twofold. First of all, to avoid focusing on just one aetiological aspect of osteoarthritis, but rather to embrace its multifactorial nature, and consider multiple aetiological agents of the condition. These are in particular genetics, activity, anatomy, age and sex. The aim is then to place the results of the analysis within the social and physical environments of the populations under study, and so attempt to find osteoarthritis a place within the osteoarchaeological discussion again. Secondly, the aim is to consider a more theoretical approach to the study of palaeopathology in general, and osteoarthritis in particular. To this end the question is raised whether it is possible to consider disease in archaeology from factors external to the aetiology of the disease, but rather from the lived experience of those who suffer from it. Considering the degenerative effects of osteoarthritis, the focus is placed on how it is possible to discuss issues such as disability, ageing and quality of life within palaeopathological research.

The conclusions drawn from this thesis demonstrates that by avoiding focusing on one feature of osteoarthritis but rather take into account its complex nature, it is possible to offer a varied discussion on osteoarthritis in archaeological material. The identification of a genetic osteoarthritis opens up a discussion on the family in archaeology and the use of the medieval cemetery in Iceland; the variation between sites in terms of activity related osteoarthritis demonstrates changes both

geographically and through time in the intensity of the activities being carried out, while thinking about age in terms of osteoarthritis opens up new avenues for exploring age and ageing within archaeological populations.

Ágrip

Ýtarlegar fornmeinafræðilegar rannsóknir hafa verið gerðar á slitgigt í gegnum tíðina. Lengi vel var talið að bein tengsl væru á milli þeirra verka sem fólk vann og slit¬gigtar, og hefur þessi skoðun gjarnan endurspeglast í meinafræðilegum rann¬sóknum á fornum beinum. Til að mynda voru oft settar fram mjög nákvæmar túlkanir á atvinnu og lifnaðarháttum sem byggðust á greiningu á slitgigt. Á fyrri hluta tíunda áratugar síðustu aldar voru fræðimenn farnir að sammælast um að orsakafræði slitgigtar væri í raun of flókin til að leyfa svo einfaldar túlkanir. Þetta leiddi af sér töluverðan samdrátt í rannsóknum á sjúkdómnum í fornleifafræðilegum beinasöfnum, þar sem hann hafði að miklu leiti tapað hlutverki sínu innan fornmeinafræðinnar. Innan læknisfræðinnar hafa rannsóknir á slitgigt aftur á móti færst að miklu leiti yfir á erfðafræðilegan orsakaþátt sjúkdómsins á síðustu þremur áratugum. Mikið hefur verið um slíkar rannsóknir á Íslandi og sýnt hefur verið fram á að sligigt, í mjöðmum, höndum og að einhverju leiti hnjám, er tengd erfðafræði og hafa verið borin kennsl á nokkrar slitgigtarættir á Íslandi.

Meginmarkmið þessa verkefnis er að endurvekja rannsóknir á slitgigt innan fornmeinafræðinnar með rannsóknum á sjúkdómnum í fimm íslenskum mannabeinasöfnum. Er um að ræða beinasöfn úr kumlum og úr kirkjugörðunum á Skeljastöðum, Hofstöðum, Haffjarðarey og í Reykjavík, en þessir staðir spanna Íslandsöguna frá landnámsöld fram til 19. aldar. Nálgunin á viðfangsefnið er tvíþætt. Annarsvegar er reynt að forðast að einblína eingöngu á einn orsakaþátt slitgigtar, en takast frekar á við flókna orsakafræði sjúkdómsins með því að taka til greina marga orsakaþætti í greiningunni og þá sérstaklega erfðir, álag, líkamsbyggingu, aldur og kyn. Eru niðurstöður rannsóknarinnar þvínæst settar í víðara samhengi með því að staðsetja þær innan þess félagslega- og landfræðilega umhverfis sem fólkið bjó í. Hinsvegar er reynt að kryfja kennilegar nálganir á rannsóknir innan fornmeinafræðinnar, með sérstakri áherslu á slitgigt. Þetta er gert með því að spyrja hvort mögulegt sé að nálgast rannsóknir á sjúkdómum í fornum mannabeinasöfnum út frá þáttum sem tengjast ekki orsakafræði sjúkdómsins, heldur frekar upplifun fólksins sem þjáðist af honum. Þar sem slitgigt orsakar hrörnun einstaklingsins þá er sérstaklega skoðað hvort og þá hvernig er hægt að nálgast umfjöllunarefni eins og fötlun, öldrun og lífskjör, út frá fornmeinafræði.

Niðurstöður rannsóknarinnar benda til þess að með því að forðast að einblína eingöngu á einn orsakaþátt slitgigtar og taka frekar mark á flókinni orsakafræði sjúk¬dómsins, þá sé hægt að setja fram margþætta umræðu um slitgigt í fornleifafræðilegum beina¬söfnum. Sem dæmi má nefna að greining á arfgengri slitgigt opnar fyrir umræðu um fjölskylduna innan fornleifafræðinnar og nýtingu

kirkjugarða á miðöldum á Íslandi. Sýnt er fram á að slitgigt sem tengja má áverkum í beinasöfnunum bendir til þess að töluverður munur hafi verið á líkamlegu álagi, bæði á milli landssvæða og tímabila. Einnig er bent á að greining á slitgigt opnar nýjar leiðir til að fjalla um aldur og öldrun í fornleifafræðilegum beinastöfnum.

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Over a decade ago I was offered to take part in a study with Dr. Jón Þorsteinsson, Dr. Helgi Jónsson and the late Dr. Juliet Rogers, which involved reassessing the diagnosis of osteoarthritis in the skeletal population from Skeljastaðir. The questions raised within that study led to this project, and I am eternally grateful to them for involving me.

This project was carried out in the Faculty of History and Philosophy within the School of Humanities at the University of Iceland, but it would not have been possible without the participation of several institutions which supported me by allowing me access to skeletal material and offering me workspace, and company, during my time there. They are in no particular order Þjóðminjasafn Íslands (The National Museum of Iceland) – Vesturvör, in particular Lilja, Kristín Halla, Magga, Freyja and Nathalie; Minjasafn Reykjavíkur (Reykjavík City Museum), in particular Anna Lísa and absolutely everyone at Fornleifastofnun Íslands (The Institute of Archaeology, Iceland). A special thanks also to the National Museum and Ívar Brynjólfsson, who took most of the photographs in this thesis. In addition I extend thanks to the Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Llubljana, Slovenia, in particular Žiga and Melita. The month I spent there as a visiting scholar saw start of the writing of this thesis, after a long time spent staring panic struck at my data. A big 'thank you' also to all those who have worked with me on the excavation and post-excavation at Hofstaðir. They are far too many to be mentioned here, but you know who you are.

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1 Introduction

Joint disease, and in particular osteoarthritis, has in the past received considerable focus in osteoarchaeology, and the link between activity and osteoarthritis has been intensively researched. The assumption that there is a clear-cut association between the two has persisted for a long time within osteoarchaeological work. There are countless publications, in particular prior to the 1990s, where often quite specific behavioural interpretations based on osteoarthritis in archaeological skeletal remains have been made, supported by superficial reference to clinical data (cf. Angel 1971; Bridges 1985; Jurmain 1977; Wells 1964). For the past decade or two there has, however, been little consensus among those researching the link between activity and osteoarthritis. Such work continues to produce mixed results and today it is accepted that the aetiology of osteoarthritis is too multifactorial to produce simple clear-cut conclusions and it is perhaps for this reason that the interest in osteoarthritis within palaeopathological research has waned considerably (Jurmain 1999: 4-6, 107-9).

The past decade has also seen a shift in the focus of the aetiology of osteoarthritis within the medical community towards the genetic factors behind the disease. Icelandic researchers have been at the forefront of this research, with one of the teams within the Icelandic bio-pharmaceutical company deCode, the OA-team, using the National Health Sector Database to study the genetic causes of osteoarthritis (Pálsson 2003: 25-6). This team established data regarding the genetic aetiology of specific types of osteoarthritis, demonstrating, for example, up to five generations of a single family with severe osteoarthritis of the hip (Ingvarsson et al. 2001).

The nature of the Icelandic population and the type of archaeological skeletal collections means that it is an ideal place to study osteoarthritis with a focus on these two aetiological factors, that is, biomechanical stress on the joints and genetics. Only settled in the 9th century AD by a relatively small founding population, people in the early centuries of occupation buried their dead primarily in small farm plots, making it ideal to question whether the genetic nature of the disease can be identified archaeologically, as chances are that if the same family occupied the farm during the period the cemetery was in use, that the people buried there may be biological relations. In addition, during the first centuries of settlement, status variation, while significant on the household scale was not marked within the population at large (Byock 1988, 117-20; Miller 1990: 111-6). This means that the small local cemeteries represent populations with comparable lifestyles, involving a heavy focus on continuous repeated activities mostly

associated with subsistence farming and fishing, making them ideal to discuss the effects of activity on the disease.

The remainder of this chapter will present a discussion on joint anatomy, and the pathogenesis of osteoarthritis and its diagnosis, both in radiological and clinical terms. Following this will be a discussion of some of the main aetiological factors of osteoarthritis, activity, age, sex, anatomy and genetics and demonstrate how they have been discussed in relation to osteoarthritis, both in the medical and archaeological literature. In the concluding remarks of the chapter, the aims of the project will be described in detail.

Chapter 2 *Genetics* focuses on the nature the Icelandic population, presenting the various studies which have been carried out of the origin of Icelanders. The chapter goes on to discuss the interest in documenting familial history in Iceland, which has facilitated the setting up of a genealogical database (*Íslendingabók*), which has combined all genealogical records in Iceland dating back to the 13th century. These are then placed in the context of the extensive work which has been carried out on the hereditary nature of osteoarthritis in Iceland, in particular of the hip and the hand, and to a lesser extent the knee. This has demonstrated a strong link with the genetic nature of these conditions, as well as the identification of several osteoarthritis families in Iceland, some of which can be traced back several generations. This is extremely relevant to the current study, as questioning whether the hereditary nature of osteoarthritis can be identified within the archaeological populations is one of its key aims.

The five skeletal populations analysed in this study are introduced in chapter 3, *The skeletal material.* As the populations used in the study span the period from the earliest settlement of Iceland in the late 9th century to the 18th-19th century the discussion is placed in the context of the settlement history of Iceland, as well as the nature of funerary archaeology. The discussion of the sites gives an overview of historical references to each site, alongside a presentation of the excavation, or excavations carried out there, as well as all the dating evidence available. The nature of the burials at each site is also described in as much detail as possible.

Chapter 4, *Methods* presents the methodology used during the analysis, ageing, sexing, and recording of preservation and pathological changes. Great emphasis is placed on the recording of preservation of the skeletal material, both of the skeletons as a whole, and of the joint surfaces. A new approach was attempted in recording the latter, using zoning methods based on recording breakage patterns in zooarchaeology. This was done to minimize the effects of differential preservation and the small size of the populations in the study.

The results of the analysis of osteoarthritis in the five populations in the study are presented in chapter 5 *Results.* The chapter is in two sections. The first presents the results on a site basis, detailing the joints affected as well as descriptions of the

individuals diagnosed with osteoarthritis. The second section presents the results by joints affected, combining all the sites in the study, and thus presenting a comparison of the prevalence of osteoarthritis in each joint.

Chapter 6, *Discussion* starts off with a description of the taphonomic factors which are likely to affect the different populations within the study, and how they are likely to influence preservation and the calculations of prevalence. The remainder of the chapter focuses on the main aetiological factors of osteoarthritis; genetics, activity, anatomy and sex and explains how these elements can be used to ground a discussion on the diagnosis of osteoarthritis in the archaeological populations in the study. That discussion is then placed in the context of the social, economic and physical environment of those populations.

Finally, chapter 7, *Theoretical approaches to palaeopathology*, creates a more theoretical framework with which to approach the osteoarchaeological discussion of palaeopathology in general and of osteoarthritis specifically. The focus of the discussion shifts to factors which are external to the aetiology of osteoarthritis. Here concepts such as disability, ageing and quality of life are discussed, and placed within the context of the osteoarthritis in the populations in the study.

1.1 Normal joint anatomy

The joints of the body are divided into three different types, based on their histological features and joint movement (Roberts and Manchester 1995: 100; Rogers and Waldron 1995: 1).

1. Fibrous joints (synarthrosis) are those where the bones are joined by fibrous tissues, and are relatively immobile (for example the sutures between the bones of the skull and the membrane which joins the tibia to the fibula).
2. Cartilaginous joints (amphiarthrosis) are joints where the bone is separated by a plate of cartilage. They can be divided into two groups.
   - Primary cartilaginous joints, which are defined as joints where the joint surfaces are separated by hyaline cartilage. These are capable of limited movement (for example between the ribs and the sternum).
   - Secondary cartilaginous joints are separated by fibrocartilage and generally allow more movement than primary joints (for example intervertebral disks).
3. Synovial joints (diarthroses) are the most common and complex types of joints in the human body. In a synovial joint the bone ends are covered by a hyaline cartilage and the joint itself is joined by a fibrous capsule which is attached around the periphery of the articular cartilage supported by capsular ligaments. The interior of the joint is lined with a synovial membrane which secretes synovial fluid into the joint space. This fluid both lubricates the joint and provides nutrition for the articular cartilage. In some joints ligaments are discrete from

> the capsule, either as extracapsular ligaments (for example the costoclavicular ligament of the shoulder) or intracapsular ligaments (for example the ligament of the head of the femur). Synovial joints are characterised by their high mobility and are often classified according to the shape of the joint surface (e.g. saddle, plane or ball-and-socket) or by the type of movement they permit (e.g. sliding, pivot or hinge). Examples include the hip, elbow, or small joints of the digits (Gosling et al. 1996: 1.12-1.13; Palastanga et al. 2002: 13-6; Norkin and Levangie 1992: 60-70)

The cartilage within joints has several functions: the transmission and distribution of loads, maintaining contact between the bones forming the joint while minimizing the friction, and absorbing shock. In a normal, non-pathological joint, the surfaces move against each other with remarkably little friction and the physiology of the joint is dynamic and capable of considerable repair (Norkin and Levangie 1992: 81; Jurmain 1999: 19; Roberts and Manchester 1995: 101).

1.2 Joint disease

Any of the structures which form the joint can be subject to pathological changes, although it is the synovial joint, the most movable joint in the body, which is in most instances affected by degenerative changes and joint disease. The earliest classification of joint disease was into chronic and acute arthritis, depending on observational differences. By the 18th century, with the advent of the microscope, a deeper understanding of joint disease was obtained, for example, the presence of urate crystals in gout. The most important step in the classification of joint disease came however with the introduction of radiographs in the late 19th century, when it became possible to identify directly the changes involved in the two types of recognised joint disease. Firstly there was what was termed atrophic joint disease, which was seen to affect mainly younger people, and involved the inflammation of the soft tissues along with erosion of the joint margins, usually affecting multiple joints in the same individual. The second was referred to as hypertrophic joint disease, so termed as it was associated with overgrowth of marginal and articular bone seen both as osteophytosis and sclerosis. This affected older individuals more than the atrophic disease, as well as fewer joints. In 1904 Garrod first identified atrophic arthritis as rheumatoid arthritis and hypertrophic arthritis as osteoarthritis. Since then there has been much in the way of redefinition of joint diseases, in particular within the rheumatoid arthritis spectrum, for example the identification of seronegative spondyloarthropathies in the 1960s. The classification of these diseases is dependent on a set of identifying criteria. There is however always a danger that the results of the examination will to some extent be made to fit the defined concept of the disease, that is the researcher will only look for the identified criteria, a factor which is extremely important to keep in mind when dealing with

palaeopathological analysis of joint disease, as a majority of the information available to clinicians for their diagnosis (i.e. the soft tissues) is absent, and frequently the skeletal remains which are being studied are fragmentary and incomplete (Rogers and Waldron 1995: 3-4).

1.3 Osteoarthritis

Osteoarthritis is a very complex disease or condition which is triggered by a number of environmental and genetic factors. In fact, today it is accepted by most that osteoarthritis may not represent a single disorder, but rather a disease spectrum which leads to similar clinical and pathological alterations (Cibere 2006: 28; Franklin 2010: 7). This is not a new idea, as reflected by Dieppe. “The term OA describes an abnormal state of a synovial joint. It is not a disease. Each of several different ‘diseases’ can trigger a reaction pattern leading to the characteristic features of the OA joint: focal loss of articular cartilage and hypertrophy of the subchondral bone. Not surprisingly attempts to define and classify OA as a single disease entity have not been helpful” (Dieppe 1990: 262)

It is therefore of utmost importance, if one is to attempt a discussion of osteoarthritis, to consider the complex, and often very poorly understood aetiopathogenesis of the condition (Jurmain 1999: 14). To begin with, there has been much discussion relating to the terminology. Many researchers have objected to the use of the term osteoarthritis, as it implies an inherently inflammatory condition. Osteoarthrosis and degenerative joint disease have been suggested as alternative terms; however, these have their detractors as well, and although there is no consensus, osteoarthritis continues to be the most common term used for the condition (Weiss and Jurmain 2007: 437-8), and will be retained here.

1.3.1 The pathogenesis of osteoarthritis

In general, the earliest changes of osteoarthritis are in the articular cartilage, and these can range from slight surface irregularity to full-thickness loss of cartilage. This leads to a reactive proliferation of the subchondral bone plate. As the bone plate defines the contours of the articular surface as well as contributing to the strength and resilience of the joint, this reduces its function as a shock absorber, which in turn leads to ever increasing damage to the articular cartilage. Eventually the entire articular surface becomes deformed which results in the normal bone trabeculae being lost, cysts may develop within the bone and osteophytes form at the margins of the articular surface (Gallagher 1996: 804-5; Sharma et al. 2013: 19807-8). However, because of the complex aetiology of osteoarthritis, it cannot be expected that the condition will always follow the same course (Dieppe et al. 1993: 557; Dieppe and Lohmander 2005: 967-8). There are for example some recent

studies which suggest that it is uncertain which occurs first, the bone changes or the cartilage changes, and that in fact the first sign of osteoarthritis in a joint could be subchondral bone cysts (Lane and Nevitt 2002: 2-3; Hayami et al. 2004: 1193-4; Sharma et al. 2013: 19810).

1.3.2 Radiological v. clinical diagnosis

The first symptom of osteoarthritis tends to be joint pain, which is initially associated with movement and can be alleviated with rest. It is however not really known what causes joint pain of osteoarthritis, as cartilage is aneural. Raised intraosseous pressure, inflammatory synovitis and periosteal elevation have been suggested as causes. Stiffness, usually due to inactivity, is also a common symptom. These symptoms frequently lead to a reduced function of the arthritic joint which results in poor mobility, potentially affecting the sufferer's ability to participate in daily activity (Franklin 2010: 7; Gallagher 1996: 805).

The standards for the radiological diagnosis of osteoarthritis set forward by Kellgren and Lawrence in 1957 and accepted by a World Health Organisation (WHO) symposium in 1961 are still the most commonly used today (Altman et al. 1986: 1039; Kellgren and Lawrence 1957). The radiological diagnostic features of osteoarthritis are as follows:

1) Osteophytes on the joint margin.
2) Periarticular ossicles, mainly on the distal (DIP) and proximal (PIP) interphalangeal joints.
3) Narrowing of the joint space, associated with sclerosis of subchondral bone.
4) Small cysts within the subchondral bone.
5) Altered shape of bone ends, particularly seen in the head of the femur.

(After Kellgren and Lawrence 1957: 494).

It must however be noted that radiographs do not define the clinical syndrome, since various studies have shown that up to 40% of patients with radiological changes of osteoarthritis are asymptomatic (Altman et al. 1986: 1048). Therefore, in 1981 the American Rheumatism Association asked the Diagnostic and Therapeutic Criteria Committee to establish a subcommittee on osteoarthritis to standardise and clarify the clinical definition of osteoarthritis. The committee defined osteoarthritis "as a heterogenous group of conditions that lead to joint symptoms and signs which are associated with defective integrity of articular cartilage, in addition to related changes in the underlying bone and at the joint margins" (Altman et al. 1986: 1039). The non-specific nature of osteoarthritis means that the development of criteria for its classification has proven to be highly problematic. The high proportion of asymptomatic patients and the lack of

diagnostic tests confound the problem, as well as the fact that osteoarthritis has different clinical manifestations in different parts of the body. Due to this, the development of the criteria was carried out on specific joints; the knees (Altman et al. 1986), the hands (Altman et al. 1990) and the hips (Altman et al. 1991). The main aim of these classifications was to separate osteoarthritis from other joint conditions (for example rheumatoid arthritis and spondyloarthropathies) and to distinguish clinical osteoarthritis from the asymptomatic histopathologic osteoarthritis that is seen in post mortem examination as well as from asymptomatic radiological osteoarthritis (Altman et al. 1991: 505; Altman et al. 1990: 1601-2). All the studies concluded that a combination of radiological and clinical diagnosis was the best way to diagnose osteoarthritis. Radiological diagnosis was of the least value in diagnosing hand osteoarthritis (Altman et al. 1990: 1607) while for the knee it was demonstrated that combined radiological and clinical diagnosis was 86% specific, as opposed to 69% specificity for clinical diagnoses alone (Altman et al. 1986: 1047). Criteria were however put forward for a purely clinical diagnosis of osteoarthritis with pain being the primary symptom, with a combination of three or more accompanying symptoms. The diagnostic criteria for hand and knee osteoarthritis are given in table 1.1.

Table 1.1: Criteria for classification of hand and knee osteoarthritis (after Altman et al. 1990: 1606; Altman et al. 1986: 1047).

Hand pain, aching or stiffness	Knee pain
& 3 or 4 of the following:	& at least 3 of 6 of the following:
-Hard tissue enlargement of 2 or more of 10 selected joints	-Age >50 years
-Hard tissue enlargement of 2 or more DIP joints	-Stiffness <30 minutes
-Fewer than 3 swollen MCP joints	-Crepitus (a crackling, crinkly, or grating feeling or sound in the joints)
-Deformity of at least 1 of the following joints: 2nd & 3rd DIP, 2nd & 3rd PIP, 1st CMC of both hands	-Bony tenderness
	-Bony enlargement
	-No palpable warmth

1.3.3 Idiopathic v. secondary osteoarthritis

The classification of osteoarthritis separates patients into two categories: those with no underlying predisposing factor; idiopathic osteoarthritis, and those with a known event or disease (for example trauma, inflammatory disease, metabolic, endocrine, neuropathic problems or congenital malformations) associated with the development of osteoarthritis; or secondary osteoarthritis. This classification takes into account the fact that all osteoarthritis may be secondary to phenomena not yet

discovered, therefore the term idiopathic osteoarthritis should always be used, rather than primary osteoarthritis (Altman et al. 1986: 1040; Jurmain 1999: 14).

1. Idiopathic.
    a) Localized.
    b) Hands: for example Heberden‘s and Bouchard‘s nodes.
        i. Feet: for example hallux valgus, hallux rigidus, contracted toes (hammer/cockup toes), talonavicular.
    c) Knee.
        ii. Medial compartment.
        iii. Lateral compartment.
        iv. Patellofemoral compartment (for example chondromalacia).
    d) Hip.
        v. Eccentric (superior).
        vi. Concentric (axial, medial).
        vii. Diffuse (coxae senilis).
    e) Spine (particularly cervical and lumbar).
        viii. Apophyseal.
        ix. Intervertebral (disc).
        x. Spondylosis (osteophytes).
        xi. Ligamentous (hyperostosis [Forestier’s disease or DISH]).
        xii. Other single sites: for example shoulder temporomandibular, sacroiliac, ankle, wrist, and acromioclavicular.
    f) Generalised: includes three or more areas listed above.
        xiii. Small (peripheral) and spine.
        xiv. Large (central) and spine.
        xv. Mixed (peripheral and central) and spine.
2. Secondary.
    g) Post-traumatic.
    h) Congenital or developmental diseases.
        xvi. Localized.
            1) Hip diseases: for example Legg-Calvé-Perthes, congenital hip dislocation, slipped capital femoral epiphysis, shallow acetabulum.
            2) Mechanical and local factors: for example obesity (?), unequal lower extremity length, extreme valgus/varus deformity hypermobility syndromes, and scoliosis.
        xvii. Generalised.
            3) Body dysplasias: for example epiphyseal dysplasia, spondylo-epiphyseal dysplasia.
            4) Metabolic diseases: for example hemochromatosis, ochronosis, Gaucher’s disease, hemoglobinopathy, Ehlers-Danlos disease.
        xviii. Calcium deposition disease.
            5) Calcium pyrophosphate deposition disease.
            6) Apatite arthropathy.
            7) Destructive arthropathy (shoulder, knee).

xix. Other bone and joint disorders: for example avascular necrosis, rheumatoid arthritis, gouty arthritis, septic arthritis, Paget’s disease, osteopetrosis, osteochondritis.
xx. Other diseases.

8) Endocrine diseases: for example diabetes mellitus, acromegaly, hypothyroidism, hyperparathyroidism, Neuropathic arthropathy (Charcot joints).
9) Miscellaneous: for example frostbite, Kashin-Beck disease, Caisson disease.

(After Altman et al. 1986: 1040).

1.3.4 Multiple joint involvement and generalised osteoarthritis

As early as the 1850s Adams noted the occurrence of osteoarthritis in multiple joints in the same individual (Adams 1857). In 1941 Stecher defined the condition generalised osteoarthritis (GOA) as the polyarticular involvement of Heberden’s nodes (Stecher 1941). The definition of generalised osteoarthritis was further refined by Kellgren et al. to include osteoarthritis involving three or more joints, divided into nodal, with Heberden’s nodes, and non-nodal, without Heberden’s nodes (Kellgren et al. 1963: 241-2). There is no real consensus as to the definite criteria for diagnosing generalised osteoarthritis, although hand involvement, in particular the interphalangeal and carpometacarpal joints, is the defining criteria (Cushnaghan and Dieppe 1991: 12; Arden and Nevitt 2006: 7). For example, one project within the Ulm osteoarthritis study defined generalised osteoarthritis if osteoarthritis was found in two or more proximal- or distal interphalangeal joints, and at least one carpometacarpal joint in addition to at least one large joint (Günther et al. 1998, 719). However, a more recent project within the study specified the involvement of at least one 1st carpometacarpal joint (in addition to the interphalangeal joints and one large joint) to diagnose generalised osteoarthritis (Stürmer et al. 2000, 303), A strong familial association with generalised osteoarthritis, in particular among women, has been noted since the middle of the 20th century, with strong suggestions for a Mendelian mode of inheritance (Irlenbusch and Schäller 2006, 425-6; Jurmain 1999: 17). It is also worth noting that there are studies which have demonstrated that there is a genetic link to multiple joint involvement in osteoarthritis, even when generalised osteoarthritis has not been diagnosed (cf. Riyazi et al. 2005).

1.4 Palaeopathology and the aetiology of osteoarthritis

The following section will present examples of how osteoarchaeology has tackled the varied aetiological factors which affect osteoarthritis, accompanied with a

discussion of how the medical approach to these factors have been used, or in some cases ignored, within the osteoarchaeological literature.

1.4.1 Palaeopathology, osteoarthritis and activity

Interpreting activity from the skeleton has long been the focus of those working with archaeological human skeletal remains, with the earliest such studies dating back to the early 20th century (Jurmain 1999: 3). J. Lawrence Angel was at the forefront of such research in the U.S. Examples of his work include the identification of "atlatl elbow" and seed-grinding based on osteoarthritis of the elbow in seven Early horizon (c. 2500-1000 B.C.) skeletons from Tranquility, California (Angel 1966: 2-3), as well as diagnosis of whiplash due to frequent osteoarthritis of the cervical vertebrae in the Early Neolithic – Middle Bronze Age skeletal population from the Lerna, Greece. In the same population Angel identified a single woman as a weaver, based on osteoarthritis of the right shoulder, as well as an enlargement of the attachment of the anterior and medial scalenus muscles on the 1st rib (Angel 1971: 88-9).

Calvin Wells was at the forefront of such studies in the U.K. In his 1964 publication *Bones, bodies and disease* he stated that injury, and in particular repeated episodes of minor stress are the main aetiological features of osteoarthritis. He went on to refer to various cases which support this statement. For example osteoarthritis of the lower spine in Anglo-Saxons indicative of pivotal trauma caused by farming; osteoarthritis of the foot, in particular the 1st MT, indicative of marching in skeletons of Macedonian soldiers of Alexander the Great excavated in Chatby near Alexandria; as well as osteoarthritis in the shoulder and elbow in early Patagonians caused by the rotational movement of using the bola as a hunting weapon (Wells 1964: 60-5). In addition Wells states that "...apart from specifically localized areas of osteoarthritis determined by occupational trauma there is a broader relationship between this disease and the general standard of living. Other things being equal, when the over-all stress of life eases for a people they tend to be less afflicted with it" (Wells 1964: 65-6). To support this he compares Neolithic and early Bronze Age skeletal remains from Greece, whom he refers to as "inefficient hoe farmers" subsisting on an inadequate diet, to those dating to the Mycenean Period (late Bronze Age) who have benefitted from the introduction of irrigation, manuring, crop rotation and the plough, which allowed for higher individual consumption, if not an increase in the range of food consumed. These advances, Wells concludes, resulted in an increase in stature, longevity and population, as well as a decrease in the prevalence of osteoarthritis (Wells 1964: 66).

In the decades that followed the work of Angel and Wells, there were numerous archaeological publications (cf. Wells 1967) where interpretations of behaviour were based on the diagnosis of osteoarthritis. This work however quickly moved away from identifying the occupation of individuals based on their skeletal changes to

population studies, and in particular comparing different skeletal groups and the pattern of osteoarthritis within these groups. In particular, there grew an interest in testing how differences in osteoarthritis between populations might relate to differing activities related to aspects of subsistence economies (Bridges 1992: 69-70). An example of this type of study was Jurmain's (1977) comparison of four skeletal populations, modern American whites, modern American blacks (both derived from the Terry Collection), Native Americans from Pecos Pueblo, New Mexico and Alaskan Eskimos. Jurmain does briefly discuss other factors which may predispose the individual to osteoarthritis, age, sex, metabolic factors, impaired nutrition of articular cartilage, vascular profusion, endocrine factors and heredity (Jurmain 1977: 353-4). Within this study, however, he places the greatest emphasis on chronic functional stress as the main aetiological factor, in particular when considering variations in prevalence between the different populations. Therefore, higher prevalence and earlier age of onset of hip, elbow and knee osteoarthritis in the Alaskan Eskimo population are explained as being due to a more strenuous lifestyle in harsher conditions than seen in the other three populations. In particular a comparison with the Pecos Pueblo population indicates, Jurmain argues, that the agricultural way of life involves less joint stress than in a hunter-gatherer community. In the same study, a higher incidence of shoulder osteoarthritis among American Black females is said to be due to gender-associated occupational practices, in particular domestic cleaning (Jurmain 1977: 357). Jurmain concludes by stating that given enough time the combined effects of biological ageing and other systemic agents all joints will eventually develop some form of degenerative joint disease, and that "The most convincing etiological argument relates directly to the kind and amount of environmental stress typical of the varying lifestyles of the populations sampled." (Jurmain 1977: 363). Other examples of similar studies include spinal osteoarthritis reflecting a strenuous lifestyle among Roman Britons (Thould and Thould 1983), osteoarthritis of the knee, spine and metatarso-phalangeal joints in presumed corn grinders from the Mesolithic and Neolithic settlements in Tell Abu Hureyra in Syria (Molleson 1989), and a study of a prehistoric central Californian population where osteoarthritis of the distal joints of the lower limbs was seen to indicate interpersonal violence (Jurmain 1990).

By the last decade of the twentieth century there was a marked increase in arguments which expressed concern regarding this type of research. Although, as noted above, he had previously been a spokesperson for the interpretation of activity from the diagnosis of osteoarthritis, Jurmain was amongst those criticising such approaches with his 1999 publication *Stories from the skeleton: Behavioural reconstruction in human osteology*. One of the main arguments against using the diagnosis of osteoarthritis in skeletal remains to interpret activity was that although many such studies referenced medical research which supported a link between a

specific activity or occupation and osteoarthritis, the use of this literature by osteoarchaeologists was often very selective. The fact is that although there are many medical publications (cf. Spector et al. 1996; Drawer and Fuller 2001) which do support a link between a specific occupation or activity, in particular sports, and osteoarthritis, there are an equal number of studies (cf. Hannan et al. 1993; Chakravarty et al. 2008) which are unable to establish a link. It is unfortunately far too common within the palaeopathological literature to ignore this latter group when discussing the link between occupation and osteoarthritis in archaeological skeletal material. In his book, Jurmain publishes a long list of epidemiological studies which both find, and fail to find, a positive association between activity and osteoarthritis (Jurmain 1999: see tables pg 82-3 and 98-9). The main reason for this is the lack of understanding of joint physiology and the pathogenesis of osteoarthritis, as has already been discussed.

This superficial approach to the medical data is the main critique faced by many osteoarchaeological studies, and some have gone so far as to suggest that in many cases the positive results of pathological analysis are mainly based on the researchers' desire to be able to say something about activity based on pathological changes (Jurmain 1999: 70; Waldron 1994: 92-3; Weiss and Jurmain 2007: 442). There is however no doubting the fact that while biomechanical loading is necessary for the maintenance of cartilage, abnormal or altered joint loading can be associated with inflammatory and metabolic imbalances, which may result in the development of osteoarthritis. Several factors which may cause abnormal loading in the joint have been noted, for example overuse, which has been discussed here above, immobilisation and joint instability (Guilak 2011: 816, 820). The latter two have received little attention in the palaeopathological literature, but the role of both muscle weakness and immobilisation (for example due to paralysis), are recognised aetiological factors of osteoarthritis as a result of an interference with the nutrition of the cartilage, within the medical literature. This is particularly seen in the larger weight bearing joints (Kidd et al. 1997: 190-1; Slemenda et al. 1997; Norkin and Levangie: 78). However, perhaps the most obvious factor is the development of secondary osteoarthritis due to altered joint loading caused by severe trauma, which is clearly documented in both the medical and the osteoarchaeological literature (cf. Buckwalter and Brown 2004; Valderrabano et al. 2006; Walker and Hollimon 1989; Wilczak et al. 2004). There is therefore no question that markedly altered joint biomechanics can lead to osteoarthritis. What is less well demonstrated is a full understanding of the role of biomechanical factors in the aetiopathogenesis of osteoarthritis, and whether a common pathway leading to tissue degeneration is associated with all forms of trauma or altered joint loading. While some researchers continue to argue that overuse is a major cause of the degeneration of joints and the development of osteoarthritis, this hypothesis is not universally accepted. As has

been pointed out, the main deficiency of this hypothesis is linked to its lack of precision. In other words, if biomechanical stress is *always* a determining influence in variable patterning of osteoarthritis, it must mean that other aetiological factors are not. The question to ask is therefore: if altered joint loading does contribute significantly to the development of osteoarthritis, what are the circumstances in which its contribution can be determined (Guilak 2011: 820; Jurmain 1999: 50-2)?

These critiques have resulted in researchers calling for a move toward a more scientific approach to palaeopathological analysis (Jurmain 1999: 7), with an increased emphasis on standardised methods of recording osteoarthritis and joint disease in general, to ensure the comparability of the data from different studies, as well as an increase in the statistical testing of results to glean whether the differences seen are meaningful (Rogers and Waldron 1995; Rogers et al. 1987). Some have stated that the use of ethnohistorical records or historical accounts for comparative purposes is haphazard and lacks precision, and that without the means to carry out rigorous testing of the archaeological data "skeletal biologists can only hypothesize in a theoretical vacuum" (Jurmain 1999: 7). An example of a study where such stringent testing was possible was the analysis of the 18th-19th century skeletal remains from the crypt of Christ Church in Spitalfields, London. The crypt included 367 named skeletons, and historical documents were used to determine the occupation of these individuals. Weavers were a particular focus of the study, mainly because it was the most common profession within the collection. The study tested whether those individuals who were known to have been weavers during their lifetime displayed increased osteoarthritis of the hands or spine compared to other workers, both manual and non-manual, an association which had been suggested by other studies as already mentioned (Angel 1971: 88-9; Wells 1967). The results indicated no such correlation in the Spitalfields collection, nor indeed any increased osteoarthritis of the hands or spine of those individuals who had been manual labourers compared to those whose professions had been non-manual (Waldron and Cox 1989).

Critiques of those studies that have inferred activity directly from osteoarthritis in archaeological skeletons have had a broader impact on the way in which osteoarchaeologists approach and interpret their data (Waldron 1994: 92-9). There are some activity-related lifestyles that have been shown clinically to demonstrate a consistent correlation with osteoarthritis. The primary example is the association between farming and osteoarthritis of the hip. Several epidemiological studies in various countries have confirmed these results (Croft et al. 1992; Thelin and Holmberg 2007; Walker-Bone and Palmer 2002). Although the aetiology of the processes involved here is not fully understood, various theories have been proposed. For example, one study noted a higher prevalence of hip osteoarthritis in farmers who worked in close proximity to large animals than in those who did not,

and suggested an immunological response (Thelin et al. 2004). Another theory is related to the age of onset of the biomechanical stress on the joint. Farming tends to be an inherited profession, with many individuals starting physical activities associated with farm-work while still children (Weiss and Jurmain 2007: 443-444). The field of sports medicine has also demonstrated a link between osteoarthritis and activity. For example a correlation has been noted in professional baseball players and osteoarthritis of the elbow. This is particularly noted in individuals who started playing regularly as children, therefore often referred to as "Little league elbow" (Jurmain 1999: 90-2; Wells and Bell 1995: 251), so again the age of onset is likely to be significant. Another study has demonstrated a link between competitive long-distance skiers and an increased risk of needing arthroplasty of the knee and hip due to osteoarthritis later in life. This suggests that extremely intensive exercise may increase the risk of osteoarthritis (Michaëlsson et al. 2011).

Ultimately, the analysis of osteoarthritis within archaeological populations should only be used cautiously as an indicator of the overall level of activity within that population and not directly linked to specific activities, as even though a link has been demonstrated between specific activities and osteoarthritis, as discussed above, there is no way to validate the conclusions. In other words, people who are not farmers get osteoarthritis of the hip, and people who are not long distance skiers get osteoarthritis of the knee. However, studies have demonstrated (cf. Weiss and Jurmain 2007) that osteoarthritis can in some instances be more likely to develop in one population than another, in particular where biomechanical stresses on the joint are high and begin early in life, especially during childhood. It is important to remember that because of its complex aetiology different joints, or even different populations may not respond in the same way to similar stresses (Weiss and Jurmain 2007: 444).

The critiques of the link between osteoarthritis and activity resulted in a noticeable reduction in interest in osteoarthritis from the mid-1990s. From this time, other factors such as entheseal changes and trauma have been more widely used in the study of activity in archaeological populations (cf. Legge 2010; Lieverse et al. 2013; Torres-Rouff and Costa Junqueira 2006; Villotte et al. 2010). However, there are still studies which continue to interpret very specific behaviour patterns. An example of this is the study by Lieverse et al. (2007) of five pre-historic skeletal populations from the Cis-Baikal region of Siberia, where very specific activity changes associated with different adaptive strategies were interpreted from the pattern of osteoarthritis within the group. Here spear-throwing, paddling and skin-scraping were interpreted based on osteoarthritis of the elbow, while osteoarthritis of the knee was said to be caused by squatting, kneeling and walking over rough, steep and snow-covered terrain while carrying heavy loads (Lieverse et al. 2007: 12-3). Another, more recent study is that carried out by Klaus et al. (2009) on skeletal populations in post-contact Peru, which presents some very ambitious

conclusions based on the analysis of osteoarthritis. Here, activity is presented as the only aetiological factor of osteoarthritis. For example osteoarthritis of the wrist is associated with repetitive motions such as flexion and extension, and osteoarthritis of the knee with repetitive bending. The authors discuss all changes in prevalence between different periods as indicators of changes in activity, and all variation between the sexes as evidence of sex-related divisions of labour (Klaus et al. 2009: 211-3). The authors go so far as to conclude that the pattern and changes in prevalence of osteoarthritis "stem from a synergism of broad, hemispheric level sociopolitical alterations, specific changes to Mochica activity and behavior, regional economic intensification, and local microenvironmental characteristics, which were all focused into these biological outcomes by the operation of a colonial Spanish political economy on the north coast of Peru from A.D. 1536 to 1751" (Klaus et al. 2009: 204). In other words, despite an increased understanding of the complex aetiology of osteoarthritis, studies continue to be presented, where the interpretation is based entirely on activity as a causative factor.

The bigger picture within the study of osteoarthritis in osteoarchaeology is this: as our understanding of the complexity of the multifactorial aetiological nature of the changes associated with osteoarthritis increases, the clear association between behaviour and/or activity has been lost. The result of this is that population based studies of the condition have become less attractive to osteoarchaeologists, given the interpretive limitations. In other words, we no longer seem to have a clear understanding of where to place osteoarthritis within the archaeological discussion. It is one of the main aims of this thesis to tackle this problem, to embrace the complex nature of the condition and attempt to place it within the archaeological discussion based not only on the aetiological factors, but also by considering the nature the populations within the study, their social and physical environments.

1.4.2 Palaeopathology, osteoarthritis and age & sex

1.4.2.1 Age

One of the greatest risk factors of osteoarthritis is ageing. This has probably never been more obvious than in modern, ageing populations. One result of this is that the prevalence of osteoarthritis is constantly on the rise. This means that disability due to osteoarthritis is also increasing. Given the strong correlation between osteoarthritis and age, it is therefore surprising how frequently comparisons of the prevalence of osteoarthritis in different populations fail to consider different age structures (Bridges 1992: 70). Several authors have addressed the problem of age-adjustment (see chapter 5.2.1 for a discussion of age-adjusted prevalence) when comparing populations with differing age structures, emphasising its importance in particular when dealing with diseases which do not contribute to death, as well as

diseases which are more likely to affect people of a specific age group (cf. Baker and Pearson 2006; Waldron 1994: 48-51). Osteoarthritis, of course, fits very well into both of those categories. However, it must be remembered that although osteoarthritis is a disease closely associated with the aged, it is not an inevitable disease of ageing, and some clinical studies have even suggested that incidence does not continue into extreme old age, with a decrease in new cases of osteoarthritis after the age of 70 years (Hamerman 1995: 83-4).

As has already been mentioned (see chapter 1.4.1), although not as obvious as links between old age and osteoarthritis, there are some suggestions that childhood, and in particular the intensity of the activities an individual participates in during childhood, can have an effect on the development of osteoarthritis later in life. It may therefore be more fruitful to focus on the younger individuals within a population when dealing with the link between osteoarthritis and activity. This will be one of the aims of the current study.

1.4.2.2 Sex

A statistical variation in the prevalence of osteoarthritis between men and women is often noted in population studies, both epidemiological and osteoarchaeological. Within the medical literature, although these sex differences are frequently reported (Kaufman et al. 2001; Manninen et al. 1996; Picavet and Schouten 2003: 169-70), they are not necessarily accompanied by a discussion of the aetiology of these differences. When this occurs, the explanations tend to be biological; for example an increased prevalence of knee osteoarthritis in women being due to a link between sex hormones as well as a higher perception of pain in women compared to men (Paradowski et al. 2006: 43). Other studies have likewise linked this to differences in pain behaviour between men and women. There are studies which go so far as to dismiss the difference between men and women by suggesting that women are more likely to respond to pain by 'catastrophizing'[1] (Keefe et al. 2000: 331). Yet other studies (Aspelund et al. 1996: 35; Nevitt and Felson 1996: 675) have suggested that sex hormones might be involved in the development of osteoarthritis in women, in particular of the hip and knee, although the aetiology of this process is poorly understood, mainly due to the complex nature of osteoarthritis.

Sex differences in prevalence of osteoarthritis in archaeological populations are widely reported (cf. Bridges 1992; Bridges 1994; Molnar et al. 2011). When this is accompanied by a discussion of the aetiological factors behind such variation, the focus of the discussion is almost exclusively on behaviour or activity and a discussion on gender differences within these populations. An example of this is a study carried out by Sofaer Derevenski (2000) on two British skeletal populations

[1] Catastrophizing: Experiencing a situation as unbearable or impossible when it is just uncomfortable

from Ensey, Outer Hebrides (16th-19th century) and Wharram Percy, North Yorkshire Wolds (10th-16th century). The study focuses on osteoarthritis of the spine. Using ethnohistorical records of gendered division roles, Sofaer Derevenski interprets the greater prevalence of lumbar osteoarthritis, in particular in the Ensay women compared to the men, as entirely reflecting gender specific activity, in this case the female task of carrying a creel (a wicker basket carried by a strap across the chest, and resting on the lower back) to transport material such as seaweed and peat (Sofaer Derevenski 2000: 335, 349-53). The study gives no consideration to other aetiological factors which could be affecting such variations. Those might include, for example, anatomical differences between men and women, an issue discussed in detail in chapter 1.4.3. Interestingly, archaeological studies frequently report a higher prevalence of osteoarthritis in men compared to women, while the opposite tends to be true in medical studies. Within archaeology, this is usually attributed to a more strenuous life among men in past populations (Bridges 1992: 74-7). What this does not take in to account however, is the fact that modern medical studies have demonstrated that the prevalence of osteoarthritis peaks at a much younger age in men, around 55-64 years, than in women, where peak prevalence is around 65-74 years (Cushnaghan and Dieppe 1991: 9). This means that when dealing with archaeological collections, where a smaller proportion of the population is likely to have lived beyond 60-70 years, it must be taken into account that many of the women within that population will not have lived to the age at which they are likely to have developed osteoarthritis, resulting in the higher comparative prevalence among the men.

1.4.3 Palaeopathology, osteoarthritis and anatomy

The focus within the archaeological literature has been on the stresses and strains that different activities can have on joints and how this can influence osteoarthritis. This has meant that the effects of variations within anatomy and how those variations can influence torque on the joint and development of osteoarthritis tends to get very little attention (Weiss and Jurmain 2007: 440). Studies on varied anatomy as an aetiological factor for osteoarthritis are to be found within the medical literature, for example a study by Hunter et al. (2005) on the association between knee height and osteoarthritis of the knee. The results indicated that there was a positive link between relative knee height as well as proportional knee height, and both radiological and clinical osteoarthritis of the knee, particularly among women. There was also a correlation between severity of pain and knee height among the women. The authors conclude that the reason for this sex difference is anatomic, that lower fat mass and higher muscle mass in men means that males are less susceptible to increased torque on the knee joint caused by increased knee

height, accompanied by general increased robusticity of the joint surface itself giving the joint surface greater stability in men (Hunter et al. 2005: 1421-2).

The effect that body mass index (BMI) has on osteoarthritis is widely reported in the medical literature, with overweight or obese people in general suffering from more severe osteoarthritis. The relationship between BMI and osteoarthritis appears to be influenced by both mechanical and systemic effects, illustrated in particular by the fact that osteoarthritis of the weight bearing joints is most influenced by increased BMI (Weiss and Jurmain 2007: 441). Several studies have demonstrated this link (Jónsson et al. 2011: 8-9; Manek et al. 2003: 1027-8), in particular when it comes to increased BMI and osteoarthritis of the knee. This link has in some studies, been demonstrated to be particularly strong among women.

Osteoarchaeologists have attempted to study the effects of body mass on osteoarthritis in archaeological populations. One example is a study by Weiss (2006) of a pre-European contact population (500-1500 AD) from California. Body mass was calculated using measurements of femoral head breadth. The results demonstrated a negative correlation between body mass and osteoarthritis. There are however several problems, the first being that there is clearly a correlation between femoral head breadth and sex. This means that, as the author points out, the pattern of osteoarthritis and body mass is mainly reflecting the difference pattern between men and women, and that perhaps the variation in prevalence between the sexes reflects body mass differences rather than gendered roles (Weiss 2006). The main issue however with this type of analysis is that estimates of body mass from skeletal remains do not necessarily reflect the living BMI of that individual, that is, whether they were overweight or not. They are more likely to reflect robusticity. In fact, it is likely that most archaeological skeletal collections represent populations where obesity was not a problem, and that the issue of increased BMI and osteoarthritis is largely a modern phenomenon (Weiss and Jurmain 2007: 441). However, the presence of obesity in archaeological populations, and therefore its influence on the prevalence of osteoarthritis cannot be wholly excluded. In most instances obesity is likely to have been status related, as demonstrated by studies of diffuse idiopathic skeletal hyperostosis (DISH), a systemic disorder characterised by the ossification of the anterior longitudinal spinal ligament by diffuse extraspinal enthesopathies. The condition is more common in men and associated with advanced age. Its aetiology is not fully understood, but it is known to be related to obesity and diabetes. The link between DISH and high status, for example monastic populations and within the Medici family, has been demonstrated in several osteoarchaeological studies (cf. Giuffra et al. 2010; Rogers and Waldron 2001; Verlaan et al. 2007). No cases of DISH have been observed in the populations analysed in this study.

1.4.4 Palaeopathology, osteoarthritis and genetics

The past decade has seen a lot of epidemiological work on genetics and osteoarthritis. This work, particularly in Iceland, is discussed separately in chapter 2. The genetic aetiopathology of osteoarthritis has however not received much attention within osteoarchaeological research. One example where genetics and osteoarthritis is tackled is a study by Crubézy et al. (2002) of osteoarthritis in two Central European Neolithic skeletal populations; Vedrovice, Moravia in the Czech Republic (5700 BC) and the slightly more recent site at Horné Krškny in Nitra, Slovakia. The results were compared to modern and medieval populations from the same region (Crubézy et al. 2002: 581). The study concluded that the pattern of osteoarthritis of the upper limbs within the two populations suggested that microtrauma, which in bone is characterised by microfractures usually due to repeated stress, was the most important aetiological factor. However, the lack of variation in the pattern of osteoarthritis prevalence over time in the lower limb indicated that genetic factors affecting susceptibility to osteoarthritis may have been present in this part of Europe since the early Neolithic period (Crubézy et al. 2002: 587-8). A previous study of the early medieval collection from Skeljastaðir, one of the collections used in this study (see chapter 3.2) concluded that the pattern of prevalence within the collection, in particular of hip osteoarthritis, which is much higher than in contemporary British populations, was indicative of hereditary osteoarthritis (Gestsdóttir et al. 2006: 80). This conclusion was seen to be further supported by the high incidence of hereditary osteoarthritis in the modern Icelandic population (cf. Ingvarsson et al. 2000 and chapter 3).

1.5 Conclusion

What this discussion emphasises is, first and foremost, that due to the complex aetiological nature of osteoarthritis it is of utmost importance when discussing the condition in archaeological populations to avoid oversimplification in interpretation. It is vital also to remember when using medical or epidemiological data for comparative purposes to be wary of the dangers of picking out for comparison those studies which support the conclusion one might wish to be able to draw from the material. Weiss and Jurmain (2007) advise the following points be kept in mind when using medical data for osteoarchaeological analysis of osteoarthritis:

1) There are many aetiologies of osteoarthritis and there may actually be more than one ‘disease’ that is being defined as osteoarthritis.
2) Since different joints vary with regard to the effects of genes and environment, anthropologists should be cautious of aggregate scores when it comes to osteoarthritis.

3) Genotypic influences involve several loci, most of which are demonstrably polymorphic... differences between populations could reflect differences due to age, body mass and/or genotypes...
4) Sex differences that have been considered due to activity patterns may actually be related to hormones, body size, genes and anatomy. Anthropologists need to take care to dissect the causes of sex differences instead of assuming that they are cultural in nature.
5) The biomedical literature concerning osteoarthritis is extremely broad and growing dramatically. Moreover, results often continue to be contradictory. Systematic evaluation of this rich and invaluable resource presents a challenge for those of us doing osteological research."

(after Weiss and Jurmain 2007: 443)

It is also possible to add to this list the precaution of being aware of the difference between self-reported or clinically diagnosed osteoarthritis as opposed to radiologically diagnosed osteoarthritis. Palaeopathologically diagnosed osteoarthritis is most likely to reflect the radiological diagnosis of the condition, due to the fact, as has already been noted, that a proportion of radiological osteoarthritis is asymptomatic, while in some cases clinically diagnosed osteoarthritis cannot be identified from radiographs.

With this in mind, the aims of this thesis are twofold: to tackle the analysis of osteoarthritis in the archaeological human skeletal populations with the factors outlined above in mind. That is, to avoid focusing on one aetiological factor and attempt to prove or disprove its influence on the population. Rather, the aim is to take all the aetiological factors outlined above into consideration, in conjunction with the social and physical environments of the populations under study, and so attempt to find osteoarthritis a place within the osteoarchaeological discussion again. The focus here will be as follows:

- To ask whether the familial osteoarthritis which has been identified in modern Icelandic families is reflected in the archaeological material.
- To take systematic and explicit account of the multifactorial nature of osteoarthritis during the interpretation of the data, specifically genetics, activity, anatomy and sex.
- To place the discussion within the social, historical and archaeological context of the excavated sites to give the interpretation a deeper meaning.

The other aim of this thesis is to develop the theoretical aspect of palaeopathology. Osteoarchaeology has to a large extent developed as a scientific field alongside archaeology, rather than as part of it, and has therefore to some degree failed to integrate the theoretical developments which have evolved within archaeology in the past few decades (Sofaer 2006: 26). The results of the study will be used to facilitate a discussion on the nature of palaeopathological research, in particular the theoretical perspectives regarding one of the fundamental problems which lies at the heart of palaeopathological

studies, that of the dichotomy of science/nature versus culture/society. Within archaeological research, osteoarchaeology has been stamped as belonging entirely to the field of biology, and the focus of the discussion has been on the value of the analysis of skeletal material only for population statistics and hypothesis testing, "[s]ocio-behavioural sources predict **nothing** about skeletal involvement. Only skeletons themselves can provide hard data, and the lesions must be linked directly and **independently to known** (well-documented) behavioural environments (i.e., best done in clinical contexts)." (Jurmain 1999: 136, emphasis as in the original). In this the social analysis or discussion is completely ignored, which only results in setting osteoarchaeology apart from archaeology. This view reflects the gap which exists within the field of archaeology as a whole, that between archaeological theory and archaeological science, which in turn reflects an epistemological gap between the arts and sciences in general (Jones 2002: 3). The difference is that within osteoarchaeology and in particular palaeopathology, the theoretical voice has remained largely quiet.

The issue that needs to be tackled is the "hard data" and "clinical contexts" emphasis made by (Jurmain 1999: 136), or the need for scientific proof to back up interpretations presented. At the centre of this issue lies the problem that for science to be possible there must be a belief in both the consistency of the natural world as well as in our ability to describe that natural word objectively. The question then arises whether it is possible for us to take that detached position, and if not, are we then able to describe that world? The fact is that we are conditioned by the cultural world that we live in and by the tools with which we use to analyse (instruments used to measure; mathematical analysis etc.) and describe that world and represent that data (language and standardised representations of data in tables, charts etc.), which means that it is impossible for us to be completely objective (Jones 2002: 4-6; Sofaer 2006: 34). What the field of palaeopathology, like other archaeological sciences, needs to come to terms with is the subjective nature of all analysis that we carry out. In fact, if we look at a multifactorial disease like osteoarthritis and clinical approaches to it, it becomes clear that while there are several factors which we know lie behind its aetiology – age, genetics, trauma, stress, diet – the exact nature of how these different factors affect the disease are not known and various different studies can do little more than present theories as to how these different factors influence the disease. This is further compounded when discussing the nature of the disease in archaeological settings where people's lifestyles (type and amount of repetitive stress, lack of opportunity to take sick leave or receive disability compensation as well as the lack of access to modern medicine) would have had a profoundly different effect on the course of the disease. This is a very clear example of the subjectivity of clinical context, and how the cultural environment of the scientists shapes the nature of the discussion. There is a trend within osteoarchaeology to rely on the comparative method – generalisation and

universalism – to determine patterns of behaviour. This opens the field up to the criticisms reserved for the processual approach to archaeology (Sofaer 2006: 38), which assumed a systematic relationship between material and culture, i.e. that material culture was merely a by-product of human behaviour. The problem with this is of course that there is no universal cross-cultural relationship between the two, and the same can be said of palaeopathology. Frameworks of meaning will always intervene (Hodder and Hutson 2003: 14-5), and they and the effect they have on the course of the disease, how it affects the individual and how that individual affects society, will always have to be interpreted.

It is therefore necessary for palaeopathology to create a link between the natural sciences, a science fundamentally controlled by the ability, or belief in the ability, of testing and replicating results, and the social sciences, a more explicitly interpretative process (Jones 2002: 7). In dealing with the body in archaeology there is a gap between the physical, biological body and the culturally constructed body, and in trusting the science behind the physical body, the field has failed to develop a theoretical framework to deal with it (Sofaer 2006: 25). A frequent scenario within archaeological science is the production of knowledge up to a certain point, but then simply stopping once the analysis gets to the stage where the evidence cannot be described with certainty, Jurmain's “hard data” and “clinical contexts” (Jurmain 1999: 136). At the most the scientific archaeologists will hand over that data to the theoretical archaeologist to interpret at a cultural level (Jones 2002: 37-8). However, theoretical archaeologists, who in most instances are not familiar with the analytical process and context of the specialists’ knowledge, are merely using a different theoretical framework to construct their data or interpretation. This seems quite detrimental as the biological course of the disease or diseases a person suffers and the social and physical environment which that person lives in are inextricably intertwined, constantly affecting one another, and so need to be interpreted in tandem. If one attempts to completely separate the epidemiology of a disease from the contextual environment from which it comes, it limits any analysis which can be produced.

The nature of the theoretical discussion in this thesis will to a certain extent shift away from the focus on the causes or aetiology of osteoarthritis, towards thinking about how we can attempt to discuss society in broader terms, based on the results of the analysis of osteoarthritis in the skeletal populations. The focus here will be on the following

- To define concepts which can be associated with the debilitating effects of osteoarthritis, in particular disability, ageing and quality of life.
- To discuss how factors such as disability, ageing and quality of life can be approached in terms of palaeopathological analysis in general, as well as specifically based on the diagnosis of osteoarthritis in the skeletal populations in this study.

2 Genetics

2.1 The Icelandic population

Iceland was only settled in the late 9th century AD, and so has had a relatively short period of occupation (see chapter 2.3 for further detail). Although it is not certain how many people moved to the island during the initial settlement period, some have suggested a minimum of 25,000 people, which is quite a large number compared to what archaeologists normally assume about founding populations. The timing and nature of the settlement has been much debated. However recent work does suggest that while the land was occupied relatively quickly (Vésteinsson and McGovern 2012: 208-9, 215-7; Vésteinsson et al. 2002: 105-6) the movement of people into Iceland seems to have continued at least to the latter part of the 10th century (Price and Gestsdóttir in-press). There were several episodes in Iceland's history when the population was severely decimated. The 15th century saw two plague epidemics, in 1404-2 and 1494-5. These have traditionally been identified as the same disease which caused the Black Death in Europe, although there is a problem in that there was a lack of rats in Iceland during this period, which would have been essential to carry the *Xenopsylla cheopis* flea which carried the bubonic plague. It has therefore been suggested by some that the disease which affected 15th century Iceland was actually primary pneumatic plague (Jónsson 1944: 13-9; Karlsson 1996: 328-39). Whatever their cause, sources indicate that each epidemic reduced the Icelandic population significantly. There is no general consensus as to how many people were killed, some have suggested that as much as 50-60% of the population died in the first plague, and 30-50% in the second (Karlsson and Kjartansson 1994: 69-70), while other estimates have been more conservative. Steffensen (1975) estimates that a third of the population died in the first plague, and slightly fewer in the second one, as that did not reach all parts of the country (Steffensen 1975: 339). The 18th century also saw severe calamities. The first was the 1707-9 smallpox epidemic, *Stóra bóla,* during which an estimated 30-35% of the population died (Júlíusson 1990: 150-1; Steffensen 1975: 314-7). The second was *Móðuharðindin*, a famine which followed the 1783-4 volcanic eruption of the Laki fissure in southern Iceland. The emissions from the fissure caused fluoride poisoning in livestock. This, accompanied by an extremely cold winter in 1783-4 led to the death of an estimated 80% of the livestock over the nine month period of the eruption (Pétursson et al. 1984: 84-6). A famine swept the country and this, accompanied by a smallpox epidemic in 1785-7, resulted in the death of 20% of the population (Hálfdanarson 1984: 155-7). Records indicate that there were several epidemics and famines which affected the population during the first centuries of the occupation of Iceland. These include several

smallpox epidemics, each of which is likely to have had a profound effect, as smallpox never became endemic in Iceland due to the small size of the population (Jónsson 1944: 20-103; Steffensen 1975: 275, 314-7, 399-417). However, before the 18th century the records are scant. The descriptions of the diseases are ambiguous and quite often they are referred to in unspecific terms, for example *kynjasótt* (which translates literally as "peculiar illness"), so the scale of these calamities, in particular what their death toll was, is difficult to determine (Jónsson 1944: 9). What these do tell us though is that throughout its history Iceland has had several episodes where there population has been severely reduced, creating genealogical bottlenecks. It is important to be aware of these factors when discussing the genetic history of the Icelanders as it does raise the question of how representative genetic analysis of modern Icelanders is of the past population within the island.

2.2 Genealogy in Iceland

There is in Iceland a rich tradition in documenting family history. This can be traced back to the first centuries of the settlement, with *The Book of Settlements* (*Landnámabók*), the earliest extant versions of which date from the late 13th century. It tells of the settlement of Iceland and documents the names and places of origins of the earliest settlers by where within the country they settled and has through the centuries greatly influenced historical writers in Iceland (Friðriksson and Vésteinsson 2003: 140-1). Together the *Book of Settlements* and the *Sagas of Icelanders* contain a great wealth of genealogical information, to a large degree internally consistent, although its veracity is otherwise difficult to ascertain. These and other 13th-14th century sources focus on Iceland's elite from the settlement period down to the 13th century, but this period of intense historigraphic activity is followed by a hiatus which lasted into the 16th century. During this period the only genealogical data available is the limited information which can be gleaned from charters and letters. The 16th-17th century saw a rebirth in the interest in recording genealogies in Iceland, in particular those of high birth or standing. The earliest of these genealogical texts is by Þórður Jónsson from Hítardalur (d.1670), which focuses on high-born families from the 16th and early 17th centuries. This text formed the basis of many of the genealogical texts which followed in the 17th and 18th centuries. Iceland also has the earliest national census carried out in the world, completed in 1703, which is unique in that everyone living in Iceland at the time, whatever their social standing was included. The next national census was carried out in 1801 (although several censuses covering only part of the country were taken in the intervening period), followed by 1816, 1845, 1910 and 1920 (Ragnarsdóttir 2005: 14-5). The interest in documenting familial history as well as the rich data contained within the censuses has culminated in the creation of *Íslendingabók,* a genealogical database, created by Frisk Software, the construction of which started in the early 1990s. The

main sources of the database are the national censuses taken in Iceland between 1703 and 1930, church records and the up-to-date population register maintained by Registers Iceland (*Þjóðskrá*). Other sources of the database include for example the Sagas, charters and letters, annals, genealogical records, tenants' lists and obituaries (*Íslendingabók* 2011). Today approximately 650,000 individuals are included in this database (Pálsson 2003: 22).

2.3 The origin of the Icelanders

The interest in familial history is also reflected in the great interest in studying the origin of the Icelanders. In fact a clause in *Þórðarbók*, one of the surviving versions of *The Book of Settlements* dated to the 17th century but argued to copy a 13th century version of the text (Jóhannesson 1941: 19-36), states: "People often say that writing about the settlement is irrelevant learning, but we think we can better meet criticism of foreigners when they accuse us of being descended from slaves or scoundrels, if we know for certain the truth about our ancestry. And for those who want to know ancient lore and how to trace genealogies, it's better to start at the beginning than to come in at the middle. Anyway, all civilized nations want to know about the origins of their own society and the beginnings of their own race." (translation by Pálsson and Edwards 1975: 6). This text indicates that perhaps one of the reasons behind the writing of the book was to emphasise the noble birth of the original settlers of Iceland. Early scholarly research into the origin of Icelanders was dominated by analysis of *The Book of Settlements.* Hannesson (1925), for example, analysing the named individuals and the people associated with them concluded that 84% of the settlers originated from Norway, 3% from Sweden and 13% from the British Isles and Ireland. He also came to the conclusion that 33% of the settlers were noblemen, while 6% were slaves or freedmen (Hannesson 1925: 6-10).

By the latter half of the 20th century the validity of these early texts as factual records of the first settlers came increasingly under question. It was for example pointed out that as *The Book of Settlement* names mainly those of high birth, it cannot be used so literally to study the origins of the Icelanders (Guðmundsson 1938: 19-20; Sigurðsson 2000: 29-30; Steffensen 1975: 17). This criticism of focusing on the written sources coincided with a more critical approach to studying the origin of the Icelanders, for example through artefact typology (Eldjárn 2000: 473-5). In tandem with this was a greater emphasis on biological analysis, for example craniometrics (Steffensen 1975: 18-22), non-metric traits (Hallgrímsson et al. 2004; Steffensen 1975: 266-73) and blood group analysis (Bjarnason et al. 1973; Steffensen 1975: 261-3). Most of these biological studies indicated a much closer affinity with Ireland and northern Britain than is suggested by the 13th century writing. This supports the idea that the written sources cannot be viewed as accurate sources for the origin of the Icelanders. The heavy focus

on those of high birth means that a large proportion of the population is missing from the records. This creates a considerable bias, as stated by Sigurðsson, "A search for a substantial number of Gaelic people in Iceland must be concentrated on the anonymous masses." (Sigurðsson 2000: 30).

2.4 Genetics in Iceland

Much work has been carried out to look at the genetic origins of Icelanders. Early work involved the analysis of modern Icelanders, both mitochondrial DNA (mtDNA), the maternal lineage (Helgason et al. 2000a) and Y-chromosome dialectic and microsatellite variation, the paternal lineage (Helgason et al. 2000b). The premise for the research was that Iceland was settled by a relatively small founding population, originating mainly from Scandinavia and the British Isles, as discussed above. This would mean that virtually all DNA lineages observed in Iceland today are descended from the original set present in the founders 1,100 years ago. The aims of the studies were twofold. Firstly to analyse the ancestry of Icelanders and secondly to see whether there was evidence of a reduction of genetic diversity, compared with contemporary European populations due to the demographic bottlenecks of plagues and famines (Helgason et al. 2000a: 1000) which have already been mentioned (see chapter 2.1). The results indicated that the modern Icelandic genetic pool could largely be traced to Scandinavia and the British Isles, but the Y-chromosome analysis indicated that a greater percentage of the male founders originated from Scandinavia, around 80%, while the mtDNA analysis indicated that a majority of the females, around 60%, originated from the British Isles and Ireland (Helgason et al. 2001: 723; Helgason et al. 2000a: 1012; Helgason et al. 2000b: 714-5). Interestingly, the results also indicated that a large percentage of the female founders, around 20%, could not be traced to Scandinavia or the British Isles, and that it may be necessary to look to north-west and south-west Europe, and even the Near East (Helgason et al. 2000a: 1009), or the Americas (Ebenesersdóttir et al. 2010) to account for some of the mtDNA lineages present in the modern Icelandic population.

In addition to the above mentioned studies, analysis of mtDNA from 73 skeletal remains dating to the earliest settlement of Iceland have also been carried out. The results of these indicate that the present day inhabitants of Scotland, Ireland and Scandinavia (and several other European populations) are more closely related to the original settlers in Iceland, than their descendants, that is, the current inhabitants of Iceland. The results also supported those of the analysis of modern Icelanders, indicating that 65% of the matrilinear ancestry of the earliest Icelanders originated from Scotland and Ireland. As only approximately 35 generations have passed since the settlement, it is unlikely that its gene pool has diverged significantly due to mutations. There is no evidence, documented or otherwise, for large scale immigration into Iceland in the centuries after the initial settlement period ended, so the most likely explanation

for this indicates relatively high levels of genetic drift due to small population size. (Helgason et al. 2009: 1). Genetic drift is the random differential transmissions of alleles[2] between generations. What this process results in is the cumulative loss of alleles from a gene pool, and thereby reduced genetic variation. Genetic drift will have a greater effect the smaller the population, and so increases a gene pool's homogeneity. What increased homogeneity within a population means, is that shared phenotypes[3] between individuals, are more likely to be due to shared genetic material than would be the case in a more heterogeneous population (Helgason et al. 2003: 295).

This genetic characteristic of the Icelandic population coupled with the history of documenting familial history, resulted in deCode genetics, a genomics company located in Iceland, proposing the construction of a centralized health care database (The Icelandic Healthcare Database, hereafter IHD). This database was to contain information from the entire health care system in Iceland. The very ambitious function of the IHD was to provide "ideal opportunities to study interactions among genes and between genes and environment in the pathogenesis of common diseases. The ultimate goal is to discover new methods to diagnose, prevent, and cure common diseases" (Gulcher and Stefánsson 2000: 1827). In December of 1998 the Icelandic Parliament passed a bill authorising the construction of the IHD. This database can be seen to represent the core of a much larger project, the Icelandic Biogenetic Project, which allows, under very specific conditions, for the combination of medical records, genetic information and family histories. This is done by linking the database to records of all available national medical records dating back to 1918 as well as the *Book of Icelanders* genealogical database (Pálsson 2003: 20). This has allowed for extensive work to be carried out on the genetic nature of several diseases in Iceland, including osteoarthritis.

2.5 The genetics of osteoarthritis in Iceland

The study of the hereditary nature of osteoarthritis dates back to Stecher's publication in 1941 on the hereditary nature of Heberden's nodes, or osteoarthritis of the fingers, named for William Heberden (1710-1801), the English physician who first described the nodes near the joints of the fingers commonly associated with the condition (Stecher 1941; Stecher 1955: 1). This marked the beginning of a great deal of work on the familial nature of generalised osteoarthritis (cf. Kellgren et al. 1963). With the advent of DNA analysis, identifying the specific genes involved in the disease processes became a possibility (Ingvarsson 2000: 12). One of the aims of this study is to look at the

[2] An allele is one of a number of alternate forms of the same gene or group of genes (Calafell and Malats 2003: 389).

[3] A phenotype is an individual's traits or characteristics, whether or to what extent the traits are the result of that individual's genetic constitution or environment, or of the interaction of both (Malats and Calafell 2003a: 481).

relevance of research into hereditary osteoarthritis in modern Icelanders for the study of osteoarthritis in the Icelandic archaeological skeletal population. Therefore, although there have been several studies on the hereditary factors of osteoarthritis carried out elsewhere (cf. Spector and MacGregor 2004; Xing et al. 2013), the focus here will be on discussing the work which has been carried out in Iceland on the genetic nature of osteoarthritis to place the analysis of the Icelandic skeletal remains in context.

In 1992 in a special issue of the *Icelandic Medical Journal* devoted to rheumatoid diseases, Þorsteinsson stated that "It is my belief that the solution to the arthritis puzzle lies in part with analysis of arthritis-families, and many such families can be found in Iceland." (Þorsteinsson 1992: 314. Translation my own). In 1997 Jónsson and Steinsson published a letter in the *British Journal of Rheumatology* outlining the potential for genetic research in the field of rheumatology in Iceland and published a distribution map of families with rheumatology disorders in Iceland, as well as referencing the work carried out in the field to date (Jónsson and Steinsson 1997). This work culminated in the setting up of the osteoarthritis (OA) team at deCode in 2000. The team initially focused on the study of osteoarthritis of the hips and the hands, and later included the study of osteoarthritis of the knees. The OA-team used a genealogical approach to their analysis. This involved patient lists from clinicians being run through the encrypted genealogical database to create large extended pedigrees containing multiple patients. These individuals as well as their unaffected relatives were then asked to take part in the study by contributing blood samples for genotyping[4] (Gulcher et al. 2001: 266). The OA-team then used linkage analysis[5] of the sample to study the genetics of osteoarthritis. "The primary aim of linkage analysis is to determine whether there exist pieces of the genome that are passed down through each of several families with multiple patients in a pattern that is consistent with a particular inheritance model and that is unlikely to occur by chance alone" (Gulcher et al. 2001: 264). In addition, the kinship coefficient (hereafter KC) was calculated. This is a measure of the genetic relationship of two individuals, the probability that a randomly chosen allele from each of a pair of individuals in a population is inherited from a common ancestor (Jónsson et al. 2003: 392).

2.5.1 Osteoarthritis of the hip

The initial focus of the OA-team was on osteoarthritis of the hip. This followed the publication of a study of 17 siblings (born between 1917 and 1943), 14 of whom had osteoarthritis of the hip. Their mother and all five of her siblings who had survived to adulthood also had degenerative changes of the hips. Their maternal grandmother (born

[4] Genotyping is the process of determining the genotype of an individual, a genotype being an individual's genetic constitution (Malats and Calafell 2003a: 480).

[5] Linkage analysis is a strategy for gene mapping by testing for linkage between markers and phenotypes using families (Malats and Calafell 2003b: 563).

in 1875) had been a midwife, but had to stop working around the age of forty because of pain and stiffness in her hips (Ingvarsson and Baldursson 1991: 150-1). Her father, born in the mid-19th century, was also said to have had a crippling disease of the hips, which resulted in him being unable to walk in his final years (Ingvarsson et al. 2001: 2549).

In a study of 1517 Icelanders (644 men and 873 women) aged over 35, 12% of the men and 10% of the women were found to have osteoarthritis of the hips. This is very high, in particular when compared to similar studies in Malmö (2.3%), Gotland (4.5%), Denmark (4.7%) and England (2.0%). In addition the disease is observed in much younger individuals in Iceland than in the comparative samples. The authors of the study concluded that although the risk factors of idiopathic osteoarthritis are not well understood, the fact that the increased prevalence in both men and women, and the fact that it is seen in young individuals, means that hereditary factors are likely to be the main explanation for the high prevalence of hip osteoarthritis in Iceland (Ingvarsson et al. 1999: 205-7). Another population based study of total hip replacement due to idiopathic osteoarthritis which combined information from the encrypted genealogical database with the national register of all total hip replacements performed in Iceland between 1972 and 1996 demonstrated similar results. The genetic contribution was assessed by identifying family clusters of osteoarthritis patients with total hip replacements. The minimum founder test[6] was then applied to estimate the minimum number of ancestors that would account for the genealogy of all 2713 patients with total hip replacement for idiopathic osteoarthritis (Ingvarsson et al. 2000: 2785). To ensure that any familial clustering of total hip replacement patients was significant, 1000 independently drawn matched control sets were drawn using the genealogical database. The results indicated that the minimum number of founders needed for the list of patients with total hip replacement were at all times fewer than the average minimum number of founders needed for the control lists (Ingvarsson et al. 2000: 2786-8). To analyse the influence of environmental factors on the affected familial clusters, the KC calculations were also done with removal of all first- and second degree relatives. The results showed that although the difference between patients and controls was reduced, it was still significant, leading to the conclusion that the impact of environmental factors was minimal, as it was shown that the familial component in hip osteoarthritis extends multiple generations beyond the nuclear family (Ingvarsson et al. 2000: 2790-1).

Rare familial forms of osteoarthritis are known. These have a Mendelian inheritance[7] and are associated with specific mutations in genes encoding macromolecules expressed in cartilage and/or bone. These are however unusual forms of osteoarthritis, and are associated with dwarfism, congenital or early-onset anatomic abnormalities of joints, and

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[6] The minimum founder test assesses whether individuals within the study are more related to each other than the general population (Ingvarsson 2002: 40).

[7] Mendelian inheritance is a simple pattern of inheritance, determined by just one genetic locus. Mendelian inheritance can be dominant, recessive, or sex linked (Malats and Calafel 2003a: 481).

dysplasia (Stefánsson et al. 2003: 1449). It is worth noting that one of these rare mutations, associated with spondyloepiphyseal dysplasia and precocious generalised osteoarthritis, is known in an Icelandic family. The same identical mutation has been found in four other families, three from the U.S., one of British ancestry, one of Norwegian ancestry and the third of Belgian ancestry; the fourth family is from New Zealand with Irish ancestry. Analysis suggests that the chance of these mutations not being linked is very limited, and so the authors suggest that they are most likely traceable to a common ancestor, possibly of Celtic origin (Bleasel et al. 1998: 173-5).

The studies presented above, however, suggested that the common forms of osteoarthritis have genetic components that are unlike the known structural genes that are mutated in the rare familial forms of osteoarthritis (Ingvarsson et al. 2001: 2548). However, extensive radiological as well as histological findings of the Icelandic family with four known generations of hip osteoarthritis, mentioned at the start of this section, did not demonstrate any epiphyseal dysplasia or other joint disease; in other words, the degeneration was indistinguishable from idiopathic hip osteoarthritis. A genome wide scan of the family indicated linkage on chromosome-16p using nonparametric multipoint linkage analysis. In other words it is possible to demonstrate a genetic link not only for the unusual types of secondary osteoarthritis which are associated with abnormalities, but also for idiopathic osteoarthritis of the hip (Ingvarsson et al. 2001: 2553-4).

2.5.2 Osteoarthritis of the hand

As already stated (see chapter 2.5), one of the earliest studies of the inherited nature of osteoarthritis, was Stecher's study of Heberden's nodes (Stecher 1941), so the possibility of the inherited nature of osteoarthritis of the hand has been under discussion for quite some time. A 1996 study of hand osteoarthritis, focusing on the 2nd & 3rd distal- and proximal interphalangeal joints (hereafter DIP & PIP) and the 1st carpometacarpal joint (hereafter 1st CMC) of both hands, was carried out on 244 individuals in an Icelandic nursing home, where seamen have a certain priority (Aspelund et al. 1996: 34). The results showed that 3.3% of the men and 6.8% of the women demonstrated osteoarthritis of the hands. No significant difference was seen between the right and left hand, and no occupational difference seen between the former seamen and non-seamen, so no evidence was found to support a link between work-load and hand osteoarthritis. This led the authors to speculation on the inherited nature of the disease (Aspelund et al. 1996: 35-6).

To try and determine the mode of this inheritance, a study was set up by the OA-team which used 2919 patients (ratio of women to men 5.2:1) listed in the Icelandic hand osteoarthritis database, which was then cross-referenced with the encoded genealogical database. As a control 1000 individuals were selected, matched by year of birth and number of ancestors in the genealogical database. The results supported the higher incidence rates of hand osteoarthritis in women shown in the previous study. This difference increased with the severity of the disease; 7.4:1 in patients with severe DIP/PIP involvement, 9.5:1 in patients

with severe 1st CMC involvement and 18.8:1 in patients with severe osteoarthritis at both sites. A significant degree of relationship was demonstrated within the patient group, and this remained when the KC was calculated removing the 2nd and 3rd degree relatives, so demonstrating a familial rather than a shared environmental factor behind the disease. However, the authors do suggest that the joint distribution may be influenced by environmental factors (Jónsson et al. 2003: 392-3). Subsequent work has suggested that candidate gene for osteoarthritis may be *MATN3*, which encodes the noncollagenous cartilage extracellular matrix protein, matrilin-3. Matrilin-3 is one of a class of four related proteins which are expressed in the developing skeletal system, but matrilin-3 exhibits the expression pattern most restricted to developing cartilage. However, mutation in *MATN3* was only seen in a few of the patients in the study, which seems to indicate that it only explains a small fraction of hand osteoarthritis (Stefánsson et al. 2003: 1456-7) so clearly other aetiological factors are involved.

2.5.3 Osteoarthritis of the knee

The biomechanical factor in the development of knee osteoarthritis is well known, with the main risk factor for osteoarthritis of the knees being body weight or the body mass index (BMI). The familial factors of knee osteoarthritis have not been specifically studied by the OA-team, so it will get more of a scant treatment here than the joints of the hip and the hand. However, a cross-sectional, population based study of 5170 elderly individuals, carried out as a part of the AGES-Reykjavik study (Age, gene/environment susceptibility), has demonstrated a link between hand osteoarthritis, and in particular the severity of the hand osteoarthritis and total knee replacement due to osteoarthritis. These appeared to be statistically independent of the effects of BMI (Jónsson et al. 2011: 8-9).

2.6 Concluding remarks

The above studies have not pinpointed the genetic causes of these three forms of osteoarthritis; hip, hand and knee. They have however, demonstrated through the use of the genealogical database and calculations of the kinship coefficient, the familial nature of these types of osteoarthritis in Iceland. It is in this context interesting to note preliminary meta-analysis of published data of several studies (including the Icelandic studies) looking at the genetic nature of osteoarthritis. One example of this is a 2009 study of individual level-data from 14 teams, including the Icelandic team, which focused on the relationship of various polymorphisms[8] with osteoarthritis phenotypes. This study was then the largest study of the genetic effects of osteoarthritis. The results were inconclusive and the conflicting results left uncertainty with regard to the effects of these polymorphisms. The results did indicate a

[8] In molecular epidemiology, gene polymorphisms are some of the indicators used to explore genetic susceptibility to develop a disease (Malats and Calafell 2003a: 481-2).

strong support for a specific polymorphism as a determinant of risk of osteoarthritis, with the strongest and most consistent evidence for knee osteoarthritis. However, the scale of the effect was much smaller than had been originally proposed (Evangelou et al. 2009: 1718-9). The authors conclude that the "diversity between populations of different racial descents may reflect different linkage disequilibrium patterns and may even indicate that this marker is not necessarily the true or only culprit" (Evangelou et al. 2009: 1719). A more recent study has supported this, and suggests that common single-nucleotide polymorphisms are unlikely to play a great part in the aetiology of osteoarthritis. In 2011 there were only two established osteoarthritis loci which both have a small common odds ratio, and the authors suggest that the genetic architecture is likely to consist of numerous signals of similar magnitude (Panoutsopoulou et al. 2011: 866). It is worth noting that work in this field is on-going, including by the OA-team (Jónsson, H. Personal communication, 2nd December 2013).

The results of meta-analysis as discussed above raise the question how valid these studies of the genetics of osteoarthritis are at a global scale. Indeed, it has been pointed out that there is a need to carry out much more extensive studies with very careful definitions and measurements in order to understand the effects of common genetic variants on osteoarthritis outcomes (Evangelou et al. 2009: 1719). However, these points are perhaps not relevant to the current study. There is no question that the studies do demonstrate a clear familial link behind specific types of osteoarthritis within Iceland, and so one must ask how these modern studies can be significant for palaeopathological analysis of the archaeological material?

3 The skeletal material

This chapter introduces the sites from which the collections used in this study originate. The sites date from the earliest settlement of Iceland until the 19th century, so to some extent it is necessary to place the sites within the context of the history of Iceland. To achieve this, a very brief summary will be presented (for an overview see Karlsson 2000), to attempt to contextualise the discussion that follows.

Documentary sources, archaeological- and environmental evidence all support a late AD 9th century settlement of Iceland. There most likely were isolated visitors to the island prior to this, for example, stories exist of Irish monks living as hermits on the island, although no archaeological evidence supporting this has been found. However, shortly after a large volcanic eruption in AD 871±2 which covered most of Iceland in a blanket of volcanic ash (tephra), a sustained settlement of the island started (Vésteinsson 2000a: 164-5). Archaeological evidence indicates that the process of settlement in Iceland was extremely quick, that most of the habitable areas were occupied within a few decades. It also appears that the process was organised. Rather than lots of small isolated settlements or single family groups, large tracts of land were settled by groups or individuals who then organised the occupation of that land very systematically in single farms in dispersed settlements. The early economy was based on animal husbandry, hunting and fishing (Vésteinsson 2000a: 167-8). Iceland remained rural until the urbanisation of Reykjavík which started in the middle of the 18th century (Gunnlaugsson 1986: 21). The prevailing view is that the distribution of the settlement; the locations of the farmsteads, and the divisions of the land remained relatively static from the medieval period and into the 19th century (Vésteinsson 1998: 148).

The early settlers were mostly non-Christian, judging from their burial customs. Not much is known about the nature of paganism in Viking Age Iceland, but what we do know comes mostly from excavated graves. The Viking age burials (hereafter *kuml*) occur as single inhumations or small cemeteries, the largest of which excavated to date contained 13 individuals (Eldjárn 2000: 163-70). However, it has been speculated that the single inhumations are not the norm, but rather reflect the nature of their discovery and excavation. Many of them were rescue excavations carried out in the early 20th century, when only the disturbed grave was investigated, and in some instances this just involved picking up the disturbed bones and artefacts, no excavation. Where an excavation was carried out, the area surrounding the burial was rarely investigated (Eldjárn 2000).

The small plots tend to be located either just outside the home-field, or on farm-boundaries and/or roads. This has been interpreted to mean that each plot only served the farm it stood on, so that each cemetery can be seen to represent a single household (Friðriksson 2009: 10-2). Several problems exist; there are for example very few

children in these cemeteries, and almost twice as many males as females, indicating some sort of selective process as to who gets buried in these sites. The *kuml* themselves tend to be shallow pits and usually contain some grave goods and frequently animals, usually horses. They were probably never covered with anything more than a small mound, if that. They are always inhumations with the bodies placed either in a supine position with straight arms, or on their side in a foetal position. Coffins or other furniture is rare (Friðriksson 2004: 57-9). Frequently these graves have been disturbed in antiquity, in instances when the disturbance can be dated it has been seen to be pre AD 1477 or even 1300 (Friðriksson 2012: 58; Magnúsdóttir 2009: 36). The reasons for the disturbance of the *kuml* are surprisingly little debated. Usually it is explained as being due to the acquisition of artefacts, in particular iron from the grave goods (Eldjárn 2000: 263). The nature of the disturbances are, however, very varied which would seem to suggest that perhaps various factors are at play. The effect the disturbances have had on the skeletal material ranges from partial disturbance of skeletons with reburial of the disturbed bones; to disturbance of the entire burial with reburial of the bones within the re-cut; to isolated human bone finds within the back-fill, to no human skeletal remains being present in the burial. There is, as has been pointed out (cf. Pétursdóttir 2009), a problem with a lack of interpretation of these sites. The concept that the disturbance of the graves could be part of the ritual process has hardly been explored. This of course highlights inherent problems with the interpretation of the nature of these burials, as well as carrying out osteoarchaeological analysis of the skeletal remains. For example, if the disturbance of the graves is a part of the funerary process, there could be some sort of selective process behind the removal of the bones, which could in turn influence what material is preserved within the grave. Another factor which influences the preservation of the skeletal material from the *kuml* is related to the nature and small size of the *kuml.* This means that their discovery has been (especially in the earlier part of the 20th century) largely the result of some sort of a disturbance, either through natural erosion or development, in particular road work (Eldjárn 2000: 258-61). This means that between the initial deposition of the body and the excavation or recovery by the archaeologist, many burials have been disturbed at least twice.

These *kuml* represent the earliest form of burial in Iceland, dated through radiocarbon dating, tephrochronology (volcanic ash dating) and typology to the late AD 9th century to the mid-late 11th century (cf. Friðriksson 2009: 10, 19). This is consistent with the dating of the conversion of Icelanders to Christianity. The *Book of Icelanders* (*Íslendingabók*), a chronicle of the early history of Iceland written by Ari Þorgilsson in the early 12th century, gives an account of how Iceland was converted to Christianity by chieftainly consent at the *Alþing* (the Icelandic general assembly, founded in the early 10th century) in 999 or 1000 (Karlsson 2000: 11, 33).

It has been suggested that the earliest Christian cemeteries most likely followed the same pattern as the established *kuml* plots, small farm based burial grounds, with the

main changes being the nature of the burials, and the speculation is that while the *kuml* appear to be associated with only one farm, the early Christian most likely served 2-3 farms (Friðriksson and Vésteinsson 2011; Vésteinsson 1998: 153-4). This hypothesis has been supported by recent work in Skagafjörður in northern Iceland. It has been demonstrated that most of the major farms in the region had by the 11th century their own cemetery. Many of these were still in use during the 12th century, but had been abandoned before 1300, and there are indications that the intensity of burials in these smaller farm based plots decreased by the middle of the 12th century, possibly associated with the establishment of the see of Hólar in Skagafjörður in 1106 (Zoëga 2009: 31). This is again consistent with the documentary sources. In 1097 a tithe law was introduced, providing revenue for the emerging church organisation, which led to the formation of the first parishes by the end of the 13th century (Vésteinsson 2000b: 67-8, 92). This period would have seen the change from the small farm based cemetery plots to burial within parish graveyards.

The earliest excavated Christian cemeteries can be dated to the late 10th century AD (cf. Sayle et al. 2014: 816-9; Sveinbjörnsdóttir et al. 2010: 688; Zoëga and Traustadóttir 2007: 71). They are always on clearly demarcated plots, surrounded by some sort of boundary wall. In all instances where such sites have been excavated, the arrangement within the cemetery has been a central structure, oriented east-west surrounded by burials which are aligned with the contemporary church. The graves themselves are in most instances single inhumations, although there are some occurrences, in particular in later burials, of children being placed in graves with adults. There is often some sort of a wooden coffin, although this seems to be less common the earlier the burial. There is sometimes evidence of material being placed within the coffin, saw dust, wood ash or charcoal, in a few instances pillows, but very rarely anything which could be classified as grave-goods in the pagan sense. The body is most commonly placed in a supine position within the grave, the legs straight and parallel to each other, or crossed at the ankles. The arms are either parallel to the body or crossed over the pelvis, abdomen or chest (Vésteinsson and Gestsdóttir 2011: 86-9).

3.1 Pre-Christian Viking Age burials (*Kuml*)

The skeletal material from the *kuml* does not come from one site. As mentioned in the preceding section, the largest site excavated to date only contained 13 burials, and a large proportion of the material is isolated grave finds. However, this is the only material which exists from the first century of the settlement of Iceland, and it also represents a large part of the available skeletal material in Iceland, so it was decided to attempt to include the best preserved skeletons from *kuml* as one study group. To date, over 320 *kuml* burials have been excavated from approximately 160 sites (Friðriksson 2004: 57). From these approximately 200 skeletons have been recovered and are stored

in the National Museum (Gestsdóttir 2004b: 79). Of these, the best preserved 69 were selected for this study, originating from 37 different burial sites. The selection was based on a study carried out in 1999, the aim of which was to assess the preservation of all the skeletal material from *kuml* graves in Iceland, at the time a total of 182 skeletons. All the skeletons which were recorded to have over 50% preservation were included (59 skeletons in total). It was also decided to include all skeletons from each site selected, so in those instances where the preservation of the skeletal material from the site was varied, a further 16 skeletons with less than 50% preservation were included in the original study (Gestsdóttir 1999: 14). However, during the analysis six of the poorest preserved skeletons were found not to have any joints preserved, and so were removed from the final count.

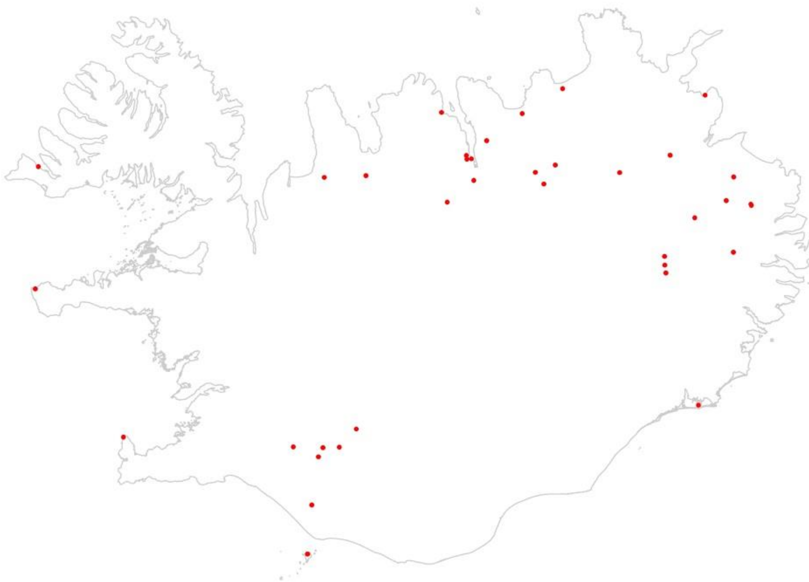

Figure 3.1: Map showing the location of the kuml sites used in this thesis

3.2 Skeljastaðir in Þjórsárdalur

The site of Skeljastaðir is in Þjórsárdalur in southern Iceland. It sits on the edge of a small gully at the base of mount Skeljafell (Gestsson and Briem 1954: 18). No contemporary records of the site exist. The earliest document which mentions a church at the site is from 1709, when it is included in a list of abandoned farms in Þjórsárdalur. However these records only say "Skeljastaðir, there is a church" (*JÁM II* 1918-1921: 218, within a footnote in the publication, translation my own). In a description of the parish of Stóri Núpur dating to 1839 the erosion of the cemetery at Skeljastaðir is noted,

with skeletal remains lying exposed in the sand (Vigfússon 1979: 100). Several anecdotal stories exists about the removal of human bones from the site in the 19th and early 20th century, either by natural forces or people carrying with them exposed skeletal remains (Gestsson and Briem 1954: 19; Ófeigsson 1928: 22).

Figure 3.2: Map showing the location of the Christian cemeteries used in this thesis

The first excavation at the site was carried out by Þorsteinn Erlingsson in 1895. He only excavated part of the farm house, although he does describe attempting to rebury or cover with sand exposed skeletal remains (Vigfússon 1979: 29-30). In 1935 Eiður Kvaran visited Skeljastaðir and removed 20-30 skeletons. These he took with him to Greifswald in Germany. Kvaran died there in 1939 and the skeletal remains were subsequently lost (Þórarinsson 1968: 53-5). The final excavation at the site was carried out by Matthías Þórðarson in 1939 as a part of a Nordic archaeological expedition in the valley. The farm houses at Skeljastaðir, as well as what remained of the cemetery were excavated, a total of 63 burials. The farm stood slightly up-slope from the cemetery, to the west of it. No remains of a church were found at the site. However the remaining burials were found in a 'U'-shape around an empty area approximately 4x8m wide, where it is most likely that the church stood (see figure 7.3). All the burials which remained at the site were west of this area, suggesting that most of the eroded burials were from the lowest part of the slope, to the east of the church (Þórðarson 1943: 133-6).

Radiocarbon dating of seven skeletons from Skeljastaðir has provided a date range of 890-1220 (Sveinbjörnsdóttir et al. 2010: 688). This contradicts earlier dating of the

cemetery to c. 1000-1104. This was mainly based on tephrochronology, and the research carried out by the geologist Sigurður Þórarinsson, which started during the Nordic expedition in 1939. Þórarinsson concluded that the entire valley was abandoned following an eruption in Mount Hekla in 1104, and the dating of the end of use of the cemetery at Skeljastaðir was based on this (Þórarinsson 1968: 52). However, there is no evidence that the 1104 (or any other tephra) remained *in situ* at the site. The fact that the intercutting of burials is rare at the site was seen as an indicator that the cemetery was not in use for a long time. In other words, the location of earlier burials was known when each new grave was cut. The use of the 1000 date is influenced by the fact that this is the documented date of the conversion of Icelanders to Christianity (Steffensen 1943: 231-4), rather than the results of the archaeological investigation. The more recent 13th century date for Skeljastaðir is supported by studies which have demonstrated that Þjórsárdalur was occupied, although on a smaller scale than before the 1104 eruption, into the 13th century (Dugmore et al. 2007; Vilhjálmsson 1996).

The cemetery appears to have been rather small, no more than 20m in diameter, and there is, as already mentioned, little intercutting of burials. The graves were all oriented the same way, northwest-southeast. Due to the erosion of the site it is difficult to determine the original depth of the graves; however the deepest preserved depth was 50cm. Evidence of wooden coffins was found in most of the adult graves. The individuals within them were all buried in a supine position. Their arms were in most cases laid out with one stretched out, parallel to the body and the other over the abdomen. The legs were straight and the feet either next to each other, or crossed at the ankles (Þórðarson 1943: 133-6).

3.3 Hofstaðir in Mývatnssveit

The farm of Hofstaðir in Mývatnssveit in northern Iceland lies to the west of Lake Mývatn, and is bordered on the west by the river Laxá. A Viking Age hall lies within the home-field of the Hofstaðir farm, west of the current farmhouses and up against a small scarp that demarcates the arable part of the home-field (the home-field boundary lies on top of the scarp). Excavations there, carried out under the direction of Gavin Lucas between 1996 and 2002, indicate that the hall was built in the middle of the 10th century (Lucas 2009b: 55-7). The site of the church and cemetery at Hofstaðir is within the home-field of the modern farm, 80m southwest of the Viking Age hall, up against the eastern edge of the old farm-mound, which was abandoned in the middle of the 20th century.

Documentary sources mentioning the church at the site are scarce. The only contemporary document is a letter of sale of several farms including Hofstaðir, dated April 12th 1477, which stipulates that there are church dues to be paid of Hofstaðir, indicating that there was an obligation to maintain a chapel on the farm (*DI VI* 1900-4: 109-10). An earlier document possibly refers to Hofstaðir. This is an inventory for the

parish church at Reykjahlíð, where there is a mention that the church gets dues from four chapels, although none of them are named (*DI II* 1893: 429-30). In a survey of the Hofstaðir farm from 1712, it is stated that a church once stood on the Hofstaðir farm, but that it was long since abandoned (*JÁM XI* 1943: 242).

Archaeological investigations at the cemetery started in 1999, with a geophysical survey of the part of the home-field known to locals as *Kirkjugarðurinn (The Cemetery)*. This revealed a circular feature, approximately 30m in diameter with a central structure, typical of early medieval cemeteries in Iceland (Horsley and Dockrill 2002: 26-8). Excavations of the site were carried out by the author between 2000 and 2004. Work on the site then started up again in 2010 and is on-going. The excavations have revealed at least two, possibly three phases of church structures in the centre of a circular area bordered by a turf wall. Little remains of the earliest church, which appears to have been deliberately demolished, except post-foundations and remains of a trampled floor surface containing birch branches. Radiocarbon dates from the birch indicate that it is from the late 10th/early 11th century (Gestsdóttir 2004a: 6-7; Gestsdóttir 2006: 12-3). The later church was built on the same spot as the earlier one, although the later church was slightly smaller. Tephrochronology indicates that this later structure was built before the 1300 eruption in Katla, which also seals all the burials within the cemetery. The earliest graves clearly respect the oldest structure on the site, and recent radiocarbon dating of six of the skeletons from the site dated from 695-1148, although this range can be tightened in some instances as many of the burials clearly post-date the tephra from the 940 eruption in Veiðivötn (Gestsdóttir and Isaksen 2011: 12; Sayle et al. 2014: 816-9).

To date, 122 skeletons have been excavated at Hofstaðir, mostly from *in situ* burials, although there are four examples of redeposited graves. There is clear organisation of the cemetery, as seen in other medieval cemeteries in Iceland. Females are mostly buried in the northern half, males mostly in the southern half and children up against the church; in particular up against its southern wall. The burials are all inhumations. The grave-cuts are very tightly spaced with a lot of intercutting, especially in the area where the children are buried. All the burials are supine with the hands usually resting on the abdomen or alongside the body (see figure 7.2). About half of the adult burials were in simple wood-coffins of which nothing survived except wood-staining of the soil. The surviving depth of the burials ranged between 30cm (in areas where there had been levelling of the land for agricultural purposes in the middle of the 20th century) to about 80cm (which represents the maximum depth of the burials while the cemetery was in use. Preservation in the cemetery was on average good and in most instances quite consistent although there were a couple of locations where variations had clearly caused the creation of micro-environments within the cemetery. An example of this is the small porch which had been added to the later church on top of three graves located immediately west of it. This resulted in poorer preservation of the skeletal material in these graves than in the rest of the cemetery (Gestsdóttir 2006: 5-12).

3.4 Haffjarðarey on Löngufjörur

Haffjarðarey is a small island located on Löngufjörur in Haffjörður, within the estuary of Haffjarðará, on the western coast of Iceland. The island is very small, today only approximately 0.25km². The island (also known as Bæjarey) is the largest in a cluster of three, which are accessible from land by foot at low tide (Hjörvar 1932: 10). The earliest documented source for a church in Haffjarðarey is a church inventory traditionally dated to around 1200 which lists all the churches requiring priests in the diocese of Skálholt, (*DI XII* 1923-32: 11). More recently the dating of the church inventory has been brought into question. It has been argued that it was a working document to keep a record of the churches within the diocese, and although it most likely originated around 1200, it was regularly updated until the early 14th century. What this means is that it is impossible to know which churches were in the original record, and which are later additions. The inventory can therefore only securely be seen to be a record of the 14th century churches in the diocese of Skálholt (Vésteinsson 2012: 128). There is also a charter for Haffjarðarey church dated to the 13th century (*DI I* 1857-76: 421-3). Although the earliest records for the church at Haffjarðarey date to at least 13th century, it is not known when the church came into use, and it is quite likely that it started out as a farm-based church and cemetery, the same as Hofstaðir and Skeljastaðir. We do know that Bishop Gísli Jónsson deconsecrated Haffjarðarey in 1563, possibly because coastal erosion had made accessing the island more difficult (*DI I* 1857-76: 421-3). Haffjarðarey served as a parish church for all of Eyjahreppur (Bjarnason 1970: 51-2), which means that people would have been brought from the mainland to be buried in the cemetery, which is likely to have been problematic, both because of its location on the periphery of the parish, and due to the fact that access to Haffjarðarey was hampered by the sea (Vésteinsson 2012: 98-9). Folk tales from the region say that several churchgoers drowned by falling through the ice on their way home from mass on Christmas Eve 1562, which resulted in the abandonment of the church the following year (Kristjánsson 1935: 2). The dating of the cemetery is therefore from at least the late 13th century to the latter part of the 16th century. Jón Steffensen, who excavated in the cemetery in 1945 suggests that the cemetery was in use for five centuries; i.e. from around 1000 (Steffensen 1946: 144). He however, has little to base this on other than the documented date of the conversion of Icelanders. By the early 18th century the island and the cemetery were suffering greatly from erosion. The last farmer left the island in 1708 (*JÁM V* 1931-3: 45-7). It is documented that in 1883 a group of locals gathered up the eroded skeletal remains and reburied them in a single pit, counting a total of 109 skulls in the collection. In 1905 Vilhjálmur Stefánson visited the island and took away with him at least 50 crania, most likely from eroded burials, rather than carrying out any excavations. These remains are currently housed at the Peabody Museum, Harvard University in Cambridge, Massachusetts. Shortly after Stefánson's visit, locals visited

the island again and gathered all the exposed skeletal material and reburied it at the cemetery of Miklaholt (Hooton 1918: 53; Steffensen 1946: 146-7).

The skeletal material housed at the National Museum and used for this study was excavated in 1945 by Jón Steffensen and Kristján Eldjárn, who visited the island with the specific aim of rescuing all the burials they could from the erosion. No structural features had survived, so it was not possible to determine the size or the shape of the cemetery. They excavated 24 *in situ* inhumations as well as disarticulated bones from at least 34 other individuals. The burials were found in two erosion faces, approximately 9m apart, and the fact that no burials could be seen west of the western-most grave led the excavators to suggest that perhaps they were in the south-western corner of the cemetery. All the *in situ* burials were supine inhumations, oriented east-west (with the head to the west) and the hands crossed over the abdomen or the chest. Clear coffin remains were found in only one grave. Most of the burials had been cut into the sand, only four were found cut into the underlying soil. The sand seems to have had a favourable effect on the preservation of the material, which is remarkably good, in particular when one takes into consideration the erosion of the site. Due to the erosion it was difficult during the excavation to determine the original depth of the grave cuts; however the deepest surviving depth was 90cm. The burials were very tightly spaced, with a great deal of intercutting, and even stacking of graves, with up to three skeletons being found one on top of the other (Steffensen 1946: 147-51).

3.5 The Reykjavík sites

The Reykjavík sites are a skeletal collection formed by combination of two contemporary cemeteries from the Reykjavík area, Víkurkirkjugarður and Viðey.

3.5.1 Víkurkirkjugarður in Reykjavík

The old cemetery in Reykjavík, Víkurkirkjugarður, is situated in the modern city centre, within what is today a small square known as Fógetagarðurinn. The area is bordered on both the north and east side by modern buildings and streets to the west and south, Aðalstræti and Kirkjustræti respectively.

The oldest documented evidence for a church at this site is again the church inventory which lists all the churches requiring priests in the diocese of Skálholt. As already noted (see discussion chapter 3.4), this is traditionally dated to around 1200 (*DI XII* 1923-32: 3-9). However, recently this has been refuted, and the argument presented that the inventory was regularly updated until the early 14th century (Vésteinsson 2012: 128). All this tells us therefore is that a church was in Reykjavík by the early 14th century; when it came into use is unknown. It is quite likely that a church was established much earlier than the oldest records, due to the early occupation of Reykjavík in the late 9th century (Eldjárn 1974: 19-21; Nordahl 1988: 11-2, 110-4;

Roberts et al. 2003: 230-1). We do know however, that the last church built on the site was constructed in 1770, a wooden church which replaced an older turf built structure. In 1785 it was decided to move the bishopric from Skálholt to Reykjavík and in 1787 the construction of the new cathedral commenced, 150m east of Víkurkirkja. The construction of the cathedral finished in 1796. It was consecrated in that same year, and the old church deconsecrated. However, the use of the cemetery for burials continued until 1838 when Hólavallakirkjugarður replaced it. For the last few years the cemetery was in use there were frequent complaints that it was far too small for the growing population of Reykjavík (Líndal 1987: 86-7; Stephensen 1996: 43-80).

The skeletons stored in the National Museum from the cemetery are from two separate excavations, both carried out due to development work in the area. The first excavation was carried out in 1940 (skeletons coded RVK-A-XXX). This excavation remains entirely unpublished. The second was an excavation carried out in 1967 (skeletons coded RVK-C-XXX) by Gísli Gestsson and Þorkell Grímsson because of the construction of Landssímahús on the northeast corner of Fógetagarðurinn (Eldjárn 1969: 133). Based on the location of the burials, the fact that they are not truncated by later graves, and the artefacts found with them (e.g. buttons), the skeletons excavated most likely belong to the last phase of the cemetery. There are no records describing the nature of the burials.

3.5.2 Viðey in Kollafjörður

Viðey is the largest island in Kollafjörður in south-western Iceland. The island, which is approximately 1.5km² (Líndal 1988: 159-60) lies just outside the Reykjavík harbour. Archaeological excavations in the island have demonstrated that its settlement dates back to the $10^{th}/11^{th}$ century (Kristjánsdóttir 1995: 45). In 1226 a monastery was established on the island and operated there until the middle of the 16th century. In the middle of the 17th century a hospital or hospice was set up in Viðey, most likely to house lepers and the disabled poor. The hospice was in operation in Viðey until 1752 when it was moved to Gufunes. The previous year governor Skúli Magnússon had moved to Viðey, and after that and into the 19th century, it continued to be the residence of government officials (Kristjánsdóttir 1995: 29-30).

The earliest documented evidence for a church in Viðey is dated to the late 12th century, with a reference to priest Bjarni in Viðey in a story describing a miracle of Saint Þorlákur (*Biskupasögur II* 1878: 350). It is of course not known when the first church was built in Viðey, but considering the early occupation of the site, it is quite likely that it was earlier than the first documented date. The cemetery which surrounds the church probably came into use at the same time as the first church, and it is still in use today. At least four churches have stood there before the current church, which was built in 1774. This last church is oriented northeast-southwest (like the contemporary Viðeyjarstofa, the manor house which stands next to the church), with its entrance to the

southwest, towards Reykjavík. The older structures on the site were all oriented closer to the expected east-west (Hallgrímsdóttir 1993: 142-4), as is the norm for Christian churches in Iceland.

Excavations of the cemetery in Viðey were carried out in advance of restoration of the church and Viðeyjarstofa between 1987 and 1989, under the direction of Margrét Hallgrímsdóttir (Hallgrímsdóttir 1989: 3). Although a total of 91 burials were excavated, not all were lifted and the 24 skeletons available for analysis were all from an area west of the church, between it and Viðeyjarstofa. These burials were all oriented northeast-southwest, like the latest church, while older burials are oriented east-west. The skeletons used for this study from Viðey are therefore all dated to after 1774, when Viðey church was consecrated (Hallgrímsdóttir 1991: 121). Most of the older burials at the site were truncated by later graves, a testament to the long period of use. However most of the later burials used in this study were untouched. The depth of the graves is not recorded in the excavation report; however all the skeletons were found within preserved wooden coffins, in a supine position with their legs straight and in some instances crossed at the ankles, while the hands crossed either over the pelvis or the abdomen (Hallgrímsdóttir 1989: 43-8).

3.6 Discussion

It is important to place these sites within the context of the nature of the populations which the skeletal collections derive from. As already stated, the *kuml* skeletons do not derive from a single cemetery or population, rather from 36 different sites distributed all over the country, and dating from the 9th-11th century. These burials tend to be interpreted as representative of the settlement population as a whole; however there are indicators that to some extent they represent a biased collection. For example, there is a lack of women and children within the collection, less than 20 child burials are known, and women represent only 32% of the total adult population where sex can be determined (Gestsdóttir 1998: 5). In addition analysis of strontium isotopes of 83 *kuml* skeletons has shown that 39% are immigrants to the island, a high percentage when one considers that this collection is supposed to be derived from the entire population of Iceland spanning 150 years (Price and Gestsdóttir in-press). These are factors which are important to keep in mind when using the skeletal collection from *kuml* as a single population representing the settlement period in Iceland.

The sites of Hofstaðir and Skeljastaðir most likely represent quite homogenous populations. They belong to the earliest phase of Christian cemeteries in Iceland, 10th – 13th century. They are small farm-based burial grounds, which had no parish, so most likely they served only the farms themselves, and possibly the neighbouring farms. Hypotheses have been presented that these sites most likely served a population that was no larger than about

20 people at any time. These people lived within rural farming communities, in areas with a population density of about one person per km² (Gestsdóttir 2009: 135-7).

Although the early use of the cemetery at Haffjarðarey may have been contemporary with Hofstaðir and Skeljastaðir, its use continued much longer than the other two sites. In 1397 the size of the parish of the church at Haffjarðarey is said to be ten farms and that within the parish there were five chapels (*DI I* 1857-76: 421-3). Extrapolating from this and the earliest nation-wide census carried out in Iceland in 1703, Steffensen (1946) estimates that by the late 14th century there would have been about 100 people in Haffjarðarey parish. Using this and his assumption that the cemetery came into use around 1000 (although this is not supported by the archaeology or documentary sources, it is based only on the date of the conversion of Icelanders to Christianity), he estimates that about 2000 people died in the parish of Haffjarðarey during the 500 years before its abandonment (Steffensen 1946: 144-5). The accuracy of this figure is questionable. It is based on far too many uncertainties, not only the period of use of the cemetery, but also concerning how many people who died in the parish were buried in Haffjarðarey; in fact all the five chapels mentioned above are likely to have had cemeteries, at least early on. Added to this is the uncertainty as to what period the skeletons excavated in 1945 belong. One thing that is highly likely, however, is that at least by the 14th century, Haffjarðarey served a much larger community than Hofstaðir or Skeljastaðir did while they were in use. Due to its geographical location (see figure 3.2), Haffjarðarey is likely to have stood out from Hofstaðir and Skeljastaðir, which are located 50 and 80 km from the sea respectively, with a much greater reliance on a marine economy. What Skeljastaðir, Hofstaðir and Haffjarðarey have in common is that it is unlikely that there will have been great variations in social status within the communities which these cemeteries served (with perhaps some exceptions, for example priests or chieftains).

The Reykjavík sites of Viðey and Víkurkirkjugarður tell a very different story. The middle of the 18th century marks the beginning of urbanisation in Reykjavík affecting the parishes served by both of these cemeteries, even though Viðey only served the population on the island. Between the 1703 and 1850 censuses for example, the population of Reykjavík grew six-fold, from 185 people to 1149 and the population density increased from 18 individuals per km² to over 100 (Gestsdóttir 2009: 134). This would have been accompanied by more variability within the population. This variability would for example involve the emergence an elite, or at least more social division than the populations which the Skeljastaðir, Hofstaðir and Haffjarðarey cemeteries represent, as well as increased specialization (Gunnlaugsson 1982: 10; Júlíusson 1990: 155).

4 Methods

This chapter will focus on the methodologies used in the analysis of the skeletal remains in this study. The emphasis will be on discussing the methods used to record preservation and pathologies. The heavy focus on the issue of preservation is mainly due to the small size of the skeletal populations available for study in Iceland, which means that any intrinsic patterns in the preservation of the material are likely to have a much greater effect on any statistical analysis.

4.1 Ageing and sexing

Analysis of age and sex within the skeletal populations used for this study was based on standardised methods which will not be discussed here in detail, beyond stating that in all instances as many methods were used as preservation allowed.

Sexing was based on sexually diagnostic characteristics of the pelvis and cranium (Buikstra and Ubelaker 1994: 15-20; Walrath et al. 2004). All the skeletons were placed within one of the following categories:

- Female
- Male
- Unknown

Ageing was based on morphological changes of the os pubis (Brooks and Suchey 1990), auricular surface (Lovejoy et al. 1985) and suture closure (Meindl and Lovejoy 1985; Nawrocki 1998). In addition dental enamel wear was recorded (Brothwell 1981: 72). However analysis of dental wear in Icelandic archaeological skeletal has demonstrated a high level of acid erosion due to the consumption of fermented milk products rich in lactic acid (Lanigan and Bartlett 2013: 1452-5). This means that existing methods which use dental enamel wear to age skeletons do not work well on the material. Skeletons of non-adults, i.e. those under 18 years of age, were excluded from the study, as idiopathic osteoarthritis is associated with the ageing process and so does not affect children (Ortner and Putschar 1981: 419). All of the skeletons were placed within one of the following categories:

- 18-34
- 35-49
- Over 50
- Unknown

One of the major problems facing a study of a disease closely linked to the ageing process, like osteoarthritis, is the difficulty associated with accurately ageing older individuals. This difficulty is the reason the oldest category is limited to over 50 years of

age as any attempt to split those over this age into smaller groups would not be viable (for a further discussion on age in archaeology see chapter 7.2).

4.2 Preservation

A problem with most standard methodologies of recording preservation of archaeological skeletal human remains is the presumption of a more or less complete individual recovered from an isolated context (Knüsel and Outram 2004: 85). In most instances, even where there has been no disturbance of the individual (for example by grave robbing, cutting by later burials or erosion); it is rarely the case that all bones are represented with 100% preservation. The most commonly used methods for recording preservation are based on an inventory style where each individual bone is graded depending on the percentage of bone which is present: for example; complete, at least 75%; partial, 25-75% and poor, less than 25%. Although the description of how to estimate the percentage present in each case does take into account the areas which are most likely to be of interest for analysis, these types of methods do not record which parts of the bones are present. For example, a humerus which is recorded as complete can still have one epiphysis missing. Another problem is that it does not account for the surface preservation of the fragment which is present, for example an entire humerus might be present, but all the cortical bone may be missing.

Bello et al. (2006) tackled this problem, stating that the concept of what constitutes a well preserved skeleton is poorly defined within the osteoarchaeological literature. To solve this they suggest a system of recording preservation based on three indices. Two of these use a system recording six classes of preservation ranging between 0 and 100%. They are the anatomic preservation index (API), assessing the quantity of bone present and the qualitative bone index (QBI), recording the ratio between well preserved and damaged cortical bone. The third index is the bone representation index (BRI) which measures the frequency of each bone in the sample. Using this methodology they were able to quantify the impact of preservation factors on palaeodemographic reconstruction and give greater meaning to what is meant by degree of preservation (Bello et al. 2006).

The method described by Bello et al. identifies more clearly the concept of preservation in qualitative and quantitative terms. There is still, however, a problem when dealing with osteoarthritis, as the method does not specifically target the preservation of joint surfaces. Most documents dealing with recording of pathological changes associated with joint disease advocate a preservation record of joint surfaces (Brickley 2004: 6; Rogers and Waldron 1995: 9-10). However a system which records mere presence versus absence of a joint surface can be problematic as in many instances only parts of the joint are preserved. When the preservation of specific joint surfaces is studied it is clear that some parts are more frequently missing than others. This can often be attributed to biological differences in bone, with more robust bone better preserved than smaller bones, or those with a lower bone density (Bello and Andrews 2006: 9).

There are on the other hand extrinsic factors which can be involved as well. The nature of the burial, for example the positioning of the body within the grave or disturbances of the skeletal material after the initial burial, can also create specific preservation patterns. Examples of this are given in the discussion in chapter 6.1.2.

4.2.1 The Icelandic issue

A problem with archaeological skeletal collections from Iceland is the size of the populations available for analysis. The largest collection in this study (and the second largest excavated to date in Iceland), Hofstaðir, has a total of 122 skeletons, of which 54 were adults used for this study (excluded are juvenile skeletons, and adult skeletons with no joint surfaces preserved, as well as those excavated after the analysis for this project was completed). This means that it was important for the purpose of this project to develop a detailed recording method for the preservation of the joint surfaces to see if it was possible to determine whether the pattern of osteoarthritis in these collections represented the prevalence of the disease, or just the pattern of preservation. In addition, by using a more detailed method for recording preservation, the aim was to look at the preservation patterns of the joints in relation to where the degenerative changes are occurring on the joint surfaces, again to see whether the patterns of osteoarthritis are reflecting the preservation patterns or the actual prevalence of the disease within these small populations. This is particularly relevant for the more complex joints, like the spine.

4.2.2 Recording preservation

One of the primary concerns in terms of data collection for this research was that the recording system was robust enough that results would not be biased by taphonomic factors which had produced differential preservation between sites. In order to address these taphonomic issues, methods obtained from the zooarchaeological literature were utilised, because animal bone specialists are more used to dealing with fragmented remains than human osteoarchaeologists. The practice within zooarchaeology is to record fragments of bones based on ‘zones’ which have been defined by using the most common fracture patterns of each individual bone (Dobney and Rielly 1988; Knüsel and Outram 2004).

For this project the recording of the presence of joint surfaces was therefore carried out in zones based on the shape of the joints, as well as the most common breakage patterns. The joint surfaces were all divided into between one and 12 zones (although two or four zones per joint surface were the most common), based on the size of each surface. The joint part was recorded as present if more than 25% of the surface zone was observable (for details on the joint zones see Appendix 1). The grading of the preservation was simple:

- Grade 0: Less than 25% of joint zone present.
- Grade 1: More than 25% of joint zone present.

This grading strays slightly away from both Dobney and Rielly, where it is suggested to record each zone present as more or less than 50% (Dobney and Rielly 1988: 3-4), and Knüsel and Outram, where each zone is recorded as present if any part of it is preserved (Knüsel and Outram 2004: 87). The reason for this is that it was observed that in instances where more than 75% of the joint zone was missing, there was a greater risk of the pathology not being preserved (as the preservation of pathological bone is frequently quite poor). In those instances there is a risk of the joint zone being recorded as present, but non-pathological. It was noted during the recording process that none of the joint zones with less than 25% preservation had pathological changes.

When presenting the prevalence of osteoarthritis in the various joints, it was determined that at least 10% of the joint zones had to be preserved for the joint to be recorded as present. This means for example that for a vertebral facet joint to be recorded as present, at least one zone had to be preserved, 11 for the wrist and five for the knee. A list of the zones recorded is presented in Appendix 1, while detailed results of the preservation and prevalence of osteoarthritis in the more complex joints is presented in Appendices 3 through 6. In addition to the recording of joint by the zone method, the anatomic preservation index (API) and the qualitative bone index (QBI) as discussed above (Bello et al. 2006), were recorded. In each instance the two indices were recorded by the following system (after Bello et al. 2006: 25):

- Grade 1: no bone preserved
- Grade 2: 1-24% of bone preserved
- Grade 3: 25-49% of bone preserved
- Grade 4: 50-74% of bone preserved
- Grade 5: 75-99% of bone preserved
- Grade 6: 100% of bone preserved

4.3 Pathology

The accuracy of dry bone analysis in relation to diagnosing specific diseases in archaeological bone has long been a matter for debate. Bone, by its very nature with a 70% mineral content, has limited ways of responding to disease. All changes associated with pathologies are either through bone proliferation or bone erosion (or a combination of the two). This, accompanied by the fact that the changes affecting bone as a part of the disease process are frequently secondary to soft tissue changes, means that in most instances individual pathological changes are not diagnostic to a specific disease (Roberts and Manchester 1995: 4-10). Workshops held at several Palaeopathology Association meetings during the late 1980s and 1990s highlighted these problems. Anthropologists, archaeologists and medical professionals participating in the workshops were given pathological dry bone specimens to diagnose. The specimens studied were archaeological samples as well as modern medical specimens, the latter with diagnosis confirmed by clinical and histological study. The results of the workshops demonstrated a significantly higher level of accuracy for

disease category diagnosis than for a specific disease diagnosis (Miller et al. 1996). There is no way of avoiding these issues, and the only way of addressing them is to use unambiguous standardised terminology when describing any lesion. This is done to ensure that the description is as objective as possible so that the diagnosis of those lesions can be independently reviewed by others. Stress is also put upon providing a precise identification of the location of the lesion (Buikstra and Ubelaker 1994: 108; Roberts and Conell 2004: 34-6).

4.3.1 The diagnostic criteria of osteoarthritis in dry bone

The bony changes associated with osteoarthritis are: eburnation, the formation of osteophytes around, and/or new bone on, the joint surface; pitting of the joint surface and alteration to the joint contour.

4.3.1.1 Eburnation

Eburnation, which manifests as an area of highly polished bone, is formed when the cartilage has been destroyed and the bone surface of the joint becomes polished as a result of the exposed bone surface moving over other structures. Eburnation is never found in a joint which is immobile, so the continued use of the joint is necessary for the lesion to form. Eburnation is pathognomic of osteoarthritis; that is, diagnosis of osteoarthritis can be made with absolute certainty when eburnation is present (Roberts and Manchester 1995: 103; Rogers and Waldron 1995: 13).

4.3.1.2 Osteophytes and/or new bone on the joint surface

Osteophytes are new bone growths which occur around the margins of a joint, at the point where the synovial membrane is continuous with the cartilage. They can vary in size from tiny growths to spicules several millimetres long. They can be isolated to a small part of the joint margin or form a ring around the entire joint surface. The new bone can be formed on the joint surface as well (Rogers and Waldron 1995: 20-1). The formation of osteophytes at the joint margins is associated with the body’s attempt to spread the load of a weakened joint. They can be found at any joint in the body, although some joints are more commonly affected than others, with the vertebral bodies being by far the most frequently involved. The presence of osteophytes around a joint margin is not of itself enough to diagnose osteoarthritis as their occurrence can be associated with degeneration relating to the normal aging of the body. It is therefore the distribution and characteristic of the osteophyte and/or bone formation, and in particular its association with other lesions such as pitting, which can lead to the diagnosis of osteoarthritis (Roberts and Manchester 1995: 101-2; Rogers and Waldron 1995: 20).

4.3.1.3 Pitting

Pitting of the joint surface is the result of the degeneration of the cartilage. In these cases the synovial fluid permeates the bone to form subchondral cysts. As with osteophytes, pitting can be diagnostically problematic. Macroscopically it is of utmost

importance to be confident in distinguishing pathologies from post-mortem damage as well as other (non-pathological) holes found around the joint. In addition it is very important to identify where on the joint surface the damage is located, as different joint disease processes affect the joints in different ways; some start at the joint margins, while others start at the centre of the joint, so such a distinction can influence the diagnosis (Roberts and Manchester 1995: 103; Rogers and Waldron 1995: 12).

4.3.1.4 Alteration to the joint contour

Osteoarthritis can result in alteration of the shape of the joint contour. This usually involves the flattening of the joint, most commonly seen in the head of the femur, which results in a mushroom-shape of the head (Rogers and Waldron 1994: 38-9, 44-5; Aufderheide and Rodríguez-Martín, 94).

4.3.1.5 Analysis, recording and diagnosis

All the analysis carried out was macroscopic. Rogers and Waldron (1995) have pointed out that the use of radiographs when diagnosing osteoarthritis in archaeological bone is unlikely to add anything to the analysis, as the main feature used to diagnose osteoarthritis from radiographs in a living patient, the narrowing of the joint space, is not available to the osteoarchaeologist. The other features of the disease, as described above, are more clearly visible on the dry bone than from radiographs, and indeed one of the main issues that needs to be tackled when recording these features on archaeological dry bone is the danger of over-diagnosis, as changes associated with joint degeneration are visible much earlier macroscopically than they are on radiographs (Rogers and Waldron 1995: 14).

As discussed above (chapter 4.3.1), the importance of unambiguous standardised terminology is emphasised when recording pathological lesions in archaeological remains. Some (cf. Buikstra and Ubelaker 1994: 108-15) have advocated an inventory style recording system, where a code key is used to identify the bone, side, section, aspect and pathology. Most researchers agree, however, that such a system is far too cumbersome to be of value. It is impossible to completely eliminate inter- or even intra-observer error when recording pathologies in archaeological collections. Any two observers never reach exactly the same conclusions, and the same researcher is unlikely to reach the same conclusions twice while observing the same material. This is an issue which affects all archaeological analysis, not just palaeopathology. What one hopes for is that the resulting conclusions are the same even though the details can never be identical. The best one can aim for is to clearly demonstrate what is meant by the terminology used (and of course using standardised terminology whenever possible), and to include descriptions of pathologies, not just diagnoses. All recording for this research was undertaken by the author using the same, standardised methodology, thus eliminating problems of inter-observer error and incompatibility of results that may otherwise compromise such analysis.

For this project, recording of pathological changes associated with osteoarthritis: osteophytes and/or bone formation on the joint surface; pitting and eburnation, followed

a three grade system (as discussed by Rogers and Waldron 1995: 11, 21-2), where the presence of the above mentioned lesions was recorded as:

- Grade 1: Small
- Grade 2: Medium
- Grade 3: Severe

The locations of the pathological changes were recorded as present or absent on each joint zone as described in the recording of the preservation of the skeletal material above. In addition it was noted whether the changes were located extra-marginally, marginally or centrally on the joint, or whether it covered the entire joint surface. Selected lesions were also recorded with photographs.

Osteoarthritis was diagnosed in those cases where eburnation was present or where there were two of the following criteria, alterations to the joint surface[9], pitting or osteophyte and/or bone formation on the joint surface graded at least 2. In and of themselves grade 1 osteophytes and pitting are not pathological changes. They are just as likely to be part of the age related degeneration of the skeleton, and would not be identified on radiographs in a living individual. However their presence was included to record the early stages of degeneration, which were particularly noteworthy in cases where other more severe changes associated with osteoarthritis were also present on the joint surface. Examples of degenerative joint changes not great enough to allow for diagnosis of osteoarthritis (grade 1 & 2 osteophytes and pitting), can be seen in figures 4.1 and 4.2. Examples of joint changes where osteoarthritis was diagnosed can be seen in figures 5.3-5.14.

Diagnosis of generalised osteoarthritis can be problematic. As noted in chapter 1.3.4 there is a problem with the lack of definitive diagnostic criteria for generalised osteoarthritis. With archaeological skeletal remains there is the added problem, as has already been discussed, that in most instances there will not be 100% preservation of all joints, with the smaller joints of the hands needed for the diagnosis often missing. It was therefore decided for this project to record all cases with osteoarthritis in at least three joint groups as multiple joint involvement, and to note specifically cases which could be classed as generalised osteoarthritis.

In an attempt to decrease the chances of the taphonomic factors biasing the prevalence of osteoarthritis within the population the development of the recording system for this project was therefore firmly focused on the zonation recording of the preservation of the joint. The recording of the pathologies themselves on the other hand, although utilising the zonation recording method for the location of the lesions, followed a more standardised grading system. The results of the analysis were entered into a Microsoft Access database designed for this project. The 95% confidence interval was calculated for the crude

[9] It should be noted that in all instances where alterations to the joint contour were recorded, it was either the only pathological change, or it was accompanied by either eburnation or grade 2 or higher pitting or osteophyte/new bone formation.

Figure 4.1: Example of a joint surface with degenerative changes where osteoarthritis was not diagnosed. ÞSK-A-045, right glenoid fossa, grade 1 osteophytes on all joint zones, grade 2 pitting on the postero-superior zone (Photo Ívar Brynjólfsson).

Figure 4.2: Example of a joint surface with degenerative changes where osteoarthritis was not diagnosed. HSM-A-039, left acetabulum, grade 1 osteophytes on both superior zones, grade 3 pitting on the antero-superior zone (Photo Ívar Brynjólfsson).

prevalence. In addition the age adjusted prevalence was calculated using common odds ratios, along with the 95% confidence interval (see chapter 5.2.1 for further detail as well as Waldron 1994: 62-3). To test the comparability of the different sites in the study Kolmogorov-Smirnov two sample tests were carried out on the preservation of the spinal joints (see chapter 6.1.5 for further detail, as well as Knüsel et al. 1997: 491). Statistical analysis was carried out using OpenEpi version 3.01.

4.3.2 Differential diagnosis

It is important when dealing with palaeopathological analysis of specific diseases to consider possible differential diagnosis for the changes recorded in the skeletons. Several other arthritic conditions can be diagnosed from human skeletal remains. The conditions which were considered for possible differential diagnosis for this project are presented in table 4.1, along with a description of the pathology of the condition as well as the main palaeopathological diagnostic criteria.

Table 4.1: Differential diagnosis

Condition	**Pathology**	**Palaeopathological diagnosis**
Rheumatoid arthritis	Chronic systemic inflammatory disease of synovial joints and connective tissue (Aufderheide and Rodríguez-Martín 1998: 99).	Main: non-proliferative erosions of the small joints of the hands and feet Also: symmetrical non-proliferative erosions of the wrist, knee, shoulder, subtalar joint, cervical spine, elbow and hip (Rogers and Waldron 1995: 58-63).
Seronegative spondylo-arthropathies	Conditions such as psoriatic arthritis, and Reiter's disease. As with RA involves inflammatory changes in the synovial membrane. Great deal of new bone formation, joints are likely to fuse and tendons and ligaments ossify (Rogers and Waldron 1995: 70).	Asymmetrical erosive arthropathies with proliferation of new bone around the margins. PA: Small joints of the hands and feet. Reiter's: Small joints of the feet. Ossification of enthuses and bony ankylosis in both, in particular of the sacro-iliac joint. This is more common in PA, where the joints of the cervical joints are also affected (Rogers and Waldron 1995: 74-7).
Gout	Disease of metabolic aberration, characterised by hyperuricemia and tissue deposition of urate crystals into joints and prearticular soft tissues associated with intense local inflammation (Aufderheide and Rodríguez-Martin 1998: 108).	Asymmetrical, punched-out lesions around or within a joint, usually in the feet, although they may be found in the hands, wrists elbows and knees (Rogers and Waldron 1995: 80-1).
Non-specific sceptic arthritis	Infection of the synovium (and later all the structures within a joint) by a pathogenic infectious agent that can lead to joint destruction (Aufderheide and Rodríguez-Martin 1998: 106).	Usually monoarticular involvement. Highly destructive, erosive lesions tend to start at the margins of the joint, but may eventually destroy the entire joint surface. Much new bone formation, and the end stage is usually bony ankylosis of the joint (Rogers and Waldron 1995: 88).

5 Results

This section will provide the analysis of the preservation of the skeletal material alongside a very general discussion of the osteoarthritis diagnosed. The joints studied for this project were the vertebral facet joints in the axial skeleton, and the post-cranial joints. The presentation of the results will be twofold. Firstly the results of the analysis of osteoarthritis by each skeletal population with a detailed description of the individuals diagnosed will be presented. Secondly the results of the analysis of osteoarthritis will be shown by joint involvement.

5.1 Osteoarthritis by site

5.1.1 *Kuml*

A total of 69 skeletons from *kuml* were available for this study (see table 5.1).

Table 5.1: Kuml age and sex.

Age	Male	Female	Unknown	TOTAL
18-34	8	7	0	15 (22%)
35-49	13	5	2	20 (29%)
50+	21	5	0	26 (38%)
Unknown	2	1	5	8 (12%)
TOTAL	44 (64%)	18 (26%)	7 (10%)	69

5.1.1.1 Preservation and osteoarthritis

The nature of the preservation of the *kuml* bones is problematic. The preservation tends to be very varied because of the different situations in which the skeletons were excavated. This is due to the fact that a large number of the burials had been disturbed in antiquity. In addition many burials were not recorded under archaeologically controlled conditions, as they had been discovered due to erosion or development work (Eldjárn 2000: 258-61). General recording of the preservation indicates that the average and median anatomic preservation index (API) is 3, while the average and median qualitative bone index, (QBI) is 4. For a comparative chart of API and QBI for all the sites see figure 5.1.

5.1.1.2 Axial skeleton

There is clearly much variation in the preservation of the vertebral facet joints within the *kuml* collection (see Appendix 3). The average preservation was 42% (with a median of 42%). By far best preserved, based on 25% element preservation were the cranium-C1 joints with 36 present (52%). The worst preserved were the C7-T1 joints, with 22 present (32%).

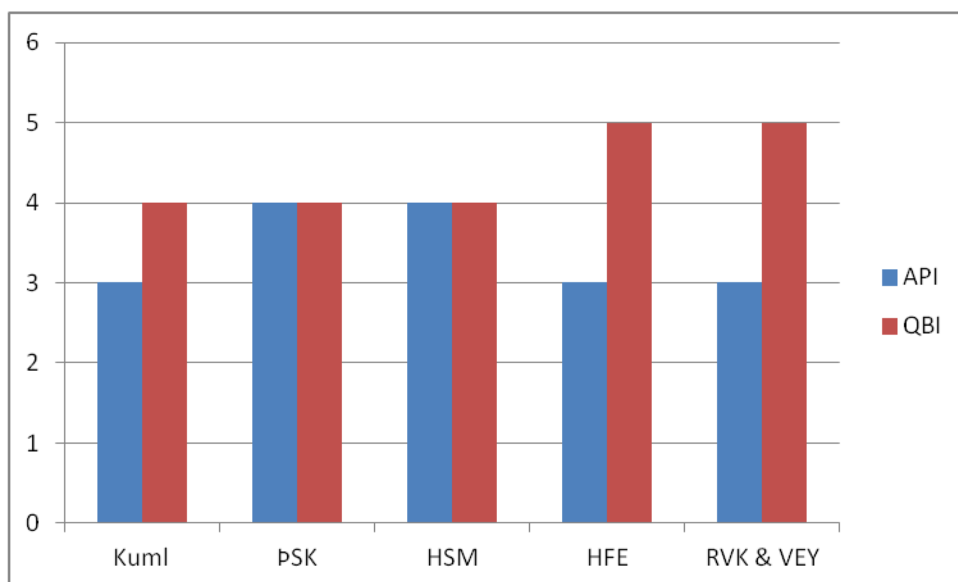

Figure 5.1 Anatomic preservation index and qualitative bone index for all sites

Osteoarthritis of the vertebral facet joints

Of the 48 individuals in the *kuml* collection who have some part of the vertebral processes preserved, 11 (22.9%) had osteoarthritis (see Appendix 3, and a summary of those results in table 5.2. Those individuals in the *kuml* collection who are affected are shown in Appendix 4). Several joints within the spinal column displayed no osteoarthritis. These were cranium-C2, C5-C7, T1-T3 and T9-L2. This can mainly be attributed to the poor preservation of the material. The average and median preservation of the spine was 42% (32-52%). The joints between C3-T7 were the worst preserved (less than 40%, with the exception of T3-T4, 42%). However the cranium-C1 was the best preserved (52%) and the joints between T11-L4 showed average preservation. The most commonly affected joints (more than 10% with osteoarthritis) were the C3-C4, T3-T4, T6-T7 and L4-L5.

Table 5.2: Kuml vertebral facet osteoarthritis summary (N= Number of cases/total number preserved).

Age	Cervical			Thoracic			Lumbar		
	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	0/10	0	0	1/9	11.1	2.0 to 43.5	0/10	0	0
35-49	1/14	7.1	1.3 to 31.5	1/14	7.1	1.3 to 31.5	1/13	7.7	1.4 to 33.3
50+	3/17	17.7	6.2 to 41.0	6/18	33.3	16.3 to 56.3	4/17	23.5	9.6 to 47.3
Unknown	0/0	0	0	0/1	0	0	0/1	0	0
TOTAL	4/41	9.8	3.9 to 22.6	8/42	19.0	10.0 to 33.3	5/41	12.2	5.3 to 25.5

5.1.1.3 Upper limb

As is to be expected in a collection with generally poor preservation, the larger joints of the upper limb were much better preserved than the small joints of the hands. The most commonly preserved joint, based on 10% zone preservation, was the shoulder joint, 48 individuals (70%), while the least common were the joints of the hands, only 33 individuals had at least 10% preservation of the finger joints (48%).

Osteoarthritis of the upper limb

Of the 48 individuals with shoulder joints preserved, one (2.1%) had osteoarthritis of the shoulder (see table 5.3). HBS-A-004 (male, 50+) had unilateral osteoarthritis of the right shoulder involving the glenohumeral joint. There was also just one case of osteoarthritis of the elbow, out of 45 with the elbow joint preserved (2.2%). SSG-A-001 (male, 35-49) had osteoarthritis of the right elbow involving the humeroulnar joint. The left elbow was not preserved so it is not possible to determine whether the osteoarthritis was bilateral.

Of the 33 individuals with wrist joints preserved, two had osteoarthritis of the wrist (6.1%), (see also Appendix 5). Both were male. HRB-A-001 (35-49) had osteoarthritis of the right wrist in the radius-scaphoid joint. VDP-A-003 (18-34) had bilateral osteoarthritis of the wrists. On the right side the 1st, 2nd, 4th and 5th CMC joints were involved, while on the left it was the distal radioulnar as well as the hamate-triquetral joints. Two individuals had osteoarthritis of the fingers, out of the 29 with finger joints preserved (6.9%). Both cases were male, and both have involvement of the right 1st metacarpo-phalangeal (hereafter MCP) joint; VDP-A-003 (18-34) and SBT-A-001 (50+).

Table 5.3: Kuml upper limb osteoarthritis summary (N= Number of cases/total number preserved).

Age	Shoulder			Elbow			Wrist			Fingers		
	N	%	95% CI	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	0/9	0	0	0/8	0	0	1/8	12.5	2.4 to 47.1	1/7	14.3	2.6 to 51.3
35-49	0/16	0	0	1/17	5.9	1.0 to 27.0	1/12	8.3	1.5 to 35.4	0/12	0	0
50+	1/21	4.8	0.8 to 22.7	0/19	0	0	0/12	0	0	1/10	10.0	1.8 to 40.4
Unknown	0/2	0	0	0/1	0	0	0/1	0	0	0/0	0	0
TOTAL	1/48	2.1	0.4 to 10.9	1/45	2.2	0.4 to 11.6	2/33	6.1	1.7 to 19.6	2/29	6.9	1.9 to 22.0

5.1.1.4 Lower limb

The larger joints of the lower limb were much better preserved than the smaller joints of the ankles and toes. The hip joint was the best preserved in the *kuml* population, with 53 (77%) present, based on the 10% element preservation. The small joints of the toes were the worst preserved, only 21 (30%) individuals had at least 10% preservation.

Osteoarthritis of the lower limb

Within the 53 individuals with preserved hip joints, there were three (5.7%) cases of hip osteoarthritis in the *kuml* population (see table 5.4). It was bilateral in one case, MEH-A-001 (female, 50+). The other two cases were unilateral. SSG-A-001 (male, 35-49) had osteoarthritis of the left hip, while SSG-A-002 (male 50+) had osteoarthritis of the right hip.

Table 5.4: Kuml lower limb osteoarthritis summary (N= Number of cases/total number preserved).

Age	Hip			Knee			Ankle			Toes		
	N	%	95% CI	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	0/12	0	0	0/11	0	0	0/7	0	0	0/5	0	0
35-49	1/16	6.3	1.1 to 28.3	0/16	0	0	0/14	0	0	0/7	0	0
50+	2/20	10.0	2.8 to 30.1	0/19	0	0	1/19	5.3	0.9 to 24.6	0/7	0	0
Unknown	0/5	0	0	0/4	0	0	0/3	0	0	0/2	0	0
TOTAL	3/53	5.7	1.9 to 15.4	0/50	0	0	1/43	2.3	0.4 to 12.1	0/21	0	0

There was one case of ankle osteoarthritis (see Appendix 6). VAS-A-001 had unilateral osteoarthritis of the right ankle involving the tibia and fibula. There was no knee or foot osteoarthritis in the *kuml* population.

Table 5.5: Kuml male v. female osteoarthritis summary (N= Number of cases/total number preserved).

Joint	Female			Male		
	N	%	95% CI	N	%	95% CI
Cervical	1/12	8.3	1.5 to 35.4	2/28	7.1	2.0 to 22.6
Thoracic	1/12	8.3	1.5 to 35.4	6/29	20.7	9.8 to 83.4
Lumbar	2/14	14.3	4.0 to 39.9	3/26	11.5	4.0 to 29.0
Shoulder	0/13	0	0	1/33	3.0	0.5 to 15.3
Elbow	0/12	0	0	1/32	3.1	0.6 to 15.7
Wrist	0/9	0	0	2/23	8.7	2.4 to 26.8
Fingers	0/9	0	0	2/19	10.5	2.9 to 31.4
Hip	1/15	6.7	1.2 to 29.8	2/35	5.7	1.6 to 18.6
Knee	0/12	0	0	0/35	0	0
Ankle	0/12	0	0	1/28	3.6	0.6 to 17.7
Toes	0/8	0	0	0/12	0	0

5.1.1.5 Male v. female

There were 44 males, but only 18 females in the *kuml* collection. A summary of the results of the analysis of osteoarthritis can be seen in table 5.5. Within the female population the most common axial osteoarthritis was seen in the lumbar vertebrae, two cases out of 14 with preserved lumbar vertebrae (14.3%), while for the males the

thoracic vertebrae had the highest prevalence, six cases out of 29 with preserved vertebrae (21.7%). In the post-axial skeleton, the highest osteoarthritis prevalence was seen in the fingers for the males, 10.5% (two cases of 19 with finger bones preserved). Only one female had post-axial osteoarthritis within the *kuml* population, a single case of hip osteoarthritis out of 15 preserved (6.7%).

5.1.1.6 Multiple joint involvement

Of the 69 skeletons in the *kuml* collection, 17 (24.6%) had some form of osteoarthritis. Of these none had osteoarthritis in three or more joints. The lack of multiple joint involvement in the *kuml* collection mainly reflects the poor preservation within the collection, as most of the individuals within this group only have some elements preserved.

5.1.2 Skeljastaðir (ÞSK)

A total of 54 adult skeletons were available for study from the Skeljastaðir cemetery (see table 5.6)

Table 5.6: Skeljastaðir sex and age.

Age	Male	Female	Unknown	TOTAL
18-34	5	5	1	11 (20%)
35-49	8	11	1	20 (37%)
50+	13	9	0	22 (41%)
Unknown	0	1	0	1 (2%)
TOTAL	26 (48%)	26 (48%)	2 (4%)	54

5.1.2.1 Preservation and osteoarthritis

The preservation of the material from Skeljastaðir is in most instances very good, with the average API and QBI in both instances 4 (with a median of 3). For a comparative chart of API and QBI for all the sites see figure 5.1. The poorer instances of preservation are in most cases explained by the fact that the site had been eroding for several decades before it was excavated (Þórðarson 1943: 134). Due to this, some skeletons are only partially preserved, and some skeletal elements show clear signs of whitening as a result of exposure and weathering.

5.1.2.2 Axial skeleton (processes)

There was not much variation in the preservation of the processes of the axial skeleton in the Skeljastaðir collection (see Appendix 2). The best preserved joint with the 25% preservation parameter was the L5-S process; 46 instances (85%) while the C3-C4 joint was the worst preserved; 32 instances (59%). The average preservation of the process joints of the axial skeleton was 68% with a median of 66%.

Osteoarthritis of the vertebrae

Of the 53 individuals in the population who had some vertebral processes preserved, 27 (50.9%) had osteoarthritis, and there was evidence of osteoarthritis in almost all the process joints of the spine as well as the facet of the C1 and dens of the C2 in the Skeljastaðir collection (see Appendix 3, and a summary of those results in table 5.7. Those individuals in the Skeljastaðir collection who are affected are shown in Appendix 4). The only processes not involved were the C6-C7 and L1-L2. The most frequently affected joints (with greater than 15% osteoarthritis) were the C2-C3; C7-T2; T4-T7 and L5-S1.

Table 5.7: Skeljastaðir vertebral facet osteoarthritis summary (N= Number of cases/total number preserved).

Age	Cervical			Thoracic			Lumbar		
	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	1/9	11.1	2.0 to 43.5	1/9	11.1	2.0 to 43.5	0/10	0	0
35-49	6/18	33.3	16.28 to 56.3	6/15	40.0	15.2 to 64.7	7/19	36.8	15.2 to 58.5
50+	7/22	31.8	12.4 to 51.3	11/19	57.9	36.3 to 76.9	6/20	30.0	14.6 to 51.9
Unknown	0/0	0	0	0/1	0	0	0/0	0	0
TOTAL	14/49	28.6	17.8 to 42.4	18/44	40.9	27.7 to 55.6	13/49	26.5	16.2 to 40.3

5.1.2.3 Upper limb

As with the axial skeleton there was not much variation in the preservation of the joints of the upper limb. With the 10% element preservation parameter over 85% of the skeletons in the collection had the wrist, elbow and shoulder joints preserved, with the elbow being the best preserved joint; a total of 51 individuals (94%) had at least 10% of the elbow joints preserved. A slightly lower number, 41 individuals (76%), had preserved finger joints.

Osteoarthritis of the upper limb

A general analysis of osteoarthritis in the upper limb indicates that none of the 49 individuals with preserved shoulder joints in the Skeljastaðir population had osteoarthritis of the shoulder. However, three of the 51 with preserved elbow joints (5.9%) had osteoarthritis of the elbow. All three were aged 50+. Two were female and in both instances the osteoarthritis was in the humeroradial joint. The left side was involved in the case of ÞSK-A-002, and the right in the case of ÞSK-A-18b. The third case was a male, ÞSK-A-052 who had osteoarthritis of the right elbow involving both the humeroulnar and humeroradial joints (see figure 5.7), although this was probably secondary to a fracture of the mid-shaft of the ulna which had resulted in slight angulation of the bone (Gestsdóttir 2008).

Of the 46 individuals with preserved wrist joints in the Skeljastaðir collection, four (8.7%) had osteoarthritis of the wrist (see the table for Skeljastaðir in Appendix 5). One of these was female, aged 35-49 (ÞSK-A-017). She had bilateral osteoarthritis of the wrist,

involving the hamate-triquetral joint. The other three were all males aged 50+. ÞSK-A-029 had bilateral wrist osteoarthritis; the scaphoid-trapezoid and scaphoid-capitate joints of the left hand; and between the MC2-MC3 of the right. ÞSK-A-048 had unilateral osteoarthritis of the distal radioulnar joint of the left hand. ÞSK-A-040 had unilateral osteoarthritis of the wrist involving the left radius-scaphoid and lunate-capitate joints. This was however secondary to the spastic paralysis of the left side of the body which this individual had suffered sometime during adulthood, possibly due to a stroke (Gestsdóttir 2008).

Table 5.8: Skeljastaðir upper limb osteoarthritis summary (N= Number of cases/total number preserved).

Age	Shoulder			Elbow			Wrist			Fingers		
	N	%	95% CI	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	0/10	0	0	0/11	0	0	0/11	0	0	0/10	0	0
35-49	0/17	0	0	0/19	0	0	1/15	6.7	1.2 to 29.8	3/12	25.0	8.9 to 53.2
50+	0/22	0	0	3/21	14.3	5.0 to 34.6	3/20	15.0	5.2 to 36.0	4/19	21.1	8.5 to 43.3
Unknown	0/0	0	0	0/0	0	0	0/0	0	0	0/0	0	0
TOTAL	0/49	0	0	3/51	5.9	2.0 to 15.9	4/46	8.7	3.4 to 20.3	7/41	17.1	8.5 to 31.3

Seven of the 41 individuals with preserved finger joints (17.1%) had osteoarthritis involving the joints of the fingers. The osteoarthritis was in all instances unilateral, and most commonly involved the MCP joints. Three females were affected; ÞSK-A-018b, aged 50+: left 1st & 2nd MCP; ÞSK-A-056, aged 35-49: right 1st MCP, who also had osteoarthritis of one unsided proximal interphalangeal joint (hereafter PIP); and ÞSK-A-025, aged 50+: right 1st MCP who also had one unsided PIP joint affected, probably the 1st digit. Two males had osteoarthritis of the MCP; ÞSK-A-58, aged 35-49: left 3rd MCP and ÞSK-A-040: right 3rd & 4th MCP. One female aged 50+ (ÞSK-A-059) had osteoarthritis of a single unsided PIP and one male, 35-49 (ÞSK-A-060) had osteoarthritis of a single unsided distal interphalangeal joint (hereafter DIP) joint.

5.1.2.4 Lower limb

The larger joints of the lower limb were very well preserved in the Skeljastaðir collection with over 90% of the population having at least 10% element preservation of the hip, knee and ankle joints. The hip was the most commonly preserved joint in the entire collection, with only one individual out of the 54 in the population with no part of the hip joint preserved (98%). A much lower number, 24 (44%) had at least 10% element preservation of the toes.

Osteoarthritis of the lower limb

The hip joint was the most commonly affected of the lower limb joints, three individuals of the 53 with preserved hip joints (5.7%) had osteoarthritis (see table 5.9). Two of these were female, ÞSK-A-017, aged 35-49, had bilateral osteoarthritis of the hip, while ÞSK-

A-011, aged 50+, had osteoarthritis of the right hip only. One male, ÞSK-A-058, aged 35-49 had unilateral osteoarthritis of the left hip.

Table 5.9: Skeljastaðir lower limb osteoarthritis summary (N= Number of cases/total number preserved).

Age	Hip			Knee			Ankle			Toes		
	N	%	95% CI	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	0/11	0	0	0/10	0	0	0/11	0	0	0/5	0	0
35-49	2/20	10.0	2.8 to 30.1	0/10	0	0	0/18	0	0	1/8	12.5	2.2 to 47.1
50+	1/21	4.8	0.8 to 22.7	1/21	4.8	0.8 to 22.7	1/19	5.3	0.9 to 24.6	0/11	0	0
Unknown	0/1	0	0	0/1	0	0	0/1	0	0	0/0	0	0
TOTAL	3/53	5.7	1.9 to 15.4	1/52	1.9	0.3 to 10.1	1/49	2.0	0.4 to 10.7	1/24	4.2	0.7 to 20.2

Of the 52 with preserved knee joints, only one individual, ÞSK-A-009, female aged 50+, had osteoarthritis of the knees. The case was bilateral involving the medial epicondyle of the femur and patella. ÞSK-A-002, female aged 50+ is the only individual of the 49 with preserved ankle joints (2.0%) who displayed osteoarthritis of the ankle, with unilateral involvement of the left talus-navicular joint (see the table for Skeljastaðir in Appendix 6). In addition there was only one case of 24 preserved (4.2%) of osteoarthritis of the toes, ÞSK-A-051; female aged 35-49 had osteoarthritis of the 1st left metatarsal-phalangeal joint (hereafter MTP).

Table 5.10: Skeljastaðir male v. female osteoarthritis summary (N= Number of cases/total number preserved).

Joint	Female			Male		
	N	%	95% CI	N	%	95% CI
Cervical	4/23	17.4	7.0 to 37.1	10/25	40.0	23.4 to 59.3
Thoracic	7/19	36.8	19.5 to 59.0	11/24	45.8	27.9 to 64.9
Lumbar	9/22	40.9	23.3 to 61.3	4/25	16.0	6.4 to 34.7
Shoulder	0/23	0	0	0/25	0	0
Elbow	2/23	8.7	2.4 to 26.7	1/26	3.8	0.7 to 18.9
Wrist	1/19	5.3	0.9 to 24.6	3/25	12.0	4.2 to 30.0
Fingers	4/18	22.2	9.0 to 45.2	3/22	13.6	4.7 to 33.3
Hip	2/25	8.0	2.2 to 25.0	1/26	3.8	0.7 to 18.9
Knee	1/25	4.0	0.7 to 19.5	0/25	0	0
Ankle	1/23	4.3	0.8 to 21.0	0/24	0	0
Toes	1/12	8.3	1.5 to 35.3	0/11	0	0

5.1.2.5 Male v. female

An equal number of males and females were found in the Skeljastaðir population (26 each). A summary of the results of the analysis of osteoarthritis by sex can be seen in table 5.10.

The most common vertebral osteoarthritis among the females was seen in the thoracic, seven cases of 19 preserved (37%), and lumbar vertebrae, nine cases of 22 preserved (40.9%). In the men the cervical – 10 cases of 25 preserved (40.0%) – and thoracic – 11 cases of 24 preserved (45.8%) – had the highest prevalence. The highest prevalence seen in the post-axial skeleton for the females was in the fingers, four out of 18 preserved (22.2%), while the wrist, three out of 25 preserved (12.0%) and the fingers, three of the 22 preserved (13.6%) were the most commonly affected joints for the males.

5.1.2.6 Multiple joint involvement

Of the 54 individuals within the Skeljastaðir collection 29 (53.7%) had osteoarthritis. Of these four, or 14% of those with osteoarthritis, had multiple joint involvement. Two were males and two females. None of these could be diagnosed as generalised osteoarthritis. The joints affected are summarised in table 5.11.

Table 5.11: Skeljastaðir multiple joint involvement.

Skeleton	Sex	Age	Cervical	Thoracic	Lumbar	Shoulder	Elbow	Wrist	Fingers	Hip	Knee	Ankle	Toes
ÞSK-A-002	F	50+		✓	✓		✓					✓	
ÞSK-A-017	M	35-49			✓			✓		✓			
ÞSK-A-018b	F	50+		✓	✓		✓		✓				
ÞSK-A-058	M	35-49		✓					✓	✓			

5.1.3 Hofstaðir (HSM)

A total of 54 adult skeletons were available for this project from Hofstaðir (see table 5.12).

Table 5.12: Hofstaðir sex and age.

Age	Male	Female	Unknown	TOTAL
18-34	1	5	0	6 (11%)
35-49	10	8	0	18 (33%)
50+	14	14	0	28 (52%)
Unknown	2	0	0	2 (4%)
TOTAL	27 (50%)	27 (50%)	0	54

5.1.3.1 Preservation and osteoarthritis

The preservation at Hofstaðir is in most instances excellent. The average of the API and QBI is in both instances 4 (with a median of 5). For a comparative chart of API and QBI for all the sites see figure 5.1. There are a handful of poorly preserved skeletons, which can all be ascribed to micro-environmental preservation issues within the site. For

example, as already mentioned, the three adults buried within the porch of the church were all very poorly preserved (Gestsdóttir 2006: 7).

5.1.3.2 Axial skeleton (processes)

The preservation of the vertebral processes was very good (see Appendix 2). The most common was the L5-S1 (89% preservation), while the worst preserved were the cranium-C1 & C1-C2 (64%). The average and median preservation of the vertebral arch processes was 79%.

Osteoarthritis of the vertebral facet joints

Of the 51 individuals who had vertebral processes preserved, 32 (62.7%) had signs of osteoarthritis (see Appendix 3, and a summary of those results in table 5.13. Those individuals in the Hofstaðir collection who are affected are shown in Appendix 4). All joints except the cranium-C1 were affected. The most frequently affected joints (with over 30% prevalence), are the C2-C3, C3-C4, C4-C5, T2-T3, T3-T4 & T4-T5.

Table 5.13: Hofstaðir vertebral facet joint osteoarthritis summary (N= Number of cases/total number preserved).

Age	Cervical			Thoracic			Lumbar		
	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	0/6	0	0	1/6	16.7	3.0 to 56.3	0/6	0	0
35-49	8/18	44.4	24.6 to 66.3	8/17	47.1	26.2 to 69.0	6/18	33.3	16.3 to 56.4
50+	17/36	47.2	32.0 to 63.0	16/23	69.6	49.1 to 84.4	14/27	51.9	34.0 to 69.3
Unknown	0/0	0	0	0/0	0	0	0/0	0	0
TOTAL	25/50	50.0	36.7 to 63.4	25/46	54.3	40.2 to 67.8	20/51	39.2	27.0 to 52.9

5.1.3.3 Upper limb

The preservation of the joints of the upper limb in the Hofstaðir collection is excellent, and there is little variation. All the joints display at least 85% preservation, with 49 of the 54 individuals (91%) displaying at least 10% preservation of the elbow, while 46 (85%) have at least 10% of the joints of the fingers present.

Osteoarthritis of the upper limb

Of the 47 individuals with preserved shoulder joints, there were nine cases (19.2%) of shoulder osteoarthritis in the Hofstaðir population (see table 5.14). All of the affected individuals were aged 50+. Six of the cases were female. Of those, two were bilateral, HSM-A-002 and HSM-A-015 involving osteoarthritis of the acromioclavicular joint. In addition, HSM-A-015 had involvement of the left glenohumeral joint. Four females had unilateral osteoarthritis of the left shoulder. Of these there was one case, HSM-A-023, which involved osteoarthritis of the acromioclavicular, as well as of the left glenohumeral joint. Two females, HSM-A-003 and HSM-A-010 had osteoarthritis of the left glenohumeral joint. There was one case, HSM-A-021, of unilateral osteoarthritis of the right glenohumeral joint. Three males had osteoarthritis of the shoulder. It was

bilateral in two cases. HSM-A-033 had osteoarthritis of both glenohumeral joints as well as in the right acromioclavicular. HSM-A-057 had bilateral osteoarthritis of the acromioclavicular joint (see figure 5.6). One male had unilateral shoulder osteoarthritis, HSM-A-022, who had osteoarthritis in the acromioclavicular joint on the left side.
Only one individual, of the 49 with preserved elbows (2.0%) in the Hofstaðir collection, had osteoarthritis of the elbow. HSM-A-023 (female, 50+) had unilateral osteoarthritis of the left elbow involving the humeroradial joint.

There were 14 cases out of the 48 with preserved wrists (29.2%), of osteoarthritis of the wrist in the Hofstaðir collection. Of those affected, five were female, all aged 50+. Four cases were bilateral while one involved the right wrist only:

1. HSM-A-003: Bilateral, involving the triquetral-pisiform joint.
2. HSM-A-010: Bilateral, involving the right scaphoid-trapezium joint and left triquetral-pisiform and the 1st CMC joint.
3. HSM-A-015: Bilateral, involving both 1st CMC joints (see figure 5.8).
4. HSM-A-023: Bilateral, involving on the right side: the scaphoid-trapezium, scaphoid-trapezoid, scaphoid-capitate, trapezium-trapezoid and 1st carpometacarpal (hereafter CMC) joints. The left side has involvement of the scaphoid-trapezium, scaphoid-trapezoid, scaphoid-lunate and scaphoid-triquetral joints (see figure 5.9).
5. HSM-A-075: Unilateral, involving the right trapezoid-capitate joint.

Nine males had osteoarthritis of the wrist. Most were aged 50+, although two were in the 35-49 age group. Only two of the males had bilateral wrist osteoarthritis:

1. HSM-A-008 (50+): Unilateral, involving the left distal radioulnar and ulna-triquetral joints.
2. HSM-A-018 (50+): Only seen on the left wrist; however the right was not preserved. The joints involved were the left scaphoid-trapezium, trapezium-trapezoid and 1st & 2nd CMC joints.
3. HSM-A-020 (50+): Unilateral, involving the right distal radioulnar and scaphoid-trapezium joints.
4. HSM-A-025 (50+): Unilateral, involving the left distal radioulnar joint.
5. HSM-A-054 (35-49): Unilateral, involving the right 1st CMC joint.
6. HSM-A-057 (50+): Bilateral. On the right side it involved the distal radioulnar, ulna-scaphoid, radius-triquetral and 1st CMC joint. On the left side the osteoarthritis was seen in the ulna-scaphoid and 1st CMC joints.
7. HSM-A-076 (50+): Unilateral, involving the right distal radioulnar and ulna-scaphoid joints.
8. HSM-A-087 (50+): Bilateral. The right wrist had the involvement of the distal radioulnar and trapezoid-capitate joints. On the left side the scaphoid-trapezoid and trapezium-trapezoid joints were involved.
9. HSM-A-104 (35-49): Unilateral, involving the left distal radioulnar joint.

Of the 46 with preserved finger joints in the Hofstaðir collection, eight (17.3%) had osteoarthritis (see the table for Hofstaðir in Appendix 5). Five of these were males while three were females. The three females were all in the 50+ age group. Two had bilateral

osteoarthritis; HSM-A-023, involving the right 3rd MCP and the left 2nd, 4th & 5th MCP joints, and HSM-A-075, who had osteoarthritis of both 3rd MCP as well as the right 4th MCP, one unsided PIP and one unsided DIP joint. One female, HSM-A-114, had unilateral osteoarthritis involving the right 3rd MCP. Of the five males with finger osteoarthritis, there was only one case which was bilateral, HSM-A-057 (50+) who had osteoarthritis of both 3rd MCP as well as one unsided PIP joint and one unsided DIP joint. All other cases were unilateral; HSM-A-008 (50+), one unsided PIP joint and one unsided DIP; HSM-A-020 (50+), the left 1st MCP; HSM-A-033 (50+), the right 1st, 2nd & 5th MCP; and HSM-A-054 (35-49), the right 2nd & 3rd MCP.

Table 5.14: Hofstaðir upper limb osteoarthritis summary (N= Number of cases/total number preserved).

Age	Shoulder			Elbow			Wrist			Fingers		
	N	%	95% CI	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	0/5	0	0	0/6	0	0	0/6	0	0	0/6	0	0
35-49	0/17	0	0	0/17	0	0	2/18	11.1	3.1 to 32.8	1/17	5.9	1.0 to 27.0
50+	9/25	36.0	20.3 to 55.5	1/26	3.9	0.7 to 19.5	12/24	50.0	31.4 to 68.6	7/22	31.8	16.4 to 52.7
Unknown	0/0	0	0	0/0	0	0	0/0	0	0	0/1	0	0
TOTAL	9/47	19.1	10.7 to 33.2	1/49	2.0	0.4 to 10.7	14/48	29.2	18.2 to 42.2	8/46	17.4	9.1 to 32.0

5.1.3.4 Lower limb

The preservation of the joints of the lower limbs in the Hofstaðir population was in general excellent, with over 90% (at the 10% element preservation parameter) preserved of the hip, knee and ankle joints. The best preserved joints were the hip and knee joints. Of the 54 individuals in the population, 53 had those joints preserved. The joints of the toes were the worst preserved, 42 (72%) individuals had at least 10% of the foot joints preserved.

Osteoarthritis of the lower limb

Of the 53 individuals with preserved hip joints in the Hofstaðir population, eight (15.1%) had osteoarthritis (see table 5.15). Six of these were females, while only two were males. All the females were in the 50+ age category. Three, HSM-A-003, HSM-A-015 and HSM-A-023 had bilateral hip osteoarthritis, while three, HSM-A-001, HSM-A-002 and HSM-A-010 had osteoarthritis in the right hip only. The involvement in the two males with hip osteoarthritis was unilateral, in the left hip in both cases; HSM-A-033 (50+) and HSM-A-054 (35-49).

There were two cases out of 53 preserved (3.8%) with knee osteoarthritis in the Hofstaðir population. HSM-A-015 (female, 50+) had bilateral osteoarthritis involving the lateral facet of the patella and the femur (see figure 5.11), while HSM-A-057 (male 50+) had unilateral knee osteoarthritis involving the lateral condyles of the right femur and tibia.

Four individuals out of the 51 with preserved ankle joints (7.8%) in the Hofstaðir collection had ankle osteoarthritis, two females and two males (see the table for

Hofstaðir in Appendix 6). Both of the females were in the 50+ age category and had unilateral osteoarthritis of the right ankle. HSM-A-010 had involvement of the tibia-talus joint, while HSM-A-021 had osteoarthritis of the calcaneus-cuboid joint. The two male cases both had extensive bilateral osteoarthritis of the ankles. HSM-A-054 (35-49) had osteoarthritis in the anterior and posterior talar-calcaneus joints of the right ankle, as well as bilateral involvement of the talar-navicular joints. HSM-A-057 (50+) had osteoarthritis in the right talar-navicular and navicular-intermediate cuneiform joints as well as between the 2nd & 3rd MTs. In addition there was bilateral involvement of the navicular-lateral cuneiform, lateral cuneiform-intermediate cuneiform and the 2nd & 5th tarso-metatarsal (hereafter TMT) joints.

Of the 42 with preserved toe joints, nine individuals in the Hofstaðir collection had osteoarthritis of the toes. Of these three were females and six were males. Of the females, all three had osteoarthritis of the 1st MTP, bilateral in the case of HSM-A-021 (50+) but only involving the left foot in the cases of HSM-A-010 (50+) and HSM-A-015 (50+). Five males had osteoarthritis of the 1st MTP joint. The osteoarthritis was bilateral in the case of HSM-A-024 (50+) and HSM-A-108 (35-49). In two cases only the right foot was involved; HSM-A-087 (50+) and HSM-A-104 (35-49) both of whom also had involvement of one PIP. One individual, HSM-A-058 (unknown age) had osteoarthritis of the left 1st MTP, and one individual HSM-A-057 (50+) had osteoarthritis of two unsided DIP joints.

Table 5.15: Hofstaðir lower limb osteoarthritis summary (N= Number of cases/total number preserved).

Age	Hip			Knee			Ankle			Toes		
	N	%	95% CI	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	0/6	0	0	0/6	0	0	0/6	0	0	0/5	0	0
35-49	1/18	5.6	1.0 to 25.8	0/18	0	0	1/18	5.6	1.0 to 25.8	2/14	14.3	4.0 to 39.9
50+	7/27	25.9	13.2 to 44.7	2/27	7.4	2.1 to 23.4	3/25	12.0	4.2 to 30.0	6/21	28.6	13.8 to 50.0
Unknown	0/2	0	0	0/2	0	0	0/2	0	0	1/2	50	9.5 to 97.3
TOTAL	8/53	15.1	7.9 to 27.1	2/53	3.8	1.0 to 12.8	4/51	7.8	3.1 to 18.5	9/42	21.4	10.8 to 37.2

5.1.3.5 Male v. female

There were 27 females and 27 males in the Hofstaðir collection (see table 5.16). There was little variation in the prevalence of osteoarthritis in the vertebral column for the females, with 11 cases of 26 preserved of cervical facet joint osteoarthritis (42.3%); 10 of 25 preserved of thoracic facet joint osteoarthritis (40.0%) and 12 of 27 preserved of lumbar facet joint osteoarthritis (44.4%). In the males the cervical, 14 of 24 preserved (58.3%) and thoracic, 15 of 21 preserved (71.4%) vertebral facet joints were most commonly affected. The most commonly affected joints of the post-axial skeleton among the females were the shoulders, six instances out of 24 preserved (25.0%);

wrists, five instances of 26 preserved (19.2%) and hips six of 27 preserved (22.2%). For the males, the wrists were most commonly affected, nine cases of 22 preserved (40.9%) followed by the toes, six cases of 19 preserved (31.6%).

5.1.3.6 Multiple joint involvement

Of the 54 skeletons in the Hofstaðir collection, 35 (64.8%) had some form of osteoarthritis. Of these 12 (34.3% of those with osteoarthritis) had multiple joint involvement. Seven of these were females and five were males. Of these there was one case that could be diagnosed as generalised osteoarthritis. HSM-A-057, male aged 50+, had osteoarthritis of both 1st CMC joints as well as one unsided PIP and one unsided DIP joint. In addition osteoarthritis was seen in both shoulders, the right knee and both ankle joints, as well as all spinal groups. The results are summarised in table 5.17.

Table 5.16: Hofstaðir male v. female osteoarthritis summary (N= Number of cases/total number preserved).

Joint	**Female**			**Male**		
	N	**%**	**95% CI**	**N**	**%**	**95% CI**
Cervical	11/26	42.3	24.0 to 62.8	14/24	58.3	38.8 to 75.5
Thoracic	10/25	40.0	23.4 to 61.1	15/21	71.4	50.0 to 86.2
Lumbar	12/27	44.4	27.6 to 62.7	8/24	33.3	18.0 to 53.3
Shoulder	6/24	25.0	12.0 to 44.9	3/23	13.0	4.5 to 32.1
Elbow	1/26	3.8	0.7 to 18.9	0/23	0	0
Wrist	5/26	19.2	8.5 to 37.9	9/22	40.9	23.3 to 61.3
Fingers	3/24	12.5	4.3 to 31.0	5/22	22.7	10.1 to 43.4
Hip	6/27	22.2	10.6 to 40.8	2/26	7.7	2.1 to 24.1
Knee	1/27	3.7	0.7 to 18.3	1/26	3.8	0.7 to 18.9
Ankle	2/27	7.4	2.1 to 23.4	2/24	8.3	2.3 to 25.9
Toes	3/23	13.0	4.5 to 32.1	6/19	31.6	15.4 to 54.0

Table 5.17: Hofstaðir multiple joint involvement.

Skeleton	**Sex**	**Age**	**Cervical**	**Thoracic**	**Lumbar**	**Shoulder**	**Elbow**	**Wrist**	**Fingers**	**Hip**	**Knee**	**Ankle**	**Toes**
HSM-A-002	F	50+	✓	✓		✓				✓			
HSM-A-003	F	50+	✓		✓	✓		✓		✓			
HSM-A-010	F	50+						✓		✓		✓	
HSM-A-015	F	50+	✓	✓	✓	✓		✓		✓	✓		
HSM-A-020	M	50+	✓	✓	✓			✓	✓				

Skeleton	Sex	Age	Cervical	Thoracic	Lumbar	Shoulder	Elbow	Wrist	Fingers	Hip	Knee	Ankle	Toes
HSM-A-021	F	50+	✓	✓	✓	✓						✓	
HSM-A-023	F	50+	✓	✓	✓	✓	✓	✓	✓	✓			
HSM-A-033	M	50+	✓	✓		✓			✓	✓			
HSM-A-054	M	35-49	✓	✓	✓			✓	✓	✓			
HSM-A-057	M	50+	✓	✓	✓	✓		✓	✓		✓	✓	
HSM-A-075	F	50+	✓	✓	✓			✓	✓				
HSM-A-104	M	35-49	✓	✓				✓					✓

5.1.4 Haffjarðarey (HFE)

A total of 22 skeletons were available from the Haffjarðarey collection (see table 5.18).

Table 5.18: Haffjarðarey sex and age.

Age	Male	Female	Unknown	TOTAL
18-34	1	5	0	6 (27%)
35-49	4	6	0	10 (45%)
50+	2	2	0	4 (18%)
Unknown	0	0	2	2 (9%)
TOTAL	7 (32%)	13 (59%)	2 (9%)	22

5.1.4.1 Preservation and osteoarthritis

The preservation of the skeletal material from Haffjarðarey is very varied. This is mainly due to the fact that the excavation of the site was carried out to rescue burials which were being eroded, and so several of the skeletons from the site are only partially preserved (Steffensen 1946: 147-9). The average and median API at the site is 3. The preservation of the individual bones is, however in most instances, excellent with the average and median QBI both 5. For a comparative chart of API and QBI for all the sites see figure 5.1.

5.1.4.2 Axial skeleton (processes)

The most commonly preserved joints were the cranium-C1, L4-L5 and L5-S1, 15 cases (68%), see also Appendix 2. The least commonly preserved joints were the T5-T6 and T9-T10, which were present in nine (55%) instances. The average preservation of the vertebral joints was 53%, with a median of 41%.

Osteoarthritis of the vertebrae

Of the 22 individuals who had some part of the spinal column preserved, 12 (54.5%) had some osteoarthritis of those joints (see Appendix 3, and a summary of those results in table 5.19. Those individuals in the Haffjarðarey collection who are affected are shown in Appendix 4). The joints which were not affected were the T6-T7, T7-T8, T8-T9, T12-L1 and L1-L2. The most commonly affected joints, with over 30% prevalence, were the C2-C3, C4-C5, T4-T5, T5-T6 and L3-L4.

5.1.4.3 Upper limb

The preservation of the joints in the upper limb within the Haffjarðarey population is not good due to the erosion of the site. There are 15 (68%) shoulder and elbow joints, the most commonly preserved joints of the upper limb, while only 9 (41%) individuals have preserved joints of the fingers.

Table 5.19: Haffjarðarey vertebral facet osteoarthritis summary (N= Number of cases/total number preserved).

Age	Cervical			Thoracic			Lumbar		
	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	2/6	33.3	9.8 to 70.0	1/4	25.0	4.6 to 69.9	0/4	0	0
35-49	3/8	37.5	13.7 to 69.4	4/8	50.0	21.2 to 78.5	3/8	37.5	13.7 to 69.4
50+	3/4	75.0	30.0 to 95.4	3/3	100	43.9 to 100	3/3	100	43.9 to 100
Unknown	0/0	0	0	0/0	0	0	0/0	0	0
TOTAL	8/18	44.4	24.6 to 66.3	8/15	53.3	30.1 to 75.2	6/15	40.0	19.8 to 64.3

Osteoarthritis of the upper limb

Four of the 15 individuals with preserved shoulder joints (26.7%) in the Haffjarðarey population had osteoarthritis of the shoulder (see table 5.20). This included two males and two females. The osteoarthritis was in all cases bilateral involving the glenohumeral joint. Those affected were; HFE-A-011 (male, 35-49), HFE-A-015 (female, 50+), HFE-A-018 (male, 50+) and HFE-A-020 (female, 50+). In addition HFE-A-018 had osteoarthritis of the acromioclavicular joints.

Of the 15 individuals with preserved elbow joints, four (26.7%) had osteoarthritis of the elbow. Three were males and one was female. The single female, HFE-A-015 (50+) had bilateral osteoarthritis of the humeroradial joint. One of the males, HFE-A-14e (35-49) had bilateral osteoarthritis of the humeroulnar joint. The other two had unilateral osteoarthritis of the elbow involving the right humeroradial joints; HFE-A-011 (35-49) and HFE-A-019 (35-49).

Five individuals of the 13 with preserved wrist joints (38.5%) osteoarthritis (see the table for Haffjarðarey in Appendix 5). Of these three were female and two were male. The two females had bilateral osteoarthritis. In the case of HFE-A-015 (50+) the

osteoarthritis was in the distal radioulnar joints as well as the left 1st CMC. HFE-A-013 (35-49) had more extensive involvement; both distal radioulnar joints, the right scaphoid-trapezium and scaphoid-trapezoid joints as well as the left radius-triquetral joint. The three males with wrist osteoarthritis also had bilateral involvement. HFE-A-011 (35-49) had osteoarthritis of both distal radioulnar, radius-lunate and radius-triquetral joints. HFE-A-014e (35-49) had osteoarthritis of both distal radioulnar joints. HFE-A-018 (50+) had the most extensive wrist osteoarthritis. The osteoarthritis was in both of the following joints; distal radioulnar, radius-scaphoid, scaphoid-trapezoid, scaphoid-capitate, lunate-capitate, lunate-triquetral, 1st CMC and 5th CMC as well as in the joint between the 4th and 5th metacarpals. In addition the right scaphoid-lunate and 2nd CMC as well as the left scaphoid-trapezium joints had osteoarthritis changes.

Of the nine individuals with preserved finger joints three (33.3%) had osteoarthritis of the fingers. One of these was female, HFE-A-013 (35-49) who had osteoarthritis of the 1st right MCP. The other two affected were males; HFE-A-011 (35-49) had osteoarthritis of the right 2nd MCP, while HFE-A-018 (50+) had osteoarthritis of the right 1st MCP, as well as bilateral 2nd and 3rd MCP joints.

Table 5.20: Haffjarðarey upper limb osteoarthritis summary (N= Number of cases/total number preserved).

Age	**Shoulder**			**Elbow**			**Wrist**			**Fingers**		
	N	**%**	**95% CI**	**N**	**%**	**95% CI**	**N**	**%**	**95% CI**	**N**	**%**	**95% CI**
18-34	0/3	0	0	0/2	0	0	0/2	0	0	0/0	0	0
35-49	1/9	11.1	2.0 to 43.5	3/9	33.3	12.1 to 64.6	3/8	37.5	13.7 to 69.4	2/6	33.3	9.8 to 70.0
50+	3/3	100	43.9 to 100	1/3	33.3	6.2 to 79.2	2/3	66.7	20.8 to 93.9	1/3	33.3	6.2 to 79.2
Unknown	0/0	0	0	0/0	0	0	0/0	0	0	0/0	0	0
TOTAL	4/15	26.7	8.9 to 55.2	4/15	26.7	8.9 to 55.2	5/13	38.5	17.7 to 64.5	3/9	33.3	12.1 to 64.6

5.1.4.4 Lower limb

The joints of the lower limb were better preserved than those of the upper limb, with the hip, knee and ankle joints all displaying over 70% preservation. The best preserved joints were those of the knees and ankles, a total of 17 (77%) had at least 10% preservation. The toes were the worst preserved, with 13 individuals (59%) with at least 10% preservation.

Osteoarthritis of the lower limb

Two individuals of the 16 with preserved hip joints (12.5%) in the Haffjarðarey population had hip osteoarthritis, one female and one male (see table 5.21). HFE-A-015 (female, 50+) had bilateral hip osteoarthritis (see figure 5.10), while in the case of HFE-A-018 (male, 50+) only the left hip was involved. In the case of the latter, the osteoarthritis was secondary to a healed *contra coup* fracture of the left tibia and fibula, which had resulted in severe shortening of the left leg (Gestsdóttir 2004c: 15).

Of the 17 individuals with preserved knee joints, three (17.7%) had knee osteoarthritis. Two were females, both aged 35-49; HFE-A-008 who had osteoarthritis of the right knee only involving the medial condyle of the femur-tibia joint; and HFE-A-014h who had bilateral knee osteoarthritis involving the medial femur-patella joint. HFE-A-018 (50+) was the only male with bilateral knee osteoarthritis (see figure 5.12), which involved the medial condyle of the femur-tibia joint, again secondary to the *contra coup* fracture of the left tibia and fibula.

Seven of the 17 with preserved ankle joints (41.2%) in the Haffjarðarey population had osteoarthritis of the ankles (see the table for Haffjarðarey in Appendix 6). This includes three females, three males, and one individual for who sex could not be determined. Two of the females had bilateral ankle osteoarthritis; HFE-A-008 (35-49) had osteoarthritis of the right tibia-talus joint as well as the anterior and posterior articular surfaces of the talus-calcaneus joint. On the left foot the osteoarthritis was seen in the anterior talus-calcaneus joint as well as between the 3rd and 4th MTs. The other female with bilateral involvement was HFE-A-014h (35-49). She had osteoarthritis of both tibia-talus; talus-navicular and 2nd TMT joints. HFE-A-013 (35-49) had osteoarthritis of the left 5th TMT joint. Of the males, only one individual had bilateral osteoarthritis of the ankles, HFE-A-018 (50+) had involvement of the right 2nd and 3rd TMTs and the left tibia-talus joint (see figure 5.14), most likely secondary to the fracture of the left tibia and fibula. Two males had unilateral osteoarthritis of the right ankle; HFE-A-11 (35-49) involving the medial surface of the talus-calcaneus joint and HFE-A-14e (35-49) of the talus-navicular joint. The one individual whose sex could not be determined was an adult of an unknown age, HFE-A-004. This individual had unilateral osteoarthritis of the left ankle, involving the 2nd TMT joint.

Table 5.21: Haffjarðarey lower limb osteoarthritis summary (N= Number of cases/total number preserved).

Age	Hip			Knee			Ankle			Toes		
	N	%	95% CI	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	0/4	0	0	0/4	0	0	0/4	0	0	0/2	0	0
35-49	0/9	0	0	2/9	22.2	6.3 to 54.7	5/9	55.6	26.7 to 81.1	2/7	28.6	8.2 to 64.1
50+	2/3	66.7	20.8 to 93.9	1/3	33.3	6.2 to 79.2	1/2	50.0	9.5 to 97.3	1/2	50.0	9.5 to 97.3
Unknown	0/0	0	0	0/1	0	0	1/2	50.0	9.5 to 97.3	0/2	0	0
TOTAL	2/16	12.5	3.5 to 36.0	3/17	17.6	6.2 to 41.0	7/17	41.2	21.6 to 64.0	3/13	23.1	6.2 to 54.0

Three individuals of the 13 with preserved joints of the toes (23.1%) had osteoarthritis of the toes. Two of these were females and one was male. The two females, HFE-A-013 and HFE-A-016, both 35-49 had bilateral osteoarthritis of the 1st MTP joint. The only male with osteoarthritis of the toes in the collection was HFE-A-018 (50+), who had unilateral osteoarthritis of the left 2nd MTP (secondary to a fracture).

5.1.4.5 *Male v. female*

There were only 13 females and seven males in the Haffjarðarey collection (see table 5.22). With such low numbers any prevalence figures must be treated carefully. There was little variation in the prevalence of vertebral osteoarthritis among the females, with five cases each of cervical (11 preserved, 45.5%), thoracic (10 preserved, 50.0%) and lumbar (10 preserved, 50.0%) facet joint osteoarthritis. Cervical facet joint osteoarthritis, three cases of seven preserved (42.9%) and thoracic facet joint osteoarthritis, three cases of five preserved (60.0%), were the most common among the males.

The highest prevalence for the post-axial skeletons for the females in the collection was in the ankles (30.0%), three cases of 10 preserved. The elbow and ankles showed the highest prevalence for the males, three cases of five preserved each (60.0%).

Table 5.22: Haffjarðarey male v. female osteoarthritis summary (N= number of cases/total number preserved).

Joint	**Female**			**Male**		
	N	**%**	**95% CI**	**N**	**%**	**95% CI**
Cervical	5/11	45.5	21.3 to 72.0	3/7	42.9	15.8 to 75.0
Thoracic	5/10	50.0	23.7 to 76.3	3/5	60.0	23.1 to 88.2
Lumbar	5/10	50.0	23.7 to 76.3	1/5	20.0	3.6 to 52.4
Shoulder	2/10	20.0	5.7 to 51.0	2/5	40.0	11.8 to 76.9
Elbow	1/10	10.0	1.8 to 40.4	3/5	60.0	23.1 to 88.2
Wrist	2/8	25.0	7.1 to 59.1	3/5	60.0	23.1 to 88.2
Fingers	1/5	20.0	3.6 to 52.4	2/4	50.0	15.0 to 85.0
Hip	1/11	9.1	1.62 to 37.7	1/5	20.0	3.6 to 52.4
Knee	2/11	18.2	3.6 to 52.4	1/5	20.0	3.6 to 52.4
Ankle	3/10	30.0	10.8 to 60.3	3/5	60.0	23.1 to 88.2
Toes	2/7	28.6	5.1 to 69.7	1/4	25.0	1.3 to 78.1

Table 5.23: Haffjarðarey multiple joint involvement.

Skeleton	**Sex**	**Age**	**Cervical**	**Thoracic**	**Lumbar**	**Shoulder**	**Elbow**	**Wrist**	**Fingers**	**Hip**	**Knee**	**Ankle**	**Toes**
HFE-A-008	F	35-49		✓	✓						✓	✓	
HFE-A-011	M	35-49	✓	✓		✓	✓	✓	✓			✓	
HFE-A-013	F	35-49			✓			✓	✓			✓	✓
HFE-A-014e	M	35-49		✓			✓	✓				✓	
HFE-A-015	F	50+	✓	✓	✓	✓	✓	✓		✓			
HFE-A-018	M	50+	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓

5.1.4.6 Multiple joint involvement

Sixteen of the 22 individuals (72.7%) in the Haffjarðarey population had osteoarthritis and of these six (37.5%) had multiple joint involvement. Given the low API of many of the skeletons in the Haffjarðarey population this is most likely an underestimate. Of those with multiple joint involvement, three were females and three males. None could be diagnosed with generalised osteoarthritis. The results are summarised in table 5.23.

5.1.5 Reykjavík (RVK & VEY)

The Reykjavík collections comprised 37 adult skeletal remains (see table 5.24).

Table 5.24: Reykjavík sex and age.

Age	Male	Female	Unknown	TOTAL
18-34	3	4	0	7 (19%)
35-49	11	5	0	16 (43%)
50+	4	4	0	8 (22%)
Unknown	2	2	2	6 (16%)
TOTAL	20 (54%)	15 (41%)	2 (5%)	37

5.1.5.1 Preservation and osteoarthritis

Most of the skeletons in the two Reykjavík collections are very well preserved. There are however, some individuals within the population whose preservation is quite poor, and these bring the average preservation within the population down. The average API for the collection is 3, with a median of 4. The average and median QBI is however 5. For a comparative chart of API and QBI for all the sites see figure 5.1.

5.1.5.2 Axial skeleton (processes)

Most of the vertebral facet joints within the population are well preserved (see Appendix 2*)*. There are however four individuals with no vertebral processes preserved. The most commonly preserved joint was the cran-C1 (89%), while the C3-C4 and T2-T3 were the worst preserved (61%). The average preservation of the vertebral joints in the Reykjavík collection was 66%, with a median of 64%.

Osteoarthritis of the vertebrae

Of the 37 individuals in the Reykjavík population who had some part of the spinal column preserved, 16 had spinal osteoarthritis (43.2%). See Appendix 3, and a summary of those results in table 5.25. Those individuals in the Reykjavík collection who are affected are shown in Appendix 4). The joints with no involvement are the C6-C7 and T7-T8, as well as all the processes between T9-T10 and L3-L4. The most commonly affected joints, with over 20% prevalence were the C3-C4 and C4-C5.

Table 5.25: Reykjavík vertebral facet osteoarthritis summary (N= Number of cases/total number preserved).

Age	Cervical			Thoracic			Lumbar		
	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	2/7	28.6	8.2 to 54.1	1/6	16.7	3.0 to 56.4	0/6	0	0
35-49	5/15	33.3	15.2 to 58.3	5/12	41.7	19.3 to 68.1	2/13	15.4	4.3 to 42.2
50+	5/8	62.5	30.6 to 86.3	3/6	50.0	18.8 to 81.2	2/6	33.3	9.7 to 70.4
Unknown	0/0	0	0	0/1	0	0	0/1	0	0
TOTAL	12/32	37.5	22.9 54.7	9/25	36.0	20.2 to 57.4	4/26	15.4	6.2 to 33.5

5.1.5.3 Upper limb

The general preservation of the joints of the upper limb mirrors the preservation of the population in general. Most of the joints are excellently preserved, there are however three individuals within the collection with no upper limb joints preserved. The shoulder and elbow joints are the best preserved, with 27 (73%) instances above the minimum 10% preservation level, while only 24 wrist and finger joints (65%) are present.

Osteoarthritis of the upper limb

Only one individual in the Reykjavík population, of the 27 with shoulder joints preserved (3.7%) had osteoarthritis of the shoulder (see table 5.26). VEY-A-007 (female, 50+) had unilateral osteoarthritis of the left shoulder involving the glenohumeral joint.

Three individuals of 27 with elbow joints preserved had osteoarthritis (11.1%), one female and two males. The female, VEY-A-004 (50+) had unilateral involvement of the right humeroradial joint. The two males, VEY-A-029 (50+) and RVK-C-004 (35-49), also had unilateral osteoarthritis of the elbow, both cases involving the left humeroradial joints.

Of the 24 individuals with wrist joints preserved, there were three cases (12.5%) of wrist osteoarthritis in the Reykjavík population. Of those one was female and two were male; all the same individuals as those who had osteoarthritis of the elbow. The female, VEY-A-004 (50+) had unilateral osteoarthritis of the left wrist involving the radius-lunate and 1st & 2nd CMC joints. Of the two males, VEY-A-029 (50+) had extensive bilateral osteoarthritis, involving both scaphoid-trapezium and scaphoid-capitate joints, as well as the scaphoid-trapezoid, lunate-capitate and 5th CMC of the right wrist. RVK-C-004 (35-49) had unilateral osteoarthritis of the left distal radioulnar joint.

Four individuals of the 24 with finger joints preserved (16.7%) had osteoarthritis of the fingers. Of these two were female and two males, and includes all those who had osteoarthritis of the elbow and wrist. Of the two females, only one had bilateral osteoarthritis of the fingers, VEY-A-004 (50+) who had osteoarthritis of the right 2nd MCP, the left 1st and 3rd MCP as well as one unsided DIP. VEY-A-005 (18-34) had unilateral osteoarthritis of the right 1st MCP. Of the two males, VEY-A-029 (50+) had osteoarthritis of the right 2nd, 4th,

and 5th MCP as well as one unidentified MCP (diagnosed due to a 4th proximal phalanx with eburnation on the proximal epiphysis. This was not a 1st phalanx). RVK-C-004 (35-49) had unilateral osteoarthritis of the left 2nd MCP.

Table 5.26: Reykjavík upper limb osteoarthritis summary (N= Number of cases/total number preserved).

Age	**Shoulder**			**Elbow**			**Wrist**			**Fingers**		
	N	**%**	**95% CI**	**N**	**%**	**95% CI**	**N**	**%**	**95% CI**	**N**	**%**	**95% CI**
18-34	0/6	0	0	0/7	0	0	0/6	0	0	1/5	20.0	3.6 to 62.4
35-49	0/14	0	0	1/12	8.3	1.5 to 35.4	1/12	8.3	1.5 to 35.4	1/12	8.3	1.5 to 35.4
50+	1/5	20.0	3.6 to 62.4	2/5	40.0	11.8 to 76.9	2/6	33.3	9.7 to 70.4	2/7	28.6	8.2 to 54.1
Unknown	0/2	0	0	0/3	0	0	0/0	0	0	0/0	0	0
TOTAL	1/27	3.7	0.7 to 18.3	3/27	11.1	3.9 to 28.1	3/24	12.5	4.3 to 31.0	4/24	16.7	6.7 to 35.9

5.1.5.4 Lower limb

As with the rest of the skeletal elements, the average preservation of the joints of the lower limb was lowered by the fact that although most of the skeletons had excellent preservation there were a few where the preservation was very poor (see the table for Reykjavík in Appendix 6). Four of the 37 individuals in the Reykjavík population had none of the joints of the lower limb preserved. The average preservation of the hip, knee and ankle joints was over 70%, with the hip and knee joints being the best preserved at the at least 10% preservation level; a total of 29 instances (78%). The joints of the toes were the worst preserved, 21 individuals had foot joints (57%).

Osteoarthritis of the lower limb

There was only one individual in the Reykjavík population of the 29 with preserved hip joints (3.5%) with hip osteoarthritis (see table 5.27). RVK-C-003 (female, 35-49) had bilateral osteoarthritis of the hip. Two individuals of the 29 with preserved knee joints (6.9%) had osteoarthritis of the knee, one female and one male. The female, VEY-A-004 (50+) had bilateral knee osteoarthritis involving both of the condyles between the femur and tibia. The male, VEY-A-029 (50+) had unilateral osteoarthritis, involving the medial condyle of the left femur-tibia joint.

Of the 26 with preserved ankle joints, six individuals (23.1%) had ankle osteoarthritis (see the table for Reykjavík in Appendix 6). This included three females and three males. The three females all had unilateral ankle osteoarthritis. In the case of VEY-A-004 (50+) the osteoarthritis was very severe in the right ankle, and secondary to a healed but badly aligned fracture of the right calcaneus, which was completely deformed by the trauma (Gestsdóttir 2004c: 38-9). Osteoarthritis was observed in the following joints: tibia-fibula, tibia-talus, all the joints between the talus and calcaneus, talus-navicular, calcaneus-cuboid and the 3rd, 4th & 5th TMTs. VEY-A-007 (50+) had unilateral osteoarthritis of right the 3rd TMT, while RVK-A-001 (35-49) had

osteoarthritis of the left talus-navicular joint (see figure 5.13). Of the males, only one had bilateral osteoarthritis; VEY-A-029 (50+) had bilateral involvement of the intermediate cuneiform-lateral cuneiform joint, as well as the navicular-intermediate cuneiform joint of the right ankle. VEY-A-026 (35-49) had osteoarthritis of the left navicular-lateral cuneiform joint and RVK-C-004 (35-49) had osteoarthritis changes on the posterior articular surface between the talus and calcaneus on the left foot.

Of the 21 individuals with preserved toe joints, one female aged 35-49 (RVK-C-003) had osteoarthritis of the toes. This involved osteoarthritis of the 1st MTP joint.

Table 5.27: Reykjavík lower limb osteoarthritis summary (N= Number of cases/total number preserved).

Age	Hip			Knee			Ankle			Toes		
	N	%	95% CI	N	%	95% CI	N	%	95% CI	N	%	95% CI
18-34	0/7	0	0	0/6	0	0	0/6	0	0	0/5	0	0
35-49	1/14	7.1	52.4 to 92.4	0/14	0	0	3/13	23.1	8.2 to 50.3	1/11	9.1	1.6 to 37.7
50+	0/6	0	0	2/7	28.6	8.2 to 64.1	3/5	60.0	23.1 to 88.2	0/4	0	0
Unknown	0/2	0	0	0/2	0	0	0/2	0	0	0/1	0	0
TOTAL	1/29	3.4	0.6 to 17.2	2/29	6.9	1.9 to 22.0	6/26	23.1	11.0 to 42.1	1/21	4.8	0.8 to 22.7

5.1.5.5 Male v. female

There were 15 females and 20 males in the Reykjavík collections (see table 5.28). For both the males and the females, the cervical and thoracic vertebrae were the most commonly affected by osteoarthritis. There were six cases of cervical facet joint osteoarthritis out of 14 preserved (42.9%) among the females and six out of 18 preserved among the males (33.3%).

Table 5.28: Reykjavík male v. female osteoarthritis summary (N= Number of cases/total number preserved).

Joint	Female			Male		
	N	%	95% CI	N	%	95% CI
Cervical	6/14	42.9	21.4 to 67.4	6/18	33.3	16.3 to 56.3
Thoracic	5/10	50.0	23.7 to 76.3	4/14	28.6	11.7 to 54.7
Lumbar	2/11	18.2	5.1 to 47.7	2/14	14.3	4.0 to 39.9
Shoulder	1/11	9.1	1.6 to 37.7	0/16	0	0
Elbow	1/12	8.3	1.5 to 35.4	2/15	13.3	3.7 to 37.9
Wrist	1/11	9.1	1.6 to 37.7	2/13	15.4	4.3 to 42.2
Fingers	2/10	20.0	5.7 to 51.0	2/14	14.3	4.0 to 39.9
Hip	1/12	8.3	1.5 to 35.4	0/16	0	0
Knee	1/11	9.1	1.6 to 37.7	1/17	5.9	1.0 to 27.0
Ankle	3/11	27.3	9.7 to 56.6	3/13	23.1	8.2 to 50.2
Toes	1/10	10.0	1.8 to 40.4	0/10	0	0

Five females of the 10 preserved had thoracic facet joint osteoarthritis (50.0%) while four males out of 14 preserved (28.6%) were affected. The most commonly affected post-axial joint among the females was the ankle joint, three cases out of 11 preserved (27.3%) followed by the fingers, two cases out of 10 preserved (20.0%). The ankles were also the most commonly affected joint for the males, three cases out of 13 preserved (23.1%). This was followed by two cases of osteoarthritis each of the wrist, 13 preserved (15.4%); fingers, 14 preserved (14.3%) and elbow 15 preserved (13.3%) joints.

5.1.5.6 Multiple joint involvement

Of the 36 individuals in the Reykjavík collection, 18 (50.0%) had osteoarthritis. Of these five (27.8%) had multiple joint involvement, three females and two males. There is one case which can tentatively be identified as generalised osteoarthritis. VEY-A-004, a female aged 50+, had osteoarthritis of both 1st CMC joints, as well as only one unsided PIP. In addition there was osteoarthritis of the right elbow as well as the cervical and lumbar vertebrae. The results are summarised in table 5.29.

Table 5.29: Reykjavík multiple joint involvement.

Skeleton	Sex	Age	Cervical	Thoracic	Lumbar	Shoulder	Elbow	Wrist	Fingers	Hip	Knee	Ankle	Toes
RVK-C-003	F	35-49	✓							✓			✓
RVK-C-004	M	35-49		✓			✓	✓	✓			✓	
VEY-A-004	F	50+	✓		✓		✓	✓	✓				
VEY-A-007	F	50+	✓	✓	✓	✓							
VEY-A-029	M	50+	✓				✓	✓	✓				

5.2 Osteoarthritis by joint

This section will show the results of the analysis based on the joints affected. As can be seen in the tables in previous section (chapter 5.1), in most instances a statistical difference between the populations cannot be demonstrated when the 95% confidence interval is calculated. This is due to the small number of skeletons within each population.

5.2.1 Age adjusted prevalence

It is important when comparing disease prevalence in different archaeological populations to be aware of the different age structures within those populations. This is particularly important when dealing with diseases which do not contribute to death, as well as diseases which are more likely to affect individuals in a specific age group. Osteoarthritis fits into both these categories, being a disease that is not likely to lead to

death, and which mainly affects older individuals within the population (Baker and Pearson 2006: 218-9; Waldron 1994: 48-51).

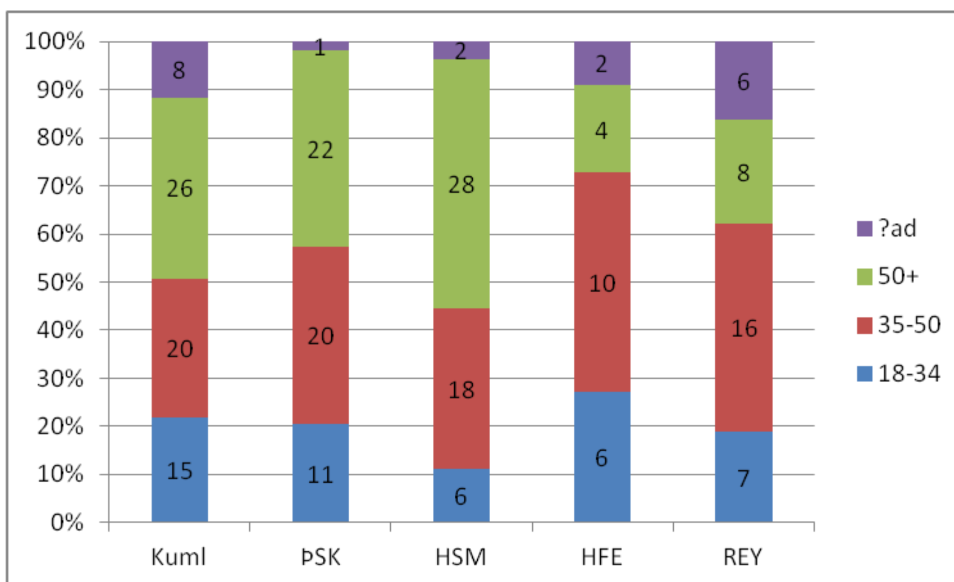

Figure 5.2: Age distribution of the populations in the study.

As figure 5.2 demonstrates, the populations used in this study have quite a varied population structure, with individuals aged over 50, those most likely to suffer from osteoarthritis, comprising between 20% (Haffjarðarey), to 50% (Hofstaðir), of the population. It is important to deal with these issues when comparing prevalence, to be certain that the prevalence is not in fact merely reflecting the age structure of the population.

To tackle this problem it was decided to calculate the age adjusted common odds ratio of the disease in the different populations. What this allows for is the summing of each age stratum to give an overall ratio which relates the age-specific prevalence in two populations to a single figure. This is done by calculating the odds ratio for each age group in the two populations which are to be compared, using the following formula:

$$\frac{p1}{1-p1} \div \frac{q1}{1-q1} \cdots \frac{pn}{1-pn} \div \frac{qn}{1-qn}$$

The odds ratio for each age group is then summed up to give a common, or overall, odds ratio (Waldron 1994: 62-3). The results of these calculations along with the 95% confidence intervals are presented in a table within each section.

It should be noted that those skeletons which could not be aged more accurately than to the "adult" age group were not included in these calculations. This means that two indi-

viduals in the study who had osteoarthritis are not included in the age adjusted common odds ratio calculations, HSM-A-059 from Hofstaðir, who had osteoarthritis of the left 1st MTP and HFE-A-004 from Haffjarðarey, who had osteoarthritis of the left ankle.

5.2.2 Osteoarthritis of the spine

Tables 5.30, 5.31 and 5.32 show the age adjusted common odds ratios for the joints of the spine. Haffjarðarey demonstrates consistently the highest age adjusted prevalence for osteoarthritis of the spinal joints (although the 95% confidence interval for the ratio between the cervical joints in the Haffjarðarey and Reykjavík populations is not statistically significant). The *kuml* population has consistently the lowest age adjusted prevalence. This is however influenced by the poor preservation of the material. Hofstaðir consistently has higher age adjusted prevalence than Skeljastaðir in all sections of the vertebral column. It is the Reykjavík population which displays a completely different pattern. The age adjusted prevalence of cervical osteoarthritis indicates a lower prevalence than Skeljastaðir, while the latter has a lower age adjusted prevalence than Reykjavík in the lumbar vertebrae (the differences between the thoracic vertebrae in the two populations are not significant). The Reykjavík population also has higher age adjusted prevalence in the thoracic and lumbar vertebrae than is seen at Hofstaðir (with the differences in the cervical vertebrae at the two sites not being statistically significant). If one looks at which area of the spine is most commonly affected, the pattern tends to be that the thoracic vertebrae have the highest prevalence (in particular the joints between the T3-T4, T4-T5 and T5-T6), followed by the cervical (in particular the C2-C3, C3-C4, C4-C5 and C7-T1), with the lumbar vertebrae demonstrating the lowest prevalence. As noted above, only the Reykjavík population does not display this pattern. Here the cervical vertebrae are most commonly affected (see figure 5.3), followed by the thoracic and then the lumbar vertebrae.

Table 5.30: Cervical vertebrae osteoarthritis, common odds ratio, age adjusted prevalence (COR).

		Kuml		**ÞSK**		**HSM**		**HFE**		**RVK & VEY**	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	9.8			0.17	0.12 to 0.25	0.07	0.04 to 0.12	0.07	0.01 to 0.42	0.11	0.07 to 0.17
ÞSK	28.6	3.98	2.71 to 5.84			0.66	0.51 to 0.85	0.46	0.32 to 0.66	0.58	0.42 to 0.79
HSM	50.0	5.82	4.02 to 8.45	1.62	1.25 to 2.11			0.55	0.37 to 0.81	0.78	0.57 to 1.06
HFE	44.4	13.94	8.02 to 24.23	2.48	1.70 to 3.61	1.82	1.24 to 2.68			1.33	0.90 to 1.98
RVK & VEY	37.5	9.12	5.77 to 14.42	1.88	1.37 to 2.57	1.28	0.94 to 1.74	0.75	0.50 to 1.12		

Table 5.31: Thoracic vertebrae osteoarthritis, common odds ratio, age adjusted prevalence (COR).

		Kuml		**ÞSK**		**HSM**		**HFE**		**RVK & VEY**	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	19.1			0.31	0.22 to 0.43	0.19	0.14 to 0.27	0.09	0.05 to 0.15	0.30	0.20 to 0.44
ÞSK	40.9	3.26	2.35 to 4.53			0.66	0.50 to 0.88	0.39	0.25 to 0.61	1.02	0.72 to 1.43
HSM	54.4	5.20	3.75 to 7.21	1.51	1.14 to 2.01			0.57	0.37 to 0.89	1.49	1.06 to 2.09
HFE	53.3	11.38	6.53 to 19.80	2.57	1.65 to 3.99	1.74	1.13 to 2.69			2.23	1.43 to 3.49
RVK & VEY	36.0	3.35	2.26 to 4.97	0.98	0.70 to 1.39	0.67	0.48 to 0.95	0.45	0.29 to 0.70		

Table 5.32: Lumbar vertebrae osteoarthritis, common odds ratio, age adjusted prevalence (COR).

		Kuml		**ÞSK**		**HSM**		**HFE**		**RVK & VEY**	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	12.0			0.49	0.37 to 0.66	0.24	0.17 to 0.35	0.06	0.03 to 0.13	0.54	0.33 to 0.90
ÞSK	26.5	2.51	1.73 to 3.63			0.64	0.49 to 0.85	0.41	0.27 to 0.63	1.82	1.22 to 2.73
HSM	39.2	4.12	2.86 to 5.93	1.56	1.18 to 2.06			0.43	0.27 to 0.69	2.45	1.62 to 3.68
HFE	40.0	15.39	7.58 to 31.24	2.44	1.58 to 3.77	2.33	1.45 to 3.74			6.10	3.41 to 10.93
RVK & VEY	15.3	1.84	1.12 to 3.02	0.55	0.37 to 0.82	0.41	0.27 to 0.61	0.16	0.09 to 0.29		

Figure 5.3: Osteoarthritis of the cervical and thoracic facet joints. ÞSK-A-040, C3-T2 superior facet joints, osteophytes, pitting and eburnation (Photo Ívar Brynjólfsson).

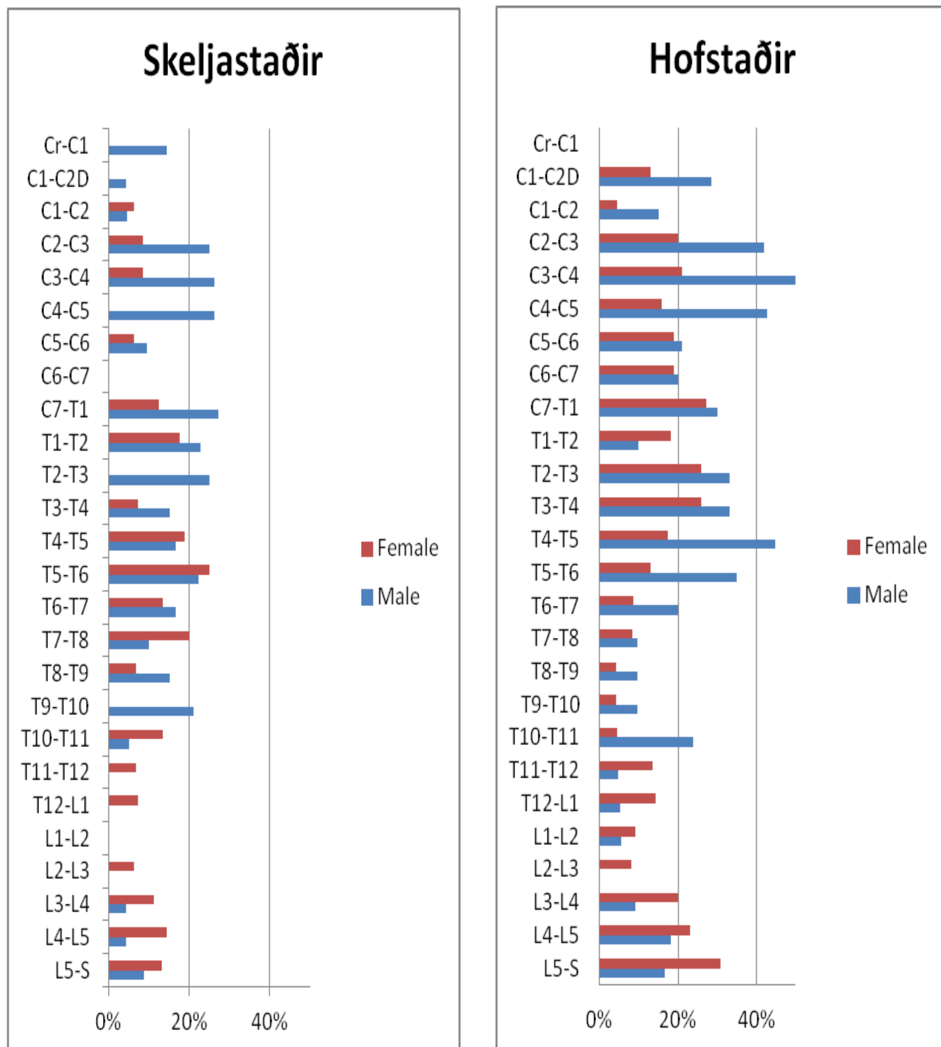

Figure 5.4: Vertebral facet joint osteoarthritis in Skeljastaðir and Hofstaðir, male v. female

5.2.2.1 Osteoarthritis of the spine, male v. female

There is a difference in the pattern of joints affected between the sexes, when comparing osteoarthritis of the spine. Among the females by far the most commonly affected spinal joint is the L5-S1, with 26.5% (18 of 68) of the females affected. Other spinal joints with well above average prevalence of osteoarthritis among the females are the C3-C4, T3-T4, T4-T5 and T5-T6. Among the males however, the most commonly affected joint is C3-C4, with 34.5% (19 of 55) of the males affected. Other joints with well above average prevalence of spinal osteoarthritis among the men are the C2-C3, C4-C5, C7-T1 and T4-T5 (see figure 6.4). If we look at the different populations within the study, this pattern is

reflected within the Skeljastaðir and Hofstaðir populations (see figure 5.4). In the Skeljastaðir collection the L5-S1 joint displays by far the highest prevalence of osteoarthritis among the females, 27.3% (6 of 22). Among the males the highest prevalence is within the C7-T1 joint, 27.3% (6 of 22), but followed closely by the C2-C3, 25.0% (5 of 20); C3-C4 and C4-C5, both 26.3% (5 of 19). In the Hofstaðir collection the L5-S1 joint is by far the most commonly affected among the females, 30.8% (8 of 26), while the C3-C4 has the highest prevalence among the males, 50.0% (10 of 20).

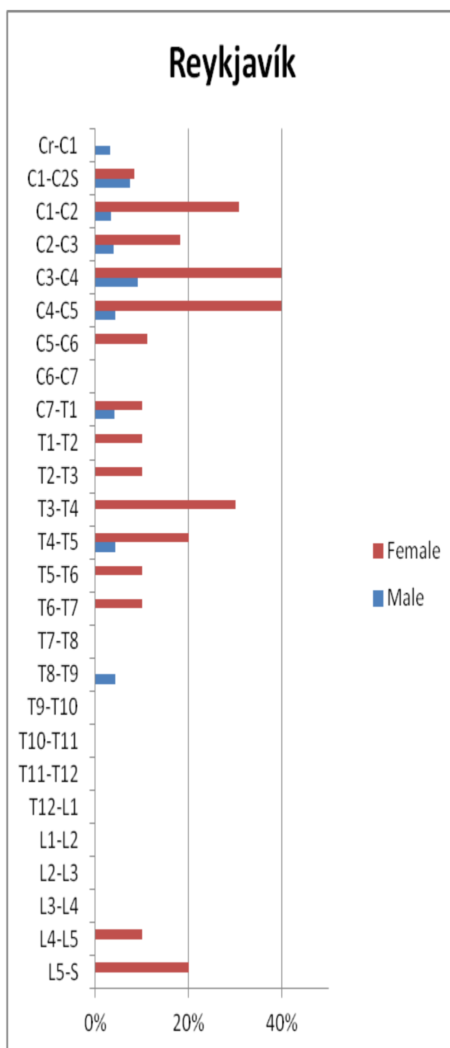

Figure 5.5: Vertebral facet joint osteoarthritis in Reykjavík, male v. female

The Reykjavík population displays a completely different pattern (see figure 5.5). Here the C3-C4 and C4-C5 joints have the highest prevalence among the females, 40.0% (4 of 10) are affected. The same area, C3-C4 is the most commonly affected among the males, 16.7% (2 of 12). The numbers within the Haffjarðarey population are too low to compare by sex; the average and median preservation of the vertebral facet joints for the females is only seven joints present, while for the men it is even lower, an average and median of only five joints present.

One pattern that is very clear, in all the populations is that the lower lumbar vertebrae (L3-sacrum) are far more commonly affected by osteoarthritis among the females than among the males, even within the populations like Reykjavík where the lower lumbar spine does not show the highest prevalence for the females.

5.2.3 Osteoarthritis of the shoulder

The overall prevalence of shoulder osteoarthritis for the Icelandic population was 8.1% (15 of 186). The Haffjarðarey population and Hofstaðir population demonstrate the highest age adjusted prevalence (see table 5.33), while the difference between the Hofstaðir and Haffjarðarey populations is not statistically significant. The other three sites all have a much lower age adjusted prevalence of shoulder osteoarthritis, there being are no cases in the Skeljastaðir population. In most instances, or in 53.3% (8 of 15) of the cases, the shoulder osteoarthritis is bilateral. There are four cases (26.6%) of the shoulder osteoarthritis affecting the left shoulder only and three cases (15.0%) where only the right shoulder is involved.

Table 5.33: Shoulder osteoarthritis, common odds ratio, age adjusted prevalence (COR).

		Kuml		**ÞSK**		**HSM**		**HFE**		**RVK & VEY**	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	2.1			--	--	0.09	0.04 to 0.18	0.06	0.03 to 0.12	0.20	0.08 to 0.51
ÞSK	0	--	--			--	--	--	--	--	--
HSM	19.2	11.25	5.67 to 22.33	--	--			1.09	0.70 to 1.69	2.25	1.07 to 4.71
HFE	26.7	16.36	0.94 to 33.74	--	--	1.53	1.00 to 2.36			8.73	4.21 to 18.09
RVK & VEY	3.7	5.00	1.95 to 12.80	--	--	0.44	0.21 to 0.93	0.11	0.05 to 0.22		

5.2.3.1 Osteoarthritis of the shoulder, male v. female

There is a difference between shoulder osteoarthritis in men and women, when comparing the overall Icelandic population, although this is not statistically significant. Shoulder osteoarthritis is more common in women, 11.1%, (95% CI 6.0 to 19.8) than men 5.9% (95% CI 2.7 to 12.2).

Figure 5.6: Shoulder osteoarthritis. HSM-A-057, right humerus and scapula. Humerus head, grade 3 osteophytes, grade 2 pitting & grade 3 eburnation. Glenoid fossa, grade 3 osteophytes, grade 3 pitting & grade 3 eburnation. Pseudoarthrosis on the accromion, grade 3 osteophytes, grade 3 pitting & grade 3 eburnation (Photo Ívar Brynjólfsson).

5.2.4 Osteoarthritis of the elbow

The prevalence of elbow osteoarthritis in the overall Icelandic population is 6.4% (12 of 187). The common odds ratio calculated for age adjusted prevalence indicates that elbow osteoarthritis is most common in the Reykjavík and Haffjarðarey populations (see table 5.34). The three other sites have a much lower prevalence, although calculations of the age adjusted common odds ratio of Reykjavík compared to Hofstaðir and Haffjarðarey indicates that the age adjusted prevalence is always higher for the Reykjavík population, in particular when compared to Hofstaðir. The difference in age adjusted prevalence between Hofstaðir and Skeljastaðir is not significant.

There is no pattern for side involvement of elbow osteoarthritis. Of the twelve cases seen in the overall population, two are bilateral (16.7%), another four involve the left elbow only (33.3%). There are three cases where only the right elbow is involved (41.7%). In addition there is one case of the right elbow being involved, but the left has not been preserved, so it is not possible to say if the osteoarthritis was bilateral. If one divides the elbow joint into three compartments, the trochlear-ulna, the capitulum-radius and the ulna-radius, in the overall population the capitulum-radius compartment is most commonly affected, 5.9% (10 of 169). There is little difference in the crude prevalence

between the other two, the prevalence for the ulna-radius compartment is 1.5% (3 of 183), while for the trochlear-ulna compartment it is 1.5% (2 of 197). However, none of these differences can be demonstrated to be statistically significant. This pattern is reflected in all of the populations within the study, where more than one case of elbow osteoarthritis is present.

Figure 5.7: Osteoarthritis of the elbow. ÞSK-A-052, right humerus and ulna. Capitulum, both zones, grade 2 osteophytes & grade 3 pitting. Coranoid process, both medial zones, grade 3 osteophytes, posterior-medial zone grade 2 osteophytes (Photo Ívar Brynjólfsson).

Table 5.34: Elbow osteoarthritis, common odds ratio, age adjusted prevalence (COR).

		Kuml		ÞSK		HSM		HFE		RVK & VEY	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	2.2			0.37	0.18 to 0.75	1.18	0.48 to 2.95	0.09	0.04 to 0.17	0.17	0.09 to 0.34
ÞSK	5.9	2.70	1.33 to 5.48			4.17	1.99 to 8.74	0.09	0.47 to 0.17	0.17	0.09 to 0.33
HSM	2.0	0.84	0.34 to 2.10	0.24	0.11 to 0.50			0.02	0.01 to 0.06	0.04	0.02 to 0.11
HFE	26.7	11.74	5.76 to 23.96	11.14	5.77 to 21.50	40.94	15.54 to 107.90			2.48	1.41 to 4.34
RVK & VEY	11.1	5.63	2.91 to 10.89	5.77	3.01 to 11.04	22.72	9.34 to 55.30	0.43	0.23 to 0.71		

5.2.4.1 Osteoarthritis of the elbow, male v. female

There is no difference between the sexes when looking at the prevalence of elbow osteoarthritis. Of the women 6.0% (95% CI 2.6 to 13.3) have elbow osteoarthritis, while the prevalence for men is 6.9% (95% CI 3.4 to 13.6).

5.2.5 Osteoarthritis of the hand

Discussing the genetics of hand osteoarthritis in archaeological populations is problematic for several reasons. One is the issue that it is not known if osteoarthritis within the different joint sites in the hand should be considered as separate genotypes (Jónsson et al. 2003: 391).

The focus of studies of the inheritance of hand osteoarthritis in Iceland has been on the 1st CMC and the interphalangeal joints (hereafter IP), although other studies have included the MCP joints (Aspelund et al. 1996: 34; Jónsson et al. 2003: 391). The emphasis of the discussion here will therefore be on the 1st CMC and the IP joints, although osteoarthritis in other joints in the hand will also be discussed to some extent.

5.2.5.1 Osteoarthritis of the 1st CMC & IP

It is again the sites of Hofstaðir and Haffjarðarey which stand out when looking at the age adjusted prevalence of osteoarthritis in the 1st CMC and IP joints of the hands (see table 5.35). Haffjarðarey has higher age adjusted prevalence than Hofstaðir.

It is worth noting that there appears not to be a correlation between osteoarthritis of the hands and osteoarthritis of the knees as seen in the modern Icelandic population (see Jónsson et al. 2011: 8-9 and chapter 3.5.3). There does, however, appear to be a much better correlation between those individuals who have osteoarthritis of the hand and of the hip (see table 5.36). This is particularly clear in the Hofstaðir population.

Osteoarthritis of the 1st CMC & IP, male v. female

When looking at the overall pattern within the Icelandic population (n=236) of osteoarthritis in the 1st CMC and IP joints of the hands in relation to sex, the same pattern is seen as with osteoarthritis in the hips (see tables 5.37, 5.38 and 5.39). While the overall prevalence for all the populations in the study is 15 individuals of the 160 with the joints of the hands preserved (9.4%), the prevalence among women is higher than for men, 12.7% (95% CI 6.8 to 22.4) v. 6.9% (95% CI 3.2 to 14.2), reflecting the female to male ratio seen in the modern Icelandic population (Aspelund et al. 1996: 35), although this cannot be demonstrated to be statistically significant.

Table 5.35: 1st CMC & IP osteoarthritis, common odds ratio, age adjusted prevalence (COR).

		Kuml		ÞSK		HSM		HFE		RVK & VEY	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	3.0			0.33	0.17 to 0.68	0.18	0.09 to 0.37	0.08	0.03 to 0.18	0.64	0.04 to 9.44
ÞSK	9.1	3.00	1.50 to 6.02			0.63	0.42 to 0.95	0.43	0.24 to 0.76	1.99	1.01 to 3.93
HSM	14.6	5.46	2.69 to 11.12	1.59	1.06 to 2.41			0.36	0.19 to 0.70	2.71	1.34 to 5.49
HFE	20.0	13.00	5.70 to 29.65	2.32	1.31 to 4.08	2.76	1.44 to 5.30			12.00	4.36 to 33.02
RVK & VEY	4.0	1.56	0.67 to 3.65	0.50	0.25 to 0.99	0.37	0.18 to 0.75	0.08	0.03 to 0.22		

Table 5.36: Osteoarthritis of the 1st CMC and IP joints.

Site	Skeleton	Sex	Age	1st CMC	PIP	DIP	Notes
Kuml	VDP-A-003	Male	18-34	Right	--	--	--
Skeljastaðir (ÞSK)	ÞSK-A-059	Female	50+	--	1	--	--
	ÞSK-A-060	Male	35-49	--	--	1	--
Hofstaðir (HSM)	HSM-A-008	Female	50+	--	--	2	--
	HSM-A-010	Female	50+	Left	--	--	Hip OA & multiple joint involvement
	HSM-A-015	Female	50+	Bilateral	--	--	Hip & knee OA. Multiple joint involvement
	HSM-A-018	Male	50+	Left	--	--	--
	HSM-A-023	Female	50+	Right	--	--	Hip OA & multiple joint involvement
	HSM-A-054	Male	35-49	Right	--	--	Hip OA & multiple joint involvement
	HSM-A-057	Male	50+	Bilateral	--	2	Knee OA & multiple joint involvement
	HSM-A-075	Female	50+	--	--	1	Multiple joint involvement
Haffjarðarey (HFE)	HFE-A-015	Female	50+	Left	--	--	Hip OA & multiple joint involvement
	HFE-A-018	Male	50+	Bilateral	--	--	Secondary hip & knee OA. Multiple joint involvement
Reykjavík (RVK & VEY)	VEY-A-004	Female	50+	Left	--	--	Knee OA & multiple joint involvement

Figure 5.8: Osteoarthritis of the 1st CMC: HSM-A-015, left MC1, grade 3 osteophytes & grade 1 eburnation, and trapezium, grade 3 osteophytes, grade 2 pitting & grade 2 eburnation (Photo Ívar Brynjólfsson).

Table 5.37: 1ST CMC osteoarthritis by sex.

Site	Females			Males		
	N	**%**	**95% CI**	**N**	**%**	**95% CI**
Kuml	0/10	0	0	1/15	6.7	1.2 to 29.8
Skeljastaðir (ÞSK)	0/17	0	0	0/18	0	0
Hofstaðir (HSM)	3/25	12.0	4.2 to 30.0	2/22	9.1	2.5 to 27.8
Haffjarðarey (HFE)	1/6	16.7	3.0 to 56.4	1/4	25.0	4.6 to 69.9
Reykjavík (RVK & VEY)	1/10	10.0	1.8 to 40.4	0/15	0	0
TOTAL	5/68	7.4	3.2 to 16.1	4/74	6.8	2.1 to 14.0

Table 5.38: IP joint osteoarthritis by sex

Site	Females		Males			
	N	**%**	**95% CI**	**N**	**%**	**95% CI**
Kuml	0/9	0	0	0/20	0	0
Skeljastaðir (ÞSK)	3/18	16.7	5.8 to 39.2	1/20	5.0	0.9 to 23.6
Hofstaðir (HSM)	1/24	4.2	0.7 to 20.2	2/22	9.1	2.5 to 17.8
Haffjarðarey (HFE)	0/5	0	0	0/4	0	0
Reykjavík (RVK & VEY)	1/9	11.1	2.0 to 43.5	0/13	0	0
TOTAL	5/65	7.8	3.3 to 17.8	3/79	3.8	1.3 to 10.6

Table 5.39: Osteoarthritis of the hands by sex

Site	Females			Males		
	N	**%**	**95% CI**	**N**	**%**	**95% CI**
Kuml	0/10	0	0	1/22	4.5	0.8 to 24.9
Skeljastaðir (ÞSK)	3/20	15.0	5.2 to 36.0	1/23	4.3	0.8 to 21.0
Hofstaðir (HSM)	4/25	16.0	6.4 to 34.7	3/23	13.0	4.5 to 32.1
Haffjarðarey (HFE)	1/6	16.7	3.0 to 56.4	1/4	25.0	4.6 to 69.9
Reykjavík (RVK & VEY)	1/10	10.0	1.8 to 40.4	0/15	0	0
TOTAL	9/71	12.7	6.8 to 22.3	6/87	6.9	3.2 to 14.2

5.2.5.2 Overall osteoarthritis of the hands

As has already been mentioned, it is not clearly understood if osteoarthritis in all the joints of the wrists and hands can be attributed to the same aetiological processes (Jónsson et al. 2003: 391). It is however worth including a discussion of overall osteoarthritis in the hands within the populations in this study. Here, the joints are divided up between the joints of the wrists (those involving the carpal bones) and the joints of the fingers (the MCP and IP joints). If one looks at the common odds ratio (see tables 5.40 and 5.41) between Hofstaðir and the other sites in the collection, the results indicate that in regards to osteoarthritis of the wrist, the age adjusted prevalence is

higher for Hofstaðir than all the sites with the exception of Haffjarðarey. However, if one looks at the common odds ratio for osteoarthritis of the finger joints, Hofstaðir only demonstrated a higher age adjusted prevalence than the *kuml* collection.

Table 5.40: Wrist osteoarthritis, common odds ratio, age adjusted prevalence (COR).

		Kuml		ÞSK		HSM		HFE		RVK & VEY	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	6.1			0.71	0.41 to 1.25	0.20	0.13 to 0.33	0.14	0.08 to 0.24	0.50	0.29 to 0.86
ÞSK	8.7	1.40	0.80 to 2.43			0.24	0.16 to 0.35	0.11	0.06 to 0.19	0.48	0.28 to 0.81
HSM	29.2	4.92	3.06 to 7.91	4.21	2.83 to 6.26			0.30	0.18 to 0.50	1.75	1.09 to 2.82
HFE	38.5	7.22	4.19 to 12.45	9.50	5.31 to 17.00	3.30	1.99 to 5.48			5.38	2.95 to 9.79
RVK & VEY	12.5	2.02	1.17 to 3.50	2.10	1.22 to 3.59	0.57	0.36 to 0.92	0.39	0.24 to 0.66		

Table 5.41: Finger osteoarthritis, common odds ratio, age adjusted prevalence (COR).

		Kuml		ÞSK		HSM		HFE		RVK & VEY	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	6.9			0.40	0.24 to 0.66	0.39	0.22 to 0.67	0.12	0.05 to 0.26	0.30	0.17 to 0.55
ÞSK	17.1	2.48	1.50 to 4.09			1.09	0.76 to 1.55	0.91	0.55 to 1.52	0.98	0.64 to 1.49
HSM	17.4	2.56	1.49 to 4.39	0.92	0.64 to 1.32			0.56	0.34 to 0.94	0.74	0.47 to 1.17
HFE	33.3	8.60	3.80 to 19.48	1.09	0.66 to 1.81	1.77	1.06 to 2.95			1.84	1.03 to 3.27
RVK & VEY	16.7	3.28	1.81 to 5.94	1.02	0.67 to 1.56	1.34	0.85 to 2.11	0.56	0.33 to 0.95		

Osteoarthritis of the hand, joint involvement

When looking at overall osteoarthritis of the hand within the Icelandic skeletal populations (n=236), the most commonly involved joints are the 1st MCP joint which affected 11 of the 133 individuals with the joint preserved (8.3%) and the radius-ulna joint which was seen in 14 out of 177 individuals (7.9%). Other commonly affected joints are the scaphoid-trapezium joint, 7.6% (10 of 131), 1st CMC, 6.3% (9 of 142) and 3rd MCP, 6.3% (9 of 144). There are two joints which have no instances of osteoarthritis, these are the 3rd CMC (n=147) and 4th CMC (n=129). It is interesting to note that when looking at the joints of the hand which demonstrate an above average (over 3.5%) prevalence of osteoarthritis a clear pattern emerges, reflecting a division into three groups.

1. The joints which are found in the medial part of the proximal wrist (radius-ulna, radius-triquetral & triquetral-pisiform).

2. The carpal joints which lie proximal to the 1st digit (scaphoid-capitate, scaphoid-trapezium, scaphoid-trapezoid, trapezoid-capitate & 1st CMC).
3. The first three MCP joints.

Osteoarthritis of the hand, male v. female

A total of 12.3% (95% CI 6.6 to 21.8) of the women in the study had osteoarthritis of the wrists, while 15.2% (95% CI 8.4 to 25.7) had osteoarthritis of the fingers. Of the men, 21.6% (95% CI 14.3 to 31.3) had osteoarthritis of the wrist, and 17.3% (95% CI 10.6 to 27.0) had osteoarthritis of the fingers. None of these differences could be demonstrated to be statistically significant.

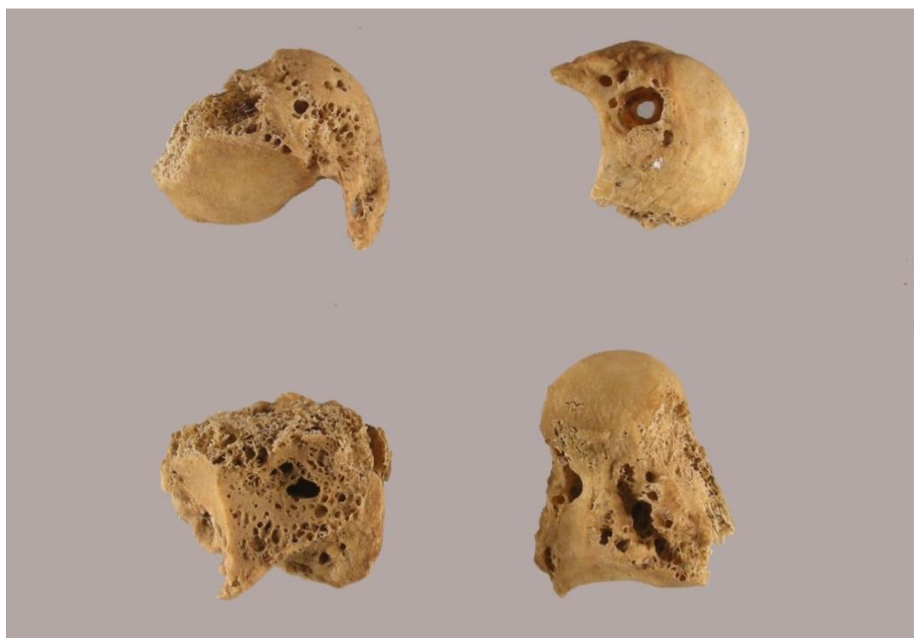

Figure 5.9: Osteoarthritis of the wrist. HSM-A-023, left scaphoid, lunate, trapezium and hamate, osteophytes, pitting & eburnation (Photo Hildur Gestsdóttir).

5.2.6 Osteoarthritis of the hip

The overall prevalence of hip osteoarthritis in the Icelandic population is 8.3% (17 of 204). The skeletal population from Hofstaðir stands out from the sites in the study when looking at osteoarthritis of the hip. The age adjusted prevalence (see table 5.42) is considerably higher at Hofstaðir compared to the other assemblages, with the exception of Haffjarðarey. The 12.7% prevalence is represented by only two individuals of the 16 who had hip joints preserved, one of which (HFE-A-018) clearly has secondary unilateral osteoarthritis of the hip secondary to a *contra coup* fracture of the left tibia and fibula. As what is of interest when considering inherited osteoarthritis is idiopathic osteoarthritis, with this case removed

from the equation, the prevalence of osteoarthritis at Haffjarðarey drops to 6.3% (1 of 15) and the age adjusted prevalence between Hofstaðir and Haffjarðarey is not significant.

Table 5.42: Hip osteoarthritis, common odds ratio, age adjusted prevalence (COR).

		Kuml		**ÞSK**		**HSM**		**HFE**		**RVK & VEY**	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	5.7			1.16	0.68 to 1.97	0.43	0.28 to 0.67	0.29	0.15 to 0.53	1.70	0.81 to 3.94
ÞSK	5.7	0.86	0.51 to 1.46			0.39	0.25 to 0.60	0.40	0.23 to 0.69	1.86	0.87 to 4.00
HSM	15.1	2.31	1.48 to 3.62	2.59	1.66 to 4.03			0.42	0.23 to 0.80	3.16	1.54 to 6.48
HFE	12.5	3.50	1.87 to 6.55	2.52	1.45 to 4.38	2.34	1.25 to 4.44			3.41	1.71 to 6.80
RVK & VEY	3.5	2.22	0.99 to 4.98	1.25	0.73 to 2.13	0.45	0.28 to 0.70	0.31	0.16 to 0.57		

Figure 5.10: Osteoarthritis of the hip. HFE-A-015. Left os coxa, grade 3 osteophytes all zones & grade 3 pitting, both superior zones (Photo Ívar Brynjólfsson).

There is no pattern in the side affected by idiopathic hip osteoarthritis, neither within the Icelandic skeletal population in general, or within the Hofstaðir site. In both instances the distribution is quite even, the overall population has five cases (31.3%) of only the right hip being involved, four (25%) where only the left hip is involved, and seven (43.7%) where the osteoarthritis is bilateral. In the Hofstaðir population there are three cases (37.5%) of only the right hip being involved, two (25%) where only the left hip is affected and three (37.5%) bilateral cases.

5.2.6.1 Osteoarthritis of the hip, male v. female

It is interesting to note the male v. female prevalence of idiopathic osteoarthritis of the hip in the total Icelandic skeletal population (n=236), see table 5.43. Of the females, 12.2% (95% CI 7.0 to 20.6) have osteoarthritis of the hip, as opposed to 5.6% (95% CI 2.0 to 10.4) of the men. This sex difference is even greater when looking at the skeletal population from Hofstaðir, where 22.2% (95% CI 10.6 to 40.8) of the women have osteoarthritis of the hip as opposed to 7.7% (95% CI 2.1 to 24.1). These differences cannot however be demonstrated to be statistically significant.

Table 5.43: Hip osteoarthritis in all the skeletal populations.

Site	Skeleton	Sex	Age	Side	Notes
Kuml	MEH-A-001	Female	50+	Bilateral	--
	SSG-A-001	Male	35-49	Left	--
	SSG-A-002	Male	50+	Right	Knees not preserved
Skeljastaðir (ÞSK)	ÞSK-A-011	Female	50+	Right	--
	ÞSK-A-017	Female	35-49	Bilateral	Multiple joint involvement
	ÞSK-A-058	Male	35-49	Left	--
Hofstaðir (HSM)	HSM-A-001	Female	50+	Right	--
	HSM-A-002	Female	50+	Right	Multiple joint involvement
	HSM-A-003	Female	50+	Bilateral	Multiple joint involvement
	HSM-A-010	Female	50+	Right	Multiple joint involvement
	HSM-A-015	Female	50+	Bilateral	Bilateral knee OA and multiple joint involvement
	HSM-A-023	Female	50+	Bilateral	Multiple joint involvement
	HSM-A-033	Male	50+	Left	Multiple joint involvement. Knees not preserved
	HSM-A-054	Male	35-49	Left	Multiple joint involvement
Haffjarðarey (HFE)	HFE-A-015	Female	50+	Bilateral	Multiple joint involvement
	HFE-A-018	Male	50+	Left	Secondary to a *contra coup* fracture of the left tibia-fibula. Also bilateral OA of the knees and multiple joint involvement
Reykjavík (RVK & VEY)	RVK-C-003	Female	50+	Bilateral	Multiple joint involvement

5.2.7 Osteoarthritis of the knee

The crude prevalence of knee osteoarthritis in the overall Icelandic population is 4.1% (8 of 201). Haffjarðarey has the highest age adjusted prevalence of knee osteoarthritis (see table 5.44), followed by Reykjavík. However, at both sites there are cases which are clearly examples of secondary osteoarthritis. In Haffjarðarey, HFE-A-018 (male, 50+) has a healed *contra coup* fracture of the left tibia and in Reykjavík, VEY-A-004 (female, 50+) has a severe healed fracture of the right calcaneus. With these cases removed the age adjusted prevalence remains significantly higher at Haffjarðarey, while the difference between Reykjavík and Hofstaðir becomes insignificant.

Figure 5.11: Osteoarthritis of the knee. HSM-A-015, left patella. Lateral facet, grade 1 osteophytes & grade 3 eburnation (Photo Hildur Gestsdóttir).

Of the eight cases of knee osteoarthritis most are bilateral or 62.5% (5 of 8). Two cases involve only the right knee, while there is one case where only the left knee is involved. The most common knee compartments affected are the medial side of the knee, 2.0% (4 of 203) and the femoral-patellar joint, 1.5% (3 of 202). The lateral compartment of the knee is least commonly affected, only 0.5% (1 of 202), although none of these differences can be demonstrated to be statistically significant. In all cases only one compartment of the knee is affected by osteoarthritis, and in the bilateral cases, it is always the same compartment which is affected on the right and left side.

Table 5.44: Knee osteoarthritis, common odds ratio, age adjusted prevalence.

		Kuml		**ÞSK**		**HSM**		**HFE**		**RVK & VEY**	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	0			--	--	--	--	--	--	--	--
ÞSK	1.9	--	--			0.63	0.29 to 1.36	0.04	0.02 to 0.12	0.13	0.05 to 0.28
HSM	3.8	--	--	1.60	0.73 to 3.50			0.06	0.03 to 0.14	0.03	0.01 to 0.07
HFE	17.7	--	--	22.63	8.11 to 63.17	16.25	7.29 to 36.22			4.29	2.13 to 8.67
RVK & VEY	6.9	--	--	8.00	3.52 to 18.16	5.00	2.51 to 9.97	0.23	0.12 to 0.47		

Figure 5.12: Osteoarthritis of the knee. HFE-A-018, left femur, grade 2 osteophytes on all & grade 3 eburnation on both lateral zones of the medial epicondyle. Left tibia, grade 2 osteophytes on all, grade 2 pitting on the medial epicondyle & grade 2 eburnation on both posterior zones of the medial epicondyle (Photo Ívar Brynjólfsson).

5.2.7.1 Osteoarthritis of the knee, male v. female

Knee osteoarthritis is slightly more common in women than in men, although this difference in crude prevalence cannot be demonstrated to be statistically significant. Of all the women in the current study, 5.8% (95% CI 2.5 to 12.9) had knee osteoarthritis. However, 2.8% (95% CI 0.9 to 7.9) of the men were affected.

5.2.8 Osteoarthritis of the feet

The results of the analysis of osteoarthritis in the joints of the feet in the current study are particularly striking (see tables 5.45 and 5.46). Overall, 10.2% (19 of 186) have osteoarthritis of the joints of the ankles (defined here as the joints involving the tarsal bones), while 11.6% (14 of 121) have osteoarthritis of the joints of the toes (the MTP, PIP and DIP joints of the feet). The most commonly involved joint of the ankle was the talus-navicular joint. A total of 4.0% (7 of 177) of the overall population had osteoarthritis of this joint. This is followed by the 5th TMT joint, 2.6% (4 of 151) and the anterior talus-calcaneus joint, 2.1% (4 of 193). All other joints demonstrated 2% or less involvement, with several ankle joints with no instances of osteoarthritis changes (these being the navicular-medical cuneiform, navicular-cuboid, medial cuneiform-intermediate cuneiform, lateral cuneiform-cuboid, 1st TMT and 3rd, 4th& 5th MTP joints). The 1st MTP joint was by far the most commonly involved in the toes, 8.4% (12 of 143) of the overall population had osteoarthritis of this joint, with all other joints demonstrating less than 1% involvement, and no instances of osteoarthritis of the 3rd, 4th or 5th MTP joints.

When looking at osteoarthritis of the feet, both the ankles and the toes within the populations in the current study, two distinctive groups appear, on the one hand

Hofstaðir and Skeljastaðir, and Haffjarðarey and Reykjavík on the other. Within the *kuml* group there is only one individual who displays osteoarthritic changes of the ankle. However, this is again most likely explained by the overall poor and varied preservation of the small joints of the feet.

Figure 5.13: Osteoarthritis of the ankle. RVK-A-001, left talus, altered joint contour, with grade 3 osteophytes, grade 3 pitting & grade 1 eburnation. Left navicular, altered joint contour, with grade 3 osteophytes, grade 3 pitting & grade 1 eburnation on the talar articular surface (Photo Ívar Brynjólfsson).

Figure 5.14: Osteoarthritis of the ankle. HFE-A-018, left talus, grade 1 osteophytes & grade 3 eburnation on the medial articular surface (Photo Ívar Brynjólfsson).

The difference between the two groups mentioned above involves the pattern and distribution of osteoarthritis in the ankle and the toes. The age adjusted prevalence for both osteoarthritis of the ankle and toes is clearly higher for Hofstaðir than Skeljastaðir. However, what the two sites share is that osteoarthritis of the joints of the toes is more prevalent than in the ankles. The reverse is seen in the Haffjarðarey and Reykjavík populations. Both Reykjavík and Haffjarðarey have a significantly higher age adjusted prevalence of ankle osteoarthritis than Hofstaðir and Skeljastaðir, even with the two cases of secondary osteoarthritis from each site removed.

5.2.8.1 Osteoarthritis of the feet, male v. female

There is no distinct pattern in the difference between the sexes when it comes to idiopathic osteoarthritis of the feet. Of the women, 10.8% (95% CI 5.8 to 19.3) had osteoarthritis of the ankle, while 9.6% (95% CI 5.1 to 17.2) of the men had the same. A total of 11.7% (95% CI 5.8 to 22.2) of the women had osteoarthritis of the toes, and 12.5% (95% CI 6.2 to 23.6) of the men had the same.

Table 5.45: Ankle osteoarthritis, common odds ratio, age adjusted prevalence (COR).

		Kuml		**ÞSK**		**HSM**		**HFE**		**RVK & VEY**	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	2.3			1.00	0.41 to 2.46	0.30	0.15 to 0.61	0.01	0.00 to 0.03	0.02	0.01 to 0.06
ÞSK	2.0	1.00	0.41 to 2.46			0.29	0.14 to 0.59	0.01	0.00 to 0.03	0.02	0.01 to 0.05
HSM	7.8	3.33	1.63 to 6.81	3.36	1.70 to 7.02			0.07	0.04 to 0.12	0.14	0.08 to 0.23
HFE	41.2	81.91	28.67 to 234.00	88.00	32.07 to 241.50	15.29	8.55 to 27.32			2.62	1.60 to 4.31
RVK & VEY	23.1	45.67	17.77 to 117.30	47.90	19.00 to 120.80	7.36	4.38 to 12.35	0.38	0.23 to 0.62		

Table 5.46: Toe osteoarthritis,common odds ratio, age adjusted prevalence (COR).

		Kuml		**ÞSK**		**HSM**		**HFE**		**RVK & VEY**	
Site	**%**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**	**COR**	**95% CI**
Kuml	0			--	--	--	--	--	--	--	--
ÞSK	4.2	--	--			0.20	0.10 to 0.39	0.19	0.09 to 0.38	1.42	0.56 to 3.61
HSM	21.4	--	--	4.95	2.53 to 9.67			0.41	0.23 to 0.72	3.67	1.77 to 7.61
HFE	23.1	--	--	5.34	2.60 to 10.97	2.44	1.39 to 4.26			6.40	3.01 to 13.60
RVK & VEY	9.5	--	--	0.70	0.28 to 1.77	0.27	0.13 to 0.57	0.17	0.07 to 0.33		

5.2.9 Multiple joint involvement

It is again the sites of Hofstaðir and Haffjarðarey which stand out when looking at the prevalence of multiple joint involvement of osteoarthritis in the Icelandic skeletal populations (see table 5.47). At Hofstaðir 13 (37.1%) of the 35 individuals who have osteoarthritis have multiple joint involvement. In the Haffjarðarey population six of the 16 individuals (37.5%) who have osteoarthritis have multiple joint involvement. The *kuml* population has the lowest percentage of individuals diagnosed with osteoarthritis: 17 out of 69 (24.6%) and none of those have multiple joint involvement.

Table 5.47: Crude osteoarthritis prevalence (OA) and prevalence of multiple joint involvement of osteoarthritis (N= Number of cases/total number with OA within the population).

	OA			**Multiple joint involvement**		
Site	**N**	**%**	**95% CI**	**N**	**%**	**95% CI**
Kuml	17/69	24.6	16.0 to 36.0	0/17	0	0
Skeljastaðir (ÞSK)	29/54	53.7	40.6 to 66.3	6/29	20.7	9.8 to 38.4
Hofstaðir (HSM)	36/54	64.8	53.4 to 77.8	16/36	45.7	29.5 to 60.4
Haffjarðarey (HFE)	16/22	72.7	51.9 to 86.9	6/16	37.5	18.5 to 61.4
Reykjavík (RVK & VEY)	18/36	50.0	34.5 to 65.5	5/18	27.8	12.5 to 50.8

6 Discussion

Before discussing the significance, cultural and epidemiological, of the results presented in chapter 1, it is important to consider to what extent the variations seen within the data are meaningful. To do this, we must first look at what agents other than the disease processes may be affecting the collections. There are two factors in particular which need to be given consideration. One of these, how the different age structures of populations within the study may be influencing the data, has been dealt with already through the calculation of the common odds ratio to get an age adjusted prevalence (see chapter 5.2.1). The second, how the pattern of preservation may possibly affect the prevalence presented will be dealt with here.

6.1 Prevalence and preservation.

A preliminary glance at the results indicates significant variations in age adjusted prevalence between the different sites. Particularly noteworthy is the consistently lower prevalence of osteoarthritis in the *kuml* assemblage.

6.1.1 Taphonomy

Taphonomy (from the Greek words *taphos* meaning 'burial' and *nomos* meaning 'laws') is a term first coined by Efremov in 1940. Within palaeontology it relates to the study of all the processes of the transition of organics from the biosphere into the geological record. In the past decades the term has become an integral part of zooarchaeological research, where it has been used to discuss the agents and factors, both cultural and natural, affecting and creating the archaeological bone collections being studied (Lyman 1994: 1-3). Although, as already mentioned in chapter 4.2, there are studies which deal specifically with taphonomy in osteoarchaeology (cf. Bello and Andrews 2006; Knüsel and Outram 2004), when mentioned in relation to human skeletal remains, it is usually in the context of either differential preservation creating a demographic bias (Walker and Johnson 1988) or of disarticulated or commingled remains (McKinley 2004: 15). Within palaeopathology the focus of taphonomy has been on the fact that poor preservation can result in the creation of a pseudopathology (Perez 2006: 31; Roberts and Conell 2004: 34).

When discussing whether the preservation of the skeletal material is creating a bias in the pattern and prevalence of osteoarthritis, it is important to consider the taphonomic processes, both extrinsic and intrinsic, which are likely to have affected the material. This is particularly true, as already mentioned, when dealing with small populations, as in Iceland, where any bias or variation within the population is more likely to have a proportionately greater effect on the results. This is coupled with the fact that in order to

diagnose osteoarthritis, the joints, which are in most instances very small parts of each bone, need to be present. This means that it is essential to be aware of the taphonomic agents and processes involved in creating the populations, and considering whether the patterns of osteoarthritis within these populations reflect prevalence or preservation.

6.1.2 Taphonomic agents

Firstly it is important to consider the intrinsic taphonomic agents which could affect the pathological study. Studies have shown (cf. Willey et al. 1997) that of all variables affecting the preservation of bony elements, the bone density as well as the density distribution within the bony element has the greatest effect on the preservation. This was shown for example in a study of the disturbed skeletal remains of the victims of the Crow Creek Massacre (a collection made up of c.500 people killed in one event), which had been affected by a variety of pre- and post-burial taphonomic processes. There is evidence of mutilation and dismemberment of the corpses, which had then been exposed to scavenging on the surface before being buried in a mass grave in a fortification ditch. The remains were subsequently exposed by erosion in the 1970s and looted, with bones of at least 45 individuals scattered around the site before archaeologists were able to carry out a systematic excavation. The investigators demonstrated that it was crucial to have an understanding of the relationship between the strength and density of bones and preservation, using this as a filter before other taphonomic variables could be interpreted. In this study it was clear that even with the multiple factors involved in creating the Crow Creek skeletal collection, the highest correlation was between bone density and survival (Willey et al. 1997). This is an important factor to keep in mind when interpreting disease in a skeletal collections in general and in particular when discussing joint disease like osteoarthritis.

Several factors which are likely to affect osteoarthritis are also likely to have an effect on bone density. Firstly there is the fact that all chronic diseases are likely to have a detrimental effect on bone density. Secondly, bone mineral density is lost with advancing age, especially in women (Walker and Johnson 1988: 187), and osteoarthritis is a disease which mainly afflicts older people. Therefore older individuals who are at greatest risk of suffering from the disease are also more likely to be poorly preserved. In addition, older males are more likely to be better preserved than older females because their bones do not undergo a comparable reduction in bone mass with age (Mays 1998: 140-2).

As discussed in chapter 3, the nature of the sites from which the material for this study originates is quite varied. They range from large Christian cemeteries, one of which is still in use today, with centuries of intercutting burials, to small enclosed sites with homogenous burial types with limited or no disturbance of the graves. There are also dispersed pre-Christian Viking age burials, *kuml*, with a great variety of burial types. In addition the *kuml* frequently have one or more episode of disturbance prior to the archaeological excavation. The extrinsic taphonomic factors in the *kuml* which have

been discovered due to erosion or construction work are perhaps clear, with multiple episodes of disturbance increasing the risk of damage to the bone. To discuss how the disturbances, in particular 'robbing' events in antiquity, are likely to affect the bones, it is important to attempt to understand the reasons for the disturbance. This has received surprisingly little attention in the literature. In *Kuml & haugfé*, the standard work on *kuml*, despite a minimum 26% of the burial sites discussed having been disturbed in antiquity (Magnúsdóttir 2009: 5), there is only a brief mention of this issue, defining it as the result of curiosity or looting of valuable grave-goods (Eldjárn 2000: 257-61). However, the possibility of a more cultural reason for the disturbance of the graves must be considered. Re-opening of graves can be a part of the burial ritual; it can be for example associated with wilful destruction of the grave or the removal of the body or a part of the body for re-burial elsewhere. Such practices increase the chances of specific elements being targeted resulting in a skewed preservation pattern (Andrews and Bello 2006: 14; Duday 2006: 45-8). The varied nature of the disturbances of the *kuml*, with examples of empty graves, burials where the skeletal material has been scattered within the backfill, partial disturbance of bodies, the reburial of gathered skeletal material within the re-cut of the grave (Eldjárn 2000: 261-4; Magnúsdóttir 2009: 22-31), does however suggest that there is not a single reason behind the disturbance of the graves. The lack of interpretation of these disturbed burials makes it even more difficult to use the skeletal remains for pathological studies, as our understanding of whether there is any selective process behind the bones that are found in the graves is limited. However, a detailed recording of the preservation is likely to limit the effects of a culturally created bias, where present, in the comparison of different sites as it is possible to test whether differences in prevalence is real or reflect the preservation.

The taphonomic effects of the Christian cemeteries must be considered too. The homogenous nature of the burials can also create specific preservation patterns. The fact that the bodies are in almost all instances laid out in a similar position increases the risk of the same elements being vulnerable to damage (Duday 2006: 34-5). For example the individuals at Hofstaðir in Mývatnssveit were buried in a supine position, frequently within wooden coffins (Gestsdóttir 2006), so the posterior parts of the vertebral bodies and femoral condyles were vulnerable to damage, both *in situ* and during excavation, in particular when the skeletons were being lifted.

6.1.3 Preservation and prevalence; *kuml*

Of the 69 skeletons used in the study, there are 31 cases (45%) where it was not noted, or not possible to record, whether the burials had been disturbed in antiquity. A total of 10 (14%) are recorded as having been robbed, while the remaining 28 (41%) are recorded as not having been robbed in antiquity. As to later disturbance by either erosion or development, there is no record regarding six (9%) of the burials. A total of 39 (51%) were found due to a disturbance, while 24 (35%) were undisturbed by erosion or development at the time they

were excavated. Of the skeletons used in the study only 14 (20%) were recorded as being *in situ* at the time of excavation (Eldjárn 2000: 39-251).

6.1.3.1 The spine

Although, as already stated, the age adjusted prevalence of osteoarthritis within the *kuml* collection is in almost all instances lower than seen for the other sites, the difference is most obvious for osteoarthritis of the spine (see Appendix 2). The prevalence there is considerably lower than seen for most the other assemblages in the study. To determine whether this pattern is significant, it is important to look at the preservation within the *kuml* population. Of the 69 skeletons within the group, 50 (72.5%) had some vertebral process joints preserved. Of these, only eight (16%) had some part of all the spinal joints preserved. Otherwise the average preservation of the vertebral process joints, for those who had some joints preserved was 59%, with a median of 62%.

Another problem with the preservation of the spinal joints within the *kuml* collection is which joints are present. The worst preserved part of the spine is between C4-T2. All of the joints in this section of the spine have less than 36% preservation. However, if one looks at the other populations in the study, they clearly demonstrate that the most common location for osteoarthritis within the spine is C2-C5, C7-T1, T3-T6 and L5-S. In other words, the section of the spine which is most likely to be affected by osteoarthritis (apart from the lumbar-sacral joint), is the worst preserved. What this means is that there is a risk that looking at overall prevalence for different parts of the spine becomes meaningless. For example looking at the cervical vertebrae in the *kuml* collection, the process joints between the cranium-C2 are the best preserved joints within the spine (51%), while, as already stated, the C4-T2 is the worst preserved (<36%). The good preservation of the upper part of the cervical spine is going to pull up the figure for average preservation, while the poor preservation of the section which is most likely to be affected by osteoarthritis (C2-C5) is going to bring down the prevalence of osteoarthritis and thereby skewing the data.

In addition, where the spinal joints are recorded as preserved, in only 48% of cases are all the zones of the joint surface present. Where the joint is only partially preserved, it is most frequently the case that the superior zone of the superior process and inferior zone of the inferior process is missing (see Appendix 1 for further detail on the joint zones). What this means is that, in cases where the part of the joint which had osteoarthritis changes is not preserved, there is an increased risk of a joint being recorded as present but without osteoarthritis. It is therefore likely that even with the zone recording method, that the low prevalence of spinal osteoarthritis in the *kuml* population does not represent the true prevalence within the population, rather the poor preservation of the material.

6.1.3.2 The hands

Similar concerns arise when looking at the prevalence of osteoarthritis in the small complex joints, such as the hands. As stated in chapter 5.1.1.3, only 33 of the 69 individuals within the *kuml* population had at least 10% of the joints of the hands preserved. The zone preservation

within the joints is so varied that it is important to be aware of what this actually means. If one looks at the 33 skeletons which have wrist joints preserved, the average preservation is only 34% (with a median of 29%). This suggests again, that there is an increased risk that even though a joint is recorded as present, the zones which displayed osteoarthritic changes within that joint are not preserved.

The best preserved joints within the wrist (more than 50% element preservation) are the distal radius, the head of the right ulna and the proximal ends of MC1-MC4. The worst preserved joints (less than 30% preservation) are the smallest carpal bones; the triquetral, pisiform, trapezium and trapezoid as well as the MC5 and middle and distal phalanges. If one then looks at the joints most frequently affected by osteoarthritis in the Icelandic population as a whole, these tend to be the joint between the ulnar notch and the ulnar head, the scaphoid-trapezoid joint, the 1st CMC joint, and the 2nd and 3rd MCP joints. These are all joint elements which demonstrate average, or above average preservation.

6.1.4 Prevalence and preservation; Haffjarðarey (HFE)

The skeletal material from Haffjarðarey presents a different problem regarding prevalence and preservation than seen with the *kuml*. Haffjarðarey, as stated in chapter 3.4, was excavated due to the erosion of the site. This means that several of the skeletons from the site are partial. However the environment on the site, where the graves were cut into natural sands (Steffensen 1946: 151), was very favourable to the preservation of the bony elements. This is reflected in the fact that the average preservation index (API) for the site is relatively low, grade 3, while the quantitative bone index (QBI) is very high, grade 5.

6.1.4.1 The spine

The issue of the pattern of preservation within the Haffjarðarey collection is well represented by the facet joints of the spine. As stated in chapter 5.1.4.2, two individuals in the collection had no vertebrae preserved. Of those who have spinal joints preserved, four individuals (20%) have only the occipital condyles of the cranium-C1 joints preserved. In addition three individuals (15%) have no cervical vertebrae preserved, six (30%) have no thoracic vertebrae preserved and five (25%) have no lumbar vertebrae preserved. On the other hand seven individuals (35%) have all the joints of the spine preserved. This means that the average preservation of the spinal joints (of those who have joints preserved) is 59%, with a median of 62%. The main difference between the preservation of the Haffjarðarey collection and the *kuml* population is the lack of fragmentation in Haffjarðarey. This means that those joint surfaces which are present tend to have 100% preservation. What this means is that it is much more likely that the zones which display osteoarthritic changes in a joint were preserved when that joint is recorded as present, and so that the prevalence presented for the Haffjarðarey collection reflects the true prevalence within the population.

6.1.4.2 The hands

A similar pattern is seen when dealing with the joints of the hands in the Haffjarðarey population. Nine individuals (41%) in the population have no joints of the hands preserved, and of those 13 who have hand-joints preserved there are seven (54%) who have 12% or less preservation. On the other hand there are a further six (46%) who have 98% or higher preservation of the hand joints. This means that while the average preservation within the Haffjarðarey population of the hand joints (of those who have joints preserved) is 63%, the median is 86%. As with the spine, when the bone is present the most common pattern is that all the joint zones are preserved.

What these results indicate is that the prevalence of osteoarthritis in the skeletal material from the *kuml* is unlikely to be comparable to the other sites within the study, in particular when it comes to complex joints like the spine or the small joints of the hand. The prevalence of osteoarthritis in the Haffjarðarey collection is more likely to represent the true prevalence within the population. However what these variations in preservation emphasise is the importance of testing the data.

6.1.5 The *kuml* issue

Paired Kolmogorov-Smirnov tests were carried out between the distribution of the presser-vation of the processes of the spinal joints between the *kuml* skeletons and the other sites in the study. The results indicated strong evidence against the null hypothesis, particularly in the cervical vertebrae, with the maximum cumulative difference between the *kuml* and Hofstaðir of r=0.19. For this reason, the *kuml* population will not be used in the following discussion within the thesis when dealing with the spine. In addition, it is difficult to look at the *kuml* collection as one population in the same way as the other collections within the study, which are all well demarcated groups representing the population of a specific area over a specific time period, while the *kuml* population is made up of a collection of individuals buried all over Iceland during the earliest period of settlement (see figure 3.1). The results of the analysis of osteoarthritis within the larger joints in the *kuml* will therefore be included in overall figures for Iceland, but no discussion at a population level attempted.

Paired Kolmogorov-Smirnov tests of the preservation of the processes of the spinal joints between all the other sites in the study indicated no evidence against the null hypothesis, with the maximum cumulative difference being between the between the preservation of the cervical vertebrae at Hofstaðir and Reykjavík, r=0.08, indicating that they are comparable to each other.

6.2 A question of scale

As already noted, the small size of the populations in this study means that the differences in crude prevalence of osteoarthritis within the populations can in most instances not be

demonstrated to be statistically significant. This issue of scale is an inherent problem in Icelandic ostearchaeological research, as with one exception,[10] larger populations do not exist (see also chapter 4.2.1 and Gestsdóttir 2014). This leaves Icelandic osteoarchaeology with the epistemological problem of how to deal with population studies. On the one hand it is possible to conclude that epidemiological studies of human skeletal populations simply should not be carried out when sample size does not fully support statistical significance. On the other, and this is the approach which will be taken here, while it is necessary to fully acknowledge and discuss the problems associated with the small size of the populations available, there will only be progress if consistent patterns in the data are identified, discussed and their possible implications theorized. The field can only move forward if the existing data – imperfect as they may be – are analysed and hypotheses developed which future research, based hopefully on larger populations, can then support or refute.

The primary aim of this thesis is to develop a framework for discussing a multifactorial disease like osteoarthritis in palaeopathology in general, and in Iceland in particular (see also the discussion on theoretical approaches to palaeopathology in chapter 1.5). With this in mind, the following discussion will focus on the joints of the body which demonstrate the most significant differences in age adjusted prevalence of osteoarthritis within the populations in the study. On this basis it will describe different approaches to understanding and presenting such differences, in full acknowledgement of the statistical limitations of the data.

6.3 Inherited osteoarthritis

As discussed in chapter 2, the focus of research on genetic osteoarthritis in the modern Icelandic population has been primarily on osteoarthritis of the hips and the hand (cf. Aspelund et al. 1996; Ingvarsson and Baldursson 1991; Ingvarsson 2000; Ingvarsson et al. 2001; Jónsson et al. 2003). The focus on the discussion of inherited osteoarthritis in the skeletal populations in the current study will therefore be on these joints, as well as on multiple joint involvement of osteoarthritis.

6.3.1 Inherited osteoarthritis in the archaeological context

The skeletal populations from Hofstaðir and Haffjarðarey stand out when looking at the age adjusted prevalence of idiopathic osteoarthritis at the sites which have been demonstrated to have a genetic link, the hips (see table 5.42) and the 1st CMC & IP joints of the hands (see table 5.35); as well as the crude prevalence of multiple joint involvement (see table 5.47). The crude prevalence for the different populations in the study is presented in figure 6.1 to demonstrate the differences between the populations, although bearing in mind that these differences cannot be demonstrated to be statistically significant.

[10] The monastic site of Skriðuklaustur in eastern Iceland, the excavation of which was completed after the analysis for this thesis had been carried out (Kristjánsdóttir 2012)

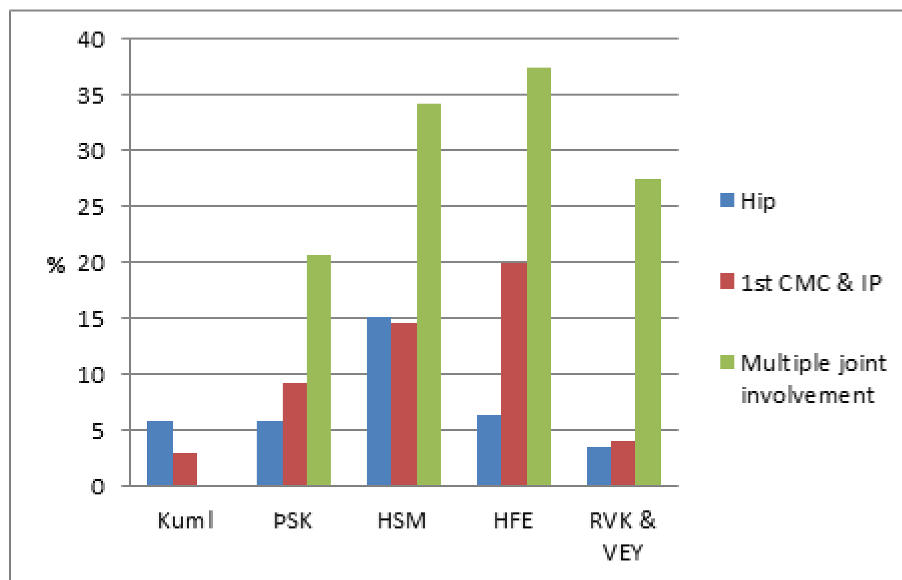

Figure 6.1: Hip, 1st CMC & IP and multiple joint involvement (MJI) of osteoarthritis, crude prevalence (nb, the prevalence for MJI is presented as a percentage of all those with OA).

The difference is even greater if one compares the crude prevalence of osteoarthritis at Hofstaðir and Haffjarðarey to the prevalence in archaeological populations outside Iceland. Comparing the prevalence of hand osteoarthritis between different studies is difficult, as there is too great a difference in which joints are included within the studies (cf. Waldron 1996), and therefore this will not be attempted here. The focus will rather be on comparing hip osteoarthritis between different populations (see table 6.1). It would be of interest to compare the prevalence of hip osteoarthritis in the Icelandic skeletal populations to those seen among the contemporary Greenland Norse, as they are most likely to have had the same genetic makeup as the Icelanders. Unfortunately the preservation of the Norse skeletal material from Greenland is extremely poor, and it was not possible to carry out meaningful prevalence calculations of osteoarthritis within the population (Lynnerup 1998: 83-5). Comparisons were therefore carried out with four populations; a study of contemporary archaeological skeletons (n=3,305) dated 990-1536 AD from Lund, Sweden (Arcini 1999); a comprehensive study of Danish skeletons (n=387) dating from the middle Neolithic to the Middle Ages (medieval period), although it must be noted, that cases with osteophytes alone were also recorded as osteoarthritis in the analysis of the Danish material (Bennike 1985: 20-1, 124), so there is a danger that there is considerable over-diagnosis compared to the present study; a study of the 2,750 skeletons excavated at the site of Barton-upon-Humber, North Lincolnshire, England dated c. 1150-1855 (Waldron 2007) and analysis of the skeletal remains (n=968) from the crypt of Christ Church, Spitalfields in East London which

was in use between 1729-1869. This last population was split into two groups, those with coffin plates which meant that information on sex and age was available (n=367) and those where age and sex was determined through osteological analysis (n=601) (Waldron 1991). As demonstrated in table 6.1, the prevalence of hip osteoarthritis in the overall Icelandic population is significantly higher than in most of the comparative populations (with the exception of the Danish population, where there is as already mentioned a great risk of over-diagnosis). In addition, the prevalence of hip osteoarthritis in the Hofstaðir population can be demonstrated to be significantly higher than most of the comparative populations.

Table 6.1: Hip osteoarthritis summary, comparative populations.

Country	**Site / period**	**%**	**95% CI**
Iceland	Overall	8.3	5.3 to 12.9
	-*kuml*	5.7	1.9 to 15.4
	-Skeljastaðir	5.7	1.9 to 15.4
	-Hofstaðir	15.1	7.9 to 27.1
	-Haffjarðarey	12.5	3.5 to 36.0
	-Reykjavík & Viðey	3.4	0.6 to 17.2
Sweden[11]	Lund	2.6	1.9 to 3.6
Denmark[12]	Overall	7.2	5.1 to 10.3
	-Iron Age	7.2	4.4 to 11.6
	-Medieval	7.6	3.3 to 16.5
England[13]	Barton upon Humber, overall	4.4	3.4 to 4.9
	-Barton upon Humber, 1150- 1500	2.4	1.2 to 2.5
	-Barton upon Humber, 1500-1855	6.7	5.1 to 8.8
	Spitalfields, coffin plate group	3.2	1.9 to 5.6
	Spitalfields, non-coffin plate group	3.0	1.9 to 4.7

It is also perhaps, of importance to place these figures in the context of modern studies of the prevalence of osteoarthritis in these populations. In a study by Ingvarsson et al., the overall prevalence of hip osteoarthritis in Iceland was demonstrated to be 10.8%, while that for comparative populations was much lower; Malmö (Sweden), 2.3%; Gotland (Sweden), 4.5%; Denmark, 4.7% and England, 2% (Ingvarsson et al. 1999: 205-7).

What the pattern of hip (and hand) osteoarthritis revealed by the current study indicates, particularly at Hofstaðir, but very likely at Haffjarðarey as well, is that inheritance is a main aetiological factor for the osteoarthritis at these sites within these populations. It is therefore quite likely that the people buried at each of these sites were

[11] (Arcini 1999: 94).
[12] (Bennike 1985: 135).
[13] Barton-upon-Humber (Waldron 2007: 63); Spitalfields (Waldron 1991: 301-2).

to a great extent biologically related to each other, members of the same family. It is however important at this juncture to take into consideration the fact that, as discussed in chapter 1.4.1, there are studies, including one carried out in Iceland, demonstrating a link between hip osteoarthritis and farming (cf. Croft et al. 1992; Franklin et al. 2010). Most of the populations in the study, in particular Skeljastaðir, Hofstaðir and Haffjarðarey are likely to be made up of individuals most of whom, if not all, were involved in farming (although due to its geographical location fishing and related activities would have made up a significant portion of the occupation at Haffjarðarey, see chapter 6.4.2). The unusually high prevalence of idiopathic hip osteoarthritis at Hofstaðir suggests however that other aetiological factors have to be identified to explain the difference between it and for example Skeljastaðir, which is similar in date, size and is likely to have served a very comparable population living in similar micro-economic conditions (Gestsdóttir 2009: 136). It is also worth noting that the prevalence of idiopathic hip osteoarthritis in the Skeljastaðir population is high compared to contemporary European populations, although this cannot be demonstrated to be statistically significant (with the exception of the later period skeletons from Barton-upon-Humber and the Danish studies, although it is quite likely, as noted, that there is some degree of over-diagnosis within those latter figures). In a previous study of osteoarthritis in the Skeljastaðir population it was concluded that the high prevalence of hip osteoarthritis in the population supported the hereditary nature of the disorder in Iceland (Gestsdóttir et al. 2006). The Reykjavík sites stand out as having much lower prevalence of hip osteoarthritis, much closer to the prevalence seen in many of the mainland European sites. The nature of the populations from the Reykjavík sites also makes them stand out from the other sites within this study. The Reykjavík sites are much later in date (18th-19th century) and mark the beginning of an urban population in Iceland. The skeletal collection is therefore likely to not only to be made up of a population where perhaps there was a greater percentage of non-farmers, but also to include the highest percentage of people who either immigrated into Iceland, or who were descended from immigrants. In fact, until the middle of the 19th century it has been said that Reykjavík was a half-Danish town (Gunnlaugsson 1982: 1-10).

The higher prevalence of hip osteoarthritis in the Skeljastaðir population, compared to the Reykjavík population is most likely due to a combination of the high incidence of inherited hip osteoarthritis in Iceland in general, without the skeletal populations from these sites being made up of a hip osteoarthritis family, as Hofstaðir in particular, and possibly Haffjarðarey as well, appear to be. Added to this may be the fact that the Skeljastaðir population is likely to be made up of a predominantly a farming population. On the other hand, the lower prevalence in Reykjavík is mainly due to a smaller proportion of farmers (see table 6.6) within the population combined with a higher proportion of people of a different genetic make-up than seen in the older populations.

6.3.1.1 The family in archaeology

As discussed in chapter 3.6, the earliest Christian cemeteries tend to be regarded as farm based sites, usually thought to have served the farm on which they stand, and possibly a small number of neighbouring farms (Friðriksson and Vésteinsson 2011: 56; Vésteinsson and Gestsdóttir 2011: 89). It is worth dwelling briefly on the question of where the idea of the function of these sites as farm-based churches came from. Documentary sources are sparse for these early churches, normally referred to as *bænhús* (small dependent churches or chapels) in texts. The assumption that they mainly served the farm on which they stood is primarily based on their small size (i.e. they simply could not fit a large congregation), and the fact that they received no tithes or dues, and were serviced far too infrequently for any form of dependency to have formed between the church farm and its neighbours (Vésteinsson 2000b: 288). Another argument which has been presented to support this, is how densely these sites are frequently seen to be distributed in the landscape, in some areas close to every other farm (cf. Zoëga and Sigurðarson 2010: 112), supporting the theory that their main function, both as religious buildings and burial grounds, was to serve the farm where they stood.

Most of the Icelandic sites which fall into this group appear to have come into use in the 10th- early 11th century, and many had gone out of use very early, by the late 11th-12th century (cf. Sayle et al. 2014: 816-9; Sveinbjörnsdóttir et al. 2010: 688; Zoëga and Sigurðarson 2010: 97). The end of the use of these sites is generally thought to be associated with an increased centralization of the church, and the setting up of parish cemeteries and the redirection of burial to these. It is of course likely that some of these early sites may have been converted to parish cemeteries. As has already been noted (see chapter 3), of the sites in the current study Hofstaðir and Skeljastaðir belong to the earlier group, both being in use from c. the 10th to the 13th century (Gestsdóttir and Isaksen 2011: 9; Sayle et al. 2014: 816-9; Sveinbjörnsdóttir et al. 2010: 688), although Skeljastaðir has often been assumed to be the parish church of Þjórsárdalur. A discovery of a church with associated burials at neighbouring Stöng (Vilhjálmsson 1996) makes this less likely. Haffjarðarey is likely to fall into the latter group. It probably started out as a farm based plot, but was later developed into a parish cemetery which was subsequently abandoned in the 16th century. However, the current data we have on the site gives no indication as to a more accurate date for the excavated skeletons which make up the collection (Steffensen 1946: 144-51).

Our understanding and interpretation of the use of the early Christian cemeteries in Iceland, that is that they served one, or at the most a handful of farms, is based on rather limited documentary evidence as to their function, their small size, which is consistent with them having served a small population, as well as their location and frequency within the landscape. There has been to date very little attempt to use the people buried there in order to further our understanding of how these cemeteries were used. The conclusion that the pattern of hand and hip osteoarthritis at Hofstaðir demonstrates that

the majority of people buried there are members of a single biological family brings a new dimension to the discussion.

It is at this stage therefore perhaps worth looking at how archaeology has dealt with the concept of 'the family'. Archaeologists frequently tackle issues such as 'the household', or 'the community', and within these discussions the concept of family frequently appears, although often without clear definition. The study of households tends to focus on architecture and artefact assemblages. They are based on the idea that dwellings are measurable socio-economic units. Studies have been carried out to calculate the mean household size based on average house sizes (cf. Allison 2002), and have then been used as a base to estimate the number of households and therefore the size of populations of archaeological sites or even whole regions. The distribution and type of artefacts found within these houses are then used to interpret the behaviour of the people who lived there. The focus of such studies tends to be on the spatial division of domestic activities, in particular in relation to production and consumption, as well as the question of gender, both in terms of division of labour as well as the visibility of gender within the household. Frequently such studies are supported by ethnographic or textual evidence (Allison 2002: 1-10). The notion of 'the community' is an idea that is perhaps more difficult to deal with archaeologically. It can be said to be situated between household archaeology and regional studies, with a focus on providing insights into identity and group membership, social organisation and socioeconomic integration. Early studies (cf. Canuto and Yaeger 2002) of the community within archaeology were criticized for simply equating community with the site. By the latter half of the 20th century approaches to the study of the community within archaeology became more method-based, focusing on archaeologically visible functions such as social reproduction, subsistence production and self-identification/social recognition and correlating these with archaeological indices of labour investment, inter- and intra-site spacing, and exchange and stylistic patterning. In these terms archaeological discourse views the community as a socio-spatial phenomenon. In recent years such approaches have been criticised for ignoring issues of social creation, manipulation, and meaning that have become increasingly important as concepts of agency, practice, and interaction have come into our archaeological models of the past. This has encouraged the focus on approaches which conceive of the community as a dynamic socially constituted institution that is contingent upon human agency for its creation and continued existence (Canuto and Yaeger 2002: 1-12). What such approaches consistently lack however, despite their focus on agency and the lived lives of the people who are being studied, is actually including the physicality of those people.

In recent years, the greatest focus of the study of biological relationships within archaeology has been on ancient DNA studies and the concept of kinship. Early studies tended to focus on DNA analysis alone, often focusing on large scale genetic relations spanning the long term (cf. Haak et al. 2005; Helgason et al. 2000b), but recent years have

seen an increase in inter-disciplinary approaches, where aDNA studies are combined with archaeological, osteoarchaeological and isotopic approaches to study biological relationships within smaller populations (cf. Haak et al. 2008; McEvoy et al. 2008).

The family itself (as opposed to household or community) has received greater interest within other fields, for example history and anthropology. The greatest problem faced by such research is how to define the 'family'. On the one hand it is a concept so familiar to us all, and in some aspects regarded as an institution with such clearly visible boundaries that its existence is something that may frequently be regarded as un-problematical, a static structure not capable of real change. On the other, a problem quickly arises when attempting to set down a firm definition of what constitutes a family, which means that frequently the attention, in particular within historical research, often turns to the household and its size, as well as biological factors such as birth and death rates and marriages, in an attempt to establish measureable units and a firmer ground (Casey 1989: 2-3; Mitterauer and Sieder 1982: 1-2). Within historical research, such approaches have been criticised for presenting a one dimensional view of the structure of the family, focusing too much on their biological nature and not constituting much more than a demonstration of the fertility of couples. The family, many researchers have argued is much more of a social construct, and needs to be studied as such (Flandrin 1979: 3; Mitterauer and Sieder 1982: 1-2). Mitterauer and Sider (1982) argue that the family is the oldest form of social community and that the concept of the family has served as a model of sorts for the formation of social groups. This is most clearly visible in the use of terminology about blood-relationships within social groups, for example the use of words like 'father' or 'sister' within religious communities, or the swearing of blood-brotherhood (Mitterauer and Sieder 1982: 2-3).

The multiplicity of the concept family needs therefore to be considered. The present day understanding of the term can be seen to be twofold; on the one hand the 'nuclear family' which can be understood as people living together in one household, usually the parent or parents and offspring. On the other hand there is the 'extended family', those relatives to which the individual or group is linked by blood or marriage (Mitterauer and Sieder 1982: 5-6). One of the main criticisms that much historical research has faced is that its main aim has often been to explore the origins of this modern western concept of the family; a man and a woman around the domestic hearth dedicated to the upbringing of their offspring. The dangers of such an approach, is that people forget to look for alternative ways of ordering relationships, for example patronage (Casey 1989: 1). In fact, if we look back in time, we find that prior to the 18th century most European languages had no collective term meaning the group consisting of parents and children. In fact words denoting 'family' in most European languages back into the medieval period, tend to encompass the members of a household, whether related by blood or not; husbands, wives, grandparents, biological and fostered children, servants, serfs, paupers or apprentices (Mitterauer and Sieder 1982: 6-7).

6.3.1.2 A family at Hofstaðir

As already stated (see chapter 6.3.1), the pattern of hand and hip osteoarthritis at Hofstaðir indicates that what we are dealing with is a group of people who are to a large extent a biological family. In other words, we can now not only state that the people buried there during the 2-300 year period in which the cemetery was in use are likely to have lived in one or only a few households, but they were to a large extent biologically related to each other. In a recent study of the neonatal skeletons from Hofstaðir, Jeffries (2011) attempted to calculate the life-table for the cemetery to estimate the size of the population which it is likely to have served. Although it must be noted that the excavations of the cemetery are on-going, a substantial percentage of the site has been excavated (approximately 62% of the total area of the cemetery, including the central part, where the burials are the densest), so it is quite likely that the 122 skeletons excavated at the site to date are representative of the total population buried there. Her calculations indicated that based on 2-300 years of use, the size of the population which the cemetery at Hofstaðir served at each time was between 11-17 people (Jeffries 2011: 46-9). This fits well with previous estimates of the population which such cemeteries are likely to have served (Gestsdóttir 2009: 136). It is of course difficult to say how many households the people buried at Hofstaðir represent, possibly two to three (see discussion on estimates of household sizes below) and it is quite possible that people living on neighbouring farms in 10th to 12th century Mývatnssveit were to a large extent biologically related to each other. What this suggests is that during this period there was a certain amount of stability in the population living in this part of Mývatnssveit, probably with limited movement of people into the area. It is unfortunate that there are no further cemetery excavations in Mývatnssveit. It is therefore difficult to answer the question whether this familial pattern of osteoarthritis is seen throughout the entire region, or whether Hofstaðir is unique in this aspect, which would perhaps indicate that these early sites were not only used for those who lived in associated households, but also people who were linked to each other through biological kinship, families in the modern sense of the word.

It is perhaps also at this stage worth placing this in the historical context of the Icelandic family and household during the early medieval period. Documentary evidence for the period in which Hofstaðir was in use is of course scant. The traditional view is that prior to the 13th century Icelanders were politically equal, free independent farmers, who mostly owned their own farms (Byock 1988: 56-9). Recently it has however been pointed out that the documentary sources upon which these interpretations are based, the Contemporary Sagas (for further detail see chapter 7.1.1) only details a very select group, the households which occupies the largest estates which formed the ruling elite over a large class of nameless economically dependent and politically powerless householders, or peasants (Vésteinsson 2007: 137). Documentary sources suggest that during this period households would have been made up of a husband and wife, and their offspring (family), as well as

servants. We do know that by the 18th century the average Icelandic household was 7-8 people (Arnórsdóttir and Þorláksson 1998: 46-8; Gunnlaugsson 1988: 60). Whether the size of the Icelandic household changed much during the early centuries is difficult to say. There is evidence that there were instances where two families (that is two husbands and wives with their offspring) lived on the same farm, usually in split households. One thing that the documentary sources do suggest is that family ties were viewed differently from today. For example, friendships sealed with the exchanging of gifts were considered as important as biological relations. This is perhaps most greatly reflected in the common practise of fostering children from other families (Arnórsdóttir and Þorláksson 1998: 48-53).

The scant documentary evidence for this period has prompted many to focus on later periods, particularly after the 18th century, and Iceland's first census in 1703. In his PhD thesis *Family and household in Iceland 1801-1930*, Gunnlaugsson (1988) notes that according to the 1703 census two thirds of all households had seven members or less, although there was quite a difference between different areas, those in good farming districts tended to be larger than those where fishing/farming was the dominant livelihood. (Gunnlaugsson 1988: 60-5). During this period owner occupancy of farms was very rare, with tenant farms being the common form. The effect this had on the population was that there was a great deal of movement of people, which meant that structural changes within parishes could occur within relatively short time-periods (Gunnlaugsson 1988: 51-2). For example a study of six different parishes in the 1816 census demonstrates that an average of 63% (ranging between 27% and 76%) of heads of households in that period were born outside of the parish. There was also a great deal of migration of servants; within two of the parishes 40-47% of the servants, according to the 1816 census, were born outside the parish in which they resided. In fact, through the various censuses taken in the 19th century it is possible to trace the movement of servants, some of whom moved up to seven times within three to four decades (Gunnlaugsson 1988: 75-82). A common practice in this period, closely associated with this, was for children to leave their parental home once they reached 15-19 years of age to work as servants on other farms. This was seen not only among the poorer families, but those who were well-to-do as well. It is likely that the fact that tenant farmers did not expect their children to take over their farm would have contributed to this practice. During this period paupers would also be housed by the district with non-relatives. These practices meant that each household would have included people who were largely not related to each other (Guttormsson 1983: 97-105).

Skútustaðir parish, which is within Skútustaðir district where the farm of Hofstaðir is located, is one of the parishes in the 1988 study by Gunnlaugsson. In the 1801 census there are 17 households in Skútustaðir parish, all with heads of households recorded as farmers. Only three of the households were owner-occupied. The population of the parish was 130, and the mean household size was 7.6. The average nuclear family was 5.9 and the average number of servants per household was 1.2. Of the 17 households in

the parish, 41% had relatives living in them. A total of 11, or 18% of the children living in the parish were foster children (although it is not stated whether they were born in the parish or not). Of the 17 households none had only one generation living at the farm, 11 had two generations and six had three. Figures are not given for the 1801 census, but by the time the 1816 census was carried out there were 16 households recorded in the parish and 56% of the heads of households within these were born outside the parish (Gunnlaugsson 1988: 57, and tables on pages 64, 66, 72, 75).

The relevance of these later figures to the study of the much earlier medieval site of Hofstaðir can be placed in the context that there is a tendency to view the socio-economic conditions in Iceland as relatively stable until the latter part of the 19th century, when industrialisation started (Gunnlaugsson 1986: 20). It is thought that what people were doing, and how they were doing it did not change much, although not everyone agrees with this view (cf. Júlíusson 1990: 153). The results of the analysis of osteoarthritis in the medieval skeletal population at Hofstaðir do not reflect the occupation pattern described in later periods. What they suggest is that during the c.2-300 years in which the cemetery at Hofstaðir was in use, the farm was occupied by people who were closely biologically related to each other. It must be noted that because of the limited information as to the use of these early sites, it is of course possible that not everyone who lived within the area which Hofstaðir served were buried at the cemetery. It may for example have only served a particular family. Even if that is the case, it does not necessarily detract from the fact that during the period the site was in use, the same biological family occupied the area and controlled the farm. So, even though we cannot say whether the pattern of osteoarthritis seen at Hofstaðir is particular to that site, or reflects the pattern that would be seen within the entire population of Mývatnssveit, it is still possible to state that the people buried at Hofstaðir do not represent a migratory population, where new people and families were moving in and out from other parishes or districts, with each person or family stopping only a few years at each farm. This is a stable population where the same family stayed locally for several generations. This long term occupation of the same land by the same family with the placement of a cemetery within the home-field of the farm can be seen as a strong indicator that during the use of the cemetery, Hofstaðir was owner occupied.

It is perhaps worth noting here that this conclusion does not mean that the people buried at the other sites, Skeljastaðir in particular, were not biological related to each other, only that it is not possible to conclude based on the analysis of osteoarthritis within the population that they were related to each other. It is equally possible that the aetiology of all the idiopathic hand and hip osteoarthritis seen within the Icelandic population is genetic, but that the people buried there do not have the same level of biological kinship as demonstrated at Hofstaðir.

6.4 Activity related osteoarthritis

6.4.1 Activity and osteoarthritis of the upper limb

Many osteoarchaeological studies looking at the association between physical stress and osteoarthritis have focused on the large joints of the upper limbs, both in regards to identifying specific activities (cf. Angel 1966: 2-3; Jurmain 1977: 357) as well as interpreting larger scale economic changes through time (cf. Kelley and Angel 1987; Klaus et al. 2009). Osteoarthritis of the shoulder and elbow has also received much focus in modern sports medicine. In particular this has been considered in the context of throwing sports, where unusual strain is put on the joint from an early age (cf. Lyman et al. 2001). This has been associated with the development of osteoarthritis, in particular of the elbow, later in life (Wells and Bell 1995: 251). In addition direct trauma to the joint has been demonstrated to be an aetiological factor, in particular in association with acromioclavicular osteoarthritis (Burbank et al. 2008: 454). Such associations between physical stress or trauma and the development of osteoarthritis are particularly interesting in the archaeological context. It is however important to remember that these aetiological factors are not clear-cut, and studies which do not show such a clear secondary association between shoulder or elbow osteoarthritis can also be found (Altman et al. 1986: 1040; Doherty and Preston 1989).

Table 6.2: Shoulder osteoarthritis summary, comparative populations.

Country	Site / period	%	95% CI
Iceland	Overall	8.1	4.9 to 12.9
	-*kuml*	2.1	0.4 to 10.9
	-Skeljastaðir	0	0
	-Hofstaðir	19.1	10.7 to 33.2
	-Haffjarðarey	26.7	8.9 to 55.2
	-Reykjavík & Viðey	3.7	0.7 to 18.3
Sweden[14]	Lund	1.5	0.9 to 2.6
Denmark[15]	Overall	3.5	1.8 to 6.7
	-Iron Age	3.6	1.6 to 7.6
	-Medieval	1.8	0.3 to 9.8
England[16]	Barton upon Humber, overall	1.9	1.4 to 2.5
	-Barton upon Humber, 1150- 1500	1.5	1.0 to 2.3
	-Barton upon Humber, 1500-1855	3.2	2.1 to 4.7

[14] (Arcini 1999: 92).
[15] (Bennike 1985: 135).
[16] (Waldron 2007: 62).

As demonstrated in table 5.33, Haffjarðarey and Hofstaðir have the highest age adjusted prevalence of shoulder osteoarthritis in the current study (see figure 6.2). They clearly stand out from the other sites, with no cases found in the Skeljastaðir population, which all have a crude prevalence of shoulder osteoarthritis much closer to the comparative studies from Denmark, Sweden and England (see Bennike 1985; Arcini 1999; Waldron 2007 and chapter 6.3.1 for further detail on the populations). As demonstrated in table 6.2, the overall crude prevalence of shoulder osteoarthritis is significantly higher than in all the comparative populations (with the exception of the Danish populations, where there is a risk of over-diagnosis compared to the current study). The crude prevalence of shoulder osteoarthritis at Hofstaðir and Haffjarðarey is also significantly higher than all the comparative populations (with the exception of Haffjarðarey and the mediaeval Danish population, although there is a risk of overdiagnosis in the latter).

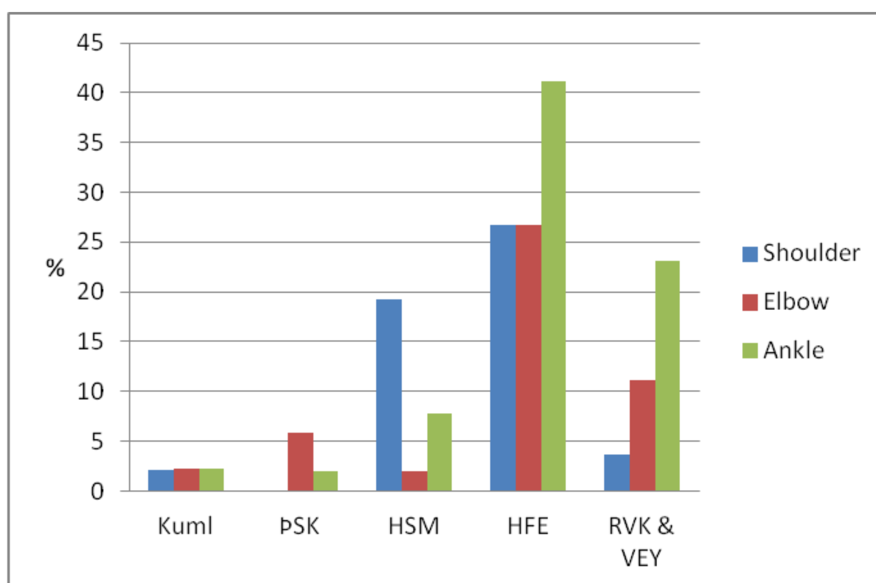

Figure 6.2: Shoulder, elbow and ankle osteoarthritis, crude prevalence

Hofstaðir is particularly interesting in this regard, in that there is a high percentage of acromioclavicular osteoarthritis. Of the nine cases of shoulder osteoarthritis, five (55.6%) involve the acromioclavicular joint exclusively or alongside the glenohumeral joint. The fact that acromioclavicular osteoarthritis is frequently associated with trauma would indicate that a substantial percentage of the shoulder osteoarthritis cases at Hofstaðir are associated with a traumatic event. There are no instances within the collection of a diagnosable trauma to the shoulder with which the osteoarthritis can be linked; rather it is long standing biomechanical stress which leads to instability of the

shoulder joint which is most likely to result in the development of osteoarthritis (Burbank et al. 2008: 454). With this in mind, it is important to compare Hofstaðir with the Skeljastaðir site. As has already been mentioned, these two sites are likely to represent very comparable populations; they are similar in date, and are likely to have been occupied by people who carried out similar activities. It is therefore of particular interest that while Hofstaðir has an unusually high prevalence of shoulder osteoarthritis, there are no cases found at Skeljastaðir. This raises the question of whether the high prevalence of shoulder osteoarthritis at Hofstaðir is most likely to be explained by the underlying genetic predisposition to osteoarthritis within the population. In other words, because of their genetic disposition to the condition, the people at Hofstaðir are more likely to respond to the generally stressful lifestyle which can be expected at both sites by developing shoulder osteoarthritis, than is seen within the Skeljastaðir population.

Table 6.3: Elbow osteoarthritis summary, comparative populations.

Country	**Site / period**	**%**	**95% CI**
Iceland	Overall	6.4	3.7 to 10.9
	-*kuml*	2.2	0.4 to 11.6
	-Skeljastaðir	5.9	2.0 to 15.9
	-Hofstaðir	2.0	0.4 to 10.7
	-Haffjarðarey	26.7	8.9 to 55.2
	-Reykjavík & Viðey	11.1	3.9 to 28.1
Sweden17	Lund	1.9	1.3 to 2.8
Denmark18	Overall	4.7	2.9 to 7.5
	-Iron Age	3.6	1.6 to 7.6
	-Medieval	12.7	6.6 to 23.1
England19	Barton upon Humber, overall	5.2	4.4 to 6.1
	-Barton upon Humber, 1150- 1500	3.4	2.6 to 4.5
	-Barton upon Humber, 1500-1855	9.9	7.9 to 12.3

When it comes to elbow osteoarthritis in the Icelandic populations, it is Haffjarðarey and Reykjavík which have the highest prevalence age adjusted prevalence (see table 5.34 and figure 6.2). The other sites all have a crude prevalence more comparable to the Danish, Swedish and English studies (see Bennike 1985; Arcini 1999; Waldron 2007 and chapter 6.3.1 for further detail on the populations). As demonstrated in table 6.3, the crude prevalence of elbow osteoarthritis is significantly higher in Haffjarðarey then in most of the comparative populations (with the exception of the medieval Danish skeletons, and the later population from Barton upon Humber). The crude prevalence in the Reykjavík population

[17] (Arcini 1999: 92-3).
[18] (Bennike 1985: 135).
[19] (Waldron 2007: 62).

can however only be demonstrated to be significantly higher than that in the Swedish population from Lund.

Table 6.4: The association between shoulder and elbow osteoarthritis.

Site	Skeleton	Sex	Age	Shoulder	Elbow
Kuml	HBS-A-004	Male	50+	Right: glenohumeral	Left only, no OA
	SSG-A-001	Male	35-49	Right only, no OA	Right: humeroulnar
Skeljastaðir	ÞSK-A-002	Female	50+	--	Left: humeroradial
	ÞSK-A-018b	Female	50+	--	Right: humeroradial
	ÞSK-A-052	Male	50+	--	Right: humeroulnar & humeroradial
Hofstaðir	HSM-A-002	Female	50+	Bilateral: glenohumeral	--
	HSM-A-003	Female	50+	Left: glenohumeral	--
	HSM-A-010	Female	50+	Left: glenohumeral	Right only, no OA
	HSM-A-015	Female	50+	Bilateral: Right-glenohumeral; Left-acromioclavicular & glenohumeral	--
	HSM-A-021	Female	50+	Right: glenohumeral	--
	HSM-A-022	Female	50+	Left: acromioclavicular	--
	HSM-A-023	Female	50+	Left: acromioclavicular & glenohumeral	Left: humeroradial
	HSM-A-033	Male	50+	Bilateral: Right-acromioclavicular & glenohumeral; Left-glenohumeral	--
	HSM-A-057	Male	50+	Bilateral: acromioclavicular	--
Haffjarðarey	HFE-A-011	Male	35-49	Bilateral: glenohumeral	Right: humeroradial
	HFE-A-014e	Male	35-49	--	Bilateral: humeroulnar
	HFE-A-015	Female	50+	Bilateral: glenohumeral	Bilateral: humeroradial
	HFE-A-018	Male	50+	Bilateral: acromioclavicular & glenohumeral	--
	HFE-A-019	Female	35-49	--	Right: humeroradial
	HFE-A-020	Female	50+	Bilateral: glenohumeral	--
Reykjavík	RVK-C-004	Male	35-49	--	Left: humeroradial
	VEY-A-004	Female	50+	--	Right: humeroradial
	VEY-A-007	Female	50+	Right: glenohumeral	--
	VEY-A-029	Male	50+	--	Left: humeroradial

What is noteworthy in regards to osteoarthritis of the larger joints of the upper limb is that there is no correlation between those who suffer from osteoarthritis of the shoulder, and those who suffer from osteoarthritis of the elbow (see table 6.4). This supports the theory that the main aetiological factors behind the development of osteoarthritis in these two joints are not the same.

6.4.2 Strenuous activity in Haffjarðarey and Reykjavík

As is clear when comparing the Icelandic material to other contemporary European populations from Denmark, Sweden and England (see Bennike 1985; Arcini 1999; Waldron 2007 and chapter 6.3.1 for further detail on the populations) the overall prevalence of ankle osteoarthritis in Iceland is very high (see chapter 5.2.8 and figure 6.3). Although the crude prevalence of ankle osteoarthritis within the Hofstaðir population is high compared to the contemporary European populations presented below with suffering from the condition, it is the Reykjavík and Haffjarðarey populations which stand out as the having the highest age adjusted prevalence of the Icelandic population (see table 5.45). In addition the crude prevalence of ankle osteoarthritis in the Haffjarðarey population is significantly higher than in all the other Icelandic populations, with the exception of Reykjavík. Compared to the Icelandic figures the prevalence in the European contemporary populations is extremely low. As demonstrated in table 6.5 the crude prevalence is significantly higher in the overall Icelandic population, as well as the Hofstaðir, Haffjaðarey and Reykjavík populations than in all the comparative populations.

Table 6.5: Ankle osteoarthritis summary, comparative populations.

Country	Site / period	%	95% CI
Iceland	Overall	10.8	7.1 to 16.0
	-*kuml*	2.3	0.4 to 12.1
	-Skeljastaðir	2.0	0.4 to 10.7
	-Hofstaðir	7.8	3.1 to 18.5
	-Haffjarðarey	41.2	21.6 to 64.0
	-Reykjavík & Viðey	23.1	11.0 to 42.1
Sweden[20]	Lund	0.3	0.1 to 0.8
Denmark[21]	Overall	0	0
	-Iron Age	0	0
	-Medieval	0	0
England[22]	Barton upon Humber, overall	0.2	0.1 to 0.5
	-Barton upon Humber, 1150- 1500	0	0
	-Barton upon Humber, 1500-1855	0.6	0.2 to 1.4

In modern populations, by far the most common aetiological factor of ankle osteoarthritis is trauma. A recent study of 390 cases of ankle osteoarthritis demonstrated that 78% was post-traumatic, 13% was secondary to other conditions, for example rheumatoid arthritis or osteochondritis dissecans, while only 9% was idiopathic. By far the most common trauma to lead to ankle osteoarthritis was malleolar fracture (39%),

20 (Arcini 1999: 95).
21 (Bennike 1985: 135).
22 (Waldron 2007: 62).

followed by ankle ligament lesions (16%), tibial plafond fracture (14%), tibial shaft fracture (5%), talus fracture (2%) and severe combined fractures (2%) (Valderrabano et al. 2009: 1801-2).

As already stated (see chapters 5.1.4.4 and 5.1.5.4), two of the cases in the current study clearly fit into the above categories, HFE-A-018 (male, 50+) had a *contra coup* fracture of the tibia and fibula, while VEY-A-004 (female, 50+) had a severe fracture of the calcaneus. Considering the extremely high prevalence of ankle osteoarthritis in the Icelandic population, and the fact that of modern day ankle osteoarthritis, almost 80% is post-traumatic, it would seem most likely that a large percentage of the cases seen in the archaeological populations are osteoarthritis secondary to a trauma which is not diagnosable from the skeletal material. Today, ankle ligament lesions are the most common injuries in sports and recreational activities. For example such injuries account for about 25% of the injuries sustained in running and jumping sports. The stabilizing lateral ligament complex is the most commonly injured structure, usually associated with inversion ankle sprain. Even with treatment and physical rehabilitation, it has been demonstrated that between 10%-30% of individuals with this type of injury experience chronic ankle instability (Valderrabano et al. 2006: 612).

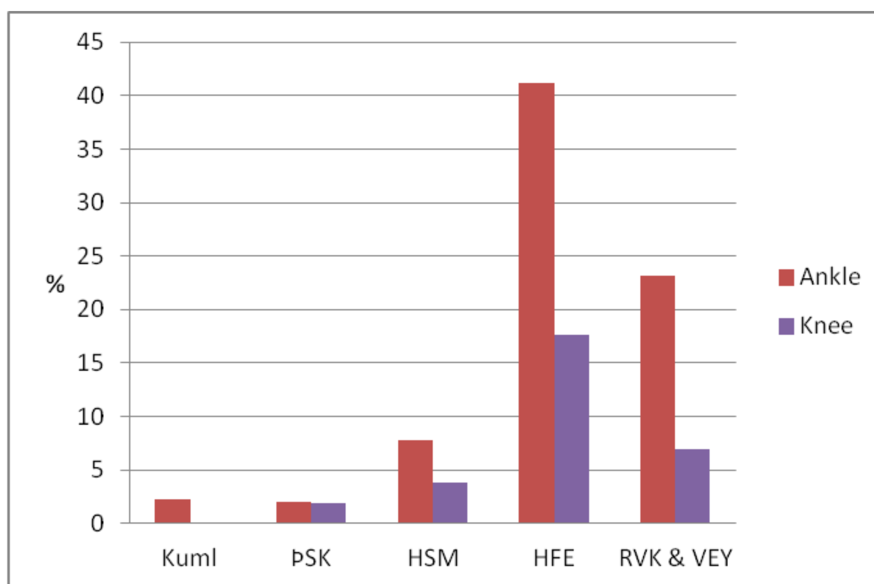

Figure 6.3: Ankle and knee osteoarthritis, crude prevalence.

Although it is of course unlikely that the ankle osteoarthritis in the current study group is related to sports or recreational injuries, it is likely that the individuals within all the groups led a physically active life, which would have increased the risk of ankle ligament trauma. The question remains however why the prevalence of ankle

osteoarthritis is so much higher in Iceland than in the comparative countries. It is of course likely that although idiopathic ankle osteoarthritis is rare, and there is no modern medical evidence of genetics being specifically an aetiological factor, the high rate of hereditary osteoarthritis in Iceland played some part, that is that a population with a genetic disposition towards developing osteoarthritis would be more sensitive to developing ankle osteoarthritis subsequent to ligament trauma. However, external factors are likely to have played a major part.

One such external factor which needs to be considered is the weather, which in Iceland is characterised by rather cold and wet conditions. The temperature range is quite narrow, with mild winters and cool summers. Today, the annual mean temperature ranges from 2°-6°C in the lowlands (Einarsson 1984: 680). Historical sources and environmental evidence indicate that from the settlement and into the 12th century (corresponding with the Medieval Warm Period), temperatures in Iceland were relatively mild, probably comparable to today. The latter part of the 12th century and into the 16th century was marked by short periods of harsh climate, culminating in prolonged cold periods, with annual temperatures probably 1°-2°C lower than today, lasting into the middle of the 19th century. This corresponds with the Little Ice Age, traditionally said to last between c. 1550-1850 (Ogilvie 1991: 249; Ogilvie and Jónsson 2001: 42-5). Iceland is also, as is typical of a country where low pressure systems pass frequently, quite a windy country; this will of course increase the wind chill. Also, due to its maritime climate, Iceland is very humid (Einarsson 1984: 684, 688-9). Discussions of the effects of climate on joint disease have often been anecdotal, for example stating that arthritics can predict weather changes by their symptoms (Aikman 1997: 195). There are however, studies that have demonstrated that wet and cold weather conditions have an adverse effect on the symptoms of osteoarthritis, in particular pain and rigidity (Aikman 1997: 195-6; Guedji and Weinberger 1990: 158-9). One study which looked at the effects of time of day, wind speed, temperature, barometric pressure and relative humidity on various rheumatoid diseases concluded that of these, the most significant independent variables in regards to pain and rigidity and osteoarthritis are in descending order: temperature, relative humidity and time of day. The study demonstrated that 41.5% showed worsened symptoms when cold, and that temperatures over 20°C were associated with reduced mean pain and rigidity. A total of 14.6% demonstrated worse symptoms with increased humidity (Aikman 1997: 198-9). However, it must be noted that such studies do tend to focus on the short term effects of weather on self-reporting pain and rigidity, rather than long term effects on pathological changes to the joint.

If one adds to this discussion the poor footwear made of untanned sheep or cattle hide or fish skin, that most Icelanders would have worn until the 19th century, and even shoes made of felted sheep wool (*vaðmál*) worn prior to the sixteenth century, as suggested by both archaeological and textual evidence (Sigurjónsdóttir 2004: 237-8; 243), it is clear that wet and cold feet were endemic within the Icelandic population until well into the 20th century. In

fact, the then Chief Medical Officer in Iceland, Jónas Jónassen published an article in 1900 warning of the health risks for young women in particular, of wearing poor footwear while working in wet conditions (Jónassen 1900). This practice would have meant that peripheral cold injuries, all of which would have led to paraesthesia, would have been rife in Iceland. This would have included conditions like chilblain, which results from a non-freezing cold exposure to the hands and feet, which usually produces swelling, arrhythmia, and some discomfort; immersion foot, caused by long term cold water immersion which increases conductive heat loss, and trenchfoot, a circulatory and neuralgic injury which results from an exposure to a cold, wet environment (Hamlet 1998: 127-8). Even if these peripheral cold injuries did not contribute directly to the development of ankle osteoarthritis, they are likely to have contributed substantially to the risk of foot injuries. The results of the analysis of ankle osteoarthritis in the Icelandic population therefore suggests that trauma to the ankle, most likely ligament trauma due to a strenuous and active lifestyle coupled with poor footwear in cold and damp weather played the most important role. The extremely high prevalence was then exacerbated by the high rate of inherited osteoarthritis within the Icelandic population.

Another issue that needs to be tackled is the fact that modern studies have demonstrated that the period between the trauma and development of ankle osteoarthritis is quite long. The mean latency period was demonstrated to be 34.3 years in one study, with a range of 6-57 years (Valderrabano et al. 2006: 614). Of those in the current study affected by ankle osteoarthritis, there is a near equal number in the 50+ age group, 50,0% (10 of 20) and the 35-49 age group 45,0% (9 of 20). One case is an adult of an unknown age. The fact that many of the people suffering from ankle osteoarthritis are in the 35-49 age group would suggest that at least some of the traumatic events which led to the development of osteoarthritis occurred during childhood. This is not unlikely at all, as it is almost certain that throughout Iceland's history, well into the 20th century, children would have been heavily involved in the daily activities, taking part in labour intensive work from a very early age. Records from the early 18th century show for example that there was a negative correlation between the number of children over the age of 10 within the household, and the number of servants (Guttormsson 1983: 98). In other words, once an individual reached the age of around 10 they were seen to be able to take on the duties of adults within the household and thereby reducing the need for servants.

The greater prevalence of ankle osteoarthritis at Haffjarðarey and Reykjavík compared to Hofstaðir and Skeljastaðir does require further explanation. The fact that the aetiology of ankle osteoarthritis is in most instances post-traumatic would support that perhaps the main reason for the difference in prevalence is due to different physical activities being carried out by the individuals buried at Haffjarðarey and Reykjavík, compared to Hofstaðir and Skeljastaðir. One factor that needs to be considered is how little is known about the use of the earliest medieval cemeteries. It is possible that there

was some sort of selection as to who was buried in the small medieval plots, and if so, this perhaps accounts for the difference in ankle osteoarthritis between sites like Hofstaðir and Haffjarðarey. That is, that Hofstaðir was reserved for family members, and servants were buried elsewhere, while Haffjarðarey was a parish cemetery, and so all and sundry were buried there. Added to this is the issue (as noted in chapter 3.4), that little is known about the layout of the cemetery in Haffjarðarey, and where within the cemetery the burials which were available for this analysis were located. It is therefore possible that there was some selection as to who was buried where within the cemetery, and that this had an effect on the prevalence within the population. In other words there is the possibility that higher prevalence of ankle osteoarthritis in Haffjarðarey (and Reykjavík) is due to the fact that a higher percentage of servants who would have led physically strenuous lives are buried there, compared to Hofstaðir and Skeljastaðir. However, the difference between the prevalence of ankle osteoarthritis in Haffjarðarey and Reykjavík on the one hand, and Hofstaðir and Skeljastaðir on the other is so great, that it seems unlikely that a status variation can provide the sole explanation. This is also supported by the fact that the high prevalence of acromioclavicular shoulder osteoarthritis in Hofstaðir (see chapter 6.4.1) does suggest that those who were buried there were no strangers to strenuous activity. It therefore becomes essential to look at the possibility that different activities provide an explanation for the variation of ankle trauma within these populations.

As already stated, Hofstaðir and Skeljastaðir are likely to have been very comparable sites. They are similar in date, and the people buried there are very likely to have been involved in similar farm-related activities. Both sites are also very far inland; Hofstaðir and Skeljastaðir lie approximately 50km and 80km from the sea, respectively (see figure 3.2). This means that it is quite likely that fishing related activities would not have ranked high among the population. Reykjavík and Haffjarðarey, although not contemporary in date, are both coastal sites, and so activities associated with fishing or a maritime economy are likely to have been very common among the individuals buried there. It must be noted that many of the people, most likely the men, at Hofstaðir and Skeljastaðir would have been involved in fishing to some extent. Evidence of this can for example be seen in the marine fish and shellfish excavated from the Viking age site at Hofstaðir (McGovern et al. 2009: 226-36), as well as preliminary results of the analysis of $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ isotopes which suggests that at least some of the people buried in the cemetery at Hofstaðir had a high marine diet (Sayle et al. 2014: 817). This would most likely have been brought by men who spent several weeks each winter working in the fishing stations (Kristjánsson 1982: 381). However, the intensity of the work experienced by those living at Hofstaðir and Skeljastaðir is unlikely to have been comparable to that of those living by the coast, both in terms of time spent, and the age at which the work started. Possibly affecting the intensity of fishing related activities for those buried in Haffjarðarey is the fact that by at least the 14th century fish resources had

become the main export from Iceland, and so an intensive marine economy had developed on the westernmost tip of Snæfellsnes, west of Löngufjörur, where Haffjarðarey lies. During this time there were people who lived all year round in the fishing cottages, and small fishing villages were established (Guðmundsson et al. 1988: 83-102; Valdimarsson and Bjarnason 1997: 16). Tenant farmers were obliged to work, or send people to work on the fishing boats for varied amounts of time, some for the whole fishing season, others for the whole year. For example, in 1702 of the 17 farms in Miklaholtshreppur and Eyjahreppur (which were the farms which Haffjarðarey is likely to have served), 16 had such obligations to the fishing industry on the Snæfellsnes peninsula (Guðmundsson et al. 1988: 199-207). Reykjavík in the 18th and 19th century also had a marine economy. As demonstrated in table 6.6, in 1880 fishing was the primary occupation in Reykjavík, with 41% occupied in the marine industry. Meanwhile agriculture was the least common occupation (Gunnlaugsson 1982: 92).

Table 6.6: Occupation in Reykjavík 1880 (after Gunnlaugsson 1982: 92).

Occupation	**%**
Fishing	41.0
Industry	17.0
Non-physical work[23]	9.5
Day-labour	9.5
Retail & services	8.0

Occupation	**%**
Unknown	6.0
Pensioner	4.5
Other	2.5
Agriculture	2.0

Fishing in Iceland from the first settlement and into the 19th century was mainly carried out on rowing boats. Most common were boats for six oarsmen, although boats for between two and 12 oarsmen are recorded (Kristjánsson 1982: 93-100, 202-3). Fishing was carried out both by line fishing and with nets (Kristjánsson 1985: 124-147). Once the boats had landed, the catch had to be carried onshore and the fish processed. In earlier periods this mainly involved the preparation of stockfish. Several methods were used for this, all involved gutting and beheading the fish and then washing it. The fish would then be beaten flat in preparation drying. The drying would be carried out either by laying the fish out in stacks or hanging them up on racks. This work would usually be carried out on the beach. Stockfish was produced in Iceland from the earliest periods and transported all around Iceland. Evidence of this can be found in archaeological excavations far inland, for example at the Viking age site at Hofstaðir (Kristjánsson 1985: 175-8, 305-16; McGovern et al. 2009: 228-34). By the 13th century Icelanders were exporting stockfish to Europe, in particular England (Barrett et al. 2008: 852). Other methods of processing fish are also known. Documentary evidence suggests that

[23] Non-physical work includes for example priests and various officials.

by the 15th century Icelanders were salting fish in small very quantities to export to England and Germany. By the middle of the 18th century the production of salted fish for the export market was on the increase and a by the middle of the 19th century salted fish was Iceland's main export (Valdimarsson and Bjarnason 1997: 19-37). There were various methods used for the salting, but a common process used in Iceland was that once the fish had been beaten, it was rinsed in sea water, and then stacked up and salted. The fish lay in the salt for a few days, after which it was washed thoroughly in sea water. Again, this process would usually be carried out on the beach, usually using barrels or some sort of vessel to wash the fish in, although in earlier periods it seems to have been done directly in the sea. The fish washing was considered very difficult and very cold work. Once the washing was done, the fish was spread out to dry, before being stacked again for transport (Kristjánsson 1985: 324-35). It must be noted at this stage, as stated in chapter 1.4.1, that diagnosis of osteoarthritis is not a suitable tool to discuss specific activities. It is therefore not the aim here to link any of the specific activities described above to the development of ankle osteoarthritis. On the other hand, if wet and cold conditions coupled with a physically strenuous lifestyle leading to a high prevalence of ankle trauma are, as has been suggested, the main aetiological factors behind the high prevalence of ankle osteoarthritis in Iceland, then these conditions appear to have been even more severe among those involved in fishing and fish processing activities, than those who were primarily involved in farming.

There was no difference in ankle osteoarthritis between males, 9.6% (95% CI 5.1 to 17.2) and females, 10.8% (95% CI 5.8 to 19.3), neither within the overall population, nor the individual sites. This would suggest that the strenuous lifestyle which led to the high prevalence of ankle osteoarthritis affected men and women equally. In light of this, it is perhaps relevant to look at the documentary sources for women's involvement in fishing and the fishing industry. Written sources suggest that women were involved in fishing from early on. There are a few references within the Icelandic Sagas of women fishing, but it is by the 17th century the documented evidence for fishing women increases. This includes stories of named women, but also other records, for example legal documents where a woman's occupation is noted as "fisherman" or in records of fishing-boats sinking, listing women as amongst those who drowned (Magnúsdóttir 1984: 17-23; Sigurðardóttir 1985: 193-5, 200-4). Evidence of women fishing is most commonly found in Breiðafjörður in western Iceland (just north of where Haffjarðarey lies), where women formed a large part of the fishing community, and were said to be as used to rowing as the men (Kristjánsson 1939: 15-7; Magnúsdóttir 1984: 33-45; Sigurðardóttir 1985: 205). That being said, there is no denying that the fishing itself was very much a male dominated activity. Where the women did participate heavily was in the fish processing. Women (and often children for that matter) were involved in all aspects of this, from assisting in landing the boats, to gutting the fish and other processing (Karlsson 2007: 42; Kristjánsson 1985: 305, 326; Thorarensen 1945: 58-9).

In fact in some parts of the country specific tasks of the process were considered women's work, for example in Vestmannaeyjar, off the southern coast of Iceland, it was women and children who carried the catch from the boats (Kristjánsson 1985: 176-7), and at least by the 19th century the difficult work of washing the fish after salting was mainly carried out by women (Valdimarsson and Bjarnason 1997: 192). With all this in mind, it is perhaps not surprising that women within the Icelandic population were likely to be as susceptible to ankle trauma caused by the activities associated with a maritime economy, as the men. They were active participants in the industry.

It is also of interest to link the of ankle osteoarthritis in the Icelandic population with the analysis of knee osteoarthritis within the population (see chapter 5.2.7 and figure 6.3). The prevalence of knee osteoarthritis within the Icelandic population is considerably lower than that for ankle osteoarthritis. The age adjusted prevalence for knee osteoarthritis was the highest in Haffjarðarey, and Reykjavík (see table 5.44). As demonstrated in table 6.7, there is no statistical significance in the prevalence difference of knee osteoarthritis between the overall Icelandic populations and the comparative populations from Denmark, Sweden and England (Bennike 1985; Arcini 1999; Waldron 2007).

Table 6.7: Knee osteoarthritis summary, comparative populations.

Country	Site / period	%	95% CI
Iceland	Overall	4.1	2.0 to 7.7
	-*kuml*	0	0
	-Skeljastaðir	1.9	0.3 to 10.1
	-Hofstaðir	3.8	1.0 to 12.8
	-Haffjarðarey	17.6	6.2 to 41.0
	-Reykjavík & Viðey	6.9	1.9 to 22.0
Sweden[24]	Lund	2.2	1.5 to 3.2
Denmark[25]	Overall	6.5	4.4 to 9.5
	-Iron Age	5.0	2.7 to 9.2
	-Medieval	6.8	2.7 to 16.2
England[26]	Barton upon Humber, overall	5.0	4.3 to 5.9
	-Barton upon Humber, 1150- 1500	4.3	3.4 to 5.4
	-Barton upon Humber, 1500-1855	7.2	5.5 to 9.2

As has already been discussed (see chapter 1.4.3) the main aetiological factor in knee osteoarthritis today is obesity (cf. Manek et al. 2003), and modern Icelandic studies have suggested a link between knee osteoarthritis and osteoarthritis of the hand (Jónsson et al. 2011: 8-9), which, as has been noted, is not reflected in the current study (see chapter

[24] (Arcini 1999: 94).
[25] (Bennike 1985: 135).
[26] (Waldron 2007: 62).

5.2.5.1). Where there does appear to be a correlation, is between knee osteoarthritis and ankle osteoarthritis, in that all eight individuals in the current study who suffered from osteoarthritis of the knees, also had osteoarthritis of the ankles (see table 6.8). It is unlikely that the people who make up the skeletal collection in the current study suffered from obesity, so a high BMI is not likely to be the main aetiological factor behind the cases seen here. The fact that all the individuals who have osteoarthritis of the knees also suffer from osteoarthritis of the ankles would however suggest that the two share the main aetiological factor, that is that the knee osteoarthritis in this study is secondary to trauma, probably ligament trauma particularly to the ankles. It is worth noting here the connection demonstrated in the modern Icelandic population between fishermen and total knee replacement (Franklin et al. 2010: 5 and chapter 3.5.2).

In addition to the high prevalence of ankle osteoarthritis, the overall difference in prevalence at Haffjarðarey, both with the other Icelandic sites and the comparative sites must be addressed. This is where Haffjarðarey and Reykjavík differ. As already noted (see chapter 6.3.1), Reykjavík is likely to have had a higher proportion of people who were not biologically related to each other, and a high proportion of immigrants, or descendants of immigrants, and in this population there is less of osteoarthritis in the joints associated with genetics, the wrists and the hips, than seen in the other Icelandic populations (see table 6.9). What is also noteworthy about the high prevalence at Haffjarðarey is not only the overall prevalence, but also the high prevalence of osteoarthritis in the population of those aged under 50. As seen in table 6.9 the overall prevalence in the total population is in most instances only slightly higher than in the under 50 age group, while at Hofstaðir and in Reykjavík, there is in most instances quite a difference between the total population, and those who are under 50. In other words, not only does the Haffjarðarey population suffer from a high prevalence of osteoarthritis, they seem to be developing the condition at a much earlier age than seen at the other sites.

To find a site that shows a comparable pattern to Haffjarðarey, it is necessary to turn to the African Burial Ground (ABG), from Lower Manhattan, New York. This site, which was excavated between 1991 and 1992, was the burial ground for enslaved Africans and their descendants. The earliest documentation of the cemetery is from 1712, although there are indications that it may have come into use earlier. The official use of the cemetery ended in 1794 (Blakey 2004: 1-3). Analysis of osteoarthritis within the ABG population was carried out on 187 skeletons aged over 15 at the time of death, with similar scoring methods of pathological changes to those used for the current study (Wilczak et al. 2004: 406-7), and the results demonstrated a very high prevalence of osteoarthritis in all joints (see table 6.9). Within the total population, there was above

Table 6.8: The association between knee and ankle osteoarthritis

Site	Skeleton	Sex	Age	Knee OA	Ankle OA
Kuml	VAS-A-001	Male	50+	n/a	Right: tibia-fibula
Skeljastaðir	ÞSK-A-002	Female	50+	n/a	Left: talus-navicular
	ÞSK-A-009	Female	50+	Bilateral: medial femur-patella	Ankle joints not preserved
Hofstaðir	HSM-A-010	Female	50+	n/a	Right: tibia-talus
	HSM-A-015	Female	50+	Bilateral: lateral femur-patella	Ankle joints not preserved
	HSM-A-021	Female	50+	n/a	Right: calcaneus-cuboid
	HSM-A-054	Male	35-49	n/a	Bilateral: talus-navicular. Right: anterior & posterior talus-calcaneus
	HSM-A-057	Male	50+	Right: lateral femur-tibia	Right: talus-navicular, navicular-intermediate cuneiform
Haffjarðarey	HFE-A-004	Unknown	Adult	n/a	Left: 2nd TMT
	HFE-A-008	Female	35-49	Right: medial femur-tibia	Right: tibia-talus, anterior & posterior talus-calcaneus, 3rd-4th MT
	HFE-A-011	Male	35-49	n/a	Right: medial talus-calcaneus
	HFE-A-013	Female	35-49	n/a	Left: 5th TMT
	HFE-A-014e	Male	35-49	n/a	Right: talus-navicular
	HFE-A-014h	Female	35-49	Bilateral: medial femur-patella	Bilateral: tibia-talus, talus-navicular, 2nd TMT.
	HFE-A-018	Male	50+	Bilateral: medial femur-tibia	Right: 2nd& 3rd TMT. Left: tibia-talus
Reykjavík	RVK-A-001	Female	35-49	n/a	Left: talus-navicular
	RVK-C-004	Male	35-49	n/a	Left: posterior talus-calcaneus
	VEY-A-004	Female	50+	Bilateral: medial & lateral femur-tibia	Right: tibia-fibula, tibia-talus, all talus-calcaneus, talus-navicular, calcaneus-cuboid, 3rd, 4th& 5th TMT
	VEY-A-007	Female	50+	n/a	Right: 3rd TMT
	VEY-A-026	Male	35-49	n/a	Left: navicular-lateral cuneiform
	VEY-A-029	Male	50+	Left: medial femur-tibia	Bilateral: intermediate-lateral cuneiform. Right: navicular-intermediate cuneiform

Table 6.9: Comparison between Haffjarðarey, Hofstaðir, Reykjavík, and the African Burial Ground. ABG after (Wilczak et al. 2004: tables on pg 409, 423, 426).

	Haffjarðarey				**Hofstaðir**				**Reykjavík**				**ABG**			
	All		**<50 (%)**		**All**		**<50**		**All**		**<50**		**All**		**<50**	
	%	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**	**%**	**95% CI**
Cervical	44.4	24.0 to 66.3	35.7	4.0 to 64.3	50.5	36.7 to 53.4	33.3	18.0 to 53.3	37.5	8.2 to 54.1	31.8	16.3 to 54.9	26.4	19.0 to 35.5	29.0	19.2 to 41.3
Thoracic	53.3	30.1 to 75.2	41.7	19.3 to 68.1	54.4	40.2 to 67.8	39.1	22.2 to 59.2	36.0	15.2 to 58.3	33.3	33.3 to 56.3	34.4	25.6 to 45.5	39.6	27.6 to 53.1
Lumbar	40.0	19.8 to 64.3	25.0	8.9 to 53.2	39.2	27.0 to 67.8	25.0	12.0 to 44.9	15.3	30.6 to 86.3	10.5	2.9 to 31.4	48.1	39.0 to 57.5	48.4	36.6 to 60.4
Shoulder	26.7	8.9 to 55.2	8.3	1.5 to 35.4	19.2	10.7 to 33.2	0	0	3.7	0.7 to 18.3	0	0	20.6	31.7 to 48.3	13.0	7.1 to 22.3
Elbow	26.7	8.9 to 55.2	27.3	9.7 to 56.6	2.0	0.4 to 10.7	0	0	11.1	3.9 to 28.1	5.3	0.9 to 24.6	30.7	23.7 to 38.8	27.5	18.9 to 38.1
Wrist	38.5	17.7 to 64.5	30.0	8.1 to 64.6	29.2	18.2 to 42.2	8.3	2.3 to 28.5	12.5	4.3 to 31.0	5.6	1.0 to 25.8	26.4	19.0 to 35.5	25.4	16.1 to 37.8
Fingers	33.3	12.1 to 64.6	33.3	9.7 to 70.0	17.4	9.1 to 32.0	4.3	9.7 to 70.0	16.7	6.7 to 35.9	11.8	3.3 to 34.3	23.0	16.7 to 30.8	16.8	10.1 to 26.8
Hip	12.5	3.5 to 36.0	0	0	15.1	7.9 to 27.1	4.2	0.7 to 20.2	3.5	0.6 to 17.2	4.8	0.8 to 22.7	39.6	31.8 to 47.9	39.0	29.2 to 49.9
Knee	17.7	6.2 to 41.0	15.4	4.3 to 46.3	3.8	1.0 to 12.8	0	0	6.9	1.9 to 22.0	0	0	35.4	28.1 to 43.5	32.9	23.7 to 43.7
Ankle	41.2	21.6 to 64.0	38.5	17.7 to 64.5	7.8	3.1 to 18.5	4.2	0.7 to 20.2	23.1	11.0 to 42.1	15.8	5.5 to 37.6	50.4	55.1 to 73.3	45.9	23.7 to 43.7
Toes	23.1	6.2 to 54.0	22.2	6.3 to 54.7	21.4	10.8 to 37.2	10.5	1.8 to 34.5	9.5	0.8 to 22.7	6.3	1.1 to 28.3	36.4	28.7 to 44.9	63.2	35.2 to 57.2

20% prevalence of osteoarthritis in all the joints of the spinal column and post-axial skeleton, and particularly noteworthy, a very high prevalence of ankle osteoarthritis, 50.4% for the total population. Another pattern worth noting in the ABG population is the high prevalence of osteoarthritis in those aged under 50 at the time of death (see table 6.9). Both isotope (lead, strontium and oxygen) and aDNA analysis was carried out on a sample of the population. The results indicate West- or Central African origin. The aDNA analysis suggested that the individuals buried in the ABG originated from the areas that today are modern Benin, Niger, Nigeria and Senegal, and were of varied macro-ethnic origin, belonging to the Fulbe, Yoruba, Hausa and Mandiki peoples (Jackson et al. 2004: 194). The isotope analysis demonstrated that those who had died as children had been born in New York, while most of the adults had clearly spent their childhood in various parts of Africa or the Caribbean (Goodman et al. 2004: 263-4). What this means is that although there may have been kinship groups within the cemetery (Jackson et al. 2004: 207), it is highly unlikely that the cemetery as a whole represents a group of people who were closely related to each other biologically. It is therefore unlikely that the high prevalence can be explained as being due to genetics. What we do know of course, is that physical labour was the principal task for the enslaved Africans in the Americas. In 18th century New York the most common work carried out by slaves would have been associated with fisheries, industry, transportation, shipping, construction and domestic work (Wilczak et al. 2004: 404). The very high prevalence of osteoarthritis in the ABG population is therefore most likely associated with extremely strenuous labour (and this is supported by the analysis of musculo-skeletal markers and trauma within the population), which in many cases clearly started at a young age, as demonstrated by the high prevalence among the younger adults (Wilczak et al. 2004: 448).

It is of course not the contention here to suggest that the people interred in the cemetery at Haffjarðarey were enslaved. However, the unusually high prevalence of osteoarthritis, in particular the high prevalence of ankle osteoarthritis, coupled with the high prevalence in those individuals under 50, would suggest that perhaps the people there were involved in comparably strenuous labour, starting at an early age, to those interred in ABG. The pattern of osteoarthritis in Haffjarðarey indicates that the level of biomechanical stress there is much higher than in the other populations, and although there is a possibility that part of that pattern can be ascribed to the fact that there may be a higher percentage of servants in the Haffjarðarey cemetery, than for example at Hofstaðir or Skeljastaðir, the difference between the sites is far too great (in particular in regards to the ankle osteoarthritis) for this to be the sole explanation. It is much more likely that the activities carried out by the people buried in Haffjarðarey and the intensity of those activities is the main reason. The geographical location of Haffjarðarey suggests that the activities associated with fishing and fish processing are the main causative factor. This is supported by the high prevalence of ankle osteoarthritis in the 18th-19th century Reykjavík populations, which are known to have been heavily reliant on the fishing industry.

6.5 Anatomy and osteoarthritis

6.5.1 Osteoarthritis of the spine

Spinal osteoarthritis has frequently been the focus of studies dealing with the link between activity and osteoarthritis (cf. Lovell 1994; Novak and Šlaus 2011). However, before discussing the prevalence of osteoarthritis in the spine within the Icelandic population and how that relates to activity, it is necessary to look at the anatomy of the spine and consider if that may be influencing the development of osteoarthritis.

The spine is formed by four groups of vertebrae, seven cervical, 12 thoracic, five lumbar and the sacrum (formed by five fused sacral vertebrae). The human spine has four natural curvatures which form at different stages of development. During most of the foetal stage the human spine has a single posterior curvature. However, late in the foetal stage the anterior cervical curvature, which is the shallowest of the four, begins to form. This becomes more accentuated during the first months of life as the infant begins to hold its head in an upright position. The anterior lumbar curvature starts to develop as the infant starts being able to sit up, and becomes more prominent with the onset of walking as it helps keep the trunk upright as the pelvis tilts forwards. The posterior curve seen at the foetal stage remains, forming the thoracic curve. Once the sacral bodies fuse at puberty, the posterior sacral curve is formed. In old age, the vertebral column is often seen to revert somewhat back to the C-shaped curve, as the intervertebral discs, which determine to a large extent the shape of the spine, begin to degenerate. Although it varies between individuals, the main curvatures of the spine are around: the cervical curvature between C1-T3, with the greatest curvature between C2-C7; the thoracic curvature between T2-T12, with the greatest curvature between T4-T7; the lumbar curvature between L1-S1, with the maximum curve at the L3-S1 and the sacral curvature, formed by the fused sacral bone (Palastanga et al. 2002: 447-9; Schwartz 1995: 80-1, 92).

What is clear when one looks at the overall prevalence for spinal osteoarthritis within the Icelandic population, shown in figure 6.4, is that the joints most commonly affected are those associated with the greatest curvature of the spine within the cervical, thoracic and lumbar curvatures (for further detail see chapter 5.2.2). In other words, the pattern of overall spinal osteoarthritis in all the skeletal populations in this study appears to be mostly associated with anatomy, not activity. This pattern is to a large extent also seen within the overall prevalence for the individual sites, in particular Hofstaðir and Skeljastaðir. The same result, that is the association between spinal curvature and joint degradation, has been demonstrated in other studies (cf. Knüsel et al. 1997). As already noted, however, the Reykjavík skeletal population does not appear to follow this pattern, in particular when it comes to the prevalence of osteoarthritis in the lower lumbar facet joints, which is much lower in the Reykjavík population (see figure 5.5). What we are probably looking at here is that although the main factor affecting the location of spinal

facet osteoarthritis is the natural curvature of the spine, it is very likely that the development and severity of osteoarthritis is being affected by other aetiological factors.

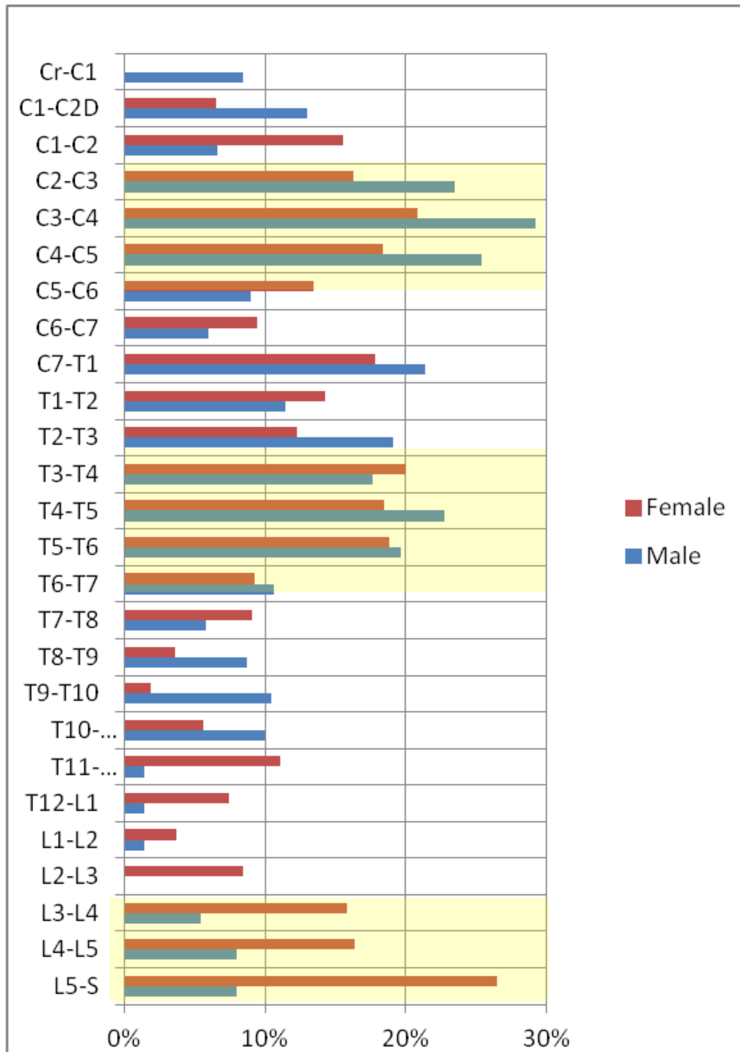

Figure 6.4: Combined vertebral facet joint osteoarthritis in Skeljastaðir, Hofstaðir, Haffjarðarey and Reykjavík. The highlighted areas indicate the greatest spinal curvature

Another factor which must be considered is differences in physical stress within the populations. The Reykjavík collection is contemporary with the beginning of urbanisation in Iceland, more likely to be mixed in terms of status and occupation than the other populations in the study. This raises the question whether differences in physical stress between these populations could be affecting the prevalence and distribution of spinal osteoarthritis. However, a study by Jóhannesdóttir (2009), which used cross-sectional geometry

measurements of long bones as indicators of physiological activity in several Icelandic skeletal population (including some of those used in the current study; Skeljastaðir and the Reykjavík populations), spanning the 10th-19th century indicated very little difference between the 10th-12th century populations and 18th-19th century populations, and if anything there were indicators of greater physical stress in the 18th-19th century populations from Reykjavík (Jóhannesdóttir 2009: 51). The high prevalence of ankle osteoarthritis in the Reykjavík population (see chapter 6.4.2) points in the same direction, suggesting that it is unlikely that the differences in spinal osteoarthritis prevalence are explained by less physical stress in the Reykjavík population due to differences in status. As already discussed, the Reykjavík population is much more likely to be affected by immigration than the other populations in the study, so there is possibly a different genetic makeup, and thereby probably a slightly reduced risk of inherited osteoarthritis compared to the earlier populations. Although this has not been specifically studied within the modern Icelandic population, other studies have suggested that spinal osteoarthritis, in particular of the cervical and lumbar spine, is to a large extent inherited (Spector and MacGregor 2004: S40).

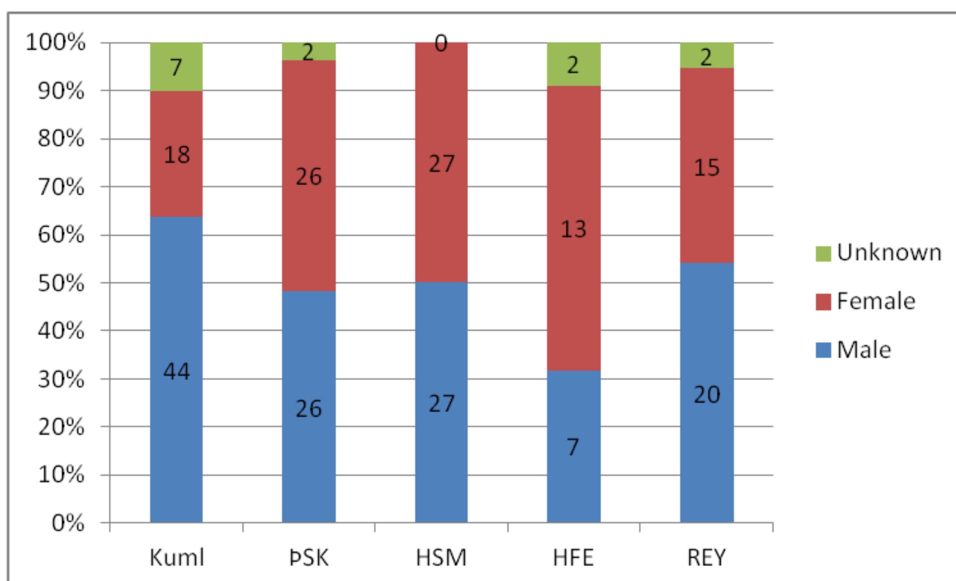

Figure 6.5: Sex distribution of all the sites in the study

6.5.2 Osteoarthritis, gender v. sex

As noted in chapter 1.4.2.2 there is quite a difference between how the medical and the osteoarchaeological literature tends to deal with different prevalence of osteoarthritis between the sexes. Within the medical literature the focus tends to be on biological factors, while within the osteoarchaeological literature it is usually on different gender roles within the societies under study. The following section will focus on the joints where a difference

was seen in the prevalence of osteoarthritis between men and women. The distribution of sex within the populations in the study is demonstrated in figure 6.5.

6.5.2.1 Gendered occupation in Iceland

Although there is plenty of evidence of gendered occupation in Icelandic society (cf. Jónasson 1961; Erlendsdóttir 1978; Sigurðardóttir 1985, as well as the discussion on fishing in Iceland in chapter 6.4.2), the evidence is scant before the 18th century (Sigurðardóttir 1985: 368-74). In addition, even though there is evidence that through the ages certain occupations were gendered; men cut the hey, while the women raked (Sigurðardóttir 1985: 227, Jónasson 1961: 76-81); men tended the livestock, while women made cloth and clothes (Sigurðardóttir 1985: 221, 303), there are throughout these sources frequent references to women carrying out tasks which were usually considered "men's work", and men carrying out "women's work" (see Sigurðardóttir 1985 and chapter 6.4.2). In fact it is a commonly stated that during the early years of the settlement there would have been little differentiation, everyone had to be involved in everything to keep going (Jóhannesson 1965: 44), although this is probably quite a romanticised idea of the strong settlers succeeding in dispersed settlements, against all odds. There are however other indications. For example in 1720 it was written into law that women should get the same pay as men for the same job: "En ef hún gjörir karlmannsverk með slætti, róðri eða torfristu, þá á að meta verk hennar sem áður segir um karlmenn til slíkra launa" [But if she carries out man's work through cutting hey, rowing or cutting turf, then her pay should be the same as for a man, as stated earlier] (*Alþingisbækur X* 1967: 565 translation my own). As noted earlier (see chapter 1.4.1), the interpretation of occupation based solely on the diagnosis of osteoarthritis is problematic. First of all there are several studies, both archaeological and medical which fail to demonstrate an association between the two (cf. Waldron and Cox, 1989; Aspelund et al. 1996), and secondly even when there is an association between a specific occupation or activity and osteoarthritis, it is impossible to validate the results. This validation then becomes even more problematic when it is not even possible to determine if people kept to their gendered roles as suggested by the written sources. It therefore becomes important to consider other possible aetiological factors for differences seen in prevalence of osteoarthritis between men and women.

6.5.2.2 The spine

Differences in the pattern and prevalence of osteoarthritis between men and women have frequently been used to discuss different gender roles within archaeological populations (cf. Sofaer Derevenski 2000). When discussing the overall prevalence of osteoarthritis of the spinal facets, it is important to note the difference between men and women. As already stated (see chapter 5.2.2.1 and figure 6.4), when looking at the overall population, there is a great difference between the most commonly affected facet joints of the spine between men and women; with the L5-S1 most commonly affected among the women, but the C3-C4

among the men. If we look at the high prevalence of lumbar osteoarthritis in women, this is again most likely explained by anatomy. This is caused by two factors. First of all, there is the fact that the lumbar curve tends to be more prominent in women than in men, and usually ends in the lumbo-sacral junction. This can then be exaggerated during pregnancy (thus placing greater biomechanical stress on this area of the spine) as the orientation of the pelvis changes by tilting forwards, to move the centre of gravity backwards to prevent overbalancing (Palastanga et al. 2002: 449).

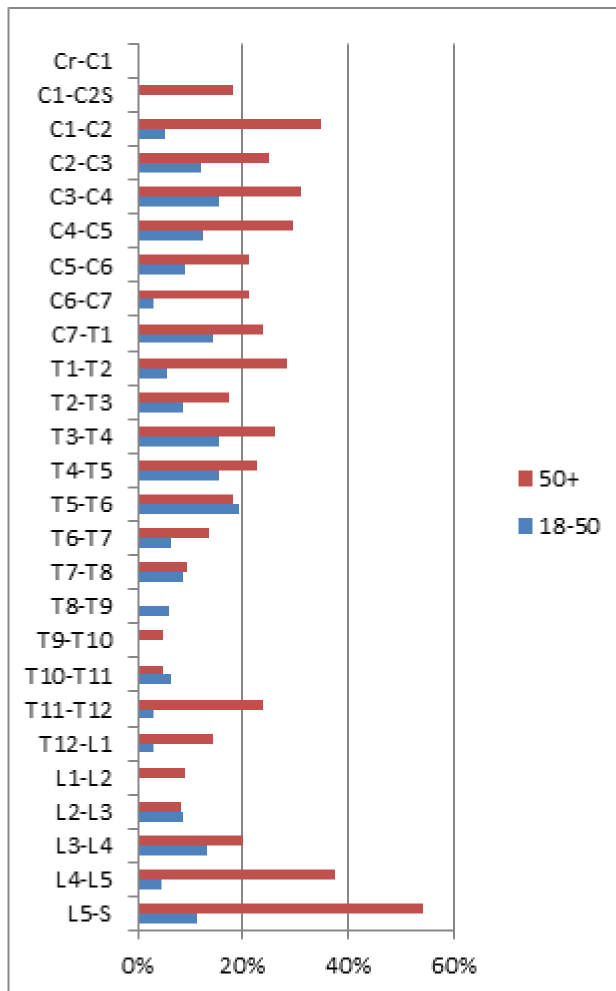

Figure 6.6: Combined female vertebra facet joint osteoarthritis in Skeljastaðir, Hofstaðir, Haffjarðarey and Reykjavík, over and under 50 years of age

Another noteworthy factor is that the prevalence of lumbar osteoarthritis increases greatly among the females in the study with age. As shown in figure 6.6, of the females in the study who are over 50 years of age, 37.5% (9 of 24) have osteoarthritis of the L4-L5 and

54.2% (13 of 24) have osteoarthritis of the L5-S1 facet joint. By comparison 4.7% (2 of 43) in the under 50 age groups have osteoarthritis of the L4-L5 and 11.4% (5 of 44) have osteoarthritis of the L5-S1. This is perhaps not surprising, as old age is the main aetiological factor of osteoarthritis. However, paired Kolmogorov-Smirnov analysis of lumbar facet osteoarthritis between the over 50 and under 50 females within the study (p=0.256) speaks against the null hypothesis. In other words, not only does the prevalence of lumbar osteoarthritis increase in women with age, but the pattern changes. This is most likely associated with the fact that women, especially post-menopausal women tend to lose bone mineral content considerably more rapidly than men, and the lumbar spine tends to be affected first, with evidence of loss of bone mineral in the lumbar spine starting as early as the third decade of life in women (Geusens et al. 1986: 1546-8).

Medical studies have suggested that osteoporosis and osteoarthritis are inversely related in modern populations (Dai 1998: 46; Dequaker et al. 1996). However, archaeological studies have shown the reverse to be true (cf. Brickley and Waldron 1998), that is individuals, and in particular women, with low bone density are more likely to have osteoarthritis than those with a high bone density. Why there is this difference between modern and archaeological population is not fully understood. It has been suggested that it is related to differences in nutritional status. Today, women who suffer from osteoarthritis tend to be overweight, which has been associated with increased peripheral formation of estrogens and subsequently a reduced rate of bone resorption. Obesity is however, as has already been mentioned, unlikely to have been a serious problem in most archaeological populations, including the ones in the current study, which may go some way to explain the difference between modern and archaeological populations (Brickley and Waldron 1998: 281-2). In other words, it is most likely that the high prevalence, as well as the age-related differences of the involvement of the lumbar facet osteoarthritis among women in the study, is associated with anatomy, (and possibly pregnancy) and age related changes, rather than gender specific activity.

6.5.2.3 The hip

As noted in chapter 5.2.6.1 there is a higher crude prevalence for hip osteoarthritis in women than men. Although the crude prevalence cannot be demonstrated to be significant, the age adjusted prevalence is (r=2.5, 95% CI 1.8 to 3.5). The difference is even greater if we look at the Hofstaðir population, where the difference age adjusted prevalence is significant with a common odds ratio of women v. men, (r=2.8 95% CI 1.6 to 4.7). It is worth mentioning, as noted in chapter 1.4.1 that although there is evidence that there is a link between farming and hip osteoarthritis (cf. Croft et al. 1992), it is not clear why hip osteoarthritis associated with farming would affect women rather than men. There is however some medical evidence to suggest that women develop a more severe form of the condition. They tend to have an increased frequency of radiographic change and worsening symptoms in hip osteoarthritis (Ledingham et al. 1993: 266). The

fact that women more likely to develop radiological hip osteoarthritis, means that hip osteoarthritis is more likely to be diagnosable in females in archaeological skeletal populations, compared to men. It would therefore seem likely that the difference seen between women and men in this study is more likely to be biological rather than social.

6.5.2.4 The wrist

Another joint where there is a difference between men and women is the wrist. Within the overall Icelandic population, women have a higher prevalence of osteoarthritis in the 1st CMC & IP joints (see chapters 5.2.5.1.1. and 5.2.5.2.2). This difference can be demonstrated to be significant when looking at the age adjusted prevalence, with common odds ratio of women v. men (r=2.0 95% CI 1.5 to 2.8). As already noted (see chapter 2.5.2), hereditary osteoarthritis of the wrist, the 1st CMC and IP joints, primarily affects women (Aspelund et al. 1996: 35-6; Jónsson and Valtýsdóttir 1995: 1), so it would seem that this is the main aetiological cause of the differences seen between the men and the women in the Icelandic population.

It must be noted that in all the above cases it is obviously not possible to state that different gendered roles do not play any part in the development in the osteoarthritis of the spine, hip and wrist. It is however the contention here that the main explanation for the prevalence difference between men and women in these joints is biological differences.

6.6 Concluding remarks

This chapter has dealt with some of the main themes associated with the aetiology of osteoarthritis, genetics, activity and anatomy. This has been done, not only by focusing on the disease process, but also by placing the populations under study within their social context in an attempt to give the interpretations a deeper meaning. As such, the high prevalence of osteoarthritis of the hand and hip in the Hofstaðir population, conditions which have been shown to have a high genetic component in Iceland, indicates that the people buried within the cemetery likely to be close biological relations. This has facilitated a discussion on the meaning of family and household in medieval Iceland, and added new depth to our understanding of the make-up of the Icelandic household, and the use of early medieval cemeteries.

On the other hand, the high prevalence of ankle osteoarthritis in Haffjarðarey in particular, and to a lesser extent in the Reykjavík populations, has opened up a discussion on activity as an aetiological factor of osteoarthritis. Ankle osteoarthritis is in almost all instances secondary to ankle trauma, and so the high prevalence in these populations indicates that the people buried at these sites lived more strenuous lifestyles likely to lead to ankle trauma than seen for example at Hofstaðir and Skeljastaðir. In addition the overall high prevalence of osteoarthritis in the Haffjarðarey population, and in particular the high prevalence of osteoarthritis in people under the age of 50, supports this interpretation of intense activity as a main aetiological factor (although genetics are

likely to have played a role), and indicates that the activity started at an early age. The coastal location of these sites, coupled with documentary sources suggesting that the people buried at these sites relied heavily on fishing and related industries, and the heavy work associated with the processing of fish in wet and cold conditions, are most likely the main causative factors of the high intensity of labour within the Haffjarðarey and Reykjavík populations.

Some consideration is also given to anatomy and osteoarthritis, in particular osteoarthritis of the vertebral facet joints of the spine. The focus is placed on the differences in prevalence of the various facet joints of the spine, as well as differences between men and women, which have traditionally been interpreted as associated gender based activities. In the case of spinal osteoarthritis it is however demonstrated that the prevalence differences, both between different spinal elements and between the sexes, are associated with anatomy and the curvature of the spine, and are not activity related. The difference between men and women in the prevalence of hip and wrist osteoarthritis seen within the study, is also suggested to be mainly associated with biology, rather than gendered roles. Modern medical studies have shown that women tend to develop a more severe radiological form of hip osteoarthritis than men (which is more likely to be diagnosable osteoarchaeologically), and inherited wrist osteoarthritis has been demonstrated to affect women to a greater extent than men.

7 Theoretical approaches to palaeopathology

Attempts have been made in the preceding chapter to determine the main aetiological factors behind the diagnosed cases of osteoarthritis within the populations in the study, and how this reflects on the society which produced these collections. There are cases where it is possible to identify the main aetiological factors, for example the high age adjusted prevalence of hip osteoarthritis at Hofstaðir pointing towards inheritance; the high age adjusted prevalence of ankle osteoarthritis at both Haffjarðarey and Reykjavík indicating secondary osteoarthritis due to trauma associated with a strenuous lifestyle; and the high prevalence of osteoarthritis in people under 50 in Haffjarðarey indicating that the strenuous activity started at an early age. However, in most instances, identifying a specific aetiology is very difficult, due to the much discussed multifactorial nature of the condition. This raises the question of whether it is possible, in addition to studying the aetiology of disease, to approach the study of palaeopathology in general, and the study of osteoarthritis in particular, from a different point of view. One avenue to explore is to move the focus away from thinking about what came before, that is the cause of the osteoarthritis, and to start to think about its effects. In other words what effect would the osteoarthritis have had on the individuals who suffered from it, and on a larger scale, the society within which they lived? This leads to some avenues to explore, which reflect how we think about degenerative and debilitating diseases like osteoarthritis. One is the disabling affect osteoarthritis would have had on the sufferer and the other is how the degeneration would have reflected on and influenced the natural ageing process, and in turn how these would have affected and the quality of life.

7.1 Disability

Arthritis is the main cause of disability in the developed world today. This is particularly true for older adults, although it ranks near the top for middle aged individuals as well. Arthritis reduces the quality of life; it restricts the capacity to work as well as to carry out daily activities; it increases health-care expenses; causes pain and even depression. It is the main contributor to high medical costs, lost income and lost years of disability free life today (Verbrugge and Juarez 2006: 102). A study of the most common causes of disability in Iceland in 2009 ranked musculoskeletal diseases as the main cause for disability among women (35.7%), and the second most common for men (17.2%), with mental disorder being the main cause (Thorlacius and Stefánsson 2010: 6). A second study, based on self-reported causes of disability in Iceland, demonstrated that 65% of people claimed that musculoskeletal diseases were the main cause of their

disability status, and of those 43% named arthritis. This study also showed that women were much more likely to claim disability due to arthritis than men; 83% of those reporting arthritis were women (Hannesdóttir 2010: 56).

It is of course not possible to draw direct parallels between those Icelanders who are considered disabled due to arthritis today and their ancestors who may have suffered the same affliction. However the high prevalence of osteoarthritis in the populations in the current study warrants that the disabling effects of the condition be considered. Before attempting to discuss disability in archaeological populations, there are several factors which need to be considered. First of all, what do we mean by the term disability, especially when dealing with archaeological remains? What is clear when one reviews the palaeopathological literature and approaches to disability is that there is a tendency to equate the physical impairment with disability in a social context. A disease is a temporary or permanent medical condition, which can lead to impairment, physical or mental (Knudson and Stojanowski 2008). Disability in the social model is however defined by the environment, both social and physical, and whether the impairment somehow hinders or affects a person's ability to survive and take part in that society (Cross 2007: 181-2; Metzler 2011: 45-6). In other words, a man has multiple sclerosis (a disease), which results in the paralysis of his legs (an impairment). As a result of this he is in a wheelchair and has trouble accessing buildings with stairs (a disability). The medical model of disability differs somewhat from the social; it is classified as a personal medical tragedy whereas disability is defined by incapacity. In other words, the medical model does not differentiate between a physical impairment, and the disabling effect of that impairment (Cross 2007: 181).

If one reviews the literature, it becomes clear that the medical definition is the one usually associated with disability in palaeopathological contexts (cf. Keenleyside 2011; Sugiyama 2004). The focus on physical impairment rather than social disability is clearly associated with the fact that the emphasis in palaeopathology has tended to be on how certain behaviour or actions may have caused the disease that is being studied. However the reverse question of how a disease may have affected the individual's ability to take part in a certain behaviour or action is rarely asked. This is because the focus of palaeopathology is usually on the disease or impairment and not the disability it could have caused. The disease is viewed in an epidemiological rather than social context, becoming itself the actor, rather than the person suffering from the disease (Cross 2007: 187). This is perhaps not surprising, given the nature of the material available to palaeopathologists; it is the physical impairment which can be gleaned from the skeletal remains. On the other hand, the distinction between the physical impairment and the socially defined disability should be of great importance when interpreting pathological information in a social setting.

Recently, the social model of disability has come under criticism, in particular from anthropologists. The crux of the argument against the social model, as described above,

is that it is constructed by and for the able bodied, and so does not give enough importance to the individual lived experience of the impairment suffered or disability. In fact, if one looks towards disability activists today, many people argue that the only way for an individual to be considered disabled is if that individual identifies themselves as being disabled (Battles 2011: 110; Cross 2007: 180-3).

Even when the concept of disability in the social and individual context has been described, one still needs to deal with the issue of whether it is possible to transfer these ideas onto archaeological populations. It cannot be assumed that people with disabilities have always been ostracised or treated differently, in all cultures and all time periods. Nor can it be assumed that what is considered a disability is universal; a person who may be labelled disabled within one group may not be by another (Hubert 2000: 1; Knüsel 1999: 32-3; Roberts 2000: 55; Winzer 1997: 80). How individuals who are considered somehow disabled are treated within a society cannot be examined without knowing something about the physical and social conditions affecting all the individuals within that society to place such a discussion in context (Winzer 1997: 75). That is, to understand how a society treated those who are different, we need to know something about those who were considered "normal" within the society. To complicate this point even further, it would be easy to assume that the concept of a normal body is unchanging and universal. It is however a social construct, rather than a natural one. It has even been argued, for example by Davis (1997), that within European culture the social concept of disability only dates to the 18th-19th centuries, associated with industrialization, alongside notions of nationality, race, gender, sexual orientation and so on. Davis argues that these ideas are closely linked with the development of statistics, and crystallized in the writings of the French statistician Adolphe Quetlet (1796-1847), who applied the Law of Errors to the distribution of human features, and so constructed the average man. Once the idea of an average man had been presented, this paradoxically became a kind of ideal, and people with disabilities, those who do not meet this ideal norm, become thought of as deviants (Davis 1997: 9-13).

Not everyone agrees with Davis's analysis that the concept of disability is a relatively modern one, mainly associated with complex societies. In the introduction to her book, *Madness, disability and social exclusion*, Hubert (2000) argues that differential treatment, and in particular physical and social exclusion due to disability are not recent developments (Hubert 2000: 2). There are several archaeological examples which have been used to support the argument for a concept of disability in ancient populations. Some of these examples focus on individuals who would not have been able to survive without help and care from others. This includes for example a skeleton of a juvenile-onset quadriplegic adult male from the Neolithic site of Ban Mac, who possibly suffered from Klippel-Feil syndrome (Oxenham et al. 2009). Another example is a severely impaired adult male skeleton from the site of Gran Quivira Pueblo in New Mexico. Analysis of the skeleton suggests that this individual suffered from

juvenile chronic arthritis (Hawkey 1998). The discussion as to why these severely impaired individuals have been cared for has often focused on the time and energy which would have had to be spent on keeping these individuals alive as evidence of compassion. Hawkey (1998) in the discussion of the juvenile arthritis case mentioned above, uses for example the nature of his burial, the positioning of the body, that there was no difference between the grave goods placed with this individual and others within the community, and the fact that he was buried in a sub-floor context, usually reserved for children, as evidence of the care which was given to this man (Hawkey 1998: 335-8). This approach has often been critiqued, notably by Dettwyler (1991) in an article entitled *Can paleopathology provide evidence for "compassion"*. Dettwyler criticises cases where skeletons with evidence of impairment so severe that they would have needed a lot of assistance to survive, have been interpreted as evidence of compassion from other members of the community. She uses for example the case of an adolescent male achondroplastic dwarf skeleton recovered from the cave site of Riparo del Romito in Italy, quoting the original publication "…this skeleton provides evidence of tolerance and care for a severely deformed individual in the Palaeolithic" (Frayer et al. 1987: 60). Dettwyler's critique of such statements centres on the concept of viewing physical ability as the only way to measure an individual's productivity and the interpretation being coloured by modern ideas about the qualities of life of disabled people and the notion that a physical disability will automatically reduce an individual's productive value (Dettwyler 1991: 383; Metzler 1999: 62). Tilley and Oxenham (2011) deal with this type of critique in a subsequent publication dealing with the paraplegic from Ban Mac mentioned above. There they quantify the type of treatment this individual would have needed to survive, using an understanding of the progression of the disease based on modern medical literature. They discuss the basic care he would have needed; food and water, transport, shelter and dressing, as well as advanced care; personal hygiene, general supervision, for example monitoring injury due to lack of sensation and health maintenance, such as dealing with secondary complications, for example constipation and bedsores (Tilley and Oxenham 2011: 37-9). They go on to discuss that while the motivations for providing this care cannot be known, the fact that the community did care for this individual still informs us about the society in which he lived "[T]he effective and long-term response to M9's condition argues for a socially stable and cohesive community experienced in nursing the sick; capable of assessing the likely demands and costs of care-giving in relation to a serious and permanent pathology; able to develop a set of procedures for responding to this situation successfully; and willing and able to maintain these procedures over years. The Man Bac community made an informed commitment to the extended care of one of its members, probably one reviewed and re-committed to in response to changes in – and the inevitable decline of – M9's health status" (Tilley and Oxenham 2011: 40)

Studies which focus on individuals with impairments who have received unusual burials have also been used to discuss disability in the past. This has been interpreted as evidence for differential treatment of those with physical disabilities, in most instances exclusion from society in some form. An example of this is the prone burials of several individuals with physical impairments within the Romano-British site of Poundbury in Dorset, England, a cemetery where the norm was to bury individuals in a supine position. These included a young woman with bowed legs; an old man with unusual facial features, and a deaf child (Molleson 1999: 72). Another example is the male burial within a well in Athens, dated to 900-850 BC. This individual had suffered two fractures to the skull as well as compression fractures to two lumbar vertebrae, some years prior to his death. The nature of the cranial fractures meant that the likelihood of this man having suffered permanent neurological damage was very high. The authors suggest that the deviant nature of the burial (as well as other similar burials found around Greece), indicates that the individual was considered an outcast, relegated to the status of a new-born child, who were not considered part of the family until the fifth or seventh day after the birth. The children who died before that time would not be given a formal burial, similar to this individual (Papadopoulos 2000: 104-11).

Other studies focus on the other end of the spectrum, the burials of individuals with physical impairments who were buried in the same way as everyone else within the group. These have been presented as evidence of no differential treatment of those who were disabled within the societies to which these individuals belonged. Examples of this are the inclusion within the communal tombs of several individuals with developmental defects (congenital scoliosis, congenital dislocation of the hip, club foot and a possible case of hemifacial microsomia to name but a few), from the Iron Age cemetery complex of Aymyrlyg in south Siberia (Murphy 2000). Similarly four individuals from Bronze Age sites belonging to the Agrar Culture on the Iberian Peninsula who had physical impairments (a man and a woman who would have used a walking aid and two men with dislocated shoulders), had not been treated differently in death than those individuals with no discernible impairments (Roca et al. 2012). The argument for the former example is probably sound, that is, that abnormal burials of people with clear physical impairments, most likely reflect differential treatment of disabled individuals. However, to state that where there is no difference in the way that individuals with or without clear physical impairments are buried, represents a society which did not treat individuals with disabilities differently, has to be questioned. Just because differential treatment is not discernible within the burial customs of a society does not mean that it did not exist within the group. There are far too many variables which affect how people bury their dead, both within and between societies, to draw such simplistic conclusions.

What all the examples presented above have in common, as in fact do most of the published examples of disability in archaeological skeletons, is that they deal with case studies, and in most instances cases where the impairment would have been very visible

and obvious. It could very easily be argued that this focus on the individual is the only way to discuss disability within archaeological collections, especially when one considers the recent arguments against the social model of disability, that it does not give enough weight to the lived experience of the impairment. This suggests that the only way to discuss disability is at an individual level. On the other hand, it must be remembered that if we wish to approach the discussion of disability as a social category, away from an individual characteristic only of interest to those who suffer the disability (Kudlick 2003: 765), it is necessary to ask; is it possible to consider disability in archaeological skeletons at a population level, and is there room for approaching pathologies which would not have necessarily caused obvious, visible impairments, from the point of view of disability theory?

7.1.1 Disability in the Icelandic sources

As already stated, it is impossible to attempt a discussion of disability within a population, without first demonstrating an understanding of what constituted the norm, and therefore conversely a disability, within that population. To do this when working with archaeological populations in Iceland it is possible to turn to the written sources. The earliest of these are the Sagas. They were mainly written in the 13th and 14th centuries. Here, the focus will be placed on two groups of Sagas, The Icelandic Family Sagas, *Íslendingasögur,* which are set in the 10th and early 11th century, and the Contemporary Sagas, for example the *Sturlunga Saga,* which record events in the 12th and 13th century, so only decades before they were written down. There has of course been much debate as to how reliable these texts are as sources for particular events (Sigurðsson 2008: 227). This is not an issue in this context, as the aim is not to use the Sagas as evidence of events, but rather as an indicator of attitudes towards those who were disabled, or perceived as different in some way. In fact, scholars have argued that this is where the strength of the Sagas as sources lies, "as models of and for Icelandic social life as it lasted over several centuries" (Turner 1971: 358)

The Icelandic Sagas are filled with depictions of social difference; Irish slaves, abandoned concubines, teenaged mass murderers, as well as paranoid old men and impaired Viking veterans (Bragg 2000: 128). What is interesting to note, however, is that although the Family Sagas depict a large and diverse lower-class, physical impairments alone do not serve as markers for social exclusion. Other factors, for example a lack of family connection or wealth, seem to be much more debilitating. Physical impairments are often described in a very matter-of-fact way, often as an aside. Frequently an individual's impairment is not mentioned until well into the narrative, when it becomes pertinent to the story (Bragg 2000: 131; Sexton 2010: 150). An example of this can be seen in *Sturlunga Saga*, where chieftain Einarr Þorgilsson's severe near-sightedness is only mentioned when it causes him to kill the wrong man (Bragg 1997: 172-3). In addition, Saga characters are frequently known by nicknames

based on their identifying marks, often associated with physical imperfection. Rather than being seen as debilitating or ugly, as they would be in modern society, such conditions may even have been seen as marking the individual as different from his normative but lesser peers, that in fact the impairment was associated with some kind of social distinction (Bragg 1995: 16; Bragg 2000: 130; Sexton 2010: 150). It must be noted in this context however, that the Family Sagas do focus on those of higher birth, and so perhaps do not necessary reflect the attitudes towards impairment amongst those who would have been considered of lower standing (Jakobsson 2013: 66).

Where the presence of a physical impairment seems to have a derogatory effect within the Family Sagas, is when it comes to the source of the impairment: a battle wound would be less shameful than a wound afflicted by a slave girl. There are also instances where, although the impairment does not seem to affect how the individual was treated, there is concern for the dangers an individual's impairment may pose to the society. There are also cases when an impaired individual worries that he will seem less in the eyes of others because of his disability (Bragg 1997: 165; Bragg 2000: 135). To demonstrate this we can for example look toward Önundur *tréfótur* Ófeigsson in *Grettis Saga.* After losing one of his legs in battle, and thus earning his nickname *tréfótur [wooden leg]*, Önundur worries about how this will affect his reputation, but is reassured by his friend Þrándur that he will be viewed no differently than before. Önundur goes on to have a successful career, conducting feuds against those who wrong him and establishing farms and offspring in Iceland, and therefore a legacy. His reputation grows following the loss of his leg, prompting the writer of *Grettis Saga* to state "Onundur var svá frækin maðr, at fáir stóðusk honum, þótt heilir væri" [Onund was so brave a man that few could stand against him despite being entirely whole] (*ÍF VII* 1938: 23; translation by Sexton 2010: 156). In other words, Önundur's impairment, rather than making him an outcast, can be seen to enhance his reputation, largely due to his ability to overcome his disability (Sexton 2010: 151-7). It is not only the people who are impaired. Within Norse mythology, impairment is seen among the gods, Týr lost a hand, and Óðinn lost an eye. As with the heroes of the Sagas, the impairment in these cases is not seen as disabling, and if anything plays a part in the strength of those who suffer from it (Jónatansdóttir 2013: 31-8, 46).

What we see in the Icelandic sources is in line with models of impairments seen in other texts in medieval Europe. In the sagas exceptional physical characteristics were rarely seen as disabling in practical terms, but rather as evidence of supernatural contact. However, Christian religious writings on impairment tend to focus on the suffering of the disabled individual and the pity one should feel for them (Bragg 1997: 172; Jakobsson 2013: 64). The earliest Christian writings in Iceland, Lives of Bishops, Saints and miracle stories, reflect this. They contain many tales of sick and disabled individuals, usually in association with miracles; the poor sick person being saved by the Christian saint. An example of this is the story of Bishop Guðmundur Ararson the

good (1203-1237), who restores an old woman's sight, and it is seen as a sign of Guðmundur's goodness that he sees fit to heal such an old person who is of little use (Margeirsdóttir 2001: 101) – "Má þat sýnast nokkut einkanligt, at þessum góða guðs vin líkaði at lækna svá gamlan aldr ok til lítillar nytsemdar færan eptir manna ásýn." [It may seem quite remarkable that this good friend of God saw fit to heal a person so old and considered to be of such little use] (*Biskupasögur II* 1878: 170, translation my own). Later chronicles rarely mention disabilities, but when they do they also focus on the debilitating nature of impairments, and in particular individuals who are seen to overcome their disability and so become valued members of the community. An example of this can be seen in Fitjaannáll from 1696, where three deaf-mute siblings are said to be as capable as unhindered persons at farm-work (Margeirsdóttir 2001: 102) – "Allar þessar manneskjur kunnu búskaparþjónustu, bæði ullar- og útivinnu, sem óhindruð væru" [All these people could carry out farm-work, both working wool and outdoor chores, as if unhindered] (*Annálar II* 1933-1955: 325, translation my own).

What all the above examples have in common is that where a disability is mentioned, the focus tends to be in one form or other on how the disability will affect the individual's ability to work, and how it will affect society. The only difference perhaps is that in the Sagas the disability can be seen more as a mark of difference, in particular in cases where people have managed to succeed despite their disability, rather than something which merits exclusion, while in the Christian religious writing, the disability is seen as something which should be pitied. However, there is no clear evidence in any of the writings that a physical disability is something that marks an individual as an outcast or someone who should be excluded.

The earliest Icelandic legislation dealing specifically with the disabled is from 1936. Prior to that those who were disabled and in need of support were subjected to the same laws as those who were poor. The longest standing legislation regarding the poor was *Jónsbók* (introduced in 1280), where those in need of support were split into two groups, *þurfabændur*, farmers who needed support (often due to some traumatic circumstances, for example poor health) from the district to keep their farm running and *ómagi* or incapable person, those who could not support themselves and were therefore supported by relatives, where possible, otherwise by the county. Although the contemporary sources do not specify who would have been considered an *ómagi,* this is likely to have included orphaned children, or people who could not work, due to poor health, old age or some physical impairment. These laws were not changed until 1834, although the basic regulations as to the definition of those needing support or who should support them remained little changed (Margeirsdóttir 2001: 106-10).

7.1.2 Disability at Hofstaðir?

In terms of the current study, the place to start is to focus on the fact that as people began to suffer the stiffness, pain and reduced immobility which osteoarthritis would

have caused this would have diminished their ability to take part in the daily activities of the household. This would have been particularly true for the smaller farm-based populations, such as Hofstaðir and Skeljastaðir, where it is unlikely that many people of higher status (for example priests or chieftains), who perhaps would not have had to take as active a part in physical labour, would have been buried.

Hofstaðir is particularly interesting in this regard, due to the very high prevalence of osteoarthritis in the skeletal population. In addition, the environment of the Hofstaðir farm has been studied extensively archaeologically. The Hofstaðir home-field sits on a terrace on the eastern banks of the Laxá River which runs from Lake Mývatn to the North Sea. The terrace is approximately 500m at its widest point, and drops gently to the west about 20m to the Laxá River and rises steeply to the east by about 60m onto the Hofstaðaheiði heath. The home-fields were levelled in the middle of the last century, but the archaeological investigations at the site have revealed that prior to that the land would have been extensively covered in frost-heave hummocks, *þúfur,* which would have made walking around the farm even more difficult for someone who was suffering due to osteoarthritis of the lower limbs. Most of the routes in and out of the farm run either along the top of Hofstaðaheiði, or involve crossing the Laxá River. Crossing points on the river are few and far between, the closest to Hofstaðir is 1.5km to the south of the farm (Jónsson 2006: 17-8; Lawson et al. 2009: 26-9; Vésteinsson 1996: 72-90). These routes would have had to have been taken on foot or on horseback. Before the turn of the 20th century, the horse-drawn cart was only used by the elite in Iceland (Ólafsson 2010: 83-4; Þorsteinsson 1990: 62), as prior to that there were no roads in Iceland which were passable by wheel. Both of these modes of transportation would have been difficult for those who suffered from stiffness and pain due to osteoarthritis.

The cemetery itself sits on the edge of a farm-mound which was abandoned in the middle of the 20th century. The farm-mound has not been excavated (Gestsdóttir and Isaksen 2011). There has however been a complete excavation carried out of a nearby Viking-Age hall. This lies approximately 100m to the north of the cemetery at Hofstaðir, and was built around 940 and abandoned by around 1030 (Lucas et al. 2009: 57), so its use was contemporary with that of the cemetery. Although there is clear evidence at the Viking Age hall that it had a ceremonial function, possibly as some sort of feasting hall, there is plenty of evidence that the site was also a functioning farm, which means that the people living there would have been involved in the activities associated with its daily running. This included the management of the domestic livestock, haying, processing of (probably imported) cereals, gathering of wood, peat and turf for fuel, as well as the making of charcoal. Other physical activities evidenced by the archaeological record are smithying, textile production as well as the upkeep of the turf and stone structures (Batey et al. 2009: 271-89, 321; Guðmundsson 2009: 334; Lucas 2009a: 379; Lucas et al. 2009: 103-7, 127-31; McGovern et al. 2009: 250-1; Simpson et al. 2009: 341, 359).

Of course the activities described above are only a small percentage of those which would have occupied the inhabitants of Hofstaðir. They are only the ones which can be gleaned from the archaeological evidence. What is clear, however, is that in a household consisting of an average of seven people (Gunnlaugsson 1988: 60), every individual contribution would have been very important to keep the farm running. It is of course difficult to know what the customs were in the middle ages, but we do know that by the 18th century the tasks which had to be carried out were clearly segregated (although see chapter 6.5.2.1). There were jobs which the children carried out, and the teenagers. Women carried out specific tasks and men others (Jónasson 1961: 56-117). So then the question becomes: what effect would the loss of ability to take part in those activities have had on both the individual and the society as a whole, and furthermore: was this a society which could afford to maintain or had tasks for those who could not carry out those duties expected of them?

With the high percentage of individuals with osteoarthritis, it is certain that a large percentage would have been impaired by the disease and so in some way restricted from participating in the daily activities which were essential to maintain the farm. The idea of what this impairment may have involved in the past can perhaps be gleaned if we look at the treatment and management of hip and knee osteoarthritis today, which aims towards reducing pain, improving joint mobility, and limiting functional impairment. It is recognised that pain in hip and knee osteoarthritis typically increases with weight-bearing activity and improves with rest, as well as being associated with morning stiffness. The main focus of the management of osteoarthritis is therefore in the form of non-pharmacologic therapy, which differs between patients, but the focus of which is listed in table 7.1. In cases where non-pharmacologic treatment is not sufficient, pharmacologic therapy is recommended in addition. This includes analgesics and non-steroidal anti-inflammatory, both oral and topical, as well as intra-articular treatment with anti-inflammatory steroids or hyaluronan (used to increase the lubrication of the joint). In cases where the pain does not respond to medical management, surgical intervention, either joint arthroplasty or osteotomy may be the only solution (*ACR* 2000: 1905-12).

Table 7.1: Non-pharmacologic treatment of hip and knee osteoarthritis (after ACR 2000: 1906).

Patient education	Assistive devices for ambulation
Self-management program	Patellar taping
Personalized support	Appropriate footwear
Weight loss (if overweight)	Lateral-wedged insoles
Aerobic exercise programs	Bracing
Physical therapy	Occupational therapy
Range-of-motion exercises	Joint protection and energy conservation
Muscle-strengthening exercises	Assistive devices for activities of daily living

There is no question that in the absence of modern medical treatment a lifestyle which would have involved a great deal of weight bearing activity would have had an adverse effect on the occupants at Hofstaðir who suffered from osteoarthritis. The pain and stiffness would have gradually increased to the extent that it would have affected their ability to be active participants in the tasks they had previously been involved in, as well as on their mobility within their physical environment. A progressive impairment will often also put a greater strain on the society, especially if the resources are limited and the means to take care of the disabled individuals are restricted (Roberts 1999: 85). It is clear that, as described in the social model of disability, those who suffered from osteoarthritis at Hofstaðir would have been disabled by the combination of their condition, and the physical and social environment within which they lived. However, the question remains, would the society within which they lived have considered them disabled?

In 1998 Samúelsson published *Sjúkdómar og dánarmein íslenskra fornmanna*, a compilation of all descriptions of diseases and traumas in the Icelandic Sagas, along with an attempted diagnosis and categorisation according to modern medicine. The section dealing with all rheumatic diseases is noticeably short, only five pages, the same as epilepsy, while the section on heart conditions is for example 27 pages long, and the section on eye diseases is 13 pages long. This obviously does in no way reflect the prevalence of these diseases in the earliest centuries of Iceland, only the emphasis placed upon them in the written records. It is also worth noting that all the descriptions which relate to rheumatic diseases involve individuals with hunched backs or extremities which have become deformed by the disease to such an extent that they are often non-ambulatory. In all instances Samúelsson diagnoses either rheumatoid arthritis, or juvenile rheumatoid arthritis, as well as one case of schlerodema (Samúelsson 1998: 75-80). In other words, all the instances where rheumatoid diseases, or at least diseases which have been diagnosed as such are mentioned in the Sagas, are cases where there are visible physical deformities. There are no cases describing stiffness and pain in the joints which Samúelsson feels he can diagnose as cases of osteoarthritis.

There are however instances within the documented sources in Iceland where people describe themselves as having lost their former abilities, in particular physically. These descriptions are rarely in relation to descriptions of diseases, although attempts have been made to diagnose them as such (cf. Byock 1995). What they always relate to is descriptions of old age (cf. Samúelsson 1998: 210).

7.2 Age

Age is an integral part of osteoarchaeological research. Analysis and determination of the sex and age-at-death of the skeleton are the first steps taken in almost all studies of human skeletal remains. The late 1970s and early 1980s saw a change in the way sex and gender were approached in archaeological research with the advent of gender archaeology. It is therefore surprising how, until recently, the study of age and ageing have remained largely under-theorised (Gowland 2006: 143; Appleby 2010: 145). The

differing roles that individuals of different age groups can play within societies, has not been fully considered when interpreting archaeological material. Far too frequently the researchers' own ideas as to what meaning should be given to different age groups, be it children or adolescents or old people, and how they should behave, are influencing the interpretation (Gowland 2007: 154-5; Lucy 2005: 43; Appleby 2010: 146).

It is clearly not possible to theorise age in osteoarchaeological research without first thinking about how we discuss age in general within osteology. The age of an individual at the time of their death is determined by documenting the growth, maturation and/or degeneration indicators on the skeleton and comparing these to studies of skeletons of known ages to determine the age-at-death in years. When a skeletal collection is being analysed, the usual practise is to aggregate age distributions into discrete age intervals, so that demographic analysis based on the ages-at-death of individuals within the group can be carried out (Chamberlain 2006: 15, 98). The determination of the age of adult skeletons is recognised as being one of the main problems of human skeletal analysis – "In immature remains, age at death can be **estimated** using aspects of skeletal growth and development. Once skeletal maturity is attained in the adult, age at death can be **inferred** from the progress of degenerative conditions and wear on the teeth" (Mays 1998: 42 - emphasis my own). The main problem encountered here is that skeletal age is not always an accurate indicator of chronological age. This is particularly true when dealing with changes associated with degeneration. The problem is that once growth and maturation are completed, around 25 years of age, degenerative changes are the only factors associated with age that the osteoarchaeologists has to infer age-at-death. The problems associated with using these to determine age are mainly due to the fact that degenerative changes can be influenced by so many factors, for example individual or population differences, general health etc., over which the osteoarchaeologist has no control. In fact, in many instances it is not even known what is causing the skeletal changes used to infer age in the adult skeleton, which means that determining what may be influencing the changes is impossible (Chamberlain 2006: 98-9, 105-10; Gowland 2007: 157-8; Mays 1998: 49-55; Appleby 2010: 148). Another problem, as demonstrated by Bocquet-Appel and Masset (1982), is that age distributions in archaeological populations tend to mirror the distribution in the reference population used to develop the methods. This statistical bias has also been demonstrated to result in the tendency of under-ageing older individuals, as well as over-ageing younger individuals (Bocquet-Appel and Masset 1982: 321-325; Gowland 2006: 146).

There are also issues concerning how osteoarchaeologists tend to present the results of their analysis. Within the social sciences, there can be several different meanings for 'age'. The most common uses of the term can be seen to be threefold. First of all there is chronological age, which represents the time elapsed since birth. Secondly there is biological age, which represents the physiological ageing of the body and thirdly there is social age, which represents the social attitudes and behaviour seen as appropriate for a particular

chronological age (Gowland 2006: 143; Lucy 2005: 55). What osteoarchaeologists tend to do is to use an individual's biological (or skeletal) age to fit them within a chronological age bracket, for example 0-1, 18-25 or 45+. This age bracket is then frequently presented as a social age, for example infant, young adult or mature adult. In other words, these terms which relate to biological, chronological and social age are frequently interchanged, as if they mean the same thing, which in reality they do not. The social age of an individual is clearly very culturally loaded (Gowland 2006: 144), for example, our concept of what it means to be a teenager or an old age pensioner in 21st century Iceland is unlikely to have had any meaning to the medieval Icelander (cf. Ariès 1962: 18-19). In addition, as noted above, biological or skeletal age is not necessarily well correlated with chronological age, with statistical biases, and population or individual differences resulting in a known under-ageing of older adults and over-ageing of younger adults. In other words, when we present the results of our osteoarchaeological analysis, we know that a percentage of our skeletal population is aged incorrectly.

When looking at publications of osteoarchaeological research, or for that matter any archaeological study, the picture tends to be one of a past peopled by physically capable adults (Lucy 2005: 43). There has been an effort in recent years to deal with this issue. The focus has however, tended to be on infants and children, in particular in relation to infanticide (cf. Halcrow and Tayles 2011; Mays 1993). Ageing and the aged have received much less attention (however, see Gowland 2007; Appleby 2010; 2011). This is perhaps largely due to the fact that it is generally believed that in the past people did not tend to live long enough to reach what would be considered old age today. There are perhaps two factors which explain this. The first is a misunderstanding of what average life expectancy figures represent. The average life expectancy in past populations is often quite low, especially when compared to modern western populations. However, this difference is more associated with much higher infant mortality rates in the past, than increased senescence today, although this does play a part. In most early populations there was a very high neonatal death rate, which affected the overall low average life expectancy. However, if one survived the first year of life the likelihood was that people would have lived into old age, some even by modern standards (Lucy 2005: 55). The other factor is, as discussed above, the problems with the ageing techniques available to osteoarchaeologists today. As already mentioned, the results of age estimation studies of skeletal populations are usually presented within pre-determined age brackets, and within this system the results for the oldest individuals in the collections tend to be presented as over a specific age, usually 45+ or 50+, as accurately ageing individuals older than this is problematic using current macroscopic methods. What this often means is that people tend to focus on the given figure (45 or 50) as the maximum age attained by the individuals within the population. The effect of this is that those who are quite a bit older at the time of death, in their 70s or 80s (or even older) are effectively undetected (Aykroyd et al. 1999: 58).

However, these issues clearly relate to problems associated with the analysis and interpretation of biological and chronological ageing in archaeology. Even if these issues could be easily solved, they would not provide answers regarding questions relating to the social age of the individuals being studied, how they themselves and the society they lived in would have perceived and treated different age groups. In her paper, *Ageing the past: examining age identity from funerary evidence*, Gowland (2006) discusses two approaches to analysing age in archaeological research. The first is an age-differentiated approach. This focuses on age-grades and cohorts (a group of people born at approximately the same time) and has traditionally dominated much of anthropological and sociological research on age. However, the problem with this approach is that age cohorts are almost impossible to identify within archaeological populations. This is due to the fact that, as in most instances an archaeological cemetery would have been in use for a long period of time, and all the individuals within a specific age group were not all of that age at the same time, which means that their experiences of ageing may not necessarily have been the same. This is because there is a tendency to conceptualise age-groups as homogenous and static and members of a particular age-grade are seen to fit within particular norms which only change when they move up into the next age group, and there is no consideration of gender, social status or other factors which may have affected the way in which they were perceived or treated (Gowland 2006: 144-5; Wood et al. 1993: 344). An alternative approach, which is increasingly being used by researchers, is to think about age within archaeological populations in terms of the life course (that is, the passage of life from birth to death). In other words, instead of focusing on a series of demarcated age groups, to concentrate on 'life pathways' and the transitions that occur throughout the course of life, and therefore allowing for greater sensitivity towards the fluidity of age-related shifts in identity (Gowland 2006: 145). In her book, *The body as material culture,* Sofaer (2006) argues, based on the work of the philosopher Rom Harré, that the concept of the life-course can be divided into different, but overlapping, aspects, similar to that of age. These are the biological life-course, the social life-course, and the personal life-course. The biological life-course is the time between birth and death. The social life-course is not constrained by the living body, it can for example be marked by a parent's definition of their child before its birth, or the memories people have of a person after their death. The personal life-course is on the other hand fitted within the biological life course, and is based on the consciousness of the individual, beginning in infancy once the individual becomes aware of the self, and can end in old age and senility, before the person's death (Harré 1991: 34-6; Sofaer 2006: 120).

The idea of using the skeleton to discuss an individual's life-course is quite a departure from the traditional approach to presenting the results of osteoarchaeological analysis. Within the field there is a tendency to view the excavated skeleton as a static object. The individual is viewed as a snapshot of their selves at the time of death, a person of a specific sex, age, stature, build and suffering from specific diseases. The skeleton is often treated more like a specimen than an individual and the analysis viewed more as a means to an end

rather than an end in itself. In this way, the processes that an individual's skeleton went through in his or her lifetime are ignored, even though none of these features are unchanging within the individual; the body is a dynamic system which constantly affects and is affected by its environment (Sofaer 2006: 24-6). Although sex does not change, the features on the skeleton used to identify it do not develop until after a child has reached puberty. Similarly, as already mentioned, the factors used to determine age follow first a process of development and growth, then one of degeneration (cf. Mays 1998: 33-50). This is just as relevant when looking at diseases in the skeleton. We are seeing the course of the disease frozen at the stage where it happened to be at the time of death. In many instances, we are dealing with chronic non-terminal diseases, which would not have been the cause of death, nor even had any influence in the death of the person. Disregarding the process of the disease and the lived lifetime of the person who suffered from it, means that a large part of the story of the pathology is ignored.

7.2.1 The aged in the Icelandic sources

Osteoarthritis is such a disease, a non-terminal condition which in most instances gets progressively worse throughout the individual's lifetime, having an ever-increasing debilitating effect. As noted earlier (see chapter 7.1.1), within the Icelandic Sagas, this loss of ability or physical or mental reduction is not usually associated with a disease process or increased disability, but rather with becoming old. This view is not isolated to Iceland, but is commonly seen in other European medieval texts (Jakobsson 2008: 120). In his 2008 paper, *Ageism and taking care of the elderly in Iceland c. 900-1300,* Sigurðsson (2008) noted that in medieval Iceland, the life course was divided into three stages, childhood, adulthood and old age. During this period, the transition between childhood and adulthood seems to have occurred sometime between 12 and 16 years of age. The reason for the variation was due to the fact that reaching adulthood was not defined by a specific chronological age, but rather by the individual's function within the social group. Once a person was able to carry out the tasks society demanded from an adult, they were seen to have reached adulthood. There are however two terms which are used in the Sagas to discuss old age. On the one hand there is the term "*gamall"* [old] which is used for those who have lived to a chronological old age, but are still active in running their farms or working as servants. On the other hand there is "*elli"* [aged], which was used to denote those who due to degeneration could no longer carry out the tasks expected of them and had become reliant on others, a transformation which meant the loss of rights and social position. In this case the chronological age of the individual appears to have been irrelevant, or was at least, not the decisive factor (Sigurðsson 2008: 229-34).

There are examples of ageism within the Sagas. The clearest of this is perhaps in *Egils Saga.* Egill Skalla-Grímsson was a great warrior and chieftain, who had the misfortune of becoming old: "Egill Skalla-Grímsson varð maðr **gamall**, en í **elli** hans gerðisk hann þungfærr, ok glapnaði honum bæði heyrn ok sýn; hann gerðist ok fótstirður. Egill var þá at

Mosfelli með Grími og Þórdísi. Þat var einn dag, er Egill gekk uti með vegg og drap fæti ok fell; konur nökkrar sá þat ok hlógu ok mæltu: „Farinn ertu nú, Egill, með öllu, er þú fellr einn saman."... Egill varð með öllu sjónlaus. Þat var einnhvern dag, er veðr var kalt um veturinn, at Egill fór til elds at verma sik; matseljan ræddi um, at þat var undr mikit, slíkr maðr sem Egill hafði verit, at hann skyldi liggja fyrir fótum þeim, svá at þær mætti eigi vinna verk sín. ‚Ver þú vel við' segir Egill, „þótt ek bökumk við eldinn, ok mýkjumst vér við um rúmin." „Statt þú upp," segir hon, „og gakk til rúms þíns ok lát oss vinna verk vár." [Egill Skallagrimsson lived a **long life**, but in his **old age** he grew very frail and both his hearing and sight failed. He also suffered from very stiff legs. Egill was living in Mosfell with Grim and Thordis then. One day Egill was walking outside alongside the wall when he stumbled and fell. Some women saw this, laughed at him and said, 'You are completely finished, Egill, now that you fall over of your own accord'...Egill went completely blind. One winter day when the weather was cold, he went to warm himself by the fire. The cook said it was astonishing for a man who had been as great as Egill to lie around under people's feet and stop them going about their work. 'Don't grudge me that I warm myself through by the fire,' said Egill. 'We should make room for each other.' Stand up,' she said, 'and go off to your bed and leave us to get on with our work.'] (ÍF II 1933: 294-5; translation by Bernard Scudder in Hreinsson 1997: 174-5, emphasis my own). The message is clear. Egill through his decrepitude has become someone with no power who can be laughed at and chastised by women who would have been considered of a much lower status than he was. In this way the Icelandic writing again mirrors that seen in the rest of Europe during this time period. Becoming aged is associated with degeneration and impotence (Jakobsson 2008: 125-8; Sigurðsson 2008: 234-5).

7.2.2 The aged at Hofstaðir and Skeljastaðir

The obvious conclusion to draw from this discussion, in regards to the skeletal collection from Hofstaðir, is that individuals who suffered pain and stiffness due to their osteoarthritis, although clearly disabled by their environment as defined by the modern model of disability, would not necessarily have been considered disabled by the society within which they lived. They are much more likely to have been seen as the aged within the group. They were the people who due to their physical deterioration were not able to contribute to society as they did before. What this means is that perhaps it is possible to start thinking about age other terms than chronological age when looking at archaeological populations. As already discussed, it is important to clearly define what is meant when talking about age, that is, to clearly differentiate between biological, chronological and social age, and to think about which of these categories would have had most significance within the society (see also Appleby 2010: 157-60). Figure 7.1 demonstrates how it is possible to start dividing up different meanings and attitudes towards age based on the diagnosis of osteoarthritis. It is difficult to know which individuals would have been adversely affected by their osteoarthritis as there is not

necessarily a direct correlation between the presence or severity of bony changes and pain and stiffness (Lawrence et al. 1966). For the sake of this study it was decided to focus on those individuals who had multiple joint involvement of osteoarthritis, to select a subset of the population which had advanced osteoarthritis changes in several joints and are therefore most likely to be representative of those who suffered due to the disease. It also includes a substantial number of the cases of osteoarthritis within the study, for example 12 of the 17 cases of hip osteoarthritis, 11 of the 15 cases of shoulder osteoarthritis and 15 of the 19 cases of ankle osteoarthritis.

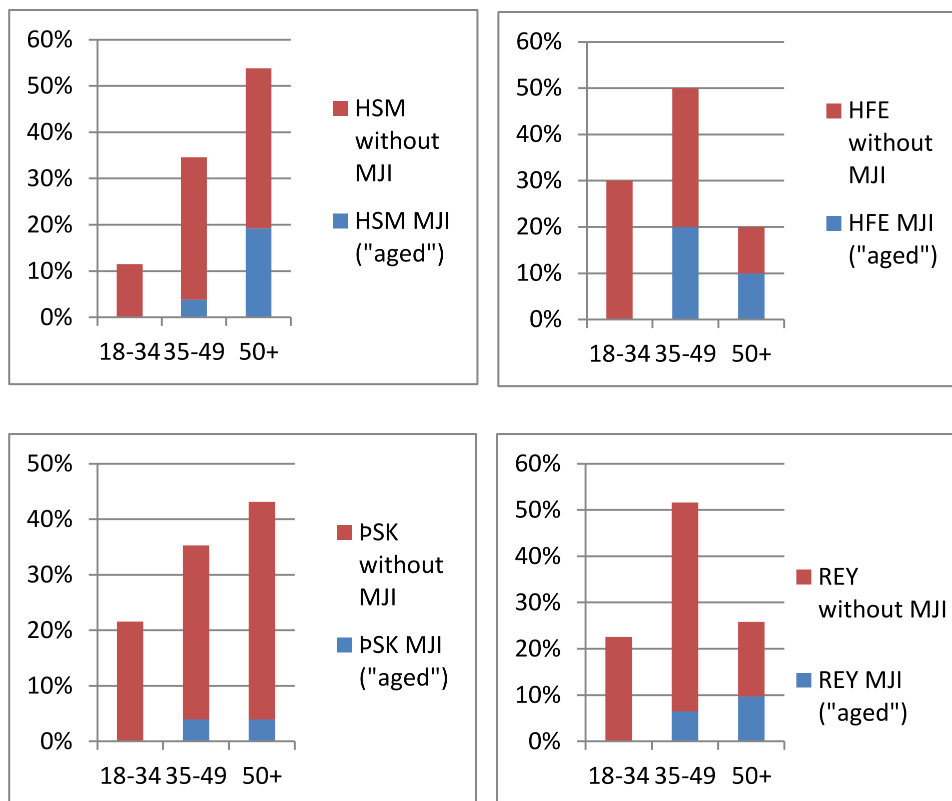

Figure 7.1: Chronological age brackets v. "the aged", based on multiple joint involvement (MJI) of osteoarthritis

There is a pattern at Hofstaðir, as with other medieval cemeteries in Iceland, of people's age and sex determining – at least to a certain extent – where within the cemetery they were buried, with women in the northern part, men in the southern part, and children up against the southern wall of the church (see figure 7.2). There are no contemporary historical sources (cf. Jónsson 1919-1929) documenting this practise, nor any other regulations regarding who should be buried where within the cemetery. Such sources are known from medieval Norway and Sweden. In a study of age and gender structures in medieval Sweden and

Norway, Jonsson (2009) points out, that historical documents from the period indicate that there was an organisation of the cemeteries which could be described as a series of concentric circles. The holiest areas were around the high altar, east of the church, while the least desirable parts of the cemetery were in the west and around the peripheries (Jonsson 2009: 123). The segregation of the sexes, with women to the north and the men to the south were known from these sites as well as the burial of infants in clusters, for example at Västerhus, in Jämtland in modern Sweden, but part of Norway in the medieval period (Jonsson 2009: 126-33). The burial of those who were disadvantaged at the outer limits of cemeteries is known from Nordic Medieval cemeteries. For example, Arcini (1999) noted that in the earliest cemeteries in Lund, Sweden (c. 990-1100) the lepers were buried in the outer peripheries, and there was a higher proportion of individuals with cribra orbitalia and porotic hyporostosis there, compared to other parts of the cemetery (Arcini 1999: 152). It has also been demonstrated in some of the larger Nordic medieval cemeteries, where it is possible to divide by social status that the old within the higher social strata, in particular the men, were likely to get preferential treatment in burial (Jonsson 2009: 136).

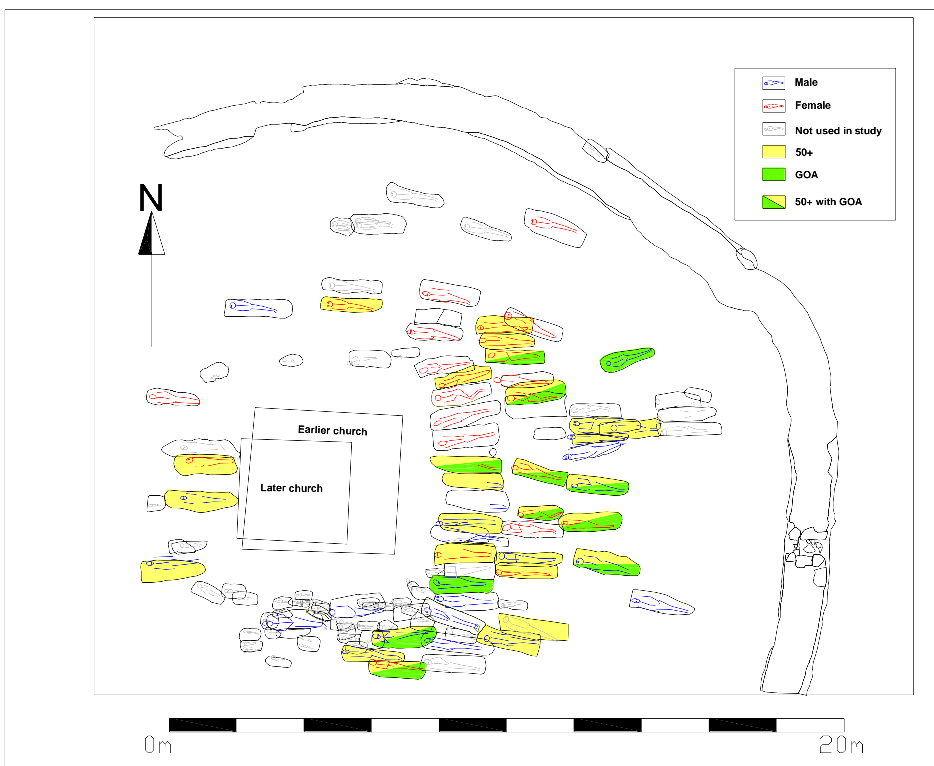

Figure 7.2: Burial pattern at Hofstaðir

The lack of comparable written records from Iceland means that it would be of interest to see if it were possible to use the archaeology to determine whether there were other factors at play which determined where people were buried within the cemetery. This would for example include physical degeneration which would have marked people as aged, to see if old age was a determining factor in the location of burial. A detailed analysis of this nature is perhaps premature at this stage, as the excavation of the cemetery of Hofstaðir is not yet complete and a large part of Skeljastaðir had eroded away prior to excavation. In addition further pathological analysis should be carried out to identify other conditions which might resulted in the physical degeneration of the individual. It can however, be tentatively pointed out as an exercise to highlight potential work, that as demonstrated in figure 7.2, where those individuals at Hofstaðir who had multiple joint involvement of osteoarthritis and those aged over 50 are marked, there is no clear age pattern if one looks at the location of the adult burials (apart from most of them being in the eastern part of the cemetery, where all but three of the burials used in this study are located). Both the chronologically old and those with multiple joint involvement of osteoarthritis are distributed evenly throughout the excavated part of cemetery.

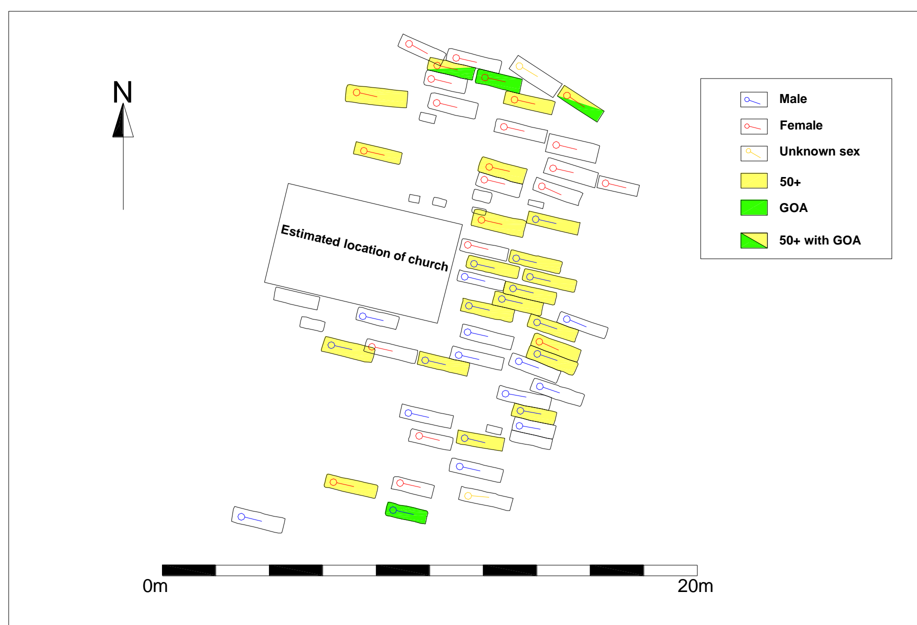

Figure 7.3: Burial pattern at Skeljastaðir. Based on Þórðarson (1943: 308).

At Skeljastaðir, the pattern of burial is the same as at Hofstaðir, the women are in the northern part of the cemetery, and the men in the south (see figure 7.3). There are very few juvenile burials at the site, which is thought to be a preservation issue, due to the erosion of the site prior to excavation. The juvenile burials found at the site were however located close

to the church. What is interesting about Skeljastaðir is the fact that the four individuals with multiple joint involvement of osteoarthritis are all buried towards the outer edge of the cemetery. If one looks at the pattern of burials of those aged over 50, they are clearly found in all areas of the cemetery. However there appears to be a cluster of burials of men aged over 50 immediately east of the central church. Of the 13 men aged over 50 in the Skeljastaðir population, nine (69%) are buried immediately east of the church, of the nine women in the same age group, only two (22%) are in the same area. In fact, if one looks at the cluster of 17 burials immediately east of the church, fourteen (82%) are men, even though men represent 48% of the population as a whole. Eleven (65%) of the seventeen people in the cluster east of the church are aged over 50, despite that age group only being 41% of the population as a whole.

As already stated, this analysis is presented mainly to highlight potential approaches to looking at the aged within archaeological populations. These sites are both small, and are only partially excavated, which makes any analysis of this type problematic.

7.3 Quality of life

There are other avenues which can be explored in the study of the life course and osteoarthritis. If Icelanders in the past equated becoming aged [elli] with diminished ability, then it perhaps becomes relevant to think about osteoarthritis in terms of quality of life. Being able to study lifestyle and life quality, whether the focus is on the changes within a population, or difference between populations, is one of the holy grails of archaeological research. Looking at the physical wellbeing of individuals is of course a major marker of life-quality, and so osteoarchaeological research is of course an important tool in answering such questions.

The issue of quality of life based on historical and archaeological research has been broached in the past, but usually in association with extreme conditions, and extreme changes in conditions. Examples of historical studies include analysing the impact on living conditions of the industrial revolution in Europe based on changes in relative mortality risks by socioeconomic status in several regions. The results of one study showed that there is no evidence that industrialisation caused an increase in social differences in mortality (Bengtsson and van Poppel 2011). There are also studies which combine historical and osteoarchaeological research to discuss quality of life. An example of this is a study by Barrett and Blakey (2011) on the life course of the slaves from the 18th century New York African Burial Ground (see also chapter 6.4.2 for a discussion on this population). This study uses a combination of historical research, palaeopathology (including analysis of enamel hypoplasia, Harris lines, enthesopathies and osteoarthritis), as well as isotope and aDNA analysis to look at origins. The results indicated that those born in New York demonstrated the greatest risk of morbidity and mortality, with a large percentage who did not survive beyond the age of four. Of those

who reached adulthood, those born in the city demonstrated high physiological stress between the ages of nine and 16, in particular among those who died between 15 and 25 years of age. Conversely those who survived beyond 25 years of age were mostly those born in Africa, and show far less early childhood hyperplastic stress (Barrett and Blakey 2011). Another study looked at the biological impact of the arrival of Europeans to the Americas on the Native American populations in Spanish Florida. The study used skeletal material from dozens of sites dated from around 400 B.C to A.D. 1700, and looked at palaeopathology, infectious diseases, osteoarthritis, cribra orbitalia & porotic hyperostosis, dental and skeletal indicators of physiological stress (enamel hypoplasia & porotic hyperostosis), stable isotope analysis for diet (carbon and nitrogen), tooth microwear, and skeletal morphology (cross-sectional geometry). The results revealed major changes in the quality of life and lifestyle in the native population after the arrival of Europeans (Larsen et al. 2001).

So, the question to be asked here is this: can osteoarthritis be used to assess the quality of life? One way to tackle this would be to look at the progression of the condition, that is how fast the disease process is, and therefore how long the sufferer lived disease-free. This is, however, far from simple. If one looks at studies of the radiological progression of osteoarthritis, the complicated nature of the condition becomes clear (see chapter 1.3 for more detail). Studies of the radiological progression of hand osteoarthritis have for example demonstrated that osteoarthritis in different joints progresses at different rates and that old age is associated with an increased rate of progression. In a study of 59 patients with hand osteoarthritis, half the patients showed radiological worsening after 10 years (Hochberg 1996: 685). A study of the radiological progression of knee osteoarthritis involving 71 patients who were re-examined after 10 and 18 years demonstrated radiological progress in a majority of the cases which correlated with worsening symptoms (Hochberg 1996: 686). On the other hand, in another 11 year follow-up study with 63 patients, only 50% showed radiological progression, and 10% showed improvement (Spector et al. 1992: 1108). A three year follow-up study of hip osteoarthritis involving 136 patients showed radiological progress in 47%, although the rate of progress varied due to various factors, for example age and sex (Ledingham et al. 1993: 264-6). A similar picture is painted if one looks at studies involving long term progression of self-reported symptomatic changes in osteoarthritis. Several studies have demonstrated an improvement in symptoms over time, indicating that worsening is not inevitable (Hochberg 1996: 686; Ledingham et al. 1993: 210). What this demonstrates is that it is impossible to determine on the basis of the changes seen in the skeleton, not only if and how the individual suffered due to the osteoarthritis, as has already been discussed, but also how long-standing the disease was. If one wishes to discuss quality of life in terms of osteoarthritis, it is therefore necessary to look at other factors.

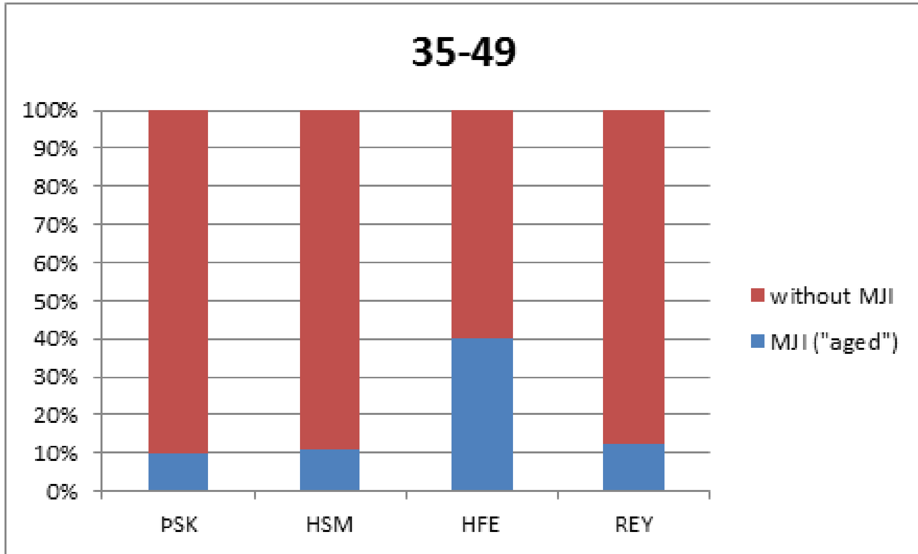

Figure 7.4: The proportion of those with multiple joint involvement (MJI) of osteoarthritis within the 35-49 age group

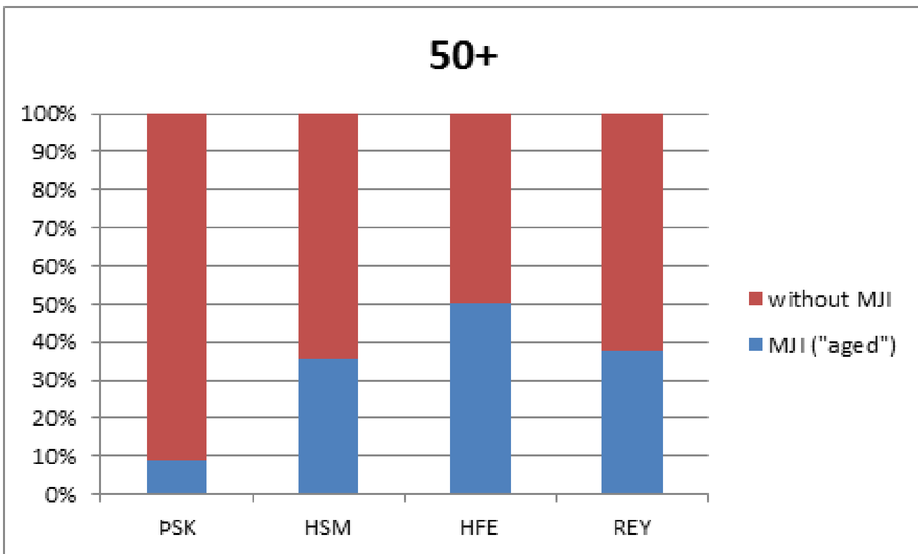

Figure 7.5: The proportion of those with multiple joint involvement (MJI) of osteoarthritis within the 50+ age group

One approach is to look at variance of the proportion of each age cohort with osteoarthritis.[27] If we again turn to those individuals with multiple joint involvement of osteoarthritis we see that there are varied patterns in each of the sites, as demonstrated in figure 7.4. In Skeljastaðir, Hofstaðir and Reykjavík the proportion of those aged 35-49 diagnosed is very low, between 10-13%. The pattern for Haffjarðarey is completely different. There 40% of those in the 35-49 age group have multiple joint involvement of osteoarthritis. If we then look at the 50+ age group the pattern of those with multiple joint involvement changes (see figure 7.5). The proportion of those diagnosed from Skeljastaðir continues to be very low, only 9%, while Hofstaðir, Haffjarðarey and Reykjavík are all relatively high, 36-50%.

We can start by looking at the two contemporary medieval sites, Hofstaðir and Skeljastaðir, which, as has already been mentioned are likely to represent very similar populations, subsistence farming communities. Hofstaðir has a much higher prevalence of osteoarthritis. However a similar, low proportion of the 35-49 population is affected as at Skeljastaðir. It is within the 50+ age group that the difference becomes clear, 36% at Hofstaðir versus 9% at Skeljastaðir. If we are thinking about quality of life in terms of number of active years, then the difference between the people at the two sites would perhaps not have become clear until in later life, that is that the chronologically old [*gamall*] people at Hofstaðir were more likely to have been considered aged [*elli*], than those at Skeljastaðir, who remained less hampered, at least by osteoarthritis, in their (chronological) old age. The Reykjavík sites show a very similar pattern to Hofstaðir, which could be considered to indicate a similar quality of life, even though the conditions would have been very different, with the Reykjavík population belonging to the earliest phases of urbanisation in Iceland. However, it must be noted that the age distribution at Reykjavík is very different to that at Hofstaðir; those in the 50+ age group make up 33% of the adult population as opposed to 52% at Hofstaðir, suggesting that a large proportion of those living in 18th-19th century Reykjavík were not reaching more (chronologically) advanced ages. As has already been noted, the notion that the Reykjavík population lived a more physically stressful life than the earlier rural population has been suggested (Jóhannesdóttir 2009: 51). It is however, the population at Haffjarðarey that stands out. Within the 35-49 age group, 40% had multiple joint involvement of osteoarthritis, the figure only rising slightly to 50% within the 50+ age group. However the indications clearly suggest that not only was the prevalence of osteoarthritis at Haffjarðarey very high, but the age of onset was very early. Of all the populations within the collection it is therefore the Haffjarðarey population which seems to have suffered the poorest quality of life, in terms of lived years without osteoarthritis. It must be noted here, that the very high prevalence of osteoarthritis in the 50+ age

[27] Again it must be noted that the following analysis is offered as a discussion on possible ways to approach the issue of quality of life based on palaeopathological analysis, none of the prevalence presented here can be demonstrated to be statistically significant.

group at Haffjarðarey does not necessarily indicate that a higher proportion of the individuals within that population reached extreme old age than within the other populations in the study. As pointed out in chapter 1.4.2.1 incidence of osteoarthritis does not continue into extreme old age, with a decrease in new cases of osteoarthritis after the age of 70 years (Hamerman 1995: 83-4).

It is likely that genetics play a role in the aetiology behind the high levels of osteoarthritis within the Haffjarðarey population. However, a strenuous lifestyle is also a major factor, as indicated in particular by the unusually high prevalence of ankle osteoarthritis in the population (see chapter 6.4.1), and the fact that the most comparable population to Haffjarðarey in terms of unusually high prevalence of osteoarthritis is the African Burial Ground population from New York. The main difference between Haffjarðarey and the African Burial Ground is that in the latter there is a much higher prevalence of osteoarthritis in the youngest adult cohort (15-24), indicating that the extremely strenuous lifestyle started at a much earlier age (Barrett and Blakey 2011: 239-40; Wilczak et al. 2004: 406-15). As has already been broached in chapter 6.4.2, the most likely difference is to have been associated with a greater emphasis on fishing and fish processing in Haffjarðarey, as opposed to a mainly farming economy as seen at Hofstaðir and Skeljastaðir, which perhaps explains a more active, or at least more strenuous lifestyle, with very heavy labour starting at an early age.

8 Conclusion

What has been demonstrated here is that despite the aetiology of osteoarthritis being complicated by, for example, inheritance, activity, anatomy and sex, it is nevertheless possible to construct a meaningful discussion about the condition in archaeological material. A single aetiological factor cannot be used to test the material; it is impossible to discuss biomechanical stress without considering genetics, or gendered activity roles without considering anatomy. As long as this complexity is considered it becomes possible to draw conclusions about a variety of issues based on the results of the analysis. It has also been demonstrated that in order to give such results a deeper meaning, it is necessary to consider factors which are not connected with the aetiology of the disease. These are factors which the disease may be influencing at an individual or social level, such as disability, ageing and quality of life.

The story which emerged based on the analysis of osteoarthritis in the five populations in this study was varied, both in terms of subject and details. Analysis of the *kuml* population (late 9th-early 11th century) indicated that the preservation was too varied and poor for the results to reflect the true prevalence of osteoarthritis within the group, in particular when dealing with the small joints of the spine. In addition, as the skeletons in this collection originate from 37 different sites spread over the entire country, it is difficult to argue that they represent a coherent population in the same sense as the other collections in the study. Due to this the *kuml* population was not included in the population analysis.

The Skeljastaðir population (late 10th-13th century) perhaps mainly served as a comparative population for the other sites in the study. It did however have a high prevalence of hip osteoarthritis in comparison to the English, Swedish and Danish populations used for comparison supporting the theory of a high prevalence of inherited osteoarthritis in Iceland.

The Hofstaðir population (10th-13th century) provided some of the best evidence for inherited osteoarthritis. The prevalence of osteoarthritis in joints which have been demonstrated to have a strong genetic factor in Iceland, the hip and the 1st CMC and IP joints of the hands was extremely high, both in comparison with the other populations in the study (with the exception of Haffjarðarey, which will be discussed shortly), and in particular in comparison with populations from Sweden, Denmark and England. This high prevalence suggests that the individuals buried at Hofstaðir were to a large extent biologically related to each other. This provides osteoarchaeological evidence for about whom the cemeteries of the small churches served as well as giving an indication of the composition of the household in the medieval period. In later centuries in Iceland there was a pattern of high mobility with each person or family only residing a decade or less

on each farm. Conversely the pattern of inherited osteoarthritis at Hofstaðir indicates a continuity of occupation (at least at the farm, but quite possibly within the whole region), with the same family living within the area, if not the farm, for several generations spanning 2-3 centuries.

The Haffjarðarey population (c.11th/12th-16th century) is both an interesting, and a problematical population. The problem is mainly created by the small number of skeletons within the collection, only 22 individuals, and the varied preservation (a low anatomical preservation index, API), due to the erosion of the site. In addition there is no information about the nature of the burials, structural elements had been eroded away by the time the site was excavated, so it is impossible to know where within the cemetery the skeletons used for the study, were buried. What this means is that it is difficult to know if there was some sort of differential burial based, for example on status, within the site. However, the very high prevalence of osteoarthritis at Haffjarðarey is tremendously interesting. In fact 16 of the 22 individuals have some form of osteoarthritis. As with Hofstaðir, there is a high prevalence of hip and 1st CMC & IP, indicating a genetic component to the aetiology of osteoarthritis at the site, suggesting perhaps a familial connection between those buried there. There are, however, other osteoarthritic patterns that intrigue, in particular the remarkably high prevalence of ankle osteoarthritis. This is high when compared to the other Icelandic populations, in particular Hofstaðir and Skeljastaðir, but the difference is very pronounced when compared to the comparative populations from Sweden, Denmark and England, where ankle osteoarthritis is negligible (less than 1%) or non-existent. Idiopathic ankle osteoarthritis is very rare; in most cases it is associated with some sort of ankle trauma. This would therefore indicate that the population at Haffjarðarey was subjected to a much more strenuous lifestyle than seen at Hofstaðir and Skeljastaðir. This is supported by the fact that Haffjarðarey also has a much higher prevalence of osteoarthritis in individuals under the age of 50 than seen in the other populations. This early onset of osteoarthritis indicates that not only was the Haffjarðarey population subjected to a more intensively stressful lifestyle, but that this lifestyle started at a young age, during childhood. The geographical location of Haffjarðarey, on the coast, suggests that the stressful lifestyle may have been due to a society focused on fishing and fish processing.

The Reykjavík populations (18th-19th centuries) display a very different pattern of osteoarthritis to the other sites in the study. This is most likely due to the fact that the period these skeletons belong to marks the beginning of urbanisation in Reykjavík, and therefore a very different society to that seen in the other populations in the study. The inhabitants of Reykjavík would have been less likely to have been closely related, and there would have been a higher percentage of people who were non-locals, or descendants of immigrants. There would also have been more specialisation in the work force, although most were employed in fishing and related industries. The diagnosis of

osteoarthritis within the population reflects this as there is a very low prevalence of osteoarthritis in the joints known to have a genetic aetiology, the hip, 1st CMC and IP, with figures much closer to what is seen in the comparative populations from Sweden, Denmark and England. This means that not only is there no indication that the people in the Reykjavík populations are biologically related to each other, but also they appear to be of a different genetic makeup than the rest of the populations in the study. There is however a very high proportion of ankle osteoarthritis in the Reykjavík population, mirroring that seen in Haffjarðarey, lending further support to the hypothesis of the strenuous lifestyle of people occupied in a mainly marine economy.

If one looks at the Icelandic population as a whole, in particular in comparison with comparative populations from Sweden, Denmark and England, there are two factors which stand out. One is the higher prevalence of osteoarthritis of the hip and 1st CMC and IP joints, which demonstrates the high proportion of inherited osteoarthritis in Iceland. This is mirrored by studies of the modern population. In fact even when other aetiological factors are at play, such as physical stress or anatomy, the effects of the underlying genetic disposition towards osteoarthritis in the Icelandic population can usually be noted. The second is the indicator of the coastal population demonstrating more evidence of physical stress, in particular based on ankle osteoarthritis probably secondary to trauma, indicating social and economic differences. No evidence of difference in osteoarthritis based on gendered activities was seen in the Icelandic material. Any differences in prevalence between males and females were shown to be mainly linked to anatomy or inheritance.

There are of course several new issues and questions which have arisen as a result of this project, which point the way ahead. One is the zone method used to record preservation and prevalence. This has opened up a way of recording joint disease, which makes the calculation of the prevalence of disease more accurate, and makes it easier to identify populations where the preservation of the joints is too poor or too varied for the results to be meaningful, can be identified. There are also other uses for the methodology. For example, focusing on differences in prevalence of osteoarthritis within different elements of joints may be of use when analysing larger populations than were available for this study. This opens up the possibility of considering whether there are aetiological differences for where within the joint the osteoarthritis is found.

There are also further avenues to explore to strengthen the conclusions drawn in the study. In regard to the familial connection at Hofstaðir demonstrated through the high prevalence of hip and hand osteoarthritis, it would be of great value to be able to delve further into this issue, to get an understanding of whether this is a pattern isolated to Hofstaðir, or whether it is seen in the whole of Mývatnssveit. This would be of great value not only to our understanding of the hereditary nature of osteoarthritis in Iceland, but also to the occupation pattern in Mývatnssveit, and the use of the early medieval cemeteries in the area. This is of course not possible without the excavation of further

sites in Mývatnssveit. In the meantime it is of course possible to look at other ways of studying kinship, for example aDNA or questioning whether other features of the collection are linked to genetics, for example whether the fact that more of those buried at Hofstaðir are surviving into chronological old age, compared with for example Skeljastaðir, could be linked to genetics?

One result which was not expected was the great variation in the levels of physical stress between the coastal sites on the one hand; Haffjarðarey and Reykjavík, as demonstrated through the high prevalence of ankle osteoarthritis at both sites, and overall high prevalence of osteoarthritis in Haffjarðarey; and the inland sites on the other. Before this study was carried out the premise was that before the urbanisation of Reykjavík in the 18th/19th century, there was little variation between populations in Iceland both in terms of intensity of work and status. Further work can also be carried out to look at this variation in greater detail, for example through studies of other elements associated with activity, enthesopathies, trauma and non-specific stress indicators, such as enamel hypoplasia and Harris lines.

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Appendix 1. Joint zones

Cranium & axial skeleton

Bone	Joint	Zone[28]
Occipital	Condyle	Anterior
		Posterior
C01	Facet	n/a
	Superior process	Anterior
		Posterior
	Inferior process	Lateral
	Inferior process	Medial
C02	Dens	n/a
	Superior process	Lateral
		Medial
	Inferior process	Lateral
		Medial
C03	Superior process	Lateral
		Medial
	Inferior process	Lateral
		Medial
C04	Superior process	Lateral
		Medial
	Inferior process	Lateral
		Medial
C05	Superior process	Lateral
		Medial
	Inferior process	Lateral
		Medial
C06	Superior process	Lateral
		Medial
	Inferior process	Lateral
		Medial
C07	Superior process	Lateral
		Medial

Bone	Joint	Zone[28]
C7	Inferior process	Lateral
		Medial
T01	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
T02	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
T03	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
T04	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
T05	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
T06	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
T07	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
T08	Superior process	Superior
		Inferior

[28] Right and left recorded where applicable.

Bone	Joint	Zone[28]
T8	Inferior process	Superior
		Inferior
T09	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
T10	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
T11	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
T12	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
L01	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
L02	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
L03	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
L04	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
L05	Superior process	Superior
		Inferior
	Inferior process	Superior
		Inferior
Sacrum	Superior process	Superior
Sacrum	Superior process	Inferior

Upper limb

Bone	Joint	Zone[28]
Scapula	Glenoid fossa	Antero-superior
		Antero-inferior
		Postero-superior
		Postero-inferior
Humerus	Head	Antero-superior
		Antero-inferior
		Postero-superior
		Postero-inferior
	Trochlea	Antero-lateral
		Antero-medial
		Postero-lateral
		Postero-medial
	Capitulum	Anterior
		Posterior
Radius	Head	Antero-lateral
		Antero-medial
		Postero-lateral
		Postero-medial
	Articular circumference	Anterior
		Posterior
		Lateral
		Medial
	Distal	Antero-lateral
		Antero-medial
		Postero-lateral
		Postero-medial

Bone	Joint	Zone[28]
Radius	Ulnar notch	n/a
Ulna	Olechranon process	Supero-lateral
		Supero-medial
		Infero-lateral
		Infero-medial
	Olechranon process	
	Coranoid process	Antero-lateral
		Antero-medial
		Postero-lateral
		Postero-medial
	Radial notch	n/a
	Head	Antero-lateral
		Antero-medial
		Postero-lateral
		Postero-medial
	Styloid process	n/a
Scaphoid	Radial facet	n/a
	Lunate facet	n/a
	Trapezium facet	n/a
	Trapezoid facet	n/a
	Capitate facet	n/a
Lunate	Radial facet	n/a
	Scaphoid facet	n/a
	Triquetral facet	n/a
	Capitate facet	n/a
	Hamate facet	n/a
Triquetral	Radial facet	n/a
	Lunate facet	n/a
	Pisiform facet	n/a
	Hamate facet	n/a
Pisiform	Triquetral facet	n/a
Trapezium	Scaphoid facet	n/a

Bone	Joint	Zone[28]
Trapezium	Trapezoid facet	n/a
	MC1 facet	n/a
	MC2 facet	n/a
Trapezoid	Scaphoid facet	n/a
	Trapezium facet	n/a
	Capitate facet	n/a
	MC2 facet	n/a
Capitate	Scaphoid facet	n/a
	Lunate facet	n/a
	Trapezoid facet	n/a
	MC3 facet	n/a
Hamate	Triquetral facet	n/a
	Capitate facet	n/a
	MC4 facet	n/a
	MC5 facet	n/a
MC1	Trapezium facet	n/a
	Head	Palmar
		Dorsal
MC2	Trapezoid facet	n/a
	Trapezium facet	n/a
	MC3 facet	n/a
	Head	Palmar
		Dorsal
MC3	Capitate facet	n/a
	MC2 facet	n/a
	MC4 facet	n/a
	Head	Palmar
		Dorsal
MC4	Capitate facet	n/a
	Hamate facet	n/a
	MC3 facet	n/a
	MC5 facet	n/a
	Head	Palmar
		Dorsal
MC5	Hamate facet	n/a
	MC4 facet	n/a
	Head	Palmar

Bone	Joint	Zone[28]
MC5	Head	Dorsal
Proximal phalange	Proximal	n/a
	Head	n/a
Middle phalange	Proximal	n/a
	Head	n/a
Distal phalange	Proximal	n/a

Lower limb

Bone	Joint	Zone[28]
Os coxa	Acetabulum	Antero-superior
		Antero-inferior
		Postero-superior
		Postero-inferior
Femur	Head	Antero-superior
		Antero-inferior
		Postero-superior
		Postero-inferior
	Patellar surface	Supero-lateral
		Supero-medial
		Infero-lateral
		Infero-medial
	Lateral condyle	Antero-lateral
		Antero-medial
		Postero-lateral
		Postero-medial
	Medial condyle	Antero-lateral
		Antero-medial
		Postero-lateral
		Postero-medial
Patella	Lateral facet	Medial
		Lateral

Bone	Joint	Zone[28]
Patella	Medial facet	Medial
		Lateral
Tibia	Lateral condyle	Antero-lateral
		Antero-medial
		Postero-lateral
		Postero-medial
	Medial condyle	Antero-lateral
		Antero-medial
		Postero-lateral
		Postero-medial
	Fibular facet	n/a
	Distal	Antero-lateral
	Distal	Antero-medial
	Distal	Postero-lateral
	Distal	Postero-medial
	Fibular notch	n/a
Fibula	Tibial facet	Antero-superior
		Antero-inferior
		Postero-superior
		Postero-inferior
	Malleolar fossa	Antero-superior
		Antero-inferior
		Postero-superior
		Postero-inferior
Talus	Trochlear surface	Antero-lateral
		Antero-medial
		Postero-lateral

Bone	Joint	Zone[28]
Talus	Trochlear surface	Postero-medial
	Lateral surface	n/a
	Medial surface	n/a
	Head	Supero-lateral
		Supero-medial
		Infero-lateral
		Infero-medial
	Posterior calcaneal surface	Antero-lateral
		Antero-medial
		Postero-lateral
		Postero-medial
	Medial calcaneal surface	n/a
	Anterior calcaneal surface	n/a
Calcaneus	Posterior talar surface	Antero-lateral
	Posterior talar surface	Antero-medial
	Posterior talar surface	Postero-lateral
	Posterior talar surface	Postero-medial
	medial talar surface	n/a
	Anterior talar surface	n/a
	Cuboid facet	Supero-lateral
	Cuboid facet	Supero-medial
	Cuboid facet	Infero-lateral
	Cuboid facet	Infero-medial
Navicular	Talar facet	Supero-lateral
		Supero-medial
		Infero-lateral
		Infero-medial
	Medial cuneiform facet	n/a
	Intermediate cuneiform facet	n/a
	Lateral cuneiform facet	n/a
Medial	Navicular facet	n/a

Bone	Joint	Zone[28]
cuneiform	Intermediate cuneiform facet	n/a
	MT1 facet	n/a
	MT2 facet	n/a
Intermediate cuneiform	Navicular facet	n/a
	Medial cuneiform facet	n/a
	Lateral cuneiform facet	n/a
	MT2 facet	n/a
Lateral cuneiform	Intermediate cuneiform facet	n/a
	Cuboid facet	n/a
	MT2 facet	n/a
	MT3 facet	n/a
	MT4 facet	n/a
Cuboid	Calcaneal facet	n/a
	Navicular facet	n/a
	Lateral cuneiform facet	n/a
	MT3 facet	n/a
	MT4 facet	n/a
	MT5 facet	n/a
MT1	Medial cuneiform facet	n/a
	Head	Plantar
		Dorsal
MT2	Medial cuneiform facet	n/a
	Intermediate cuneiform facet	n/a
	Lateral cuneiform facet	n/a
	MT3 facet	n/a
	Head	Plantar
		Dorsal
MT3	Lateral cuneiform facet	n/a
	MT2 facet	n/a
	MT4 facet	n/a
	Head	Plantar
		Dorsal
MT4	Lateral cuneiform facet	n/a
	Cuboid facet	n/a
	MT3 facet	n/a

Bone	**Joint**	**Zone**[28]
MT4	MT5 facet	n/a
	Head	Plantar
		Dorsal
MT5	Cuboid facet	n/a
	MT4 facet	n/a
	Head	Plantar
		Dorsal
Proximal phalange	Proximal	n/a
	Head	n/a
Middle phalange	Proximal	n/a
	Head	n/a
Distal phalange	Proximal	n/a

Appendix 2. Preservation – vertebral facet joints

	Kuml (69)		Skeljastaðir (54)		Hofstaðir (54)		Haffjarðarey (22)		Reykjavík (37)	
	No	%	No	%	No	%	No	%	No	%
Cran-C1	36	52.2	44	81.5	49	90.7	15	68.2	32	88.9
Fac-Den	29	42.0	37	68.5	44	81.5	12	54.5	27	75.0
C1-C2	30	43.5	39	72.2	42	77.8	12	54.5	29	80.6
C2-C3	29	42.0	33	61.1	39	72.2	10	45.5	25	69.4
C3-C4	27	39.1	32	59.3	39	72.2	11	50.0	22	61.1
C4-C5	25	36.2	34	63.0	40	74.1	10	45.5	23	63.9
C5-C6	23	33.3	38	70.4	40	74.1	10	45.5	23	63.9
C6-C7	23	33.3	37	68.5	41	75.9	11	50.0	23	63.9
C7-T1	22	31.9	39	72.2	42	77.8	12	54.5	24	66.7
T1-T2	23	33.3	40	74.1	42	77.8	12	54.5	23	63.9
T2-T3	26	37.7	37	68.5	44	81.5	13	59.1	22	61.1
T3-T4	29	42.0	35	64.8	44	81.5	12	54.5	23	63.9
T4-T5	26	37.7	35	64.8	43	79.6	10	45.5	23	63.9
T5-T6	27	39.1	34	63.0	43	79.6	9	40.9	23	63.9
T6-T7	26	37.7	33	61.1	43	79.6	11	50.0	23	63.9
T7-T8	30	43.5	35	64.8	45	83.3	11	50.0	23	63.9
T8-T9	29	42.0	35	64.8	45	83.3	11	50.0	23	63.9
T9-T10	30	43.5	33	61.1	45	83.3	9	40.9	23	63.9
T10-T11	33	47.8	35	64.8	44	81.5	10	45.5	24	66.7
T11-T12	31	33.9	37	68.5	43	79.6	12	54.5	24	66.7
T12-L1	30	43.5	35	64.8	40	74.1	13	59.1	25	69.4
L1-L2	30	43.5	36	66.7	40	74.1	13	59.1	25	69.4
L2-L3	34	49.3	39	72.2	46	85.2	13	59.1	25	69.4
L3-L4	34	49.3	43	79.6	47	87.0	13	59.1	25	69.4
L4-L5	33	47.8	45	83.3	48	88.9	15	68.2	24	66.7
L5-sacr	34	49.3	46	85.2	50	92.6	15	68.2	23	63.9

Appendix 3. Osteoarthritis of the vertebral facet joints

Kuml

	Cranium-C1		C1-C2 (dens)		C1-C2		C2-C3		C3-C4		C4-C5		C5-C6		C6-C7		C7-T1		T1-T2		T2-T3		T3-T4		T4-T5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (15)	0/10	0	0/8	0	0/9	0	0/9	0	0/8	0	0/8	0	0/8	0	0/7	0	0/7	0	0/6	0	0/6	0	0/8	0	0/7	0
35-49 (20)	0/12	0	0/12	0	0/12	0	1/12	8.3	1/12	8.3	1/10	10.0	0/9	0	0/9	0	0/9	0	0/10	0	0/12	0	1/10	10.0	0/9	0
50+ (26)	0/14	0	0/9	0	0/9	0	0/8	0	3/7	42.9	1/7	14.3	0/6	0	0/7	0	1/6	16.7	0/7	0	0/8	0	2/11	18.2	2/10	20.0
Unkn. (8)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (69)	0/36	0	0/29	0	0/30	0	1/29	3.4	4/27	14.8	2/25	8.0	0/23	0	0/23	0	1/22	4.5	0/23	0	0/26	0	3/29	10.3	2/26	7.7

	T5-T6		T6-T7		T7-T8		T8-T9		T9-T10		T10-T11		T11-T12		T12-L1		L1-L2		L2-L3		L3-L4		L4-L5		L5-Sacrum	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (15)	0/8	0	0/8	0	1/8	12.5	0/8	0	0/7	0	0/8	0	0/8	0	0/9	0	0/8	0	0/8	0	0/8	0	0/8	0	0/9	0
35-49 (20)	0/8	0	0/9	0	0/11	0	0/11	0	0/11	0	0/11	0	0/10	0	0/10	0	0/9	0	1/12	8.3	0/12	0	1/11	9.1	0/11	0
50+ (26)	1/11	9.1	3/9	33.3	1/11	9.1	1/10	10.0	0/12	0	0/13	9	0/12	0	0/10	0	0/12	0	0/13	9	1/13	7.7	3/13	23.1	2/14	14.3
Unkn. (8)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/0	0
Total (69)	1/27	3.7	3/26	11.5	2/30	6,7	1/29	3,4	0/30	0	0/33	0	0/31	0	0/30	0	0/30	0	1/34	2,9	1/34	2,9	4/33	12,1	2/34	5,9

Skeljastaðir

	Cranium-C1		C1-C2 (dens)		C1-C2		C2-C3		C3-C4		C4-C5		C5-C6		C6-C7		C7-T1		T1-T2		T2-T3		T3-T4		T4-T5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (11)	0/9	0	0/9	0	0/9	0	0/9	0	0/9	0	0/9	0	0/9	0	0/9	0	1/9	11.1	1/9	11.1	0/8	0	0/8	0	1/8	12.5
35-49 (20)	1/14	7.1	1/11	9,1	1/13	7.7	2/10	20.0	2/9	22.2	1/10	10.0	1/12	8.3	0/11	0	2/12	16.7	2/13	15.4	3/12	25.0	1/10	10.0	2/10	20.0
50+ (22)	2/21	9.5	0/17	0	1/17	5.9	4/14	28.6	4/14	28.6	4/15	26.7	2/17	11.8	0/17	0	5/18	27.8	5/18	27.8	2/17	11.8	3/17	17.6	3/17	17.6
Unkn. (1)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	3/44	6.8	1/37	18.2	2/39	5.1	6/33	18.2	6/32	18.8	5/34	14.7	3/38	7.9	0/37	0	8/39	20.5	8/40	20.0	5/37	13.5	4/35	11.4	6/34	17.1

	T5-T6		T6-T7		T7-T8		T8-T9		T9-T10		T10-T11		T11-T12		T12-L1		L1-L2		L2-L3		L3-L4		L4-L5		L5-Sacrum	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (11)	1/8	12.5	0/8	0	1/8	12.5	0/8	0	0/7	0	1/7	14.3	1/7	14.3	1/8	12.5	0/8	0	0/9	0	0/10	0	0/9	0	0/9	0
35-49 (20)	2/10	20.0	1/8	12.5	1/12	8.3	2/12	16.7	0/11	0	0/11	0	0/13	0	0/11	0	0/11	0	0/10	0	2/13	15.4	1/17	5.9	4/18	22.2
50+ (22)	5/16	31.3	4/17	23.5	3/15	20.0	2/15	13.3	4/15	26.7	2/16	12.5	0/17	0	0/16	0	0/17	0	1/20	5.0	1/20	5.0	3/19	15.8	4/19	21.1
Unkn. (1)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/1	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	8/34	23.5	5/33	15.2	5/35	14.3	4/35	11.4	4/33	12.1	3/35	8.6	1/37	2.7	1/35	2.9	0/36	0	1/39	2.6	3/43	7.0	4/45	8.9	7/46	17.4

Hofstaðir

	ranium-C1		1-C2 (dens)		1-C2		2-C3		3-C4		4-C5		5-C6		6-C7		7-T1		1-T2		2-T3		3-T4		4-T5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/24	0	0/21	0	0/22	0	0/20	0	0/19	0	0/19	0	0/20	0	0/20	0	0/21	0	0/21	0	1/21	4.8	0/21	0	1/22	4.5
35-49 (18)	0/18	0	1/15	6.7	2/16	12.5	4/14	28.6	3/14	21.4	3/14	21.4	3/15	20.0	2/15	13.3	5/15	33.3	1/15	6.7	4/16	25.0	4/16	25.0	3/16	18.8
50+ (28)	0/25	0	8/23	34.8	2/20	10.0	8/19	42.1	11/20	55.0	9/21	42.9	5/20	25.0	6/21	28.6	7/21	33.3	5/21	23.8	8/23	34.8	9/23	39.1	9/21	42.9
Unkn (2)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	0/49	0	9/44	20.5	4/42	9.5	12/39	30.8	14/39	35.9	12/40	30.0	8/40	20.0	8/41	19.5	12/42	28.6	6/42	14.3	13/44	29.5	13/44	29.5	13/43	30.2

	T5-T6		T6-T7		T7-T8		T8-T9		T9-T10		T10-T11		T11-T12		T12-L1		L1-L2		L2-L3		L3-L4		L4-L5		L5-Sacrum	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/22	0	0/22	0	0/23	0	0/23	0	0/23	0	0/22	0	0/21	0	0/19	0	0/19	0	0/23	0	0/22	0	0/23	0	0/24	0
35-49 (18)	4/16	25.0	2/16	12.5	2/17	11.8	1/17	5.9	0/17	0	1/17	5.9	0/17	0	0/15	0	0/15	0	1/17	5.9	3/17	17.6	4/17	23.5	1/18	5.6
50+ (28)	6/21	28.6	4/21	19.0	2/22	9.1	2/22	9.1	3/22	13.6	5/22	22.7	4/22	18.2	4/21	19.0	3/21	14.3	1/23	4.3	4/25	16.0	6/25	24.0	11/26	42.3
Unkn (2)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	10/42	23.3	6/43	14.0	4/45	8.9	3/45	6.7	3/45	6.7	6/44	13.6	4/43	9.3	4/40	10.0	3/40	7.5	2/46	4.3	7/47	14.9	10/48	20.8	12/50	24.0

Haffjarðarey

	Cranium-C1		C1-C2 (dens)		C1-C2		C2-C3		C3-C4		C4-C5		C5-C6		C6-C7		C7-T1		T1-T2		T2-T3		T3-T4		T4-T5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/3	0	0/2	0	1/2	50.0	0/2	0	0/3	0	0/2	0	0/2	0	0/3	0	1/4	25.0	0/4	0	0/4	0	1/4	25.0	0/1	0
35-49 (10)	2/8	25.0	0/7	0	0/7	0	1/5	20.0	2/5	40.0	3/5	60.0	0/5	0	0/5	0	1/5	20.0	0/5	0	1/6	16.7	1/5	20.0	2/6	33.3
50+ (4)	1/4	25.0	1/3	33,3	1/3	66.7	2/3	66.7	1/3	33.3	1/3	33.3	1/3	33.3	1/3	33.3	1/3	33.3	1/3	33.3	0/3	0	1/3	33.3	1/3	33.3
Unkn. (2)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (22)	3/15	20.0	1/12	8.3	3/12	25.0	3/10	30.0	3/11	27.3	4/10	40.0	1/10	10.0	1/11	9,1	3/12	25.0	1/12	8.3	1/13	7.7	3/12	25.0	3/10	30.0

	5-T6		6-T7		7-T8		8-T9		9-T10		10-T11		11-T12		12-L1		1-L2		2-L3		3-L4		4-L5		5-Sacrum	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/0	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/2	0	0/3	0	0/2	0	0/2	0	0/4	0	0/4	0	0/4	0
35-49 (18)	3/6	50.0	0/7	0	0/7	0	0/7	0	0/5	0	1/6	16.7	0/7	0	0/7	0	0/8	0	2/8	25.0	2/6	33.3	1/8	12.5	1/8	12.5
50+ (28)	1/3	33.3	0/3	0	0/3	0	0/3	0	1/3	33.3	0/3	0	2/3	66.7	0/3	0	0/3	0	0/3	0	2/3	66.7	1/3	33.3	1/3	33.3
Unkn (2)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	4/9	44.4	0/11	0	0/11	0	0/11	0	1/9	11.1	1/10	10.0	2/12	16.7	0/13	0	0/13	0	2/13	15.4	4/13	30.8	2/15	13.3	2/15	13.3

Reykjavík

	Cranium-C1		C1-C2 (dens)		C1-C2		C2-C3		C3-C4		C4-C5		C5-C6		C6-C7		C7-T1		T1-T2		T2-T3		T3-T4		T4-T5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (7)	0/7	0	0/6	0	0/7	0	1/7	14.3	1/6	16.7	1/6	16.7	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	1/6	16.7	0/6	0
35-49 (16)	1/15	6.7	0/14	0	2/15	13.3	2/14	14.3	2/12	16.7	1/13	7.7	1/12	8.3	0/12	0	1/12	8.3	0/12	0	1/11	9.1	1/11	9.1	1/11	9.1
50+ (8)	0/8	0	3/7	42.9	3/7	42.9	0/4	0	3/4	75.0	3/4	75.0	0/5	0	0/5	0	1/6	16.7	1/5	20	0/5	0	1/6	16.7	2/6	33.3
Unkn. (6)	0/2	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (37)	1/32	3.1	3/27	11.1	5/29	17.2	3/25	12.0	6/22	27.3	5/23	21.7	1/23	4.3	0/23	0	2/24	8.3	1/23	4.3	1/22	4.5	3/23	13.0	3/23	13.0

	T5-T6		T6-T7		T7-T8		T8-T9		T9-T10		T10-T11		T11-T12		T12-L1		L1-L2		L2-L3		L3-L4		L4-L5		L5-Sacrum	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (7)	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0
35-49 (16)	1/11	9.1	1/11	9,1	0/11	0	1/11	9.1	0/11	0	0/11	9	0/11	0	0/12	0	0/12	0	0/12	0	0/13	0	0/13	0	0/12	0
50+ (8)	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	1/5	20.0	2/5	40.0
Unkn. (6)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/0	0	0/0	0	0/0	0
Total (37)	1/23	4.3	1/23	4.3	0/23	0	1/23	4.3	0/23	0	0/24	0	0/24	0	0/25	0	0/25	0	0/25	0	0/25	0	1/24	4.2	2/23	8.7

Appendix 4. Individuals with vertebral facet osteoarthritis

Kuml

Skeleton	Sex	Age	Cervical OA	Thoracic OA	Lumbar OA
BBE-A-001	Male	50+	X	✓	X
DAV-A-005	Male	50+	X	✓	X
DAV-A-006	Female	50+	0	0	✓
GTE-A-002	Male	18-34	X	✓	X
HBS-A-004	Male	50+	✓	X	X
KNS-A-001	?	35-49	X	✓	X
MEH-A-001	Female	50+	0	✓	X
ORE-A-001	Male	50+	✓	✓	✓
SYK-A-001	Male	50+	X	✓	✓
VDS-B-001	Male	50+	✓	✓	✓
ÞHS-A-001	Female	35-49	✓	X	✓

✓ = OA; X = no OA; 0 = no element preserved

Skeljastaðir

Skeleton	Sex	Age	Cervical OA	Thoracic OA	Lumbar OA
ÞSK-A-002	Female	50+	X	✓	✓
ÞSK-A-007	Male	50+	X	✓	X
ÞSK-A-009	Female	50+	X	✓	✓
ÞSK-A-011	Female	50+	X	0	✓
ÞSK-A-012	Female	35-49	X	0	✓
ÞSK-A-017	Female	35-49	X	X	✓
ÞSK-A-018a	Female	35-49	✓	X	X
ÞSK-A-018b	Female	50+	X	✓	✓
ÞSK-A-019	Female	35-49	X	✓	✓
ÞSK-A-020	Female	35-49	0	X	✓
ÞSK-A-025	Female	50+	✓	✓	✓
ÞSK-A-026	Male	35-49	X	✓	X
ÞSK-A-029	Male	50+	✓	✓	X
ÞSK-A-030	Male	35-49	✓	X	✓
ÞSK-A-036	Male	50+	✓	✓	✓
ÞSK-A-037	Male	50+	✓	✓	X
ÞSK-A-039	Female	18-34	✓	✓	X
ÞSK-A-040	Male	50+	✓	✓	X
ÞSK-A-043	Male	35-49	X	X	✓
ÞSK-A-045	Male	50+	✓	✓	X
ÞSK-A-051	Female	35-49	X	✓	X
ÞSK-A-052	Male	50+	✓	✓	X
ÞSK-A-053	Male	35-49	✓	0	X
ÞSK-A-055	Male	35-49	✓	✓	✓
ÞSK-A-056	Female	35-49	✓	X	X
ÞSK-A-058	Male	35-49	0	✓	X
ÞSK-A-060	Male	35-49	✓	✓	x

Hofstaðir

Skeleton	Sex	Age	Cervical OA	Thoracic OA	Lumbar OA
HSM-A-001	Female	50+	X	X	✓
HSM-A-002	Female	50+	✓	✓	X
HSM-A-003	Female	50+	✓	X	✓
HSM-A-004	Female	35-49	✓	✓	X
HSM-A-008	Male	50+	X	X	✓
HSM-A-011	Female	35-49	✓	X	✓
HSM-A-014	Female	50+	✓	X	✓
HSM-A-015	Female	50+	✓	✓	✓
HSM-A-018	Male	50+	✓	0	X
HSM-A-020	Male	50+	✓	✓	✓
HSM-A-021	Female	50+	✓	✓	✓
HSM-A-022	Male	50+	✓	✓	X
HSM-A-023	Female	50+	✓	✓	✓
HSM-A-025	Male	50+	✓	✓	X
HSM-A-027	Female	35-49	X	✓	✓
HSM-A-033	Male	50+	✓	✓	X
HSM-A-038	Male	50+	✓	✓	✓
HSM-A-039	Male	35-49	✓	✓	✓
HSM-A-048	Male	50+	X	✓	X
HSM-A-051	Male	35-49	X	✓	X
HSM-A-052	Female	50+	✓	✓	✓
HSM-A-053	Male	35-49	✓	X	✓
HSM-A-054	Male	35-49	✓	✓	✓
HSM-A-056	Female	35-49	✓	✓	✓
HSM-A-057	Male	50+	✓	✓	✓
HSM-A-065	Male	18-34	X	✓	X
HSM-A-075	Female	50+	✓	✓	✓
HSM-A-076	Male	50+	✓	✓	X
HSM-A-087	Male	50+	✓	✓	✓
HSM-A-104	Male	35-49	✓	✓	X
HSM-A-108	Male	35-49	✓	✓	X
HSM-A-114	Female	50+	X	✓	✓

✓ = OA; X = no OA; 0 = no element preserved

Haffjarðarey

Skeleton	Sex	Age	Cervical OA	Thoracic OA	Lumbar OA
HFE-A-006	Female	18-34	✓	✓	X
HFE-A-008	Female	35-49	0	✓	✓
HFE-A-011	Male	35-49	✓	✓	X
HFE-A-013	Female	35-49	0	X	✓
HFE-A-014e	Male	35-49	X	✓	X
HFE-A-014f	Female	35-49	✓	X	X
HFE-A-014g	Female	18-34	✓	X	X
HFE-A-015	Female	50+	✓	✓	✓
HFE-A-016	Female	35-49	X	✓	✓
HFE-A-018	Male	50+	✓	✓	✓
HFE-A-020	Female	50+	✓	✓	✓
HFE-A-022	Male	35-49	✓	X	X

✓ = OA; X = no OA; 0 = no element preserved

Reykjavík

Skeleton	Sex	Age	Cervical OA	Thoracic OA	Lumbar OA
RVK-A-001	Female	35-49	X	✓	X
RVK-A-002	Male	35-49	X	✓	✓
RVK-A-003	Male	35-49	✓	X	✓
RVK-A-004	Male	18-34	✓	X	X
RVK-C-003	Female	35-49	✓	X	X
RVK-C-004	Male	35-49	X	✓	X
VEY-A-003	Male	50+	✓	✓	X
VEY-A-004	Female	50+	✓	X	✓
VEY-A-005	Female	18-34	✓	X	X
VEY-A-007	Female	50+	✓	✓	✓
VEY-A-014	Female	50+	✓	✓	X
VEY-A-020	Female	18-34	X	✓	X
VEY-A-021	Female	35-49	✓	✓	X
VEY-A-026	Male	35-49	✓	✓	X
VEY-A-028	Male	35-49	✓	X	X
VEY-A-029	Male	50+	✓	X	X

✓ = OA; X = no OA; 0 = no element preserved

Appendix 5. Osteoarthritis of the hands

Kuml

	rad-uln		rad-scap		rad-lun		rad-triq		scap-lun		scap-trzium		scap-trzoid		scap-cap		lun-triq		lun-cap		lun-ham	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (15)	1/8	12.5	0/9	0	0/10	0	0/4	0	0/7	0	0/7	0	0/7	0	1/7	14.3	0/6	0	0/7	0	0/6	0
35-49 (20)	0/17	0	0/17	0	0/17	0	0/4	0	0/7	0	0/7	0	0/7	0	0/9	0	0/5	0	0/10	0	0/4	0
50+ (26)	0/17	0	0/15	0	0/17	0	0/5	0	0/9	0	0/10	0	0/10	0	0/10	0	0/7	0	0/6	0	0/5	0
Unkn. (8)	0/1	0	0/1	0	0/2	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (69)	1/43	2.3	0/42	0	1/46	0	0/13	0	0/23	0	0/24	0	0/24	0	1/26	3.8	0/18	0	0/23	0	0/15	0

	triq-pis		triq-ham		trzium-trzoid		trzoid-cap		cap-ham		CMC1		CMC2		CMC3		CMC4		CMC5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (15)	0/5	0	1/7	14.3	0/8	0	0/8	0	0/6	0	1/5	11.1	1/9	11.1	0/6	0	0/7	0	0/7	0
35-49 (20)	0/4	0	0/6	0	0/7	0	0/9	0	0/5	0	0/12	0	0/11	0	0/9	0	0/9	0	0/7	0
50+ (26)	0/7	0	0/5	0	0/5	0	0/7	0	0/5	0	0/9	0	0/12	0	0/9	0	0/7	0	0/5	0
Unkn. (8)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/1	0	0/0	0	0/0	0
Total (69)	0/16	0	1/18	5.6	0/20	0	1/24	4.2	0/16	0	1/26	3.8	1/32	3.8	0/25	0	0/23	0	0/19	0

	MC2-3		MC3-4		MC4-5		MCP1		MCP2		MCP3		MCP4		MCP5		PIP		DIP	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (15)	0/8	0	0/6	0	1/7	14.3	1/6	16.7	0/6	0	0/5	0	0/5	0	0/5	0	0/7	0	0/5	0
35-49 (20)	0/11	0	0/8	0	0/7	0	0/9	0	0/7	0	0/8	0	0/7	0	0/5	0	0/10	0	0/5	0
50+ (26)	0/10	0	0/8	0	0/8	0	1/10	10.0	0/8	0	0/8	0	0/7	0	0/5	0	0/11	0	0/7	0
Unkn. (8)	0/2	0	0/0	0	0/0	0	0/0	0	0/0	0	0/1	0	0/0	0	0/0	0	0/1	0	0/1	0
Total (69)	0/31	0	0/22	0	1/22	4.5	2/25	8.0	0/21	0	0/22	0	0/19	0	0/15	0	0/29	0	0/18	0

Skeljastaðir

	rad-uln		rad-scap		rad-lun		rad-triq		scap-lun		scap-trzium		scap-trzoid		scap-cap		lun-triq		lun-cap		lun-ham	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (11)	0/11	0	0/11	0	0/11	0	0/9	0	0/11	0	0/9	0	0/9	0	0/9	0	0/11	0	0/10	0	0/10	0
35-49 (20)	0/17	0	0/15	0	0/16	0	0/4	0	0/12	0	0/9	0	0/19	0	0/12	0	0/9	0	0/11	0	0/7	0
50+ (22)	1/21	4.8	1/19	5.3	1/21	4.8	0/9	0	0/16	0	1/13	7.7	0/13	0	2/17	11.8	0/14	0	1/18	5.6	0/14	0
Unkn. (1)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	1/49	2.0	1/45	2.0	1/48	2.0	0/22	0	0/39	0	1/31	3.2	0/32	0	2/38	5.3	0/34	0	1/39	2.6	0/31	0

	triq-pis		triq-ham		trzium-trzoid		trzoid-cap		cap-ham		CMC1		CMC2		CMC3		CMC4		CMC5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (11)	0/8	0	0/9	0	0/9	0	0/8	0	0/9	0	0/9	0	0/9	0	0/10	0	0/9	0	0/10	0
35-49 (20)	0/5	0	1/6	16.7	0/7	0	0/9	0	0/6	0	0/11	0	0/14	0	0/13	0	0/9	0	0/10	0
50+ (22)	0/10	0	0/14	0	0/12	0	0/16	0	0/13	0	0/16	0	0/19	0	0/19	0	0/15	0	0/17	0
Unkn. (1)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/1	0	0/0	0	0/0	0
Total (54)	0/23	0	1/29	3.4	0/28	0	0/33	0	0/28	0	0/36	0	0/42	0	0/43	0	0/33	0	0/37	0

	MC2-3		MC3-4		MC4-5		MCP1		MCP2		MCP3		MCP4		MCP5		PIP		DIP	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (11)	0/10	0	0/10	0	0/10	0	0/10	0	0/10	0	0/10	0	0/9	0	0/10	0	0/9	0	0/8	0
35-49 (20)	0/14	0	0/12	0	0/11	0	1/8	12.5	0/9	0	1/13	7.7	0/12	0	0/8	0	7/11	9.1	1/7	14.3
50+ (22)	1/20	5.0	0/17	0	0/13	0	2/17	11.8	1/18	5.6	1/20	5.0	1/13	7.7	0/10	0	2/18	11.1	0/13	0
Unkn. (1)	0/1	0	0/1	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	1/45	2.2	0/40	0	0/34	0	3/35	8.6	1/37	2.7	2/43	4.7	1/34	2.9	0/28	0	3/38	7.9	1/28	3.6

Hofstaðir

	rad-uln		rad-scap		rad-lun		rad-triq		scap-lun		scap-trzium		scap-trzoid		scap-cap		lun-triq		lun-cap		lun-ham	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/5	0	0/6	0	0/5	0	0/3	0	0/5	0	0/5	0	0/5	0	0/6	0	0/4	0	0/6	0	0/3	0
35-49 (18)	1/16	6.3	0/17	0	0/17	0	0/12	0	0/16	0	0/17	0	0/16	0	0/16	0	0/16	0	0/16	0	0/16	0
50+ (28)	6/24	25.0	3/25	12.0	2/26	7.7	2/19	10.5	2/23	8.7	6/24	25.0	3/22	13.6	2/23	8.7	2/23	8.7	1/23	4.3	0/23	0
Unkn (2)	0/1	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	7/46	15.2	3/48	6.3	2/48	4.2	2/34	5.9	2/44	4.5	6/46	13.0	3/43	7.0	2/45	4.4	2/43	4.7	1/45	2.2	0/42	0

	triq-pis		triq-ham		trzium-trzoid		trzoid-cap		cap-ham		CMC1		CMC2		CMC3		CMC4		CMC5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/3	0	0/3	0	0/5	0	0/6	0	0/3	0	0/6	0	0/6	0	0/6	0	0/4	0	0/4	0
35-49 (18)	0/15	0	0/15	0	0/17	0	0/16	0	0/15	0	1/17	5.9	0/17	0	0/16	0	0/16	0	0/16	0
50+ (28)	4/21	19.0	2/22	9.1	3/24	12.5	4/23	17.4	1/21	4.8	4/24	16.7	2/24	8.3	0/23	0	0/22	0	0/22	0
Unkn (2)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	4/39	10.3	2/40	5.0	3/46	6.5	4/45	8.9	1/39	2.6	5/47	10.6	2/47	4.3	0/45	0	0/42	0	0/42	0

	MC2-3		MC3-4		MC4-5		MCP1		MCP2		MCP3		MCP4		MCP5		PIP		DIP	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/6	0	0/4	0	0/4	0	0/6	0	0/5	0	0/6	0	0/5	0	0/4	0	0/6	0	0/5	0
35-49 (18)	0/16	0	0/17	0	0/17	0	0/16	0	1/16	6.3	0/16	0	0/61	0	0/17	0	0/17	0	0/15	0
50+ (28)	0/22	0	1/22	9.5	0/22	0	2/21	9,5	2/22	9.1	4/22	18.2	2/20	10.0	2/15	13.3	3/22	13.6	3/18	16.7
Unkn (2)	0/1	0	0/0	0	0/0	0	0/1	0	0/1	0	0/1	0	0/0	0	0/0	0	0/1	0	0/0	0
Total (54)	0/45	0	1/43	2.3	0/43	0	2/44	4.5	3/44	6.8	4/45	8.9	2/41	4.9	2/36	5.6	3/46	6.5	3/38	7.9

Haffjarðarey

	rad-uln		rad-scap		rad-lun		rad-triq		scap-lun		scap-trzium		scap-trzoid		scap-cap		lun-triq		lun-cap		lun-ham	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/3	0	0/3	0	0/3	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
35-49 (18)	3/9	33.3	0/7	0	1/8	12.5	2/6	33.3	0/5	0	1/5	20.0	1/5	20.0	0/5	0	0/6	0	0/5	0	0/5	0
50+ (28)	2/3	66.7	1/3	33.3	0/3	0	0/3	0	1/3	33.3	1/3	33.3	1/3	33.3	2/3	66.7	1/3	33.3	1/3	33.3	0/3	0
Unkn (2)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	5/15	33.3	1/13	7.7	1/14	7.7	2/9	22.2	1/8	12.5	2/8	25.0	2/8	25.0	2/8	25.0	1/9	11.1	1/8	12.5	0/8	0

	triq-pis		triq-ham		trzium-trzoid		trzoid-cap		cap-ham		CMC1		CMC2		CMC3		CMC4		CMC5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/1	0	0/0	0	0/1	0	0/0	0	0/0	0
35-49 (18)	0/6	0	0/6	0	0/5	0	0/5	0	0/5	0	0/6	0	0/5	0	0/5	0	0/5	0	0/5	0
50+ (28)	0/3	0	0/3	0	0/3	0	0/3	0	0/3	0	2/3	66.7	0/3	0	0/3	0	0/3	0	1/3	33.3
Unkn (2)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	0/9	0	0/9	0	0/8	0	0/8	0	0/8	0	2/10	20.0	0/8	0	0/9	0	0/8	0	1/8	12.5

	MC2-3		MC3-4		MC4-5		MCP1		MCP2		MCP3		MCP4		MCP5		PIP		DIP	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/1	0	0/1	0	0/0	0	0/1	0	0/0	0	0/1	0	0/0	0	0/0	0	0/0	0	0/0	0
35-49 (18)	0/5	0	0/5	0	0/5	0	1/6	16.7	1/5	20.0	0/5	0	0/5	0	0/5	0	0/6	0	0/6	0
50+ (28)	1/3	33.3	0/3	0	1/3	33.3	1/3	33.3	1/3	33.3	1/3	33.3	0/3	0	0/3	0	0/3	0	0/3	0
Unkn (2)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (54)	1/9	11.1	0/9	0	1/8	12.5	2/10	20.0	2/8	25.0	1/9	11.1	0/8	0	0/8	0	0/9	0	0/9	0

Reykjavík

	rad-uln		rad-scap		rad-lun		rad-triq		scap-lun		scap-trzium		scap-trzoid		scap-cap		lun-triq		lun-cap		lun-ham	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (7)	0/6	0	0/6	0	0/6	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0
35-49 (16)	1/12	8.3	0/12	0	0/12	0	0/10	0	0/11	0	0/11	0	0/11	0	0/11	0	0/11	0	0/11	0	0/11	0
50+ (8)	0/6	0	0/7	0	1/7	14.3	0/5	0	0/6	0	1/5	20.0	1/5	20.0	1/6	16.7	0/6	0	1/7	14.3	0/6	0
Unkn. (6)	0/0	0	0/2	0	0/1	0	0/0	0	0/1	0	0/1	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0
Total (37)	1/24	4.2	0/27	0	1/26	3.8	0/20	0	0/23	0	1/22	4.5	1/21	4.8	1/22	4.5	0/22	0	1/23	4.3	0/22	0

	triq-pis		triq-ham		trzium-trzoid		trzoid-cap		cap-ham		CMC1		CMC2		CMC3		CMC4		CMC5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (7)	0/5	0	0/6	0	0/5	0	0/5	0	0/6	0	0/5	0	0/5	0	0/5	0	0/6	0	0/6	0
35-49 (16)	0/10	0	0/11	0	0/10	0	0/11	0	0/10	0	0/11	0	0/11	0	0/13	0	0/12	0	0/12	0
50+ (8)	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	1/7	14.3	1/5	20.0	0/6	0	0/5	0	1/5	20.0
Unkn. (6)	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/0	0	0/1	0	0/0	0	0/0	0
Total (37)	0/20	0	0/22	0	0/20	0	0/21	0	0/21	0	1/23	4.3	1/21	4.3	0/25	0	0/23	0	1/23	4.3

	MC2-3		MC3-4		MC4-5		MCP1		MCP2		MCP3		MCP4		MCP5		PIP		DIP	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (7)	0/5	0	0/5	0	0/6	0	1/4	25.0	0/5	0	0/5	0	0/5	0	0/6	0	0/5	0	0/5	0
35-49 (16)	0/12	0	0/13	0	0/12	0	0/10	0	2/12	16.7	1/12	8.3	0/13	0	0/12	0	0/12	0	0/11	0
50+ (8)	0/6	0	0/6	0	0/5	0	1/5	20.0	1/5	20.0	2/7	28.6	1/6	16.7	0/6	0	0/6	0	7/5	20.0
Unkn. (6)	0/1	0	0/0	0	0/0	0	0/0	0	0/0	0	0/1	0	0/0	0	0/0	0	0/1	0	0/0	0
Total (37)	0/24	0	0/24	0	0/23	0	2/19	10.5	3/22	13.6	3/25	12.0	1/24	4.2	0/24	0	0/24	0	1/24	4.8

Appendix 6. Osteoarthritis of the feet

Kuml

	tib-fib		tib-tal (ant)		tib-tal (post)		tib-tal (med)		fib-tal		tal-cal (ant)		tal-cal (post)		tal-cal (med)		tal-cal (ant)		tal-nav		cal-cub	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (15)	0/8	0	0/10	0	0/9	0	0/7	0	0/8	0	0/9	0	0/8	0	0/8	0	0/9	0	0/7	0	0/8	0
35-49 (20)	0/12	0	0/17	0	0/17	0	0/12	0	0/12	0	0/14	0	0/13	0	0/14	0	0/12	0	0/13	0	0/9	0
50+ (26)	1/18	5.6	0/20	0	0/20	0	0/9	0	0/18	0	0/20	0	0/20	0	0/17	0	0/16	0	0/15	0	0/14	0
Unkn. (8)	0/4	0	0/3	0	0/3	0	0/3	0	0/5	0	0/4	0	0/4	0	0/3	0	0/3	0	0/3	0	0/4	0
Total (69)	1/42	2.4	0/50	0	0/49	0	0/31	0	0/43	0	0/47	0	0/45	0	0/42	0	0/40	0	0/38	0	0/35	0

	nav-m.cun		nav-i.cun		nav-l.cun		nav-cub		m.cun-i.cun		i.cun-l.cun		l.cun-cub		TMT1		TMT2		TMT3		TMT4		TMT5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (15)	0/5	0	0/6	0	0/6	0	0/5	0	0/6	0	0/6	0	0/7	0	0/6	0	0/6	0	0/6	0	0/6	0	0/4	0
35-49 (20)	0/9	0	0/9	0	0/7	0	0/7	0	0/7	0	0/7	0	0/8	0	0/11	0	0/8	0	0/8	0	0/9	0	0/8	0
50+ (26)	0/12	0	0/12	0	0/11	0	0/5	0	0/10	0	0/8	0	0/9	0	0/13	0	0/12	0	0/12	0	0/11	0	0/10	0
Unkn. (8)	0/3	0	0/3	0	0/3	0	0/3	0	0/3	0	0/3	0	0/3	0	0/3	0	0/3	0	0/3	0	0/3	0	0/3	0
Total (69)	0/29	0	0/30	0	0/27	0	0/20	0	0/26	0	0/24	0	0/27	0	0/33	0	0/29	0	0/29	0	0/29	0	0/25	0

	MT2-3		MT3-4		MT4-5		MTP1		MTP2		MTP3		MTP4		MTP5		PIP		DIP	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (15)	0/6	0	0/5	0	0/4	0	0/6	0	0/5	0	0/6	0	0/3	0	0/4	0	0/4	0	0/2	0
35-49 (20)	0/8	0	0/8	0	0/9	0	0/10	0	0/6	0	0/5	0	0/4	0	0/5	0	0/6	0	0/1	0
50+ (26)	0/10	0	0/9	0	0/13	0	0/10	0	0/9	0	0/8	0	0/4	0	0/1	0	0/4	0	0/4	0
Unkn. (8)	0/3	0	0/3	0	0/3	0	0/3	0	0/3	0	0/2	0	9/2	0	0/1	0	0/2	0	0/1	0
Total (69)	0/27	0	0/25	0	0/29	0	0/29	0	0/23	0	0/21	0	0/13	0	0/11	0	0/16	0	0/8	0

Skeljastaðir

	tib-fib		tib-tal (ant)		tib-tal (post)		tib-tal (med)		fib-tal		tal-cal (ant)		tal-cal (post)		tal-cal (med)		tal-cal (ant)		tal-nav		cal-cub	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (11)	0/11	0	0/11	0	0/11	0	0/9	0	0/11	0	0/11	0	0/11	0	0/11	0	0/11	0	0/11	0	0/11	0
35-49 (20)	0/15	0	0/18	0	0/19	0	0/16	0	0/17	0	0/19	0	0/18	0	0/16	0	0/16	0	0/17	0	0/15	0
50+ (22)	0/17	0	0/19	0	0/19	0	0/18	0	0/19	0	0/20	0	0/20	0	0/19	0	0/18	0	1/18	5.6	0/19	0
Unkn. (1)	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0
Total (54)	0/44	0	0/49	0	0/50	0	0/44	0	0/48	0	0/51	0	0/50	0	0/47	0	0/46	0	1/47	2.1	0/46	0

	nav-m.cun		nav-i.cun		nav-l.cun		nav-cub		m.cun-i.cun		i.cun-l.cun		l.cun-cub		TMT1		TMT2		TMT3		TMT4		TMT5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (11)	0/9	0	0/10	0	0/10	0	0/10	0	0/10	0	0/11	0	0/11	0	0/10	0	0/9	0	0/11	0	0/11	0	0/10	0
35-49 (20)	0/11	0	0/14	0	0/12	0	0/9	0	0/12	0	0/11	0	0/10	0	0/12	0	0/16	0	0/14	0	0/16	0	0/11	0
50+ (22)	0/15	0	0/14	0	0/14	0	0/16	0	0/13	0	0/14	0	0/17	0	0/15	0	0/17	0	0/19	0	0/18	0	0/19	0
Unkn. (1)	0/1	0	0/1	0	0/1	0	0/0	0	0/1	0	0/0	0	0/0	0	0/1	0	0/1	0	0/0	0	0/0	0	0/0	0
Total (54)	0/36	0	0/39	0	0/37	0	0/35	0	0/36	0	0/36	0	0/38	0	0/38	0	0/43	0	0/44	0	0/45	0	0/40	0

	MT2-3		MT3-4		MT4-5		MTP1		MTP2		MTP3		MTP4		MTP5		PIP		DIP	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (11)	0/10	0	0/10	0	0/11	0	0/7	0	0/6	0	0/5	0	0/3	0	0/4	0	0/6	0	0/2	0
35-49 (20)	0/17	0	0/16	0	0/14	0	1/12	8.3	0/9	0	0/7	0	0/6	0	0/5	0	0/5	0	0/2	0
50+ (22)	0/20	0	0/20	0	0/19	0	0/15	0	0/13	0	0/14	0	0/11	0	0/9	0	0/8	0	0/3	0
Unkn. (1)	0/1	0	0/0	0	0/0	0	0/1	0	0/0	0	0/1	0	0/1	0	0/0	0	0/0	0	0/0	0
Total (54)	0/48	0	0/46	0	0/44	0	1/35	2.9	0/28	0	0/27	0	0/21	0	0/18	0	0/19	0	0/7	0

Hofstaðir

	tib-fib		tib-tal (ant)		tib-tal (post)		tib-tal (med)		fib-tal		tal-cal (ant)		tal-cal (post)		tal-cal (med)		tal-cal (ant)		tal-nav		cal-cub	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/5	0	0/6	0	0/6	0	0/5	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0
35-49 (18)	0/18	0	0/18	0	0/18	0	0/17	0	0/18	0	1/18	5.6	0/18	0	1/18	5.6	1/18	5.6	1/18	5.6	0/18	0
50+ (28)	1/24	4.2	0/25	0	1/25	4.0	1/25	4.0	0/25	0	0/26	0	0/25	0	0/26	0	0/26	0	1/25	4.0	1/23	4.3
Unkn (2)	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0
Total (54)	1/49	2.0	0/51	0	1/51	2.0	1/49	2.0	0/51	0	1/52	1.9	0/51	0	1/52	1.9	1/52	1.9	2/51	3.9	1/49	2.0

	nav-m.cun		nav-i.cun		nav-l.cun		nav-cub		m.cun-i.cun		i.cun-l.cun		l.cun-cub		TMT1		TMT2		TMT3		TMT4		TMT5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0	0/6	0
35-49 (18)	0/18	0	0/18	0	0/18	0	0/18	0	0/18	0	0/18	0	0/18	0	0/18	0	0/18	0	0/18	0	0/18	0	0/16	0
50+ (28)	0/24	0	1/24	4.2	1/23	4.3	0/23	0	0/24	0	1/23	4.3	0/23	0	0/24	0	0/24	0	0/23	0	0/24	0	1/23	4.3
Unkn (2)	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0
Total (54)	0/50	0	1/50	2.0	1/49	2.0	0/49	0	0/50	0	1/49	2.0	0/49	0	0/50	0	0/50	0	0/49	0	0/50	0	1/47	2.1

	MT2-3		MT3-4		MT4-5		MTP1		MTP2		MTP3		MTP4		MTP5		PIP		DIP	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/6	0	0/6	0	0/6	0	0/5	0	0/5	0	0/5	0	0/3	0	0/3	0	0/5	0	0/4	0
35-49 (18)	0/18	0	0/18	0	0/17	0	2/17	11.8	0/13	0	0/13	0	0/11	0	0/11	0	1/14	7.1	0/11	0
50+ (28)	1/24	4.2	0/23	0	0/23	0	5/23	21.7	0/21	0	0/19	0	0/16	0	0/16	0	1/20	5.0	1/16	6.3
Unkn (2)	0/2	0	0/2	0	0/2	0	1/2	50.0	0/2	0	0/2	0	0/2	0	0/1	0	0/2	0	0/2	0
Total (54)	1/50	2.0	0/49	0	0/48	0	8/47	17.0	0/41	0	0/39	0	0/32	0	0/31	0	2/41	4.9	1/33	3.0

Haffjarðarey

	tib-fib		tib-tal (ant)		tib-tal (post)		tib-tal (med)		fib-tal		tal-cal (ant)		tal-cal (post)		tal-cal (med)		tal-cal (ant)		tal-nav		cal-cub	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/4	0	0/4	0	0/4	0	0/3	0	0/4	0	0/4	0	0/4	0	0/4	0	0/4	0	0/3	0	0/3	0
35-49 (18)	0/9	0	2/9	22.2	0/9	0	1/9	11.1	0/9	0	1/9	11.1	0/9	0	1/9	11.1	1/9	11.1	2/9	22.2	0/9	0
50+ (28)	0/3	0	1/3	33.3	1/3	33.3	1/2	50.0	0/3	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0
Unkn (2)	0/1	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0
Total (54)	0/17	0	3/18	16.7	1/18	5.6	2/16	12.5	0/18	0	1/17	5.9	0/17	0	1/17	5.9	1/17	5.9	2/16	12.5	0/16	0

	nav-m.cun		nav-i.cun		nav-l.cun		nav-cub		m.cun-i.cun		i.cun-l.cun		l.cun-cub		TMT1		TMT2		TMT3		TMT4		TMT5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0
35-49 (18)	0/8	0	0/8	0	0/8	0	0/8	0	0/8	0	0/7	0	0/8	0	0/8	0	1/7	14.3	0/7	0	0/8	0	1/7	12.5
50+ (28)	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	1/2	50.0	1/2	50.0	0/2	0	0/2	0
Unkn (2)	0/1	0	0/1	0	0/1	0	0/2	0	0/1	0	0/1	0	0/2	0	0/2	0	0/1	0	0/2	0	0/2	0	½	50.0
Total (54)	0/13	0	0/13	0	0/13	0	0/14	0	0/13	0	0/12	0	0/14	0	0/14	0	2/12	16.7	1/13	7.7	0/14	0	2/14	7.7

	MT2-3		MT3-4		MT4-5		MTP1		MTP2		MTP3		MTP4		MTP5		PIP		DIP	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (6)	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0
35-49 (18)	0/7	0	1/7	14.3	0/7	0	2/7	28.6	0/7	0	0/7	0	0/7	0	0/7	0	0/7	0	0/7	0
50+ (28)	0/2	0	0/2	0	0/2	0	0/2	0	1/2	50.0	0/2	0	0/2	0	0/2	0	0/2	0	0/2	0
Unkn (2)	0/2	0	0/2	0	0/2	0	0/2	0	0/1	0	0/2	0	0/2	0	0/1	0	0/2	0	0/2	0
Total (54)	0/13	0	1/13	7.7	0/13	0	2/13	15.4	1/12	8.3	0/13	0	0/13	0	0/12	0	0/13	0/13		0

Reykjavík

	tib-fib		tib-tal (ant)		tib-tal (post)		tib-tal (med)		fib-tal		tal-cal (ant)		tal-cal (post)		tal-cal (med)		tal-cal (ant)		tal-nav		cal-cub	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (7)	0/6	0	0/6	0	0/6	0	0/5	0	0/6	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0
35-49 (16)	0/13	0	0/14	0	0/15	0	0/12	0	0/13	0	1/13	7.7	1/13	7.7	0/13	0	0/13	0	1/13	7.7	0/13	0
50+ (8)	1/7	14.3	1/8	12.5	0/8	0	0/5	0	0/8	0	1/6	16.7	1/6	16.7	1/6	16.7	1/6	16.7	1/6	20.0	1/5	20.0
Unkn. (6)	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/2	0	0/2	0	0/2	0	0/1	0	0/1	0	0/2	0
Total (37)	1/27	3.7	1/29	3.4	0/30	0	0/23	0	0/28	0	2/26	7.7	2/26	7.7	1/26	3.8	1/25	4.0	2/25	8.0	1/25	4.0

	nav-m.cun		nav-i.cun		nav-l.cun		nav-cub		m.cun-i.cun		i.cun-l.cun		l.cun-cub		TMT1		TMT2		TMT3		TMT4		TMT5	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (7)	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0
35-49 (16)	0/13	0	0/13	0	1/13	7.7	0/13	0	0/13	0	0/13	0	0/13	0	0/12	0	0/13	0	0/13	0	0/14	0	0/14	0
50+ (8)	0/5	0	1/5	20.0	0/5	0	0/4	0	0/4	0	1/4	25.0	0/4	0	0/5	0	0/5	0	1/5	20.0	1/4	25.0	1/4	25.0
Unkn. (6)	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/2	0	0/2	0	0/2	0
Total (37)	0/24	0	1/24	4.2	1/24	4.2	0/23	0	0/23	0	1/23	4.3	0/23	0	0/23	0	0/24	0	1/25	4.0	1/25	4.0	1/25	4.0

	MT2-3		MT3-4		MT4-5		MTP1		MTP2		MTP3		MTP4		MTP5		PIP		DIP	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18-34 (7)	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/5	0	0/4	0	0/4	0	0/5	0	0/3	0
35-49 (16)	0/13	0	0/13	0	0/13	0	1/10	10.0	0/10	0	0/12	0	0/11	0	0/10	0	0/12	0	0/8	0
50+ (8)	0/5	0	0/5	0	1/4	25.0	0/3	0	0/3	0	0/3	0	0/3	0	0/2	0	0/4	0	0/3	0
Unkn. (6)	0/2	0	0/2	0	0/2	0	0/1	0	0/1	0	0/1	0	0/1	0	0/1	0	0/0	0	0/0	0
Total (37)	0/25	0	0/25	0	1/24	4.2	1/19	5.3	0/19	0	0/21	0	0/19	0	0/17	0	0/21	0	0/14	0