THE BRYGGEN PAPERS

Supplementary Series No. 8

Osteoarchaeological Analyses From Medieval Bergen

Editor: Ingvild Øye

FAGBOKFORLAGET

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give a scholarly presentation of the archaeological finds from the excavations at Bryggen and other medieval and early modern sites in Bergen.

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Foreword

This volume of The Bryggen Papers deals with life and death in medieval Bergen as witnessed by human remains, *in casu* skeletons. Three osteoarcheaological studies from medieval Bergen are presented: one in-depth analysis of skeletons from the graveyard belonging to the oldest surviving church in Bergen, St Mary's, dated to the mid-twelfth century, and two more limited studies of the skeletal remains from the Nonneseter Convent from the same period. Even though some of the material was uncovered as far back as in the late nineteenth century and then later in the 1960s, these contributions represent the first analyses of osteoarcheaological material from Bergen.

Katharina Lorvik's comprehensive study of a sample of skeletons uncovered at the churchyard of St Mary's constitutes the main contribution in this volume. It was first presented as a master thesis at the University of Bergen in 2007, and has now been partly revised and elaborated on for publication in this eighth volume of the Supplementary Series. Although the corpus is limited, the analysis sheds new light on the living conditions in the early medieval town – issues related to health, diseases, life expectancy, etc. It also presents and discusses the methodological basis for such studies, and relates the finds to their contemporary settings, from the latter part of the twelfth century to around 1250.

Skeletal material from the church and cemetery of the Nonneseter Convent was first collected during investigations of the building remains in 1872 and 1891. More than a hundred years later, in 2006, the building of a new transport system in Bergen caused extended parts of the cemetery to be uncovered, adding new research material for osteological analysis. Stian Hamre presents a survey of his preliminary analysis of the old excavations at Nonneseter, while Hanne Ekstrøm presents the first osteoarchaeological results from the latest excavation.

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Bergen, March 2009

Ingvild Øye
Chief Editor

Burials and human remains from medieval Bergen – an introduction

Ingvild Øye

Altogether, skeletal remains of 5,000–6,000 individuals from the Middle Ages have been collected in Norway during the past 150 years (Sellevold 2001: 1), including material from archaeological investigations of medieval churches and churchyards. Most of this material derives from urban sites – the cemeteries and ruins of cathedrals, friaries, convents and town churches. The skeletal material from Bergen presented in this volume – from St Mary's churchyard and the convent of Nonneseter – constitutes only a very small part of this total corpus, as only little of the medieval skeletal material from Bergen has been collected and taken care of over the years. Beside the skeletal material from St Mary's and Nonneseter, there is documentary evidence for medieval burials uncovered during older investigations of abandoned medieval churches and churchyards (Lidén and Magerøy 1990).

The analysed material from Bergen presented in this volume, then, makes up only a very small fraction of the medieval burials of the town. Katharina Lorvik's analysis comprises 76 skeletons from the south-western and outer parts of the churchyard of St Mary's, while Stian Hamre's and Hanne Ekstrøm's analyses from Nonneseter include remains of 111 and 25 individuals respectively – altogether some 200 individuals. This is a far smaller corpus than those analysed from other medieval towns in Norway, such as Oslo, Tønsberg, Trondheim and Hamar (Sellevold 2001: 77–87). Compared with other Scandinavian towns, the Norwegian osteoarchaeological material is very limited (Sellevold 2001: 87).

Bergen is regarded as the largest town of medieval Scandinavia around 1300, with a population of close on 10,000 inhabitants (Helle 2006). This is a rough estimate, based partly on the number of inhabitants indicated by tax lists and other sources from the 1640s (Nedrebø 1991). How the Bergen population developed throughout the Middle Ages and the Early Modern Period escapes any kind of safe measurement.

As osteological analyses have so far only been carried out at the two sites mentioned in Bergen, the material is clearly far too small to provide new information on the medieval size of population and the development of the urban community. Nevertheless, the analyses published here provide important information on many aspects of life and death in medieval Bergen, such as health conditions, stature, life expectations for males and females, and also indirectly urban lifestyle and even religious concepts.

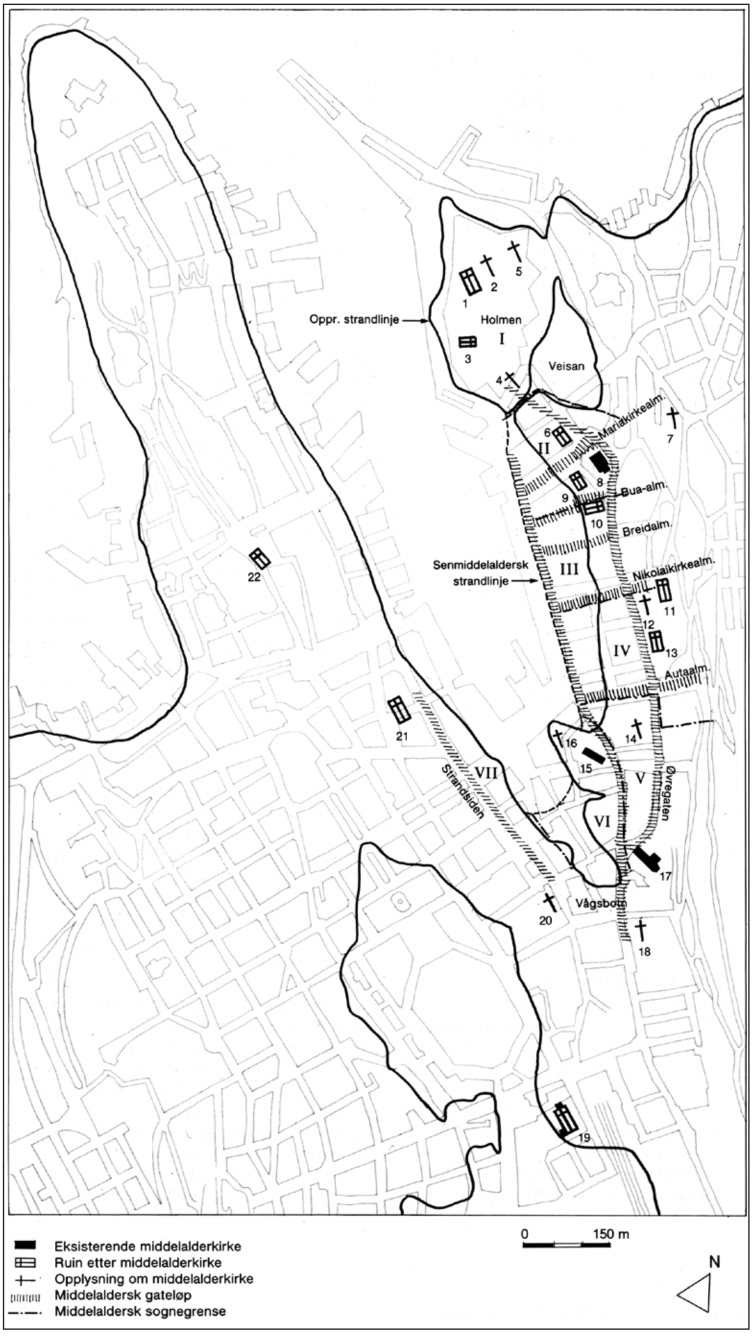

Figure 1 *Map of medieval church sites in Bergen:*

1. Christ Church Cathedral,
2. Christ Church Minor,
3. The first and second Church of the Apostles,
4. The third church of the Apostles,
5. St Olaf's in the Dominican Priory,
6. The first St Catherine's,
7. St Olaf's on the Hill,
8. St Mary's,
9. St Lawrence's,
10. St Peter's,
11. St Nicholas',
12. St Columba's,
13. St Martin's,
14. St Hallvard's,
15. St Cross
16. St Michael's in Vågsbunnen,
17. St Olaf's in Vågsbunnen, later the Franciscan Friary, and the Lutheran Cathedral after the Reformation,
18. The second St Catherine's,
19. The Convent church of St Mary's at Nonneseter,
20. All Saint's,
21. The Augustinian Abbey church of St John's,
22. The Benedictine Abbey church of St Michael's at Munkeliv

(After Lidén and Magerøy 1990).

Institutional context

The burials should also be seen in their institutional context – the establishment of the churches and monastic houses, and their status within the town. It is therefore important to approach the burials both contextually and spatially when analysing the skeletal material.

Around 1300 there were more than twenty churches in Bergen, including the Christ Church cathedral, two hospital churches, the churches of the five religious houses and four small chapels. This is the highest number of ecclesiastical institutions in any medieval Norwegian town, including the archiepiscopal centre of Trondheim (Helle 1982: 581–83). (Figure 1). Of the Bergen institutions mentioned, eleven churches and three monasteries date back to the twelfth century. Of these early churches, St Mary's and the Church of the Holy Cross are still standing and there are substantial remains of others, among them the convent church of Nonneseter, of which the south chapel of the chancel and the lower part of the west tower have survived.

The main, Romanesque part St Mary's Church was erected in the mid-twelfth century, and the chancel was extended in Gothic style in the mid-thirteenth century (Lidén and Magerøy 1990: 45). Located on a moraine plateau at a higher level north of the Bryggen tenements, the church towered monumentally above the built-up northern part of the medieval town. The Romanesque twin-towered basilica measured 18x23m and its chancel 10x10m, later extended 17m in length. It has a classical east–west orientation, close to and parallel to the town's main street, Øvrestretet (the Upper Street).

St Mary's and the convent church of Nonneseter were erected in different parts of the town, to the north and the south respectively. They appear to have been built at about the same time, from the 1140s onward (Lidén and Magerøy 1990: 46). Judging from the results of the excavations, Nonneseter was laid out as a naveless church, 33–34m long, including the west tower, and extended eastwards at the end of the thirteenth century, so that it came to measure c. 50m in length (Lidén and Magerøy 1990: 45). The Romanesque tower basis that marked the western end of the twelfth century church to the west has vaults and profiles strikingly similar to St Mary's Romanesque chancel and west doorway (Lidén and Magerøy 1990: 48, 67). The archaeological dating corresponds well with the information of written sources (Helle 1982: 141).

Although Nonneseter is sparsely documented in the late Middle Ages, we know that the convent was dissolved in the mid-fifteenth century and most of its property transferred to the abbey of Munkeliv. At the beginning of the sixteenth century, at the latest, Nonneseter was taken over by an Antonite community. It was, however, secularised soon after as the private residence of the former captain of the Bergen Castle in 1528 (Helle 1982: 287, 336, 884, 867).

It is thus evident that the burials and skeletons from the Nonneseter convent and St Mary's belong to two different institutional contexts and probable that they represent different segments of the urban population.

Excavations

The remains of several medieval churches were excavated in the latter part of the nineteenth century and the beginning of the twentieth century, and the finds included burials and skeletal material. The leaders of these excavations were the most prominent antiquarian and archaeologist of the time Nicolay Nicolaysen (1817–1911), the architects Peter A. Blix (1831–1901) and Schak Bull (1858–1956), the headmaster B.E. Bendixen (1938–1918), and the local historian Johan Chr. Koren Wiberg (1850–1945).

As a result of these investigations, the layout of eight medieval churches, including two monastic churches, were recorded completely or partially. The foundations of the Benedictine Church of St Michael's, commissioned by King Øystein Magnusson in the early twelfth century, were excavated in 1860 by Nicolaysen. In the same year Blix started his excavations at Bergenhus (Bergen Castle), and eventually also located the site of the medieval Christ Church Cathedral (1886). He investigated the stone foundations of the church of St Olaf's (the present cathedral) as well, at Vågsbunnen, the head of the harbour bay of Vågen (1880–81). The convent church of Nonneseter was excavated by Blix in 1872, and later by Schak Bull in 1891–1893. The excavation of the south-western part of the centrally placed St Nicholas' east of Vågen in 1895 was supervised by Bendixen (Øye 1997).

From the turn of the century excavations in Bergen were mainly carried out by Koren Wiberg. He identified and investigated the sites of several medieval churches: St Martin's (1899), St Peter's (1920), and St Colomba's (1908), all of them located in the medieval settlement area east of Vågen. Naturally, these old excavations did not meet the standards of modern archaeology with regard to stratigraphy and more common finds, among them graves and skeletons.

The first great name in the more professional twentieth-century medieval archaeology of Norway was Gerhard Fisher (1890–1977), originally educated as an architect. He continued the work started by Nicolaysen and Blix at Bergenhus. In 1929–31 he undertook archaeological investigations of the foundations of the Christ Church Cathedral, and started the first investigations of St Mary's (1930), later followed up by Hans-Emil Lidén (1961).

The extensive excavations at Bryggen, conducted by Asbjørn E. Herteig, 1955–1968 started a new era in urban archaeology: based on stratigraphical principles, a more detailed and comprehensive field documentation, and in principle all-inclusive finds representation, including the documentation and preservation of burials and skeletons. In the rear area of the large Bryggen site, around 180 skeletons were uncovered. The selection included in Katharina Lorvik's analysis was uncovered outside the fence of the present churchyard of St Mary's, beneath the moraine slope and at the same level as the built-up area of the rest of the Bryggen site. The skeletons were lying close to the ruins of a small stone building, measuring 10 x 8.4m externally and with an east–west orientation, identified as the remains of the chapel of St Lawrence, mentioned in contemporary written sources (Herteig 1990). The field context raises the question of whether the skeletons belonged to St Mary's original churchyard or should rather be seen as connected with St Lawrence's. As the foundation of the chapel ruin partly covered some of the burials, Lorvik concludes that they most likely belong to St Mary's churchyard. Another, but not decisive argument is that medieval chapels normally had no burial rights. The burials would then probably belong to the outskirts of the churchyard, limited to the south by the built up area of Bryggen without any trace of an outer fence.

Burials and coffins have also been found under the floor inside St Mary's, the youngest from c. 1800, but most of them from the seventeenth and eighteenth centuries and some from the late Middle Ages and the sixteenth century (Lidén and Magerøy 1980: 120).

Nonneseter is the only site where skeletons were collected from the older excavations, but they are poorly documented and also collected in a way that makes later osteological analyses rather difficult (cf. Hamre, this volume). The burials were uncovered both inside and outside the church. According to Bendixen, around a hundred burials were located inside the church, the majority in the nave, where the dead had originally been placed in wooden coffins, of which only few remains could be observed. The skeletons were located in two to three layers. Only the bottom layer, however, contained in situ burials in regular rows, while the highest were disturbed to a large extent and almost disappeared to the east. Even in the lower layers the burials were not as dense as to the west. There were also 17 burials in the chancel (Bendixen 1893: 6).

North or north-east of the church the churchyard contained several burials. The excavated ones were situated near the church and close to the wall of the chancel. The extent of the churchyard was, however, not located. The burials were generally unevenly distributed, originally placed in wooden coffins and some in stone-covered graves. Closest to the chancel, people were buried in close rows and the bottoms of the coffins had been preserved. Close to the tower a hollowed-out stone coffin was found, constructed somewhat differently from the others (Bendixen 1893: 7).

The new excavations in 2006 covered an area partly inside the chancel and partly outside the church, including parts of the churchyard to the north and north-east. The burials in the chancel were best preserved.

At the other medieval church sites that have been investigated, burials, skeletons and parts of churchyards have been observed but not documented in detail, and the skeletons have not been taken care of. At St Olaf's in Vågsbunnen, burials were uncovered in masses above the natural soil and underneath the church, but most of them disturbed by later digs (Lidén and Magerøy 1983: 96). Burials and skeletons were also uncovered at St Nicholas' when the nave was excavated in 1895. The churchyard was located to the south and east of the church and demarcated by a wall at some 13 metres' distance from the long wall of the church. 12–13 burials were uncovered in this area. Furthermore, 16 burials placed in rows were found inside the church itself, and also a burial in the west tower (Lidén and Magerøy 1980: 160). The churchyard of St Peter's is mentioned in written sources, in connection with events taking place in 1183, and parts of churchyard were uncovered by Koren Wiberg on three sides of the church. The burials were placed above each other in several layers but no burials are mentioned within the church (Lidén and Magerøy 1980: 173). As for the other investigated churches, there is no information about the burials.

The other medieval churches known from written sources have all disappeared without trace after they were demolished in the Late Middle Ages and the sixteenth century (Lidén and Magerøy 1990: 41–42). Chances for future identifications and investigations of these churches are rather small, which leaves Bergen with meagre skeletal material for further osteoarcheological analyses.

Representativeness

Skeletal corpora may reflect demographic features of the population that used the cemetery. It has been claimed that in cemeteries serving a parish population one should expect a certain sex and age ratio – approximately fifty percent males and fifty percent females (Sellevold 2001: 7). This precondition can be questioned, and does not necessarily apply to urban communities with a different economic and demographic structure from that of rural areas. A large part of the inhabitants of medieval towns consisted of people who only lived there for shorter periods of their lives and not necessarily within a family structure – labourers, servants and craftsmen. Clerics also formed a considerable group in towns serving as ecclesiastical centres. Children and elderly people may therefore have constituted a smaller part of the population than in rural societies (Helle 1982; Øye 2005). Consequently, the sex and age ratio as compared with rural assemblages is an interesting aspect of investigations of urban churchyards. Nor did all the churches serve parish communities; there were both monastic churches and churches with a special status. Furthermore, parishes did not develop before the mid-twelfth century at the earliest, and cannot be documented in Bergen until a hundred years later (Helle 1982: 479 ff; Lidén and Magerøy 1990: 17). People who wanted to be buried in another churchyard than that of their parish church, e.g. a monastic churchyard, had to pay a special fee to the parish church (Helle 1982: 610), so that most of them were probably wealthier townspeople. Monastic churches could bury both people belonging to their own communities and lay people, whereas private chapels never attained formal burial rights.

As medieval churchyards did not only have practical and religious but also social functions, even smaller parts of a churchyard may throw light on social conditions. A grave south of the church was e.g. considered more honourable than a grave to the north. The sanctity of the church made the areas closest to the building highly desirable, and a burial inside the church was the most prestigious of all, reserved for clericals and other prominent people. A grave in the chancel was particularly esteemed.

The provincial law of Eidsivathing, representative for the eastern part of the country in the twelfth and thirteenth centuries, states such a spatial system of rank explicitly: Burials in the eave's drip close to the wall on the southern side were held in the highest esteem and were reserved for the king's local representatives, while the outer areas closest to the fence had the lowest rank. The northern side of church was less prestigious and regarded as the female side. Even though there were no such rules in the Gulathing law of west Norway or the Bergen Urban Code of 1276, similar ideas may have prevailed there. No complete churchyard has been excavated in Bergen or any other Norwegian medieval town. Nevertheless, excavations of different parts of churchyards have demonstrated that social status and gender played an important role (Sellevold 2001: 93). The situation of the excavated burials within the churchyard in question is therefore important aspect for assessing the burials and their human remains.

In different contexts one should then expect to find remains of people from different social strata, and this may open for interesting comparisons. As the osteological material from Bergen stems from two different institutional and spatial contexts – an outer part of the churchyard of St Mary's, one of the main churches in Bergen, another selection from the church itself and a third one from the churchyard of the convent of Nonneseter which by the end of the Middle Ages was converted to a friary – the way is open for such comparisons.

At St Mary's no remains of the coffins were preserved, only nails indicate wooden coffins for some. With regard to artefacts as social signifiers, only few were found, e.g. a spinning whorl, as indicators of gender roles (cf. Lorvik, this volume).

The situation was rather different at the Nonneseter site. According to Bendixen's observations, the burials demonstrated a spatial social stratification, in particular where burials in the chancel signified high status. Here, all the dead were buried in coffins, some with bronze mountings, and often furnished with costly artefacts and accessories belonging to belts and clothing, and some with fine thin bronze pins and coins. One person had been buried with a chalice of bronze in Gothic style, of the same kind that usually belonged to bishops or abbots. Another had luxurious textile woven of golden threads, and with flat pieces of bronze on the chest (Bendixen 1893: 6).

South of the church, close to the church wall, probably in the chancel walk – and also with a prominent position – two burials were covered by flagstones (Bendixen 1893: 7). The stone graves had different shapes. Two incomplete hollowed out stone-coffins were found outside the church, one in the chancel walk.

Bendixen's assessment was that most of the skeletons at Nonneseter were female, only a minor part males, and there were children among them. There were two pairs of skeletons consisting of one adult, probably a woman, and a child lying above (Bendixen 1893: 6). Bendixen assumed that beneficiaries of the convent might have been buried in the church regardless of their sex and that it also might have been possible to buy a burial place (Bendixen 1893: 7). It is therefore important to have the skeletal material from Nonneseter properly analysed by means of modern scientific methodologies (cf. Hamre and Ekstrøm, this volume), though regrettably without knowledge of the original spatial contexts.

Dating

One of the most typical features of medieval churchyards is that they were intensively used. Older graves were destroyed when new ones were constructed, and the stratigraphy may therefore be difficult to sort out. The documentation of the graves of the Bergen material varies, as sampling strategies or criteria for selection of material have changed over the years.

The three studies presented here illustrate different dating methods. The corpus belonging to St Mary's churchyard is unusually well dated by stratigraphical analysis. The graves belong to the period from c. 1150 to 1250, and thus represent the first use of this part of the churchyard. The graves are also accurately located, documented and dated (cf. Lorvik, this volume). Skeletons were found partly underneath the ruins of St Lawrence's which seems to have been erected after the town fire in 1198. Consequently, the oldest burials were older than the building (Herteig 1990; Lidén and Magerøy 1980: 148). St Mary's churchyard therefore appears to have been quite extensive at an early stage, and filled with graves only a few decades after the church was erected, even on the outskirts. It is not clear why this part of the churchyard was abandoned in the Middle Ages.

The situation is rather different at the Nonneseter site, where the skeletons from the old investigations can no longer be attached to specific localities within and outside the church. The documentation is so scanty and incomplete that it is only possible to date the skeletons as a whole, not individually, and this would of course reduce their source value. Compared to the material from St Mary's, the Nonneseter graves cover a wider time-span, probably from the second part of the twelfth to the sixteenth century, altogether some four hundred years.

Although Christian norms did not permit the dead to be buried with grave goods, different items are often found, be it personal belongings, part of the clothing or special objects of religious or magical nature (Sellevold 1999: 112). Such finds may also be used for dating purposes.

We have seen that Bendixen refers to different artefacts connected with the burials, such as a bronze necklace, bronze and iron keys, a decorated silver hulk to a knife, etc (Bendixen 1893: 8), as well as more easily datable finds like coins. Altogether, 20 two-sided coins and c. 40 bracteates were found, partly in the gravel, partly in the graves. They were most numerous in the chancel which contained three quarters of all the finds. With a few exceptions from the fifteenth and sixteenth centuries, the two-sided coins are all from the period between the reign of King Magnus Haakonsson (1263–80) and that of Magnus Eiriksson (1319–55), and only a few from the fifteenth and sixteenth centuries. Most of the bracteates, too, belong to the period 1263–1355 (ibid. 7–8).

New information on the dating of the skeletons from the recent excavations has been gained by 14C-datings within the period from the early eleventh century to around 1400. The oldest datings may be questioned as they are older than the Nonneseter convent.

Final remarks

Skeletal material has long been treated as a stepchild in archaeology, and especially so in Bergen. Here the representation of medieval skeletons is minimal in relation to, all the investigations carried out at medieval church sites during the last 150 years. Modern osteoarchaeological studies have clearly demonstrated their potential as a primary and direct source to living conditions and lifestyle in the past. Although limited in extent, and partly weakened by unsatisfactory documentation and collecting methods, the studies presented here nevertheless provide new insights into people's lives and living conditions in different environments of the medieval town of Bergen.

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Life and death in the early town. An osteoarchaeological study of the human skeletal remains from St Mary's churchyard, Bergen

Katharina Lorvik

Introduction

Human skeletal remains constitute an essential part of the archaeological record. Human bones are the only direct remnants of the people themselves and carry important information on the lives they lived. The focus of this study is on a skeletal cemetery assemblage from the town of Bergen on the west coast of Norway. The material dates from the late twelfth to the mid-thirteenth century, a period assigned to the Scandinavian High Middle Ages. The remains of the cemetery were discovered in the northernmost part of the settlement area of Bryggen during the closing stages of the extensive Bryggen excavations (1955–68). The cemetery is located at the rear part of the so-called Gullskoen site, in the area where the initial development of the town took place (Herteig 1985: 11–12; Herteig 1990: 10–14, 97), some 20–30m south of St Mary's Church and at the top of a sloping beach area at approx. 20–30m from the seafront (Figure 1). During its period of use, this part of the cemetery was located just behind the tenements in the core settlement area of Bryggen. The graves most likely represent the south-west corner of the St Mary's Church cemetery. Within an area of c. 400m^2, a total of c. 180 complete and partially articulated human skeletons representing in situ graves were recovered. Together with these, there were considerable quantities of disarticulated and commingled human skeletal remains of uncertain contextual origin.

The main object of study is a sample of the human skeletal assemblage from this site. The sample consists of 76 individual skeletons from a minimum of 72 graves, representing approximately half of the excavated cemetery area and half of the existing skeletal material from the cemetery.

Skeletal remains have great value as source material in archaeological research. Changes in living conditions, hygiene, diet, the effect of poverty and the exposure to infectious diseases is often reflected in the skeleton; so are accidents and violence, ones access to medical treatment and the absence of proper social security networks (Arcini 2003: 11).

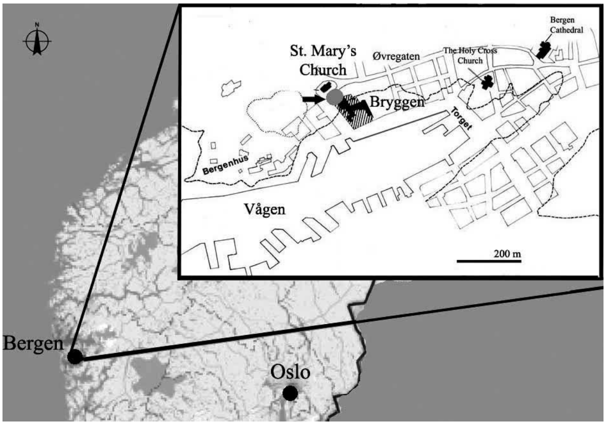

Figure 1 *Bergen, located on the west coast of Norway (modified from Helle 1982). The excavated cemetery area is marked between St Mary's Church and Bryggen (The Bryggen excavation area in black).*

Background and approaches

The main starting point of this investigation was an interest in how biological conditions and cultural circumstances – such as activity patterns, living conditions, nutritional status and social position may be reflected in skeletal remains. The idea was that the study of skeletal features in combination with relevant archaeological and historical sources would give insight into important aspects of the life and health of the population in question that are hard to come to grips with through sparse written sources and other archaeological remains. The approach is osteoarchaeological, which means that this is a study of skeletal remains from an archaeological setting. Although osteological methods will constitute the main methodological basis, the knowledge of the archaeological context from which these remains are derived is essential in understanding and interpreting the data not only as biological parameters, but as markers of social and cultural behaviour.

Prior to this study, the human skeletal remains from the St Mary's Church cemetery have not been subject to any in depth scientific analyses involving the complete remains of a large number of individuals. This is the first systematic examination and analysis of these remains, which, so far, represents the only large collection of medieval skeletal remains with known provenance from medieval Bergen.

The purpose of this study is twofold. First, it will investigate how the skeletal data and the demographic profile of the assemblage may reflect the character and composition of the town population. Second, it is a study of how various health indicators may reflect the living conditions of the buried, and the quality of life in medieval Bergen in general. The study initiates a discussion on how these aspects may be related and how they reflect the social structures in the town and the cultural aspects of urban living in the High Middle Ages. Ways in which these issues may be reflected are through mortality rates – high levels of child mortality in particular – average life span, body stature, growth patterns and the presence of skeletal pathology and trauma. Health indicators may manifest themselves directly, as signs of disease and trauma in the bones, or in a less obvious manner, through shifting mortality rates and stature.

Biological aspects of particular relevance to this study are the maturation and physical development of the body and its physical responses to environmental, social and economic factors evident in Bergen in the early High Middle Ages. All these aspects relate to the function of the town and cemetery and the composition of the population.

Osteology, in combination with archaeology and the social, biological and environmental sciences, allows us to grasp some of the underlying conditions that promote variations in health parameters and physical traits, and may reveal information on the health status of these inhabitants. Studies of the archaeological context, burial practices and the spatial localization of graves may equally reflect social and cultural conditions and offer important additional information on past health and living.

The possibility of drawing conclusions on a population level depends on the character of the assemblage, for instance its degree of representativity for a larger population, thus source criticism will be an integrated component of the analysis with a particular concern with the use and reference of methodology.

With the christening of Scandinavia in the tenth and eleventh centuries, there was a shift in burial practices. The church laws demanded that the population should be buried on consecrated ground within closed cemeteries. Choice of cemetery was determined both by social status and group membership, but also by geographical origin. Some parts of the cemetery were considered more attractive than others, for instance the areas close to the church. There may also have been a certain internal segregation of the cemeteries dividing the burial ground according to a hierarchical system and/or according to age and sex. The provincial laws from the late twelth century required a certain organizing of the burial ground. There is doubt as to whether these practices were followed at all cemeteries, but some areas that may be assigned to children's burials are reported, as well as tendencies in some areas to bury women to the north of the church and men to the south (Karlberg 2008: 126–27; Lynnerup et al. 2008a: 128). The consequence of this democratization in burial practices in the Middle Ages was an intensification of burials. Ideally, this gives us the possibility to study a cross-section of the population, rather than only the upper strata, and enables the study of demography and health over time, geographically and between social groups. The rather intensive use of many medieval cemeteries does, however, cause a great deal of disturbance and commingling of skeletal material making dating and establishing relative chronologies difficult.

As for Bergen, the statutes in the Gulathing Law resemble the laws from the other jurisdictions, but do not require any specific segregation of the cemetery (G23; Sellevold 1999: 101). As the skeletal assemblage from St Mary's originates only from the south-western corner of the cemetery, a study of the potential segregation of the cemetery has not been part of this study. A surprisingly narrow dating for a large number of graves were obtained based on the stratigraphic relations between graves and building remains in combination with the fire chronology at Bryggen.

The analysis of demographical and health issues requires a certain categorization of the findings and the population. Key concepts in osteology are the biological and physical identification of age, sex, pathologies and trauma. An understanding of urban medieval life requires that one relates these categories to the corresponding social concepts of maturation – childhood and adulthood; gender and health and morbidity. It also demands an attempt at understanding how these concepts may have structured life in the Middle Ages in a different manner than today.

What were the main structuring principles in the medieval society? Today, age is an important factor to determine one's place in society. Perhaps were there other categories that defined one's social importance in society, such as family relationships, profession or gender. For practical reasons, in demographic studies one often deals with age-categories. How one classifies these groups is decisive for how one conceptualizes medieval living and the composition of the urban populations. For instance, is a 12-year-old considered a child or an adult and belonging to the working population in town? Today we see high mean ages as a sign of good health in the population, but high mean ages in a population may come with higher levels of morbidity. This factor becomes particularly relevant when dealing with populations that have restricted or minimal access to medical care, such as the medieval society.

The town environment in the Middle Ages is often described as rather unhealthy and unhygienic. The intense aggregation of people, the close contact with animals and the large proportion of ambulant traders and visitors are believed by some to have promoted the spread of disease and raised the levels of conflict and interpersonal violence. The urban centres are also believed to have attracted large numbers of individual contract workers and job-seekers, many of limited economic resources and without social networks to provide for them if necessary. In an epidemiological and immunological perspective it is of interest to gain a better understanding of the health consequences of living in this environment, and if possible to investigate whether this phenomenon is typical of the early town and whether changes over time did occur. Skeletal studies can contribute significantly in the study of past living and health. I believe this analysis will give new insight into the lives and living conditions of the inhabitants of early medieval Bergen.

The source material and field of research

During the last period of the Bryggen excavations, a cemetery area of approximately 400 square metres was uncovered to the south of St Mary's Church at a distance of about 20–30 metres from the southern church wall. Three to five layers of graves and the skeletal remains of about 180 individuals were recovered. The area most likely represents the south-western part of the cemetery of St Mary's. The graves were distributed across the whole of this northernmost excavation area, with an increase in burial intensity closer to the church

The church of St Mary's was probably built in the first half of the twelfth century, around 1140, and the churchyard laid out around the same time (Lidén 1961: 98; Herteig 1990; Lidén 2000). It is first mentioned in Sverre's saga, about events in 1183 (Helle 1982: 134). St Mary's Church was most likely one of the six main churches in Bergen towards the end of the twelfth century, serving a part of the permanently based community in the town (Helle 1982: 582).

For the purpose of this study, a sample of the skeletons has been selected for further study. A major challenge in sampling was to limit the amount of data within the de-sign and limits of the thesis without reducing its scientific potential. The main sampling strategy was to select a number of burials that would constitute a statistical unit of acceptable size, represent a fairly random sample and give a maximum potential for dating, preferably within a very short time span. The choice fell on a group of graves from the outer cemetery area south of St Mary's Church, an area that went out of use in the mid-thirteenth century. All the graves in the sample are located within the same area of the churchyard, evenly distributed and close together in several layers. The burials are dated stratigraphically to a period between the second half of the twelfth and the mid-thirteenth century, a period of one hundred years at the most. One fourth of the graves, in at least two layers, could be dated within the period 1170/71–1198 (Herteig 1990: 74). All the graves are oriented east-west (head in west) according to medieval custom, and are well aligned with St Mary's Church. The original extent of the cemetery in the west, north and east has been estimated to be about 10–20 metres from the church building (Hansen 2005: 90). Good preservation[1] and limited commingling compared with the rest of the cemetery gave a high number of individual graves with complete articulated skeletons and added to the scientific potential of the material. Sampling of this kind automatically affects the representativity of the material making it unfit for pure

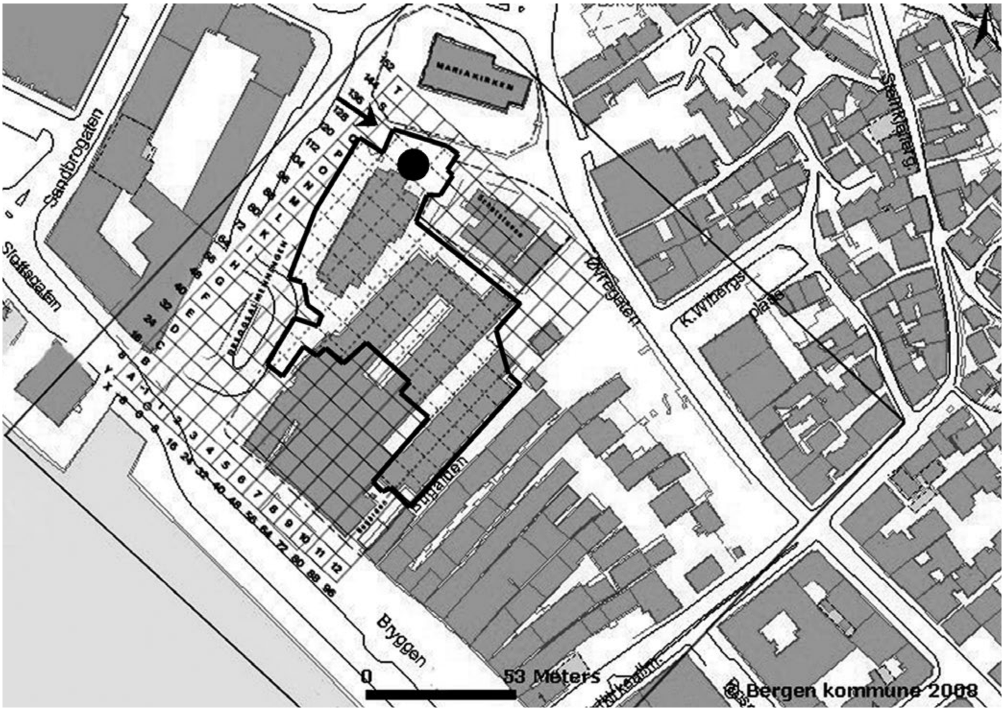

***Figure 2** The outline of the Bryggen excavation area with St Mary's Church to the upper left and the excavated cemetery area marked (Modified from Herteig 1990).*

1 Preservation was one of several criteria employed for general sampling, not for individual selection.

demographic analyses; hence this is not the main purpose of this study. Some demographical aspects, however, will be addressed.

The sample consists of the complete and semi-articulated skeletal remains of 76 individuals[2] from the south-west[3] corner of the cemetery close to the rear part of the later Gullskoen tenement from the fourteenth century. This part covers about two-thirds of the total excavated cemetery area and the extent of the burials marks the south and west delimitations of the cemetery (Herteig 1990: 74). The cemetery-period is preceded by a building phase where the remains of houses and wooden passages have been archaeologically identified. Later, this area went out of use and gave room for the expansion of the medieval town (Herteig 1990: 66). The burials are separated from St Mary's Church by what is believed to be the remains of St Lawrence (building 50), a small chapel from the late twelfth century (Herteig 1990: 73), first mentioned in written sources in 1206 (Helle 1982: 136), and St Mary's Guildhall (building 48) built on the remains of the 1248 fire (Herteig 1990: 49) and mentioned in the Urban Code of 1276. These buildings physically separate this outer area from the rest of the cemetery and St Mary's Church and it is reasonable to believe that the construction of these buildings mark the end of this area's period of use.

Several layers of burials precede the buildings, constituting yet another important criterion for dating. This part of the cemetery was later affected by the northward expansion of the town around the mid thirteenth century. In the post-burial period following the fire of 1248, the area to the south of the stone buildings is characterized

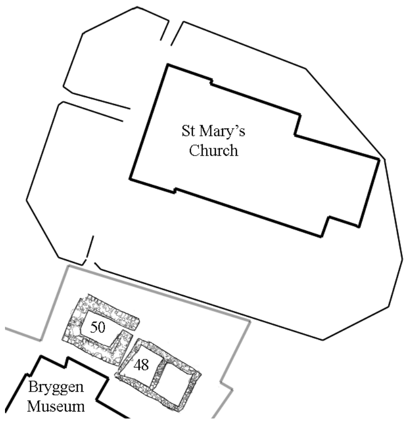

Figure 3 *Outline of the excavated cemetery area to the south of St Mary's Church. The graves and skeletons in the sample were all from the area in relation to and to the south of the two stone buildings in the map. Building 48 is St. Mary's Guildhall, building 50 is St Lawrence Chapel (Modified from Herteig 1990).*

2 The main criterion for the definition 'in situ grave' is at least two skeletal elements in articulation. An exception from this general rule is made for the 'long grave', where a single scull is included. The clear boundary of the grave, the direction of the scull, stratigrafic position and completeness indicate that the scull was found close to where the body was originally deposited.

3 For practical reasons, the north direction applied in the text deviates somewhat from true north (see figure 2) and the directions in the field documentaion and other published literature by A.E. Herteig. My directions are oriented according to the church of St Mary (E-W). The graves then lay to the south of the church. The outer graves are referred to as placed to the south of the stone buildings, not to the west as stated in Herteig 1990 etc. See maps for exact orientation.

Figure 4 *The area where the skeletal remains were found as it appears today seen from Bryggen Museum. The ruins of the two stone buildings in front of St Mary's Church (Photo: K. Lorvik).*

by various activities related to the reconstruction of these. The activities are identified archaeologically by thick layers of building waste (Herteig 1991: 50–51).

The approximate time of construction of St Mary's Church, stratigraphic relations to the two stone-buildings together with the Bryggen fire-chronology date the burials to the period between c. 1140/50–1250. This was a period of great expansion following the initial stages of urbanization in Bergen. It was prior to the introduction of new town regulations with the establishing of the Hanseatic Kontor about a hundred fifty years later, and represents the last phase of general use of the central Bryggen area before the settlement area became to a large extent dominated by Hanseatic merchants. It is of importance to establish the relationship between the graves and St Mary's Church and the St Lawrence Chapel, in order to determine the composition of the buried population, the social status of the buried, and whether the remains represent a specialist population or not. This has consequences for the representativity of the assemblage. The exact function St Mary's Church in the twelfth century is uncertain. The church functioned as a parish church from the fourteenth century, but being the largest of the town-churches in Bergen in the twelfth century, only exceeded by the Bishop's church or Christ

Church, there is reason to believe that it functioned as one of the main churches in town (Helle 1982: 147, 582), and as early as in the twelfth century, many of the town churches were not yet regular parish churches. Judging from the size of the church and its location in the heart of the main settlement area of Bergen, there is reason to believe that in the twelfth and thirteenth centuries, it served the permanently based community involved in the main activities in town – landowners, tradesmen and specialist craftsmen – perhaps also members of the building-huts involved in the extensive church building at the time. The many monumental building sites in early Bergen may have provided long term contract work for many stonemasons, both resident and ambulant (Hansen 2005: 194). It may also have served parts of the community involved in administrative and religious activities in town; high-status activities primarily associated with the male population. It is possible that the guilds in town organized religious assemblies and were connected to altars in some of these churches. The St Mary's Guild was one of the privileged guilds in town with its own guildhall also serving as town assembly, where the guild was connected to the St Mary's altar in the church (Helle 1982: 589–90). Analogous to other north-west European countries, the members of the guilds in Bergen may have been merchants, and based on mutual support in judicial affairs, inspired the town development. Following this, the buried population at St Mary's cemetery may have consisted partially of members of the upper social stratum in town (Helle 1982: 590). Even though this material consists of graves that pre-dated St Mary's Guildhall in the same area, there is still a chance that the church initially served a community of similar social status. As chapels did not normally have the right to bury, the graves in question are interpreted as belonging to St Mary's Church

The internal organization of burials at the cemetery may also have followed a hierarchical system, following a religious principle at the time, 'the closer to the church walls, the closer to the lord'. At the Trinitatis Church, one of the principal churches in Lund, Sweden in the Middle Ages, there is a tendency for the well-decorated and well-furnished cists to be placed closer to the church, while burials without cists are placed along the outer borders of the cemetery. This is an indication of difference in socio-economic status. There is a majority of women buried in this outer area and the author suggests that the high status burials represent people involved in high-status activities, while the outer areas were confined to the regular working community, represented by a large proportion of women. The burial custom does, however, not indicate that discrimination between men and women occurred (Cinthio 2002: 97).

The skeletal remains in the sample represent all in situ burials within the described area. Although grave-cuts have not been identified in all cases, possibly due to intensive burial activity, the position of the body indicates that we are dealing with undisturbed graves. The main criterion for identification of in situ burials is that at least two bones are placed anatomically correctly. Ideally, all bones should be included in the analysis, as a major part of the skeletal remains found in cemetery contexts are from disturbed graves. The disturbance is often selective, in that the more fragile skeletons of infants and older individuals are more prone to destruction, creating a negative bias in the material.

State of research and comparative material

Biological anthropology is the study of human biology and variation seen in relation with social and environmental circumstances. In an archaeological context, human remains usually have the character of osseous remains; bones. The branch of biological anthropology dealing with human skeletal remains is termed human osteology. The strength of combining these two subjects is the possibility of studying human development in time, relating living conditions in past and present (Lynnerup et al. 2008a: 21).

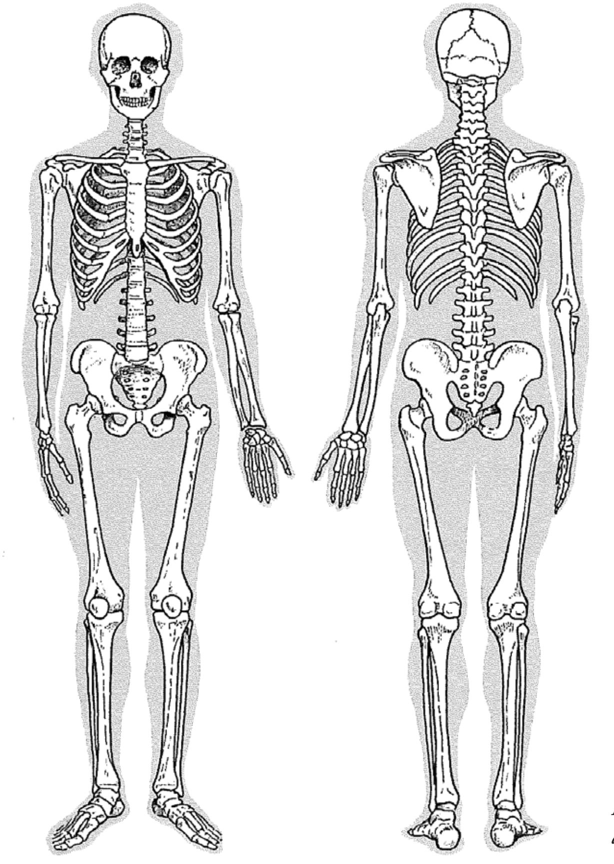

Figure 5 *The human body – skeletal anatomy (After Lynnerup et al. 2008).*

In the Nordic countries, the approaches to the discipline have been influenced by the broad scientific background of those involved – medical doctors, osteologists, anthropologists, archaeologists, biologists and dentists (Lynnerup et al. 2008a: 5).

From the research trend on racial studies in Scandinavia at the beginning of the twentieth century (Spencer 1997: 755), there has been a shift, first in the 1950s with an increased focus on population studies and palaeodemograpy, palaeopathology, nutrition, non-metric traits and multivariate statistics (Møller-Christensen 1958; 1978; Bennike 1999: 11; Sellevold 2001: 36). Later on there has been an increasing focus on the archaeological context and the importance of the chronological aspects for the osteological analysis. The transition towards a growing archaeological focus within the discipline is seen with N.-G. Gejvall's study of the rural assemblage from Västerhus, Sweden (Gejvall 1960).

While in Britain, the medical background of many osteologists led to a focus on palaeopathology and medico-historical questions in the 1970s and 80s, today, there has been a change towards a broader archaeological perspective and a growing concern with questions on health and lifestyles, and not least on methodology (Cox & Mays 2000: 100–103,143). The studies on the large post-medieval assemblage from the crypt of Christ Church, Spitalfields, London of partially known identity, has enabled the detailed analysis of social and demographic aspects, and has had an undisputable value for the development and improvement of methodology (Molleson 1993).

An extensive study on health and disease in Britain led to a compilation of data on pathology in all available prehistoric, medieval and post-medieval remains from British archaeological contexts. The work is the result of a joint study by an archaeologist and an archaeologist-anthropologist, and aims at the chronological presentation of health and disease from the past to present by collating the results from a variety of osteological reports and studies. The work is of great importance for the understanding of the processes of health and living and makes a large amount of data accessible for further research (Roberts & Cox 2003).

Recently published is a textbook on the subject biological anthropology with human osteology focusing on the Nordic area. The work reflects the multifaceted development of the discipline in this area. It also helps define the borders of the discipline in an area where there to this date is no standardized academic teaching of the subject (Lynnerup et al. 2008a: 21).

From the 1970s and 80s onwards, Scandinavia saw a changing focus towards studies in demography and the growth and development in children and adults. Important medieval studies on demography, health and nutrition are, among several; the analyses of burial customs and social structure on medieval cemeteries by L. Redin (Redin 1976) and J. Keiffer-Olsen (Kieffer-Olsen 1993), T. Sjøvold's studies on age and stature in skeletal remains (Sjøvold 1978; Sjøvold 1990) and B. Sellevold and E. Iregren's studies on the health of women and children (Sellevold 1989; 1990; Iregren 1992a; 1992b). Excavations and analyses of large skeletal assemblages in Norway, at St Olav's Church in Trondheim (Anderson 1986), St Peter's Church, Tønsberg (Holck 1989) and St Clemens' in Oslo (Sellevold 1995; Holck 2000) have contributed considerably to the accumulation of knowledge on medieval life and death. Likewise, the studies by H. Cinthio and J. Boldsen on the anthropology and demography in the Löddeköpinge assemblage from Sweden (Cinthio & Boldsen 1984), and studies on demography and mortality in Tirup, Denmark, are characteristically important for the completeness of the remains and the total investigation of the cemetery (Boldsen 1998; 2000). Several large medieval cemetery assemblages have recently been subject to extensive study: the works on Lund (Arcini 1999), Hamar (Sellevold 2001) and Sigtuna (Kjellström 2005) will serve as important references in this study.

Osteoarchaeology or historical osteology, which is a general term including faunal remains has emerged as a discipline through the increased connection to archaeology. The analytical basis has now gone from static, descriptive studies, to the focus on processes of change in the interaction between humans and their surroundings (Sellevold 1989). In addition, there is a strong focus on the importance of knowing the cultural context of the skeletal remains.

The importance of standardizing methodology is strongly emphasized within physical anthropology and osteoarchaeology today. This is partly related to the new laws on repatriation of skeletal remains emerging from the US, and the growing debate on ethics in osteology (Cox & Mays 2000; Ferembach et al. 1980; Buikstra & Ubelaker 1994; Brickley & McKinley 2004). In Sweden, the debate on repatriation and effects of reburial of archaeological remains has to some degree been a reality since the 1980s (Iregren 1983).

As mentioned, the skeletal remains from St Mary's in Bergen have not yet undergone any complete anthropological examination. A few unpublished works are worth mentioning, though: A study of cranial and dental remains in an attempt to identify ethnic groups and possible traces of migration among the Bergen population (Holter-Andersen 1970) and an analysis of dental remains, in a study of dental pathology and dental health (Klafstad: manuscript). Lately, two other master dissertations on the topic osteoarchaeology have been completed in Norway. One is on the skeletal remains from St Mary's Church in Oslo with a focus on the health and socioeconomic status of the buried and with special attention to the high frequencies of skeletal trauma in the material (Brødholt 2006). The other study is an osteoarchaeological and social analysis of the skeletal remains from St Olav's Monastery in Oslo (Ekstrøm 2006).

Apart from being influenced by general trends in anthropology and osteoarchaeology, this study draws in particular on a few major works that will serve as the main comparative sources to the finds from St Mary's churchyard. Decisive for the choice of comparative materials has been the cultural and geographical, and chronological nearness of the materials, the size of the assemblages and the completeness of the analyses. Equally important are the recent dates of the analyses and that all methods applied are in current use and referenced. Within these frames, the materials are varied; one is a high status assemblage and two assemblages represent a population of mixed social status. The materials chosen for comparisons are of urban character and Scandinavian origin. Interesting discussions could arise from comparisons between urban and rural remains but this is beyond the scope of this study.

The *Sigtuna* study is the most recent – a large osteological investigation of medieval remains from Sweden. It involved the analysis of 528 individuals from several cemeteries dating to the period 970–c. 1530 (Kjellström 2005). The investigation aimed at identifying differences in health and demographic factors, as well as signs of social ranking in the material. The osteological results, together with the archaeological and historical context of the materials, are linked to the process of urbanization in Sigtuna. Here, the author has developed a new method for investigating the relationship between preservation and sex assessment and stresses the importance of the standardization of data. The results from the analysis indicate a deterioration of health over time for the inhabitants.

The analysis of the skeletal assemblage from *Lund*, Sweden, is the most extensive osteological analysis to this date in Sweden, involving the study of c. 3300 individuals from three adjacent cemeteries dated to the period 990–1536 (Arcini 1999). The analysis has a palaeo-pathological focus and aims at investigating patterns of change in the health situation of the town's inhabitants, and explaining causative factors in the light of the growing urban population and social stratification. The study represents to a large extent the ordinary town population, and contributes considerably to the understanding of the general health and living conditions in medieval times. The study shows that the health situation of the people buried in Lund did not change considerably throughout the Middle Ages.

The total skeletal assemblage from the *Hamar* Cathedral churchyard constitutes the remains of at least 1000 individuals of which 482 skeletons associated with graves have been analyzed (Sellevold 2001). The analysis revealed important information on the spatial organization of the cemetery, the demographic composition of the buried, and their health status. The finds indicate that the assemblage from Hamar represents a population of high social status. The author emphasizes the importance of cultural historical analyses in the study of skeletal assemblages, and demonstrates the advantages of combining osteological result with information on the archaeological and cultural context of the assemblage (Sellevold 2001).

The comparative materials serve as background data to view my results in light of general trends.

Theoretical and methodological approaches

Theory – from grave assemblage to life

Human skeletal remains from archaeological contexts are a valuable source of knowledge about the past, and may provide us with information on a variety of aspects on human health and living, on past populations and environments.

The last decade has seen an increasing trend towards a focus on the biological and social context of the individual in skeletal studies. The term bio-archaeology refers to the study of human remains from an archaeological context applying osteological methods derived from physical and biological anthropology. The term is often used to illustrate arrange of scientific methods applied to the study of human remains, such as bio-molecular methods for studying ancient DNA, and histological or chemical methods for the study of pathology, isotopic variation, climatic shifts, diet and patterns of migration.

Osteoarchaeology or historical osteology is a corresponding term used for the branch of the discipline primarily concerned with skeletal remains, of which human-osteology is a subdiscipline.

Bio-archaeological approaches have become an important basis for understanding past populations as functioning, living human beings by focusing on aspects such as physiological stress, disease, injury and violence, physical activity and dietary habits and nutrition. There is also a concern with the degree of representativity of skeletal assemblages and the influence of cultural, social and post-depositional factors on the composition of death assemblages, the standardization of data collection and various problems associated with the interpretation of health levels through the study of skeletal markers. The importance of including and understanding the environmental and cultural context of the assemblage is emphasized (Larsen 1997: 4, 332–37). Culture could be defined in to ways. It refers to the lifestyles with rules and rituals of symbolic meaning, as well as strategies for survival and adaptation (Roberts & Cox 2003: 13).

This study places itself within the theoretical framework of contextual archaeology, acknowledging the fact that the development and functioning of the human body is not only a result of static biological processes, but also a product of cultural practices. The relations that exist between a society and human behaviour on one hand and the study object on the other is to a large extent dependant on individual action within a given cultural and historical context (Olsen 1997: 66). The study is interdisciplinary in the sense that it draws on the knowledge from several disciplines, from archaeology and the biological sciences in particular, and it aims at an understanding of archaeological skeletal remains in its cultural setting.

The interpretation of skeletal remains demands a reflection of cultural norms and social practices, and the way these have interacted and influenced the character of the archaeological remains. It also requires that one accepts that human behaviour is not only a product of universal laws, it is a result of the constant co-working of widely diverging factors such as biological needs, faith, social restrictions and possibilities and personal choice.

Any interpretations are attempts to give possible explanations to trends, patterns and specific events that are observable through analyses and quantifications. A good interpretation requires an evaluation of the many limiting factors that may act upon our evidence and weaken its strength, and recognizing the importance of environmental, economic, climatic, genetic and social factors on the composition and character of a population.

Studies of the human skeleton are often associated with science-based approaches aimed at the determination of fixed biological characteristics. In osteology, the main approach to the study of skeletal remains will be by identifying key biological features and to record individual variation; to establish biological profiles of sex, age and body stature and to record skeletal anomalies indicative of pathological conditions and trauma. There is awareness in osteoarchaeology that one's cultural background has implications for one's physical development and health, but are we able to distinguish between biologically and culturally promoted variations in the human body? How do we think about and distinguish between concepts like male-female, child-adult and good or poor health in the past? How are these concepts a product of social practices, and how do we identify this in skeletal remains?

Osteological identification of biological sex is achieved by visual assessment of skeletal morphological features and a categorization is based on the degree of sexual dimorphism. An individual is placed in either of the categories male-female or, if lacking determinable sexual characteristics, defined as unsexed or somewhere in the range between the two sexes. There is great variation in the degree of sexual dimorphism both within and between populations. Although sex is a biological reality and a necessary tool for categorization when studying human behaviour, the physical expression of sex changes historically and over the course of people's lives. So do people's conceptualization of the categories male–female (Sofaer 2006: 90–97). The concept 'gender' was established in the social sciences as the socially constructed expression of sex, however, its relation to biological sex is not entirely clear. The purpose was to stress that human behaviour is other than mere biology. Activities that cause osseous change, such as body modification or activity-induced physical stress may be linked to the division of labour or diet, and relate this to gender, group membership or status.

In much the same ways as sex, the investigation of age may highlight relations between the biological and the social. The physical processes related to maturation an ageing are embedded with cultural meaning and physiological changes may be socially marked life-cycle events. The ageing process is also visible in body height and in the development of secondary sex characteristics. In osteoarchaeology one primary concern is how to estimate age from the skeleton. On the other hand, there is the social construction of age, i.e. in which age category an individual is placed in society. To what degree is one's biological development decisive for the classification of an individual within the culturally variable categories infant, child and adult? In archaeology, it may be of use to define age according to three meanings; chronological age is a biological concept referring to age in years, physiological age is a medical concept referring to the ageing process and social age is socio-culturally constructed and refers to the existing age norms. Unlike gender, where the relationship to sex is strongly debated, age represents an expression of physical change and cannot be entirely culturally constructed. Its social meaning does, however, have an important structuring function in society (Sofaer 2006: 118–119, 121). In osteoarchaeology, the concepts of child and adult are defined through a distinction between the biologically immature and the mature skeleton, and biological development and degeneration is converted into chronological age. Immature skeletons are regarded as 'sub-adults' and adult mature skeletons and old age is often seen as a form of pathology, a deviation from the 'normal' (Sofaer 2006: 22). Bodies are not static, and together with the biological processes of growth and senescence, there is a constant wear and tear influenced over time by life events and circumstances also to be taken into account (Sofaer 2006: 127).

In addition to establishing biological profiles of age and sex and relating these to the appropriate social concepts, another major concern in osteoarchaeology is on the identification and diagnosing of pathology and disease. Skeletal pathology is recorded as indicators of health and living conditions. How do we define good or poor health in a population based on the study of skeletal remains? What physical expressions of health do we encounter and how are these related to the social concepts of health and wellbeing? Are we able to identify how these aspects are culturally determined?

Factors such as migration, for instance, may alter the demographic profile of a society and change the general health picture in the population; and physical conflict areas are likely to experience a range of problems from pollution of water supplies to physical and mental trauma in the population. Peoples' understanding and attitude towards disease is likewise essential for one's experience of illness or well-being, general behaviour and access to treatment (Roberts & Cox 2003: 10–12).

Social practices may influence human physiological change in the way that poor nutrition and disease can disrupt and prolong growth, reduce skeletal size according to chronological age and delay skeletal maturation (and dental, but this is less sensitive), child-bearing practices, such as time of weaning may affect an individual's health and produce skeletal changes, and sudden improvements in living condition may affect bone growth in sub-adults. Comparing growth rates between groups may be an effective means of studying stress levels between populations and activities that place a great amount of mechanical load on the skeleton may cause degenerative changes to accelerate. All these skeletal changes are produced by activities and develop over time, and are thus closely related to human life course and social practices. Indicators of stress in teeth and skeleton may develop during childhood, but it is argued that these lesions are visible and recordable only in the individuals strong enough to survive the stress episodes. Some authors term this 'the osteological paradox' (Sofaer 2006: 130–31). The essence of this theoretical view concerning the reconstruction of health in the past is that palaeopathology only in a few cases will define cause of death in the past, and most diseases will not produce any skeletal alteration. There is a risk that one will misjudge these individuals, and especially the children, as healthy. Another important source critical aspect is that a death assemblage does not directly reflect the living population, but rather those who died within a limited period of time. When studying children's health from a death assemblage, one needs to keep in mind that the representation of individuals that died at a young age does not equal the total amount of living children or have the same age and sex composition as the sub-adults in the population (Arcini 1999: 15).

Skeletal analyses are best directed towards identifying the processes that lead to skeletal modifications or pathological conditions, with a focus on the social practices that may have promoted them (Sofaer 2006: 134). The important question is not whether the human body is biologically or socially constructed, but how the expression of the body is contextually dependant and how these different aspects of human development may be archaeologically accessible (Sofaer 2006: 142).

Methodology

Dating

Proper dating of the material is essential to enable social and demographic analyses and to understand the assemblage in its cultural context. Due to long and intensive use of medieval cemeteries, the burial situation and the stratigraphy may often be confusing. The many inter-cut graves and the commingling of remains from neighbouring graves complicate the identification of graves, the relationship between them and eventually the possibility of dating the graves. The skeletal material included in this study is chosen bearing in mind the possibilities of establishing a burial date. This will enable further analysis of the health and social conditions in medieval times, and facilitate comparisons with other material.

The dating of the remains from the church of St Mary's is based on the Bryggen fire layer chronology, a combined absolute and relative dating system for the Bryggen excavations (Figure 7). Although the number of fires that struck Bergen before 1250 is debated, there is general agreement that the great fires of 1170/71, 1198 and 1248 hit the northern and middle town areas (Hansen 1998). The basis for the system is a range of fires in the area, with a dating based on historical and archaeological sources and the dendrochronological dating method. The core of the system is a chronology based on the relationship between culture layers and building remains – representing building phases and the episodes of destruction in between – represented by debris from the fire layers.

The fires are numbered VIII–0, the highest number representing the date, or suggested date of the earliest fire. Each fire represents a period of destruction between several fire interval periods, numbered in an opposite sequence (1–9); fire VIII, thus, corresponds with the end of period 1, fire VII with the end of period 2 etc. Each fire interval period may be represented by several building phases giving a further subdivision of

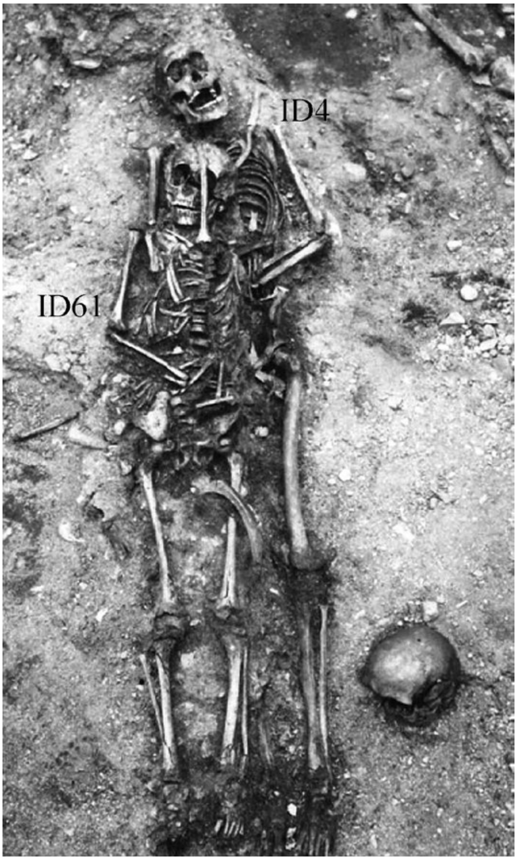

Figure 6 *Stratigraphic relation between an adult and a child burial at St Mary's. The graves are separated only by a thin layer of sand BRM 0/75030 & BRM 0/75031.*

Fire	Date	Fire Interval Period	Building phase
O	1955		
		9	9.2
I a	Prev. unknown		9.1 / 9.1.1
I	1702		
I b	Prev. unknown	8	8.2
			8.1 / 8.1.1
II	1476		
		7	7
III	1413		
			6.3
III b	1393	6	6.2 / 6.2.1
			6.1 / 6.1.1
IV	1332		
		5	5.2 / 5.2.1
			5.1 / 5.1.1
V	1248		
		4	4.2
			4.1
VI	1198		
		3	3.2 / 3.2.1
			3.1 / 3.1.1
VII	1170/71		
		2	2.2
			2.1
VIII	Prev. unknown		
		1	1.2
			1.1

Figure 7 *The Bryggen fire layer chronology of with fires, fire interval periods and building phases (After Herteig 1990).*

these, e.g. 9.1, 9.2, etc. (Herteig 1990: 12–19). The fire layers are not distributed without disruption across the entire excavation area. This has led to some problems in interpreting the relations between chronological sequences in different areas. Within the cemetery area, the fire layers are not continuous due primarily to the fact that the area lacked material such as buildings and wooden paving to represent the various building phases. The graves also represent numerous cuts out of phase causing further disruptions to the layers. The dating of the graves is based on a combination of Herteig's corrected fire chronology (Herteig 1990), dating of the two stone buildings in the area and the internal stratigraphic relations between the graves based on relational sequences according to the principles of the Harris matrix (Harris 1989).

Based on this information I was able to narrow down the dating of the graves considerably. The dating-intervals in the appendix represent the suggested date of each fire and the definitions before/ after or between these, i.e. 1198–1248 means after fire VI and before fire VII (i.e. period 4). The years rather than the number of fires are used in the appendix to better illustrate the narrow dating intervals in the sample.

Representativity

Archaeological remains are never complete. All data material is influenced by social practices and later reduced both through natural processes of decay and decomposition and through recovery and documentation procedures. This affects the representativity of the material. Skeletal cemetery remains represent a death assemblage, never a total of the once living population. Not even a total excavation of the cemetery, with the retrieval of all skeletal remains, will give access to all information on the buried population, and certainly not information on every aspect of people's lives. So is the case with all archaeological finds. Knowledge of such limiting factors is necessary to determine the character of the assemblage and avoid drawing biased conclusions.

The function of the church has implications for the representativity of the skeletal remains. If St Mary's Church functioned as a regular parish church, the skeletal remains would have a different demographic structure and health status than materials from a high status context or belonging to a specific group of people with restricted access to burial. Following the discussion on the function of the church of St Mary's, there is a chance that the representatives of the upper social classes in town were buried at the cemetery. This, however, does not rule out the possibility of other town citizens being buried at the same cemetery (Helle 1982: 590), and does not define the social status of the individuals in this skeletal sample.

That the cemetery is only partially excavated makes generalizations on population level problematic. It also limits the possibility of identifying cases of social or other forms of segregation at the cemetery. The provincial law of the Gulathing, operative in the western part of Norway and representative for the twelfth century onwards to the middle of the thirteenth century is one of the oldest provincial laws in Norway. In separate sections on ecclesiastical affairs, the law treats burial regulations and issues concerning the churches′ right and duty to bury, the right to be buried, and the prerequisites for burial. The laws exclude certain social groups such as the non-baptized, criminals and others from the cemetery. Contrary to the provincial laws from eastern

Norway, the Gulathing law does not require a spatial organization of the cemetery according to social class or sex (Sellevold 1999: 100–102).

Caution must be applied when inferring from the skeletal remains to the actual population, as one must always take into account the context of the material and be aware of the fact that the assemblage may not represent a regular population. Not only social behaviour, but also mortality influences the composition of the assemblage as it is not a random sample, but reflects the sex and age distribution, and the disease prevalence among those who died. The mortality is not random. In pre-industrialized societies and perhaps also in the Middle Ages, it tends to be high among infants and small children and higher among fertile women than men (Lynnerup et al. 2008a: 123)

Taphonomy

Taphonomy is the term applied to the processes that affects the survival and preservation of organic remains. In human osteology, it is the sum of events intervening between the death of a person and the present. This involves the action of physical, biological and chemical agents and includes methods of discovery, retrieval and curation of the remains (Spencer 1997: 1019). It is also influenced by factors like mortality and burial custom. The completeness and degree of preservation of the remains influence the representativity of the material. Taphonomic factors may influence the age and sex composition, distribution and anatomic composition of an assemblage (Lynnerup et al. 2008a: 121). The applicability of methods for ageing and sexing, metric analysis and the possibilities of identifying anomalies in the bones diminish with a high degree of fragmentation and the loss of morphological features due to breakage and decomposition. The skeletal remains from St Mary's are of varied completeness and preservation, but generally acceptable to permit further osteological analyses. The completeness and state of preservation have been recorded for each individual, which enables the results to be viewed in light of possible limiting factors.

Archaeology – techniques of excavation, documentation and recovery

Techniques of excavation, recovery and documentation affect the scientific potential of the material. The standard of procedure for the Bryggen excavations differs in many ways from today's methods of recovery and documentation, although the excavation introduced methods of recording stratigraphy and archaeological contexts that were ground-breaking at the time, and play an important role in archaeological methodology today. All skeletal remains are drawn in plan and plotted with geodetic (x,y,z) data according to an internal grid system applied during the whole period of excavation at Bryggen. Levels are taken on the scull, shoulders, chest, elbows, hands, pelvis, upper thigh bones, knees, ankles and feet. The drawings are detailed and show the direction of the scull/ face and arm/ hand/ feet/ toe position (cf. Figure 9). There are corresponding photos of the majority of the skeletons before lifting.

Unfortunately, only in rare cases are the outlines of the grave and the grave-cuts documented which must at least partially be due to disturbance of the soil from intensive burial activity. In most cases, the graves are represented only by skeletal remains. Only in cases where several individuals are found particularly close together are the

Figure 8 *Well-preserved skeletal remains from St Mary's cemerety. Note the almost intact fragile bones of the scull and the ribs. (Field doc. Bryggen excavation).*

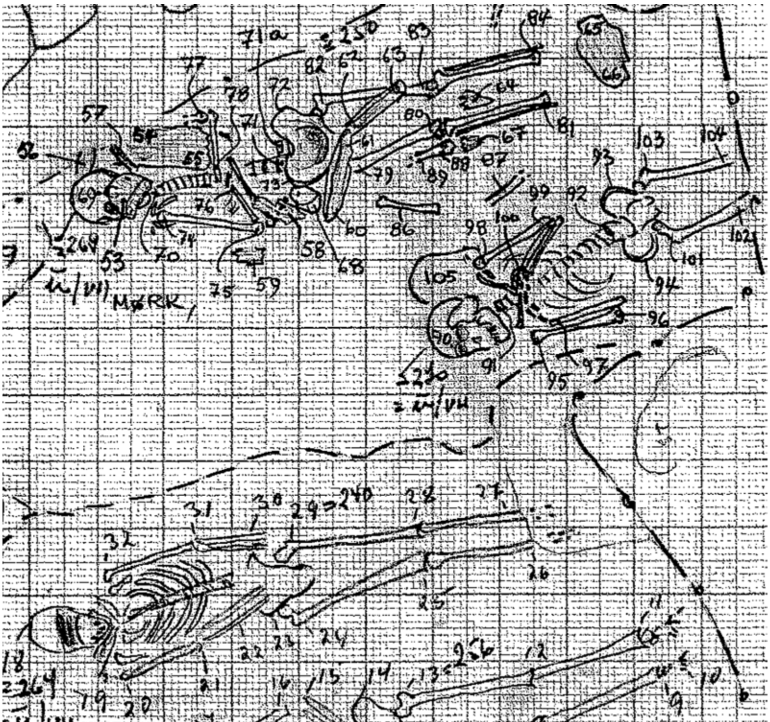

Figure 9 *Detailed plan drawing of graves south of St Lawrence Chapel (Field doc. Bryggen excavation. Drawing: Egill Reimers).*

possibilities of multiple graves discussed. Otherwise, the possible disturbance to graves, with the introduction of loose bones in the grave-fill, and possibilities of distinguishing between single and multiple burials from stratigraphy is thoroughly described in the field notes. Finds of possible remains of cists and nails, are noted, but the finds are few and do not allow for a systematic study of burial practice.

Systematic retrieval of the bone elements, with special care as to collect sex and age diagnostic elements, together with separate packing and labelling of each individual, has strengthened the analytic potential of the remains. There is, however, a systematic bias in the collection of disarticulated remains and skeletal elements that are not contextually related to graves. This is documented in the field diary which tells of large quantities of animal bones and other skeletal elements from the upper disturbed layers at the site. These were not recovered; instead, a methodology was agreed upon where only skeletal remains related to documented graves would be collected. Unfortunately, during the years following the excavation, several crania have gone missing. These have been removed from the collection for research and exhibition purposes and have not been replaced or labelled properly; proof that recovery practices do not end with the completion of an excavation.

Anthropological data

Inferring health from skeletal remains is a complicated task, involving the placing together and comparison of a vast amount of data. As mentioned, a skeletal assemblage does not represent the living population, but rather the individuals that died within a certain period of time; hence, it represents the part of the population that failed to adapt to health threats. The primary health indicators, pathological lesions, are difficult to interpret, as the absence of pathology is not always consistent with good health, but often the opposite. Healthier populations may in fact display worse skeletal health because of high age and the effect of mild, chronic skeletal pathologies (Robb 2000). There is also a possibility that only the strongest individuals survived long enough to let a disease affect the skeleton. These problems are related to the term 'the osteological paradox', an important critical view on health and disease studies in osteology (Wood 1992: 15; Arcini 1999). The absence of a disease may imply that the person did not have the disease, that the individual died before the bone changes occurred, that the immune response was strong enough to prevent bone lesions from occurring or that the disease only involved soft tissue and not skeletal elements (Scheuer & Black 2000).

The study of health indicators in skeletal assemblages often reflects death in a population over several hundred years and short-term variations in health and disease prevalence may easily be missed. Establishing the individual's background and making generalizations on the health situation in a population may prove difficult. This shows the importance of establishing a good dating for the material. This is one of the strengths of the material from the cemetery of St Mary's.

Osteological methods

The value of skeletal data is highly dependent on methodology, analytical procedures and the presentation of data. In order for results to contribute to archaeology and create a sound basis for interpretation, there are certain requirements that should be met. Reports should contain information on the archaeological context of the remains, basic data on the number of individuals and an inventory of all skeletal elements and teeth and preferably also joints present. This is crucial for determining, for instance, the prevalence of pathology. Likewise, all methods of analysis should be thoroughly referenced to avoid confusion (Roberts & Cox 2003: 397–403). This also facilitates further research on the remains and serves as an important control for the validity of results.

To establish a starting point for interpretation, it is necessary to determine the biological profile of the human skeletal remains and various methods for determining sex, age and stature have been employed. Reported degree of accuracy, facility of use and time and cost-effectiveness determine the applicability of each method within the scope of this thesis and are factors that have influenced the choice of methodology.

All skeletal observations are made by visual examination (naked-eye inspection, or using magnifying equipment and low power light microscopy). Dirt and adhesives were removed from all bones and teeth prior to the investigation. This was primarily done by dry-brushing, but in some cases careful brushing with water and methanol was necessary. Care was taken to identify any signs of commingling in the boxes, such as the presence of duplicate bones. No attempts were made to reconstruct broken bones. For measurements, a Palaeo-Tech Laboratory Osteometric Board, anthropometric sliding and spreading callipers and measuring tape were used.

As a support to the general analysis, human adult and sub-adult skeletal remains[4] and casts[5] of cranial and post-cranial elements were applied along with a selection of human osteology text. The methods used are non-destructive. All methods and techniques applied in this analysis are presented and referenced below. Although analyses of trace element, isotopes and DNA have proven valuable in studies of ancestry, migration, diet and disease in the past, it has not been possible to undertake any chemical, histological or microbiological analyses for this study without extra funding. Radiological examination may contribute significantly in diagnosing disease and detecting growth stress indicators in the bones, but a systematic examination of this kind has not been within the scope of this study.

All skeletal data has been recorded in databases. This allows for storage and the systematization of large amounts of data. The main source for the analysis is the bone inventory. In general, all bones have been identified according to bone element, part of the bone and side and all present joints are registered. Any anomalies and ante-, peri- and post-mortem damage to the bones have been recorded. Registration forms have been used for visual registration of each bone element. Any duplicate or disassociated remains have been labelled separately. Good labelling of the boxes and field documenta-

4 From the bone reference collection at the Bergen University Museum, Natural History Collection.
5 Obtained from *France Casting*, USA.

tion made successful re-association of skeletal elements possible in several cases. Photos were taken when necessary.

The skeleton database is the main database of all individuals. It is built on the standards for the main finds catalogue at Bergen Museum, the medieval collection, and it shows the accession numbers and find context of all individuals supplied with relevant information on completeness and preservation, dating, arm position, sex, age, stature, various anomalies and the presence artefacts in the grave.

The bone and joint inventory contains information on all bones, joints and teeth in the material, such as the presence, absence and degree of completeness of each bone. The information is valuable for studies of preservation and disease prevalence and is a requirement for comparative analyses. The database is based on recommendations for data collection and recording found in BABAO's *Guidelines to the Standards for Recording Human Remains* (Brickley & McKinley 2004), and the guidelines to recording joint disease offered by Rogers and Waldron (Rogers & Waldron 1995).

The *dental inventory* records the presence and absence of all teeth, deciduous and permanent, for all individuals, as well as information on ante and post-mortem tooth loss, non-erupted or erupting teeth and possibly congenitally missing teeth. The teeth are numbered according to the FDI-system classification system (Hillson 1996) which is in current use and corresponding with the system found on the visual recording forms (Buikstra & Ubelaker 1994: att 14a/b; Krogman & Iscan 1986: 357).

The *table of post-cranial measurements* contains cranial and post-cranial measurements of all individuals. The information enables comparisons on robustness, bone length and dimensions between individuals and assemblages and serves as basis for stature estimations.

The *pathology and trauma record* contains information on the presence of skeletal and dental pathology. Relevant traits are recorded and categorized according to various disease diagnoses. Together with detailed description of all traits, type of lesion and location on the body and teeth this will aid in interpreting and presenting the results. The purpose of such minute recording is to allow comparisons of prevalence in skeletal collections with different levels of preservation. The field documentation proved useful during the inventory phase as it facilitated the identification of commingled material, post-excavation damage and loss of material during storage. It is important for future research in general that osteological reports and publications report on methods of analysis and present raw data or a collation of data rather than a list of skeletons with sex, age, stature and diseases present. Stating the prevalence rate of particular conditions and diseases is likewise important (Roberts & Cox 2003: 29–30).

An important methodological problem is the bias in the assemblage on which the methods are developed. Some archaeological and contemporary assemblages either lack sufficient information on age and sex, or carry important socio-economic and genetic bias. This may affect health and mortality profiles and create systematic errors in results. Ideally, all methods applied should be developed on assemblages similar to the target population.

To minimize such errors, population-dependant or age and sex-specific methods have been applied when necessary. All methods applied are in current anthropological use. The reliability of the methods is enhanced by the fact that the degree of error has proven to be less significant in a sample than for individual estimates (Cox 2000: 64).

Sex

Assessment of biological sex is essential for establishing the demographic profile of the assemblage, for studying sex-specific age-distribution, patterns of health and the spatial organization of the cemetery (Arcini 1999: 47). Determining the sex-distribution in a population makes it possible to study demographic patterns, such as sex-specific age-distributions and mortality, health and disease or specific activity patterns. It also enables the study of patterns of behaviour, different attitudes to men and women in society and social status. The determination of sex has been necessary to enable further interpretations on the demographic composition of the assemblage and to uncover possible differences in living conditions, level of physical stress and diseases prevalence between the sexes. Additionally, the use of several techniques of stature and age-estimation requires that sex is established (Cox & Mays 2000).

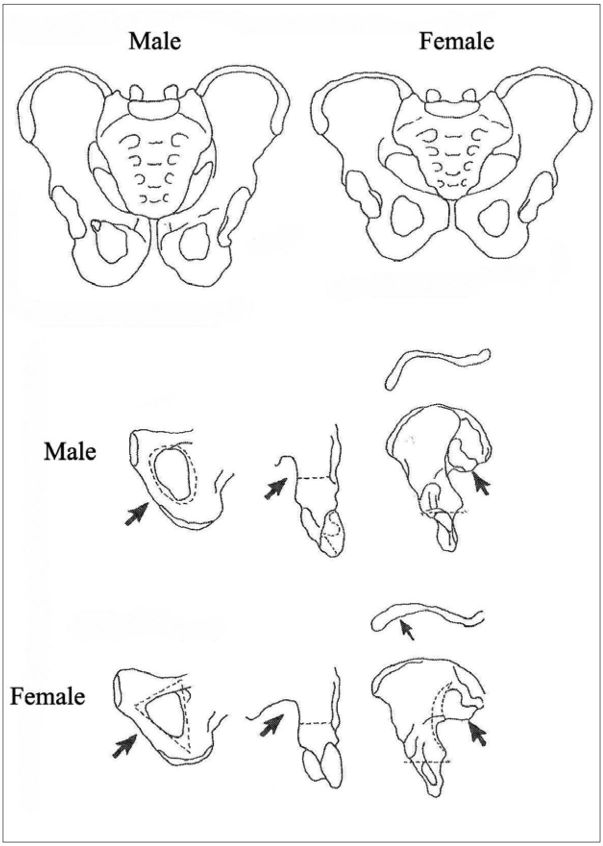

Figure 10 *Sexually distinct features of the pelvis. Male pelvis to the left (After Lynnerup et al. 2008).*

The sex-estimation is based primarily on the sexual dimorphic features of the cranium and the pelvis (Figure 10). The morphology of the pelvis is associated with the body's functional aspects and has been assigned more importance as an indicator for biological sex. Skeletal robustness and stature correlate to a certain degree with sex, and have contributed to the overall estimate, however, not as a single indicator. Choice of method has varied with preservation and degree of fragmentation of the remains. The accuracy of the method depends on the state of preservation and the completeness of the remains, as well as the general degree of expression of sexual dimorphic traits in the individuals.

The sexually distinct morphological features are expressed in the skeleton post- puberty. Assessment of sex in this study was limited to the sub-adults passed the age of c. sixteen and the adults in the assemblage and based on the sexually dimorphic features of the pelvic girdle, skull and mandible. The main differences between the male and female pelvises are the shape and width of the pelvic inlet and the degree of vertical orientation of the innominate bones. The male pelvis is generally more narrow and robust than the female. Dimorphic traits of the pelvis traditionally used for sex estimation are for instance, the angle and depth of the greater sciatic notch; the shape of the obturator foramen and the pubic bone which in turn affect the size of the sub-pubic angle and the presence of a sub-pubic concavity. Further, there is the presence or absence of a ventral arc, the sharpness of the ischiopubic ramus, the elevation of the auricular surface and the presence or absence of a pre-auricular sulcus (Phenice 1969; Buikstra & Ubelaker 1994; Rogers & Saunders 1994; Bass 1995).

The character of the composite arc and the pre-auricular sulcus are also distinguishing features (Krogman & Iscan 1986). The accuracy of the Phenice method is estimated to be between 80 and 95 per cent (Phenice 1969; Lovell 1989). A disadvantage to the use of the method is the poor preservation of the pubic part of the pelvic bone in archaeological specimens.

The morphological features indicative of sex on the skull are: the angle of the frontal bone, the rugorosity of the nuchal crest of the occipital bone, the volume of the mastoid processes, the thickness of the orbital margin, the shape of orbits and size of the glabella (Figures 11 and 12). The overall appearance of the male cranium is robust (Bass 1995; Brothwell 1981; Buikstra & Ubelaker 1994). The mandible shows sexually distinctive traits in the degree of projection of the mental eminence (chin) in particular, but due to reported sexual ambiguity, this feature is considered less reliable in the estimation of sex (Maat 1997).

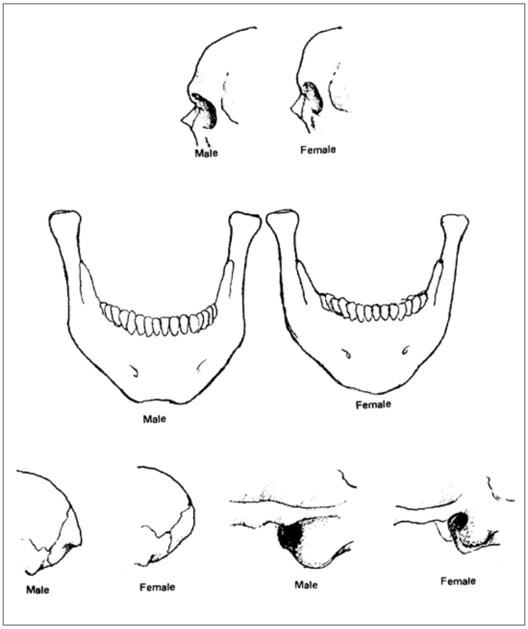

Figure 11 *Sexually distinct morphology of the skull. Female skull to the left (After Mays 1998: 37).*

The techniques for determination of sex used in this study are based on methodologies and standards developed at symposia on the consistency of methods in biological anthropology (Ferembach et al. 1980; Buikstra & Ubelaker 1994). The first method emphasizes the correct evaluation of traits by offering a numerical scoring system which ranks the significance of each trait for the determination of sex (Ferembach et al. 1980). The second method resulting in the collation of a set of standards, offers good character trait descriptions and visual figures to the methodology of the previous (Buikstra & Ubelaker

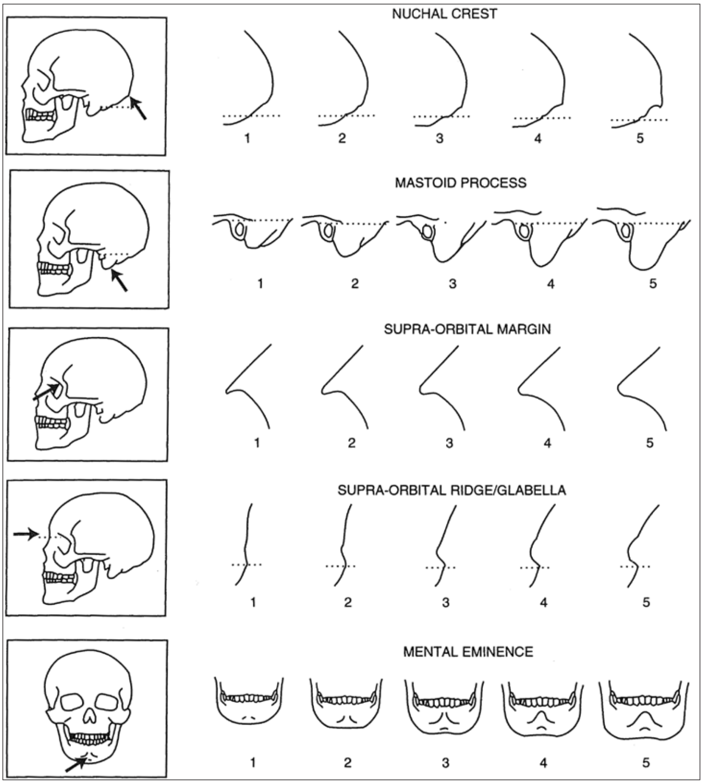

Figure 12 *The ranging of cranial features from typical female to typical male according to Buikstra & Ubelaker 1994.*

1994). The methods can be considered complementary, and elements from both were applied in this study. The procedure is as follows: Each of the examined traits is assigned to the category M (male), M? (probable male), ? (indeterminate), F? (probable female) or F (female) and each individual is scored separately for all present traits. The most numerous character, taking into account the abovementioned ranking of importance determines the overall sex. The traits considered here are listed in Figure 12.

Metric assessment of sex can be useful, and often the only possibility of estimating sex in fragmented remains. Sex may be determined from humeral and femoral head measurements (Stewart 1979: 100, 120). Table 1 shows the size ranges applied.

		Sex		
Female	**Female?**	**Indeterminate**	**Male?**	**Male**
<42.5	42.5–43.5	43.5–46.5	46.5–47.5	>47.5

Table 1 *Measurements of the femur and relation to biological sex (mm). (After Stewart 1979: 120).*

The methods are not generally applicable, however, as the reliability of the estimates depends on similarities between the population under study and the populations on which the method was developed (Brickley 2004: 19–21; Mays & Cox 2000). All sex traits have been viewed in relation to the general skeletal appearance of the individual, as men tend to be more robust and women more gracile. Deviations can be found in young men in particular, as they tend to show a more female skeletal appearance. Hard physical activity may also influence this, hence complicating the picture. It has been claimed that differences in muscle mass between sexes relates to differences in activity patterns, hence men carrying out a great deal of the hard physical labour (Kennedy 1989: 137). Some authors do, however, state that physical sex differences in muscle markers is only partially due to differences in activity patterns, and partially to a natural difference in body size between the sexes. Enhanced muscle mass is also seen with increasing age (Weiss 2004). Overlapping size and robusticity in male and female skeletons may complicate sex determination. It is suggested that on the skull in particular, the use of fewer, clearly defined dimorphic traits rather than a vast amount of traits may improve accuracy and inter-observer reliability (Walrath 2004).

The sexing techniques applied are listed in table 2. The table shows the observed traits and references to methods used. As far as possible the whole range of techniques were applied. The pelvic estimates are considered to be more reliable, hence given most importance. No definite sex (M/F) is assigned to individuals where the scull and pelvis or the pelvis only is missing or severely fragmented. Nor were any of the individuals sexed from metrical traits exclusively.

Scull	Nuchal crest	Buikstra & Ubelaker 1994
	Mastoid process	
	Supra-orbital margin	
	Glabella	
	Mental eminence	
Pelvis	Subpubic concavity	Phenice 1969
	Ischiopubic ramus Ventral Arc	
	Subpubic angle	
	Preauricular Sulcus	Krogman & Iscan 1986
	Composite arc	
	Greater sciatic notch	Brothwell 1981/ Buikstra & Ubelaker 1994
Metric traits	Diam. humeral head	Stewart 1979
	Diam. femoral head	

Table 2 *The morphological traits examined for sex-assessment and reference to method.*

To control for intra and inter-observer errors, a second round of brief sex- and age-assessment has been performed by the author and a control check by an external examiner. The results correlate well with each other.

Age

The primary reason for assessing age among the buried was to establish the age distribution in the assemblage and gain an understanding on the demographic composition of the material, health status, and age variation between the sexes (Manchester & Roberts 1995: 22–23). In addition, determination of age is fundamental to the understanding of disease and trauma in a population. Age distributions in this particular context, not dealing with a total population but a partial death assemblage, can still serve as an informant on the prevalence and distribution of certain pathological conditions according to age. This in turn could give an indication on the health situation among the town people. Studying the age distribution at a cemetery could also detect possible age segregation.

All estimates measure the biological age of the individuals, i.e. the stage of biological development or degeneration. Variations in genetics, environmental conditions and nutritional status and health, may result in deviations from the exact chronological age of an individual and one should always bear in mind these limitations to the methods.

The techniques used for the assessment of biological age is based on the various stages of dental and skeletal maturation, the fusion and obliteration of immovable articulations (synarthroses) and the ossification of cartilaginous regions in the body. Plastic casts, diagrams and photographic and text material has aided the assessment. All observations are done macroscopically. Separate non-adult and adult techniques are used.

Because none of the techniques for age estimation account for variations in growth and degeneration across sex and populations, ranges of age are given, and the individuals assigned to different age groups. The final estimates take into account the age ranges of all indicators. Overlaps indicate that the individual is more likely to fall within that particular age-range.

The individuals are assigned to different age-groups reflecting the lifespan of the individual with major stages of skeletal development and age-related degenerative changes (Table 3). The terminology varies somewhat between paediatricians and biologists, but the main age-groups used in this study are chronological phases that roughly correspond to these stages and to the categorization commonly used in skeletal biology (Scheuer & Black 2000). In sub-adults, the prenatal period corresponds to the time before or around birth, the infant and Infans I stages from birth to six years, Infans II from seven to twelve years and the juvenilis period to the ages between 13–18/23. The upper limit is characterized by the fusion of the iliac crest epiphysis between the ages 18–23. For the adults, the period adultus corresponds to early adulthood, 20–39 years and maturus to the period between 40–59 years. The elderly and old individuals are placed in the 60+ category. A further narrowing down of the adultus group into younger and older individuals is possible but has not been applied in this study. Among the older age-groups no further narrowing down is attempted due to the limitations in ageing techniques that occur at high ages. In cases where no further ageing has been possible, the individuals are categorized as merely sub-adult (<20) or grown (>20). In cases with overlap, the mean age in the estimated age-interval was decisive for the allocation. The interval 35–45 occurred in five cases, whereof four were split equally between the sexes in the adultus (20–39) and maturus (40–59) age-groups. The remaining was placed in the maturus group.

Age group	Age	Criteria
Prenatal	< 3 mths	Premature or full term
Infant	< 1y	Birth to 1 year
Infans I	1–6	Until eruption of M1
Infans II	7–12	Between eruption of M1 and M2. Epiphyses unfused
Juvenilis	13–18/23[6]	Fusion of secondary growth centres, eruption of M3, closure of sphenooccipital synchondrosis
Adultus	20–39	Minimal dental attrition, marked relief of the pubic symphysis, initial stage of cranial suture closure, youthful to worn appearance of the auricular surface
Maturus	40–59	Considerable dental attrition, pubic symphysis and auricular surface partly obliterated
Senilis	60 +	Severe attrition – often uneven, obliteration of cranial sutures. No relief on pubic symphysis or auricular surface, advanced degeneration
Grown	20 +	No further determination possible
Indeterminate		Sub-adult or adult, not determinable

Table 3 *Age-groups and general ageing criteria. After Arcini (1999), Sellevold (2001), Scheuer & Black (2000), Kjellström (2005).*

Sub-adults

The non-adult ageing methods are based on dental and skeletal formation and maturation (Figure 13). The developmental age of the child is estimated based on the stages of mineralization and eruption of the deciduous and permanent dentition, the bone mineralization and the time of fusion of the epiphyses (Scheuer & Black 2000).

In sub-adults, growth and maturation is highly influenced by nutrition, disease and various environmental factors (Scheuer & Black 2000). However, complicated this might be for the estimation of age, it may have interesting implications for the study of sub-adult health. In cases where the post-cranial estimates diverge from the dental estimates, the latter is relied on. This is due to the lower susceptibility of dental development to malnutrition and other stress factors (Hunter 2005).

Among sub-adults in late puberty and young adults, the final skeletal development of the pelvis and medial end of the clavicle, the fusion of the sacral segments and the development of the vertebral bodies may give important indications of age (Scheuer & Black 2000). Here, age-estimates for post-cranial elements and teeth are compared with available stature estimates for sub-adults. This may enable the detection of growth retardation related to episodes of poor health or disease in the child. Due to individual variations in stature, this is more relevant in the study of large assemblages. Nevertheless, this could be a good method for identifying severe cases of inhibited growth in individuals and relating this to pathology findings.

6 In the following, the teenage and young adult/adult intervals will be presented as: 13–19, 20–39. This is for practical reasons only, the osteological criteria for distinguishing sub-adults and adults are the same.

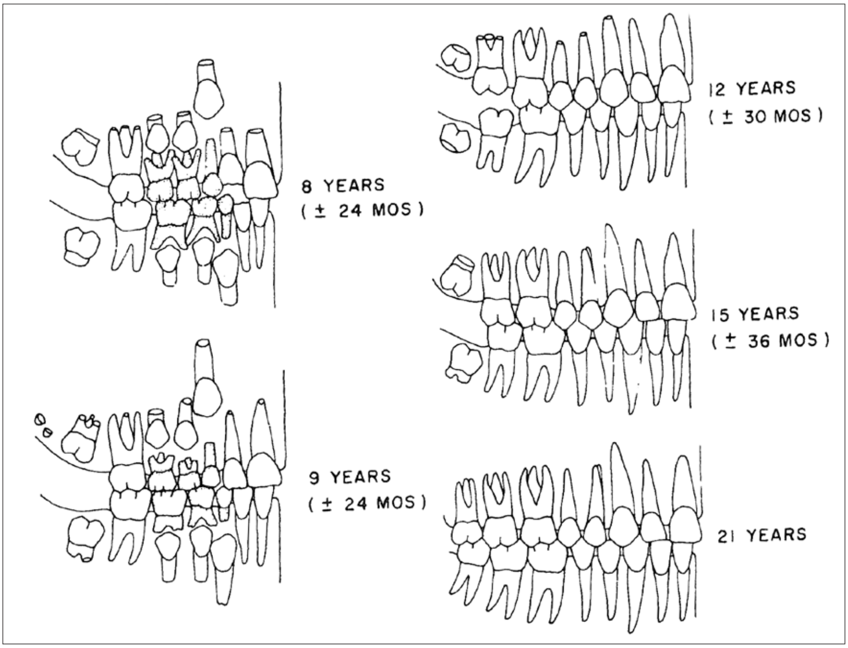

Figure 13 *Dental ageing diagram used for ageing sub-adults. Selected age-ranges (After Bass 1995: 304).*

Adults

Ageing adult skeletal remains is a complicated matter. Adult ageing methods are based on the timing of degenerative changes in the bones, but the relationship to a specific age is not straightforward. Due to large estimate errors, a combination of all applicable methods is preferred.

In mature bones, age-related degeneration of the auricular surface of the innominate bone (pelvis) and the pubic symphysis are important. Due to good preservation of the auricular surface, the former method played an important role in this study. An important advantage of the technique is that the auricular surface is less affected by movement than other joints. The degenerative changes observed are therefore less likely to be activity-induced. The morphology of the joint face is reported to change only by age, not by ancestry and sex. It is suggested that the 5-year-age-ranges applied by some authors (Lovejoy et al. 1985) are too narrow (Osborne 2004). Scoring methods to refine age-categories have been developed, and it has been indicated that the method only indicate broad stages in life (Buckberry 2002; Falys 2006). Because the age-categories applied in this study only distinguish between 'young', 'middle-aged' and 'elderly' individuals this is not believed to have had a major influence.

The degree of dental attrition and the closure of the cranial sutures are factors associated with age. Dental attrition increases with age, but is also strongly influenced by a person's diet and general health which may give slightly unreliable estimates. The great

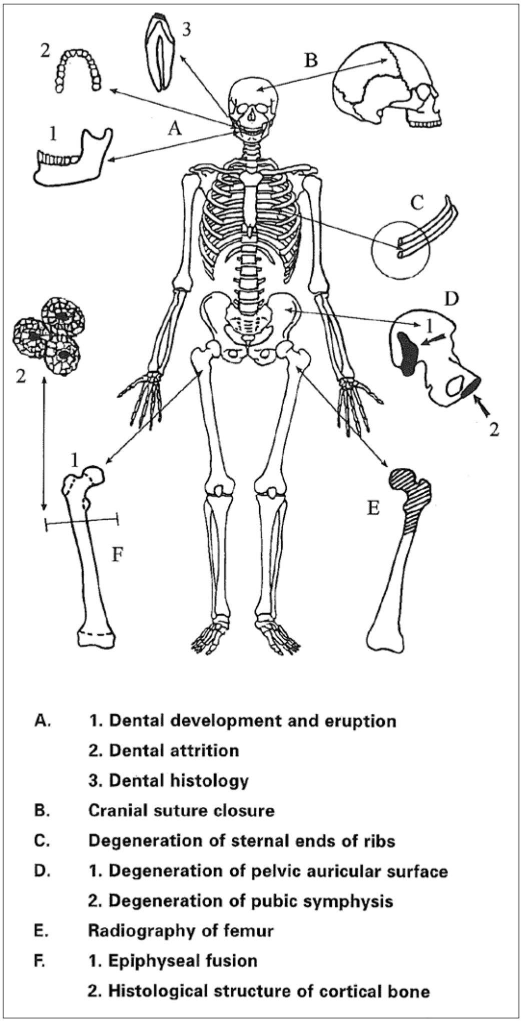

Figure 14 *Areas of the skeleton used for sexing adults. (After Hunter 1997: 112).*

variation seen in the closure of the sutures and a failure to understand the factors promoting the changes makes the method less favorable for estimating age in adults (Cox 2000: 68). One suggestion has been to apply the method only as a guideline, where open sutures indicate an age lower than 35 and obliterated sutures ages above 50 (Lynnerup et al. 2008a: 76).

Although the development of muscle insertion sites (entheses) progresses to a certain degree with age, no individuals are aged based on the size of such or the overall dimension of bones. The development of muscle markers are influenced by age, sex, activity patterns and environmental stressors, and studies have shown that age-related changes may not be statistically significant for both sexes (Wilczak 1998). Likewise, no age-estimates are based on the macroscopic study of degenerative changes or pathology, for instance arthritic changes, of the synovial joints. These changes have a complex etiology and are not solely associated with advancing age. Relying on these indicators in the estimation of age may produce circularity in arguments on disease prevalence and ageing (Brickley 2004: 18; O'Connell 2004: 18); it will create a bias in the age-estimates and important epidemiological information will be lost (Rogers & Waldron 1995: 32–33, 104–106).

Table 4 refers to the methods of age determination in the present study. Dental development and epiphyseal fusion are the preferred methods for the estimation of age in sub-adults. Dental development is influenced primarily by genetic factors rather than environmental conditions, and has been given the most importance here (Aufderheide 1998: 395).

In adults, the degenerative changes of the pelvis have shown to give more reliable estimates (Whittaker 2000: 84). The age-intervals for the auricular surface of the pelvis available presented by Lovejoy et al. (1985) may provide ages that seem overly exact. The methods are better fit for giving overall estimates on a population-level than in individuals. The intervals do, however, indicate within which age-range the individual is more likely to belong. If possible, the age estimates of the pelvis are combined with other available traits such as suture closure and dental wear.

Ageing methods	Trait	Method reference
Dental development	Mineralization/ Eruption	Schour & Massler (1941) Ubelaker 1989
Post-cranial growth centres	Medial clavicle Various post-cranial elements Sacrum segments	Black & Scheuer 1996 Scheuer & Black 2000
Pelvic growth centres	Iliac crest Ischial tuberosity Iliac spine	Scoles et al. 1988
Cranium	Suture fusion	Meindl & Lovejoy 1985
Degeneration of pelvis	Pubic symphysis Auricular surface	Brooks & Suchey 1990 Lovejoy et al. 1985
Stature/ growth	Sub-adult diaphyseal length	Maresh 1970

Table 4 *List of methods and references to methods employed in age-estimation.*

Stature

The body height depends largely on genetic factors, but a part of the growth process is influenced by external environmental factors and stature and growth rates can be an indicator of the health status in a population. Stature fluctuations in or between populations may indicate variations in health and nutritional status and point towards differences in socio-economic status. Inhibited growth in children and small adult size can be used as indicators of environmental stress and give important information on the health issues and the level of well-being in a population (Humphrey 2000: 35). There is a relation between stature and diet, where diets low in essential vitamins and trace elements are associated with growth disturbance, disease and increased mortality (Manchester & Roberts 1995: 163–164).

Measurements of long bones have been taken in adults and sub-adults with fused epiphyses and on the diaphyses of long bones in infants. All measurements are from the left side, substituted by the right when necessary. Only adult measurements are included in the calculations on individual and average height presented in this study. Although infant measurements together with age-estimates may give important insight into the health status of children, there are too few sub-adults in the material to create a valid statistical unit. An overall view on sub-adult health will be given.

The calculations of body stature (living height) are based on the regression equations developed by Trotter and Gleser (1952; 1958) and Sjøvold (1990).

The 'Trotter and Gleser method' is ancestry, sex and age-dependent and based on the study of a North American assemblage. The 'Sjøvold method' is applicable on assemblages of unknown biological profile, and has shown a reduced tendency to overestimate smaller and underestimate taller populations. The 'Trotter and Gleser method' was developed based on the body proportions of young, Northern American males that fell during the Korean War. There is a risk of introducing a bias when applying the same method on Scandinavian material from the Middle Ages, i.e. suggesting that the heights correspond when we know that body heights have increased in this period. In fact, tests on Scandinavian material of medieval date have shown that the Trotter and Gleser method have a tendency to over-estimate heights (Lynnerup et al. 2008: 100).

As the choice of method varies among osteologists and anthropologists, both methods have been applied in order to facilitate comparisons. The Sjøvold measurements have been referred to in the text, unless stated otherwise. Stature estimates in the main catalogue are calculated from measurements taken on the femur, humerus, radius and ulna, in this order of preference. Estimates used in the statistical processing of the results are either from the femur or the humerus.

Because of the range of methods for stature estimation available, it is useful to apply the proper bone lengths when comparing different skeletal materials, and not the estimated heights, as these have been influenced by yet another source of error through the stature calculation. Stature measurements may, however, be useful for illustrative purposes, bearing in mind the possible introduction of bias.

The main reason for growth retardation in an individual is malnutrition and exposure to infectious disease. The character of the developmental stress causing growth disturbance may not be possible to determine and may not have been caused by a single factor alone. Skeletal and dental studies along with the study of archaeological evidence may give useful indications as to the character and causes of such unfavourable conditions. Stress can cause a delay in skeletal and dental maturation with smaller adult bone size and a prolonged growth period along with various skeletal growth deficits as a result (Humphrey 2000). Changes in mean adult stature in a population over time, may serve as an indicator of improved or deteriorated health. The same applies to the changes in mean long bone length. Chronological changes are, however, not a main focus of this study, but studies on height variation and fluctuations in and between populations may elucidate important aspects of health and disease.

Non-metric traits

Skeletal non-metric traits represent human variation and can give important information on the diversity, gene flow or levels of interbreeding in a population. As many non-metric traits are considered to be genetically inherited, the study of these are often expected to give important information on a person's ancestry and the presence of family groups at cemeteries and on burial grounds (Tyrrell 2000: 110; Brothwell 1981). I have recorded the presence, number and location of cranial features such as the frontal metopic suture, supra-orbital foramen or notch, i.e. a bridging of bone over nerves and sutural bones in the material. Due to the complex nature and distribution of such traits, and limited sample size, further interpretation of the results is complicated. High frequencies of these traits in individuals buried within the same area of the cemetery, is considered a strong indication of biological relationship (Petersen & Alexandersen 2008: 113).

Skeletal and dental pathology and trauma

The purpose of the examination of pathologies and trauma was to identify conditions that might give evidence on standard of living, and if possible relate these to specific events or life-styles affecting an individual's physical development and general well-being. The distribution of disease with age and sex may reflect social and cultural practices such as the access to treatment and differences in living standard.

The primary goal of such studies in an archaeological context is not necessarily to identify cause and manner of death of an individual, as this would be possible only in very few cases. The purpose is to gain an understanding of the presence of disease and violence in society, or the amount of physical hardship experienced by the general population.

Pathology and trauma has been recorded using magnifying lenses and light microscopy when necessary. Drawings and photographs have aided identification, along with verbal descriptions and measurements. The lesions have been identified to side of the body, bone element, and localization on the bone.

The distribution of lesions and the possible relationship to other pathology or trauma is noted in an attempt to gain an overall picture of health status. Identification of specific diseases through dry bone studies may prove difficult because a single bone lesion could be attributed to a range of diseases. The fragmentary state of many archaeological assemblages and lack of soft tissue complicates proper diagnosing. Classification of disease is based on known characteristics of specific diseases from clinical and archaeological studies, the likely co-occurrence of different diseases and the identification of signs unique to a disease or frequently occurring with a disease. Good descriptions of lesions are important and differential diagnoses should always be considered. Since many diseases show similar bone expression, as with the many joint diseases, for this analysis, assigning a lesion to a disease category rather than reaching a specific diagnosis has been the aim.

In recording traces of disease and trauma, attempts have been made to distinguish between ante, peri and post-mortem lesions (events occurring before, around or after the time of death). Bone reacts to disease with either new bone formation, destruction of bone or a combination of the two. The character of the bone reaction may indicate the chronicity of the disease, and whether it was healing or active around the time of death. This may reflect a person's ability to overcome and recover from hardships in life.

The character and the distribution of lesions reflects the severity and longevity of the disease which in turn is linked to the general health and immunity of the sick (Roberts & Cox 2003). Healed lesions show recovery, active pathological lesions or trauma may point towards a cause of death, and post-mortem wound damage may be the result of excavation damage or taphonomic processes. Determining that a bone lesion was active at the time of death does not prove that the lesion is the cause of death. The cause of death in the past was in most cases acute diseases that killed before they had time to leave traces in the bones (Roberts & Cox 2003: 17).

During the examination, the degree of severity of the diseases has been recorded for calculus, linear enamel hypoplasia (LEH) and cribra orbitalia (CO) (Brothwell 1981: 151–61; 163–66). For the remaining pathological conditions a ranking is problematic since the size and extent of a lesion is not always related to the progress and severity of the disease or to the individual's experience of illness. There is no one-to-one relationship between the severity of a disease and the symptoms experienced by the patient. A recent study on joint disease in the elbow found a considerably higher prevalence of the condition in archaeological populations than in clinical specimens. Despite severe skeletal abnormalities of the elbow, in many cases the patients lacked clinical symptoms of the disease, such as physical pain or functional impairment. A higher prevalence in archaeological assemblages may reflect an under-estimation of the disease in modern specimens. This may affect our view on markers of stress and the degree of physical activity experienced in past populations (Debono 2004).

Dental disease

Teeth have a robust structure and are often preserved in archaeological contexts. Teeth may provide information on diet, oral hygiene, stress, occupation and cultural behaviour. Dental disease was common in past populations, particularly infectious diseases like caries, periodontal diseases often resulting in tooth loss, and enamel defects (Manchester & Roberts 1995: 45). The recording of dental pathology follows the standards outlined above. All deviations from normal tooth anatomy have been recorded. Among the pathological conditions recorded are: the presence of carious cavities, dental abscesses, calculus, tooth loss, periodontal disease, enamel defects and discoloration.

Dental caries is an infectious disease caused by the fermentation of food sugars by bacteria in the mouth. The production of acids cause demineralization of the teeth and may produce carious cavities. Influencing factors are nature of diet, the presence of pathogenic agents like bacteria, oral hygiene and tooth morphology (Manchester & Roberts 1995: 46). Dental caries can lead to dental abscess in the exposure of the dental pulp cavity through trauma or severe attrition and the introduction of bacteria in the cavity. An inflammation may cause the accumulation of pus that eventually creates a hole in the surface of the jaw, a stage where the condition can be observed in the bone. Osteomyelitis is caused by the extension of root abscesses beyond the tooth regions and the following destruction of jaw bone (Aufderheide 1998: 409).

Another indicator of oral health is calculus. This is the mineralization of dental plaque accumulated through eating and protein-secretion of the saliva. The prevalence of calculus could reflect dietary patterns and periods of inhibited chewing, for instance during illness (Manchester & Roberts 1995: 45).

Enamel hypoplasia is a defect in the structure of tooth enamel that is believed to reflect long-term metabolic stress, such as starvation or major acute, but non-lethal bacterial infections. Conditions such as Harris lines – fine, transverse patterns on the long bones, and enamel – the location of the lines enables the timing of the events causing the stress (Manchester & Roberts 1995: 58–59, 175–176).

Linear enamel hypoplasia (LEH) is seen as horizontal lines of disruption in the enamel surface of the crown. From the location of the lesion one may infer the time at which the lesion occurred and therefore the time of the stress that caused it. As the lines often develop during the first year after birth, they are commonly found in the teeth mineralizing at the time – the upper central incisors and the lower canines. The condition is often related to starvation, premature birth, major febrile infections and dietary deficiencies. The lesions have correlated with other biological stress markers such as cribra orbitalia (Aufderheide 1998: 405–407). The occurrence of LEH is recorded in this study as it may provide information on nutritional status, the presence of infectious diseases, trauma or cultural activities.

Periodontal disease is a condition that affects the tooth attachment function in the jaw such as gingivitis, periodontitis or C-vitamin deficiency. The diseases develop as an inflammation of the gum that eventually may cause resorption and destruction of the jaw bone. It could also cause bacteria to spread to other parts of the body via the bloodstream (Alexandersen 2008: 380–86). Only severe cases are recorded in this study. A systematic study of dental health would require a more detailed recording.

The number of teeth lost ante mortem is recorded for all individuals in the study. The condition has a range of causes, from severe attrition to caries or periodontal disease, and is more frequent with advancing age. The loss of teeth prior to death is a common observation in archaeological remains.

Joint disease

The degenerative joint diseases (DJD), the most common form of joint pathology are non-inflammatory, chronic and progressive pathological conditions characterized by the breakdown of cartilage and a gradual degeneration of bone tissue through abrasion. Primary DJD has no evident cause, while secondary DJD is due to an alteration of the bone by disease or specific events, such as trauma, disease, other arthritis or occupational stress. The condition is age-progressive and without gender predilection, and is caused by bio-mechanical wear and functional stress (Aufderheide 1998: 93). The disease is found in all joint systems of the body, including the vertebral column, and is commonly found in skeletal assemblages. The purpose of studying joint diseases in archaeological remains is to understand cultural activity and living conditions in past communities (Steckel & Rose 2002: 42). The presence of joint diseases may reflect the amount of occupational stress experienced in life and the socio-economic status of a population. The degenerative joint diseases include the non-inflammatory diseases osteoarthritis (OA) and intervertebral stress disorder (Schmorl's nodes) as well as inflammatory conditions, like rheumatoid arthritis (RA), ankylosing spondylitis (AS) and gout (Resnick 1988: 816).

Osteoarthritis occurs in the articular surfaces of all joints including the facet joints of the vertebral column. Degenerative changes of the vertebral bodies are often characterized by bony outgrowth (osteophytes) on the vertebral bodies (spondylosis), pitting of vertebral bodies and Schmorl´s nodes, i.e. indentations following intervertebral herniation (SN). Lipping (osteophyte growth) may cause fusion of the vertebral bodies. Arthritic changes of the synovial joints occur more frequently in the weight-bearing joints like the hip, knee and in those more subject to chronic trauma, like the shoulder and elbow (Steckel & Rose 2002: 42).

The presence or absence of the diseases is recorded for all main joints. The criterion for the skeletal diagnosis of OA in this study is the presence of eburnation. Eburnation is the polishing of the joint surfaces in bone-to-bone contact. It is pathognomic (distinctive) of OA but may not always be present in the disease (Rogers & Waldron 1995: 36). This may have led to an underestimation of the condition in the material, but it prevents including non-arthritic conditions in the calculations on disease prevalence.

Special features of the vertebral discs, such as osteophytes (OVB/ Spondylosis), fusion of vertebrae and Schmorl's nodes are recorded separately, because their presence solely is not enough for a specific diagnosis to be made. The conditions could still represent a pathological condition. This is also the case for spondylolysis, the separation of a vertebral disc in two caused by a congenital weakness in the bone in combination with injury or stress (Manchester & Roberts 1995: 78).

Compressed fractures of the vertebrae are often associated with physical stress, and the frequencies in this material are presented for each of the sexes. The condition is also believed to be more frequent in osteoporotic individuals; hence a higher frequency among elderly women could be expected.

Infectious disease

Infectious disease was the cause of many deaths in the past. The lack of treatment with antibiotics, often led to rapid death and many diseases did not last long enough to leave traces in the bones. Infections causing rapid resolution or death are often viral. Chronic, long-standing infections, on the other hand, often cause bone changes, due to the inflammatory processes reacting as the body's defense. These infections are often bacterial. Specific bacterial infections are lepra, tuberculosis and syphilis. Non-specific infections are caused by other bacteria, and are more common. These infections may cause infective processes on the bone surface (periostitis) or in the bone (osteomyelitis).

Periostitis is a stress-related inflammation of the connective tissue on the bone surface (periosteum) through infection. The inflammation causes new bone formation and has a striate or layering appearance. The conditions are visible and distinguishable in skeletal remains, but it may not be possible to distinguish trauma-induced and general, systemic infections. The former usually causes local, non-destructive lesions. The latter, is generalized and destructive and with a bilateral or multiple origin. Even trauma-related sub-periosteal bleeding can cause similar bone changes. Due to the bone's closeness to the skin, the tibia is more susceptible to these and even slight stretches of the periosteum may cause altered blood-circulation and new bone formation. Other causes of periosteal new bone formation could be hormonal changes, mechanical adaptation of the bone (compensation) or tumors (Resnick 1988). To avoid confusion the general term, periosteal reaction, will be applied in this study.

Osteomyelitis is an inflammation of the bone causing pus-formation and destruction, with thickening of the bone or the appearance of cloaca (pus-containing abscesses in the bone). It may be introduced by bacteria in the blood-stream, from local areas of infection or by penetrating trauma (Manchester & Roberts 1995: 124–27).

Osteologically there is an under-representation of the acute diseases compared to the chronic. Whereas acute, epidemic infections reflect episodes of crisis and result in high mortality levels, the chronic infections represent more long-term living conditions, dietary and nutritional deficiencies, the effect of transmissible diseases and the state of waste disposal and general hygiene in a community (Steckel & Rose 2002).

The extent and severity of the skeletal lesions, and whether the lesion was active or healed at the time of death is recorded in this study.

Metabolic disease

The metabolic diseases are termed 'stress indicators' as they represent the body's adaptive response to various stressors affecting the body during growth The diseases cause disruption of bone formation, remodelling and mineralization. The response to physiological stress is dependant on factors such as the individual's immune status and genetic pre-disposition. Both cultural and biological factors may cause stress (Manchester & Roberts 1995: 163–165).

Common metabolic diseases are scurvy and rickets, anaemia and osteoporosis. The bone deformation characteristics of scurvy and rickets are believed to be caused by the lack of vitamin C and D, respectively, possibly by dietary disturbance and factors inhibiting the uptake and benefit of vitamins. Porotic hyperostosis and cribra orbitalia are characterized by the thinning and porotic destruction of the bones of the skull and the orbital roof. The condition may reflect iron-deficiency anaemia, either through dietary defects or the exposure to infections (Stuart-Macadam 1992; Manchester & Roberts 1995; Aufderheide 1998). Some authors also have found a high incidence of cribra orbitalia in leprous specimens, others have found that the condition could result from insufficient nutrition and chronic inflammation, as well as infections to the eyes (Ortner 2003: 267). Osteoporosis is the demineralization of bone mass due to factors such as diet and changes in hormonal production, and often causes vertebral compression fractures (Aufderheide 1998: 314–315). The presence of enamel hypoplasias and cribra orbitalia has been recorded in this study. A proper identification of osteoporosis requires the use of special equipment to measure bone mineral density. Although interesting in a palaeo-epidemiological view, this analysis does not involve the study of these aspects.

Trauma

Skeletal trauma is defined as physical damage to the bones that is not related to disease, but the result of cultural activities, accidents and acts of violence. The study of the incidents producing the trauma, the effects on a population and evidence of treatment are interesting aspects of trauma analysis. Traumatic lesions are usually caused by fractures and dislocations (Aufderheide 1998: 19–38). The fractures may be the results of accidents or have the character of weapon injuries. They may also represent stress injuries related to excessive physical strain, advanced age or disease (Ortner 2003: 119–121).

Recording of trauma in this study follows the same procedure as for pathological conditions. Attempts have been made to distinguish between ante, peri and post-mortem trauma. One can easily determine whether the skeletal trait has developed over time and if the individual survived the incident, but it is not always possible to determine if the event was lethal. Many lesions do not affect the skeleton despite being lethal; this is often the case with damage to the inner organs of the body, and in wounds causing massive blood loss or damage to the nervous system and brain. The prevalence of trauma reflects important socio-cultural aspects in a population, and has implications for people's health and quality of life.

Health

When attempting to gain an idea on the health status in a population one needs to take into account a range of factors that may have contributed to the general picture. Together with data on pathology and trauma, other data on age and stature, for instance, may point towards the circumstances that promoted the conditions. It is important not to see the different conditions in isolation, but to see them as a complex whole. The most relevant factors to indicate a person's health status in this study are:

- The non-specific indicators of disease and population stress.
  These comprise various infectious diseases and inflammatory conditions, developmental defects (LEH, Harris lines, cribra orbitalia etc.) and stature and dental conditions that may reflect diet (periodontal disease, abscesses, calculus, caries, infectious disease). The degree of sexual dimporhism and life expectancy are also important indicators on health. Together these aspects may enable a distinguishing between the healthy and the non-healthy.
- Diseases of affluence and increased longevity.
  In this study, the main indicators are the degenerative joint diseases like osteoarthritis or spondylosis and various periodontal conditions including ante-mortem tooth loss.
- Metabolic and deficiency disorders.
  Of particular relevance here are the conditions cribra orbitalia, believed to reflect anemia caused either by malnourishment and the insufficient metabolism of vitamins or by infectious diseases. Osteoporosis is another condition that additionally may be associated with advanced age.
- Trauma-related lesions.
- Activity-related and occupational conditions.
  Particularly relevant are conditions such as osteo-arthritis and spondylolosis that may refletct behavioural patterns. Osteo-arthritis is also an important indicator of longevity (Knüsel & Ogden 2008).

Analyses and results

Church, cemetery and graves

A study of the archaeological context of the graves has given valuable information on the character and structure of the assemblage. Dating the burials and the period of use of the cemetery, and establishing a relative chronology between the graves, may give information on the use of the burial ground and the character and size of the population. The function of the burying church and the cemetery is equally important.

Based on the archaeological sources, in the period c. 1120–1170, the town area is characterized by the monumental construction of several churches and monasteries as well as the intensification of secular building activity. Along the northern shoreline of the Vågen bay there are signs of pressure on building space for secular buildings, particularly in the middle and northern town areas. The church of St Mary's was founded in this period, perhaps on the remains of an older stone building, but the archaeological sources to a previous church on the grounds are scarce (Hansen 2005: 152–156).

Dating the graves enables us to relate our finds to other archaeologically or historically known events. This is important when interpreting skeletal data and attempting to

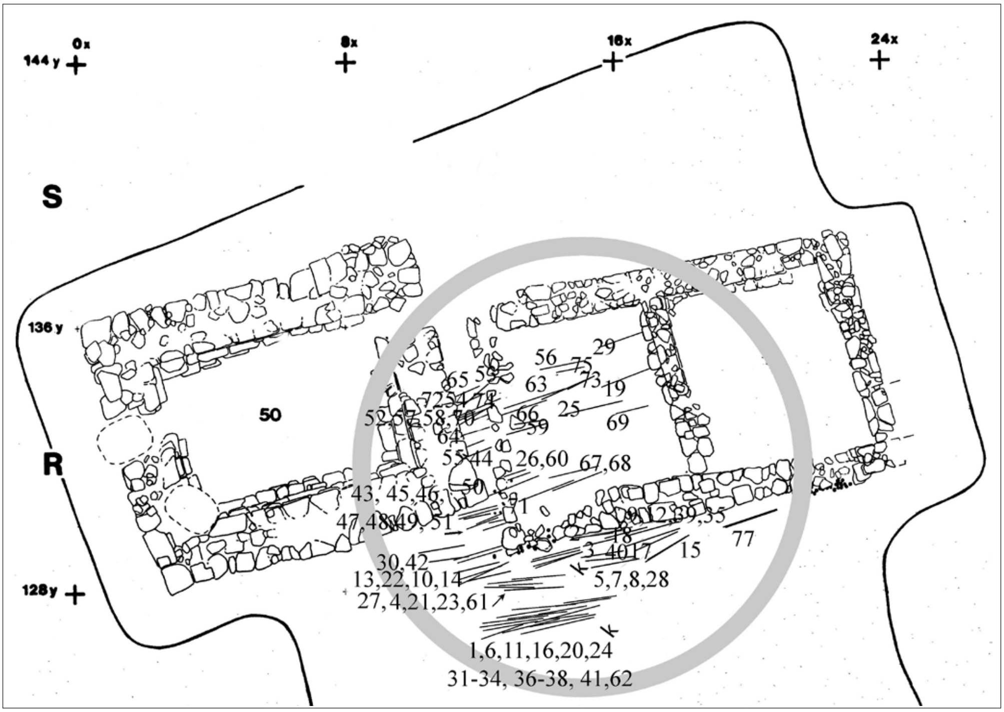

Figure 15 *The distribution of the skeletons in the sample within the excavated area. Building 50 is St Lawrence Chapel, building 48 is St Mary's Guildhall. St Mary's Church stands to the north of the stone buildings. The graves are numbered according to the catalogue in the appendix.*

understand the social and cultural events reflected in the skeletal remains. Proper dating makes the material particularly valuable for social analyses.

All the graves in the sample are from the far south-western part of the cemetery of St Mary's (cf. Figure 15). Apart from a row of burials that will be discussed in detail below, all burials to the south of St Lawrence Chapel and St Mary's Guildhall are earlier than the town fire in Bergen in 1198, termed Fire VI in the excavation reports, and known from historical and archaeological sources (Herteig 1990). This is evident in the archaeological record from the excavation; plans, section drawings and diary notes. Some of the deepest graves are dug through grey, sandy sterile soil while others are placed in the brown, organic cemetery soil, where intensive burial activity makes it difficult to identify individual grave-cuts. Because of commingling with earlier graves, loose bones sometimes occur in the grave-fill of new ones. The apparently empty space between the outermost graves and those closer to the stone buildings may at first seem intentional, but this area may in fact have been occupied by shallow graves that were destroyed and removed by later building activity. There is, however, a discrepancy in the dating between these groups of graves; the outermost row is dated after Fire VI (1198). This could indicate some sort of internal regulation of the cemetery, but this cannot be determined.

The majority of the graves in the sample are cut through or rest on layers from the suggested remains of the historically known fire of 1170/71 (Fire VII). Following this, one fourth of the graves are dated to the period 1170–1198, within an interval of only thirty years. Ten graves are dated to before fire VII (1170), and another twenty-five graves are dated from the initial use of the burial area up until the 1198-fire. If one accepts that St Mary's Church was built around the middle of the twelfth century, this represents a period of no more than c. 20 and 50 years. This narrow dating is exceptionally rare for medieval cemetery remains, where a period of use of several hundred years tends to be the case. Absence of grave goods and the intensive use of the burial ground make the use of archaeological dating methods difficult and radiocarbon analyses have not been applied on the material. Some of the graves in the sample pre-date the 1170/71 fire and are among the earliest graves in the assemblage.

Based on the dating of the graves, there could be identified three main burial phases in the material:

Phase	Date	Graves/ skeleton ID
Phase 1	Pre 1170/71	13, 15, 17, 22, 43, 45, 48, 51, 60
Phase 2	1170/71–1198	2, 3, 4, 5, 6*, 7, 8, 9, 10, 12, 14, 21, 23, 27, 28, 30, 35, 38*, 39, 42, 44*, 52*, 53*, 54*, 55*, 61, 64*, 65*, 72*, 74*
Phase 3	1198–1248	1, 11, 16, 18*, 19*, 20, 24, 25*, 26*, 29*, 31, 32, 33, 34, 36, 37, 40*, 41, 46*, 47*, 49*, 56*, 57*, 58*, 59*, 62, 63*, 66*, 67*, 68*, 69*, 70*, 71*, 73*, 75*, 76

Table 5 *Main burial phases for the material from St Mary's. *=could be older, i.e. individuals that are only given a before or after date i.e.: before 1248 or after 1170.*

A large number of the graves lay within the area later occupied by the chapel of St Lawrence and St Mary's Guildhall. The graves cut by the east wall of the former can be placed in two different phases separated by fire layers; the earliest graves, identified in four layers, are dated before the Fire VI (1170), the latest graves are dated to the period 1170–1198. The upper age limit represents a maximum range, as we do not know the exact date of the church, only that is was affected by the 1198 fire (Herteig 1990: 73).

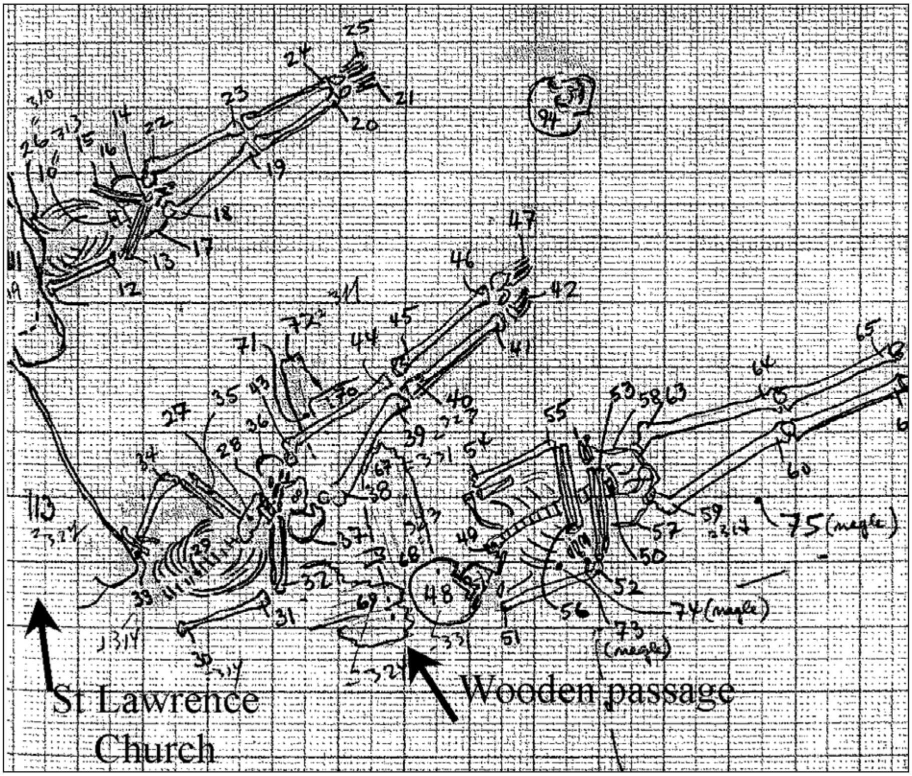

Figure 16 *Skeletons cut by St Lawrence Chapel and remains of wooden passage. (Field doc. Bryggen excavation. Drawing: Egill Reimers 1971).*

Among the burials cut by St Lawrence Chapel is one grave (Skeleton ID71) overlying the remains of a passage also cut by the church wall and most likely burnt in the 1170-fire. This indicates that there was already a break in the use of the burial ground some time after its initial use and the 1170-fire, followed by a new burial period between 1170 and 1198. In 1198 St Lawrence Chapel had already been constructed and was hit by the town fire.

The graves beneath St Lawrence are the westernmost graves in the sample, the church, thus, represents the outer western limit of the cemetery (Herteig 1991: 74). The remaining graves in the narrow passage between the two stone buildings, and the graves beneath St Mary's Guildhall pre-date the latter, and are dated to around the mid-thirteenth century.

A concentration of graves to the south of the chapel of St Lawrence and another grave farther east post-date of St Lawrence, but are earlier than the mentioned guildhall

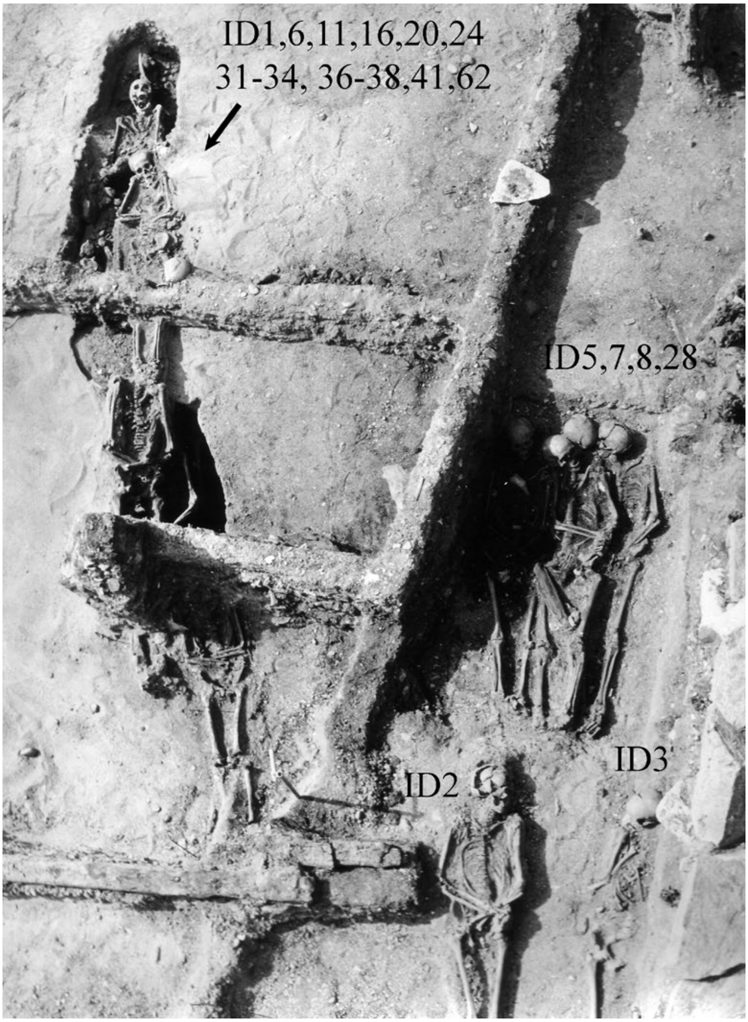

Figure 17 *The long-grave and the multiple grave during excavation. (Field doc. Bryggen excavation).*

(Herteig 1990: 73). As already mentioned, there is no reason to believe that St Lawrence had burial rights. It is, however, possible that the buried had some sort of relation to the church.

Several contemporary burials in the cemetery are identified. One multiple burial and one possible double burial lay to the south of the Guildhall and dates to the period 1170–1198. Another double grave is dated to before 1248. The multiple grave (Figure 18) contains four adult women (ID 5, 7, 8, 28), one double burial (Figure 19) contains an adult woman and an adult man (ID9, 12), and the other, one juvenile and one adult together (ID 67, 68). Although the graves may represent family burials, there is no clear evidence of this.

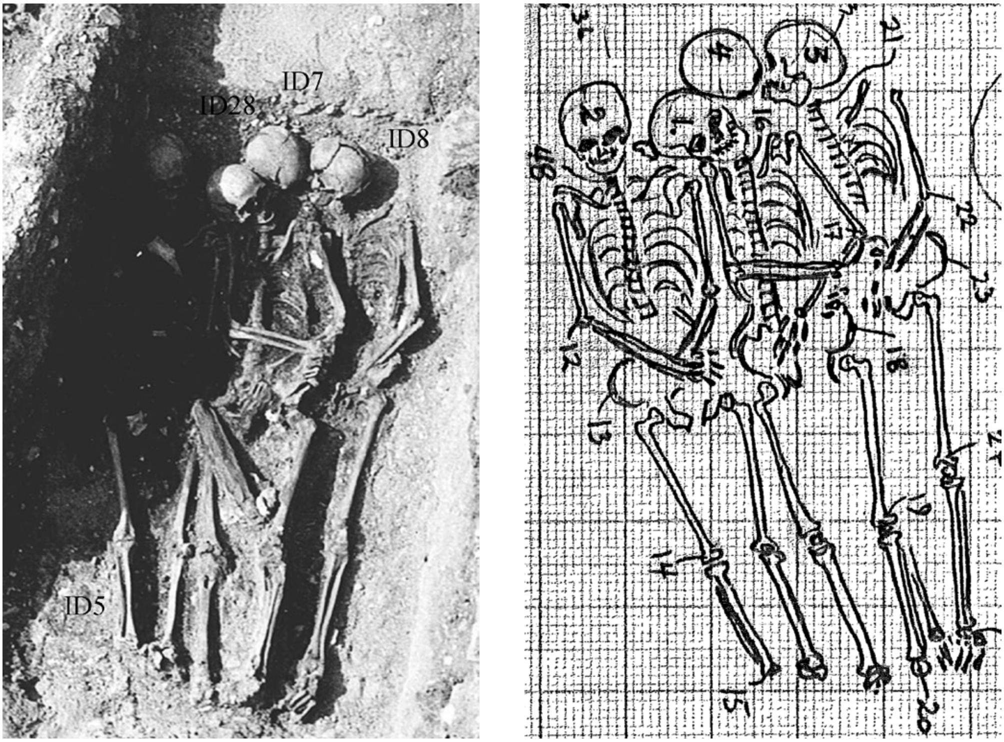

Figure 18 *Plan drawing showing the four individuals in the multiple grave. To the left, photo of the same grave. (Photo/drawing: Field doc. Bryggen excavation).*

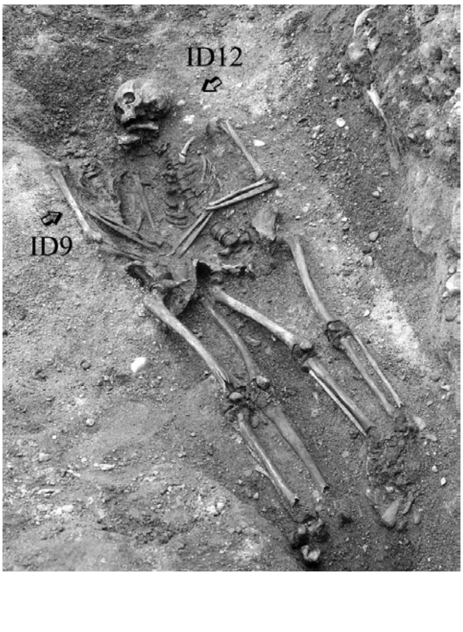

Figure 19 *Double grave. BRM 0/75011(ID 9) & BRM 0/75018 (ID 12). (Photo: Field doc. Bryggen excavation).*

Another group of graves stand out and deserves further mentioning. This is a concentration of graves to the south and east of St Lawrence' Chapel, that post-date the chapel. It is a single, narrow, approximately 5 metre long pit with several successive burials (Figure 21). (In the field note it is called 'the long grave', although representing separate burials). The pit contains the twelve complete skeletons laid down successively and in several layers only separated by thin layers of sand and in a slightly diverging direction.

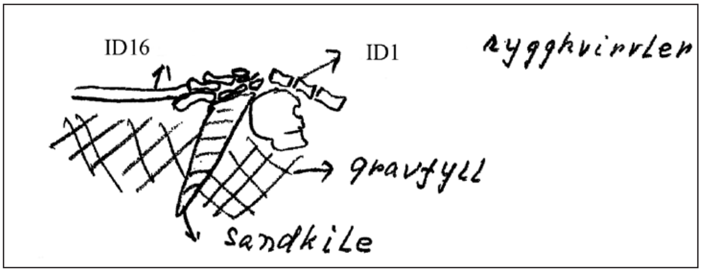

Figure 20 *The interface between BRM 0/75003 (ID 1) & BRM 0/75023 (ID 16) where ID 16 cuts ID 1 in the area of the neck, separating the head from the body (Field diary: p. 510).*

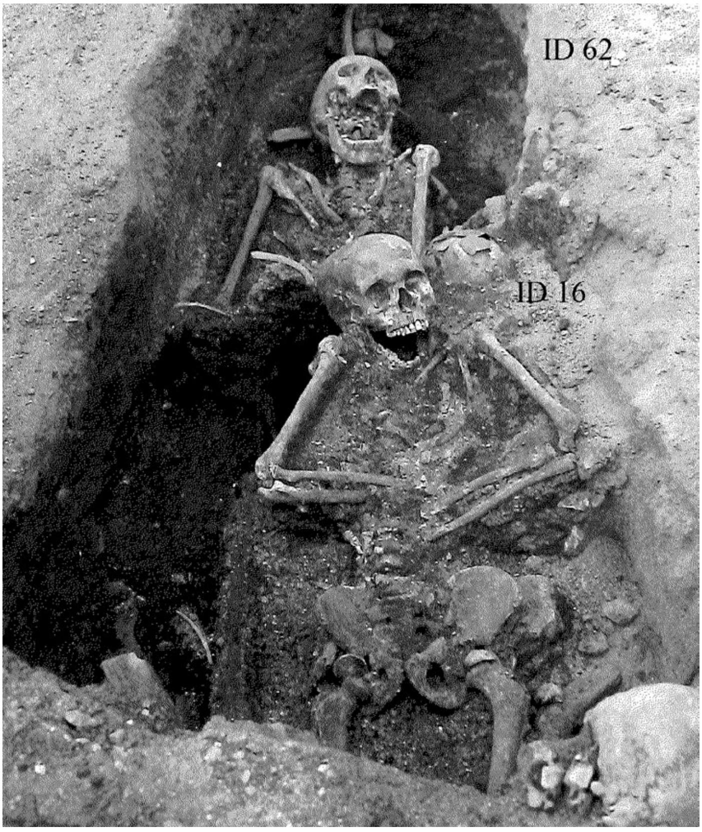

Figure 21 *The skeletons in the 'long grave'. (Photo: Field doc. Bryggen excavation).*

The continuous overlapping of burials has caused disturbance to earlier graves, in one case decapitating an individual and moving the cranium and several vertebrae that were probably still attached by soft tissue, several metres to the west. A possible explanation for this intensive burial is that this area was the outermost boundary of the cemetery directly facing the settlement area in the south. Could there have been a lack of burial space at the cemetery? Considering the fact that the cemetery was in continuous use for several hundred years after this, a more plausible explanation could be that the area was assigned a particular group of people or a family, or that being buried at the outskirts of the cemetery had a certain meaning. The thin layers of sand separating the skeletons indicate short time intervals between the burials (Field diary, Q 1–2, p.417–422, 509–511). This could perhaps indicate that the graves are related to a specific event where there was a need to bury many people within a short time interval, perhaps members of the same family. Two of the individuals, an adult woman and a middle-aged man have a metopic suture that could be genetically inherited. The group of graves contain the bodies of two children aged seven (75232) and twelve approximately (75050), three individuals, two of them teenage boys aged twelve to sixteen (75023, 75031, 75041), four women, one in her thirties (75043) the rest forty to fifty years (75016, 75041, 75042) old, and a man possibly turned sixty (75016).

A grave to the north of these individuals consists of three individuals where two, a middle-age woman and a teenager, possibly a boy show the same non-metric traits as some of the individuals in the 'long grave'. There seems to be a high frequency of these traits in this area, another factor that could support the theory of genetic relationship between the individuals in this part of the cemetery. This can, however, not be confirmed solely on the basis of the frequency of non-metric traits.

Burial custom and associated material

According to medieval burial custom, the dead should be assigned a simple inhumation with or without container and without grave goods in consecrated ground, i.e. at a cemetery. The burial custom at St Mary's Church cemetery is simple and uniform. According to the field diaries, there was no general use of coffins, clothing, or other equipment or grave goods in the graves. There are isolated reports of iron nails found scattered on the cemetery, but there are no indications as to the function of these nails. The lack of such elements, the narrow shape of some of the graves along with the almost complete lack of traces of grave furnishings and grave gifts indicate that the dead were wrapped in burial shrouds and placed in the graves without a container (Figure 23). One of the buried, a child, found completely covered in textiles could suggest that this was the case (Figure 22). Unfortunately, this individual is now missing from the collection.

Another important indicator of this apparently simple burial practice is the position of the body in the grave. Bodies placed in an open environment such as cist or a coffin tend to be less stable in the grave, and are often moved about in the process of decomposition and because of the weight of the soil. The photos from St Mary's cemetery show that for the majority of the skeletons, the arms are still placed close to and along the body. The pelvic bones are not separated from the lower back bone, but are neatly in place in many of the individuals. A burial shroud or other textile wrapping would have kept the body tight together.

Figure 22 *The skeletal remains of a child completely covered in textiles. (Photo: Field doc. Bryggen excavation).*

Figure 23 *One of the skeletons from St Mary's churchyard neatly placed in the grave suggesting the use of a burial shroud. (Photo: Field doc. Bryggen excavation).*

Another indication of burial custom was found in several cases of green staining to the bones. The stains are distributed in six of the adults, evenly among sexes and in various parts of the body; on the cranium, teeth, lower leg, fingers and pelvis. One individual shows staining on all teeth on the left side. Similar stains are recorded in the Hamar material, where the majority were found on the cranial bones, the upper vertebrae and some on the upper arm and the leg bones. The stains are believed to be caused by grave gift coins, usually placed close to the head, but no coins were recovered during the excavations (Sellevold 2001: 156). As in Hamar, there are no finds of coins or other metal objects associated with the staining and the distribution of the stains is slightly different at St Mary's. One can, however, not rule out the possibility that the green stains are related to the practice of depositing coins in the grave.

Even though the medieval burial custom was to bury the dead without grave gifts, archaeological finds do, however, show that this norm was sometimes ignored. This is also the case at St Mary's cemetery. In the so-called 'long grave', two of the twelve individuals were found with associated artefacts. These were both middle-aged women and placed in the western corner of the pit, one above the other. The individual at the bottom was buried with a circular loom-weight placed in the foot end of the grave (Figure 24). These have been found in great quantities in Viking Age graves in Norway, but are unusual in graves from the Middle Ages, often associated with female burials (Pulsiano 1993). Placing the loom-weight in the grave could be a way of expressing specific characteristics of the dead woman, perhaps related to the activities, such as textile work that she was involved in, in life. It could also have a hidden symbolic meaning unknown to us. The woman has severe spondylosis, particularly of the lower back, where she also has a partially compressed vertebra. This condition could in part be activity-related, but the porous character of the vertebrae could point towards a case of osteoporosis, and could be associated with advancing age.

Figure 24 *A middle-aged woman with a loom-weight placed in the foot end of the grave. BRM 0/75042, ID 31. (Photo: Field doc. Bryggen excavation).*

The other middle-aged woman was buried with a leather purse with 94 coins (Figure 25). The coins are one-sided bracteates possibly issued by King Sverre Sigurdsson (1177–1202) and were possibly produced in Bergen around the end of his reign. We do not know whether the coins were placed in the grave deliberately, but considering that the coins represent only a moderate sum of money at the time, they may have been embedded in the woman's clothing and buried incidentally (Skaare 1984: 57). The dating of the coins corresponds with the dating of the grave to after the 1198-fire and the coins would have been in current use when the woman was buried.

Figure 25 *Coins dated to the late twelfth century and possibly issued by King Sverre (1177–1202) and buried with individual BRM 0/7346 (ID 36). Close-up of one of the coins to the right. (Photo: Field doc. Bryggen excavation).*

A study of the archaeological context of the graves has shown that the location, distribution, dating and shape of the burials indicate a considerable degree of homogeneity both within the sample and with the other graves recovered from the cemetery. This could strengthen the representativity of the sample.

The arm position

The arm position of the buried is believed to reflect burial customs changing over time, and has been introduced and tested by some authors as a criterion for dating (Redin 1976; Kieffer-Olsen 1993). The idea is that there was a systematic change in the arm-position in graves throughout the Middle-Ages (Figure 26).

It is believed to have been a gradual shift from placing the skeleton in the grave in a supine position with the arms along the side (A), to a position with the arms placed upwards across the chest (D). Overlapping is reported to occur. A study of the arm positions at the church of St Mary's shows a predominance of the 'type B' and 'type C', with occasional overlap between the two. There is only one partial 'type A' and one 'type D' among the graves; the possible 'A-grave' is dated before 1170, the 'D-grave is dated from the mid-twelfth to the mid-thirteenth century.

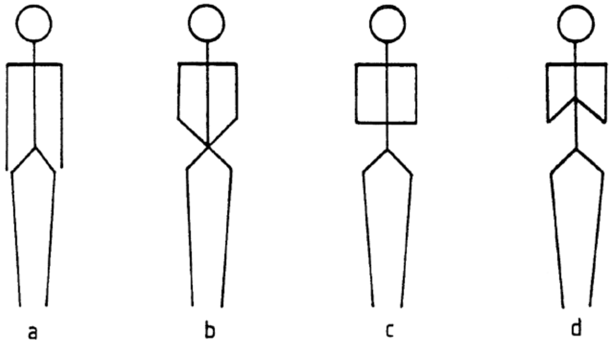

Figure 26 *Schematic illustration of the arm-position chronology (After Kieffer-Olsen 1993: 21).*

The results are in line with analyses on medieval remains from Lund, where 'type B and C' are common in the twelfth and thirteenth centuries. 'Type A' occurs in the eleventh and twelfth centuries, and 'Type D' is not observed until the fourteenth century (Cinthio 2002: 215–17). The finds from St Mary's are thus inconsistent with the finds from several Danish medieval cemeteries, where 'Type A' dominates until the middle of the thirteenth century, with a gradual change towards the types 'B' and 'C' in the mid-thirteenth and fifteenth centuries respectively (Kieffer-Olsen 1993: 78). The positions A–C are not necessarily associated with a particular religious meaning, but a position with the hands in the pelvis area or across the abdomen has been interpreted as the humble attitude of man towards death, or an expression of social position. It is worth mentioning that the predominant arm-position among high status graves in Lund was of 'type C' (Cinthio 2002: 221–22). One can, however, not infer from this that the 'C'type graves from St Mary's represent individuals of high social status.

The skeletal remains – osteological results

The skeletal sample in this study is of a limited size, it constitutes only 76 individuals. This must be taken into account in the osteological examination and the following interpretations. The sample does, however, show a high level of homogeneity when it comes to contextual circumstances, location at the cemetery, dating and preservation. This enhances its scientific potential.

Sex distribution

The assessment of sex was necessary as a means to establish the demographic profile of the sample and to identify possible differences in living conditions and activity patterns between the sexes. It helps to understand the composition of the urban population and the population buried at the cemetery and may reflect cultural and religious practices (Kjellström 2005: 68). The sex-distribution can also reveal information on the presence of disease and reflect differences in health. A sexually homogenous sample could reflect a spatial organization of the cemetery with segregation of the sexes.

Sex has been assessed in 61 out of 76 individuals (80.3%). The remaining 13 individuals are sub-adult. Because distinct sexually dimorphic characteristics of the skeleton are only expressed post-puberty (Scheuer & Black 2000: 15), no individuals under the age of 20 are included in the following estimations.[7]

Figure 27 shows a breakdown in percentages of the sex-distribution at St Mary's Church among adult individuals. Definite and tentative sex-categories are pooled; unsexed individuals are included.

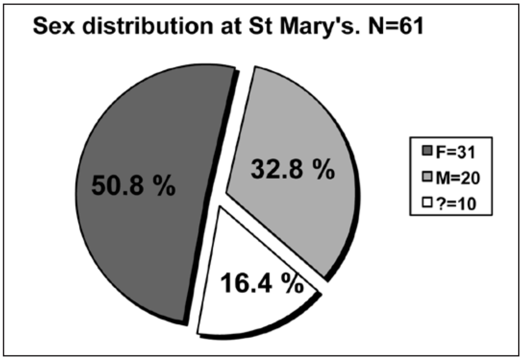

Figure 27 *St Mary's church. Sex-distribution among adults. F/F? and M/M? pooled, unsexed individuals included. F=female, M=male, ?=unsexed. N=61.*

Figure 27 shows that there is a clear female predominance in the sample: 50.8% of the adults in the sample are female, 32.8% are male and 16.4% are of undetermined sex.

The sex-distribution in the material strongly reflects the completeness and state of preservation of bone elements attributing sexually dimorphic characteristics. In general, the 'M/F' groups have observable traits in both pelvic and cranial areas, or in the pelvic area as a minimum. The '?' group consists mainly of poorly preserved and incomplete skeletal remains, with either no observable features or only fragments of the pelvis preserved.

Poor preservation may affect sex assessment in that the presence of fewer discriminating traits may give a higher number of masculine estimates. As many women may attain a more masculine physical appearance with age, there is a risk of these being placed in the male category (Manchester & Roberts 1995: 25), likewise could younger men who have not yet developed prominent masculine features, be mistaken for women (Kjellström 2005: 69). This is hardly the case here, since the analysis places the majority of the females in the categories for unambiguous sex,[8] and the mean ages-at-death is high. Metric data obtained in the study, long bone lengths and dimensions, show sizes corresponding with the sex-estimates. Measurements of the femoral heads of the unsexed adults range from 38 to 49 mm with the average at 42.2 mm. According to the sub-divisions provided by Stewart 1979, the majority of the measurements fall within the female size-ranges (4/5), only one individual is clearly within the male range (Stewart 1979: 120; Bass 1995: 231). This may indicate that the proportion of females in

7 Appendix 1 includes all sexed individuals among these four individuals below the age of twenty.

8 The categories for tentative sex (F?/M?) were applied during analysis, but are not displayed in the table. See Appendix: *Main skeletal catalogue* for the correct estimates.

the material is actually higher than first expected. This supports the interpretation of a female predominance in the material. Following this, I consider the sex-estimates as shown in the tables above as reliable.

The female bias in the sample is illustrated in Figure 28 showing a breakdown of the sex-distribution among sexed individuals only.

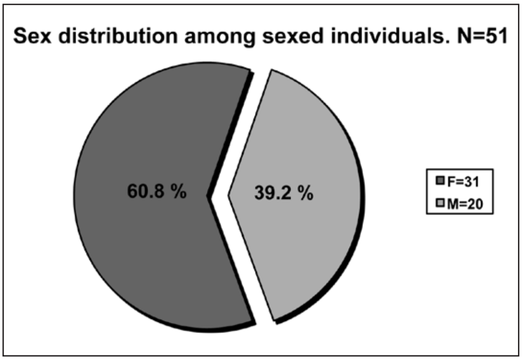

Figure 28 *Distribution of sexed individuals at St Mary's Church. N=51.*

Figure 28 shows that the female group constitutes a total of 60.8% of the sexed individuals. This is an unusual distribution in medieval assemblages, where there is a tendency towards a male bias (Arcini 1999: 160; Sellevold 2001: 182). In the assemblage from Lund, there is accordingly a male bias in all phases from 990–1536 AD (Arcini 1999: 160).

Age distribution

The age distribution in a skeletal assemblage serves as a basis to understand the demographic composition of a population. High levels of child mortality and low age-at-death may reflect unfavourable living conditions. Variations in sex-distribution between the age-groups may point towards cultural and social differences between the sexes and the distribution of pathology between age-groups could reflect specific activities and life-styles.

The socio-economic status of a population is reflected through mortality rates; hence, shorter life-expectancy would be evident among the lower social strata. A population attaining high mean ages could on the contrary represent a population that was economically well-off.

Of a total of 76 individuals in the sample, age was estimated in 71. Five individuals were not sufficiently well preserved to allow for a determination of age. Based on the epiphyseal fusion, these individuals were determined as skeletally mature and assigned to the category 'Grown' (>20).

The age group-distribution among all individuals at St Mary's is presented table 6. The table presents the age-groups with corresponding ages and the number and percentages of individuals in each group.

Age-group	Age	N	% All	% Aged adults
Infans II	7–11	4	5.3	-
Juvenilis	12–19	11	14.5	-
Sub-adult		15	19.8	-
Adultus	20–39	18	23.7	32.1
Maturus	40–59	34	44.7	60.7
Senilis	>60	4	5.3	7.1
Grown	>20	5	6.6	-
Total		76	100%	100%

Table 6 *St Mary's Church. Age-group-distribution. Total N=76/ Aged adults=56.*

The results of the age-assessment indicate that the sub-adult group accounts for 19.8% of the total number of individuals. The remaining 80.2% are adults past the age of twenty. One fourth of the sub-adults in the cemetery died between the ages 7–11, the remaining died between the ages c. 12–19. The age-distribution among the adults only shows a clear predominance of individuals between the ages 40–59, placed in the maturus group.

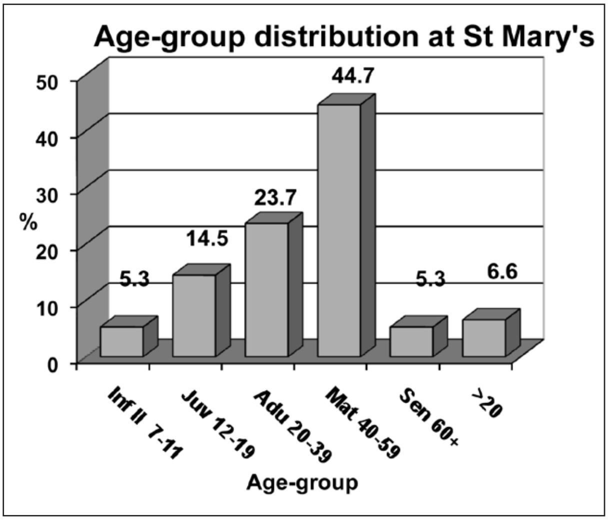

Figure 29 *The percentage of individuals within each age-group in St Mary's cemetery (N=76).*

Figure 29 shows the relative distribution of all age-groups in the material. All categories from Inf II to Senilis are represented in the material. There are no children under the age of seven in the assemblage; the proportion of sub-adults and old individuals is low and the majority fall within the maturus category (age 40–59). The complete lack of children below the age of seven is intriguing, and it is doubtful whether this reflects the real age-distribution in the population. There is a tendency towards a high representation of infants in medieval skeletal assemblages. The proportion is reported to be particularly high in rural materials (Gejvall 1960; Isaksson et al. 1998; Bratt et al.

1997; Sellevold 2001; Kjellström 2005). There is still an under-representation of infant remains in archaeological contexts. This may be due to taphonomic loss and low retrieval rate of infant bones, and could create a bias in the age-distribution in an assemblage (Scheuer & Black 2000: 14). The complete lack of infants and the youngest children in this assemblage is hardly a result of taphonomic loss. It is unlikely that preservation and excavation methods would have eliminated all skeletal remains of children up to the age of seven. Judging from the size of the bones in individuals of that age, these would be clearly visible in the ground, and severe taphonomic loss only restricted to the particularly fragile foetal and infant bones.

The juvenilis group (12–19 years) at St Mary's comprises 14.5% of the individuals in the assemblage. This number is higher than the average of c. 7.9% reported for Scandinavian medieval materials, and resembles the finds from several cemeteries in Sigtuna ranging from c. 9–18%, and St Olav's Church in Trondheim at 14.7%. The values from Lund are consistently lower, ranging from c. 4–10% and in Hamar c. 9%. The proportion of juveniles is generally higher in urban than in rural medieval populations (Isaksson et al. 1998: 45; Kjellström 2005: 42).

The proportion of individuals in the adultus group (20–39) is considerably lower than expected. The percentage at St Mary's is 23.7%, while the percentage in the maturus group (40–59) is 44.7%. A total of 60.7% of the adult aged individuals buried at the cemetery reached the age of 40. This resembles the results from Hamar, where the maturus group comprised 64.2% of the assemblage (Sellevold 2001). At St Mary's, the majority of the individuals assigned to the adultus category fell within the higher age range of 30–39 years (61%). This confirms the high ages in this material relative to other medieval assemblages. In the senilis group, the proportion of the total is 5.3%. This is within the range of other medieval materials, where the amount is between 2–8% (Sellevold 2001: 185; Kjellström 2005: 42), but higher than for all the comparative materials; Sigtuna 1.2%, Lund 3.3% and Hamar 3.1% (Arcini 1999; Sellevold 2001; Kjellström 2005). It is a common feature in archaeological materials that there is an overrepresentation of individuals in the age range 30–44 and a low representation in the 60+ group. This could partially be due to a systematic under-estimation of age causing a shift down the age-range and is an important methodological problem.

Table 7 shows the distribution of males and females within each age group. The total number of *aged and sexed* individuals is 51, the remaining are either sub-adults or unsexed adults.

	F		M		
Age	N	%	N	%	Total (N)
Adultus	10	62.5	6	37.5	16
Maturus	20	60.6	13	39.4	33
Senilis	1	0	1	50	2
Total	31		20		51

Table 7 *Sex-distribution according to age group at St Mary's church. N=51.*

As seen in table 7 there is a predominance of women in both the adultus and the maturus age-groups.

Figure 30 shows the percentage of individuals within every age group and for each of the sexes. This enables the detection of variations in age-distribution between the sexes. The total number of *sexed adult* individuals is 51.

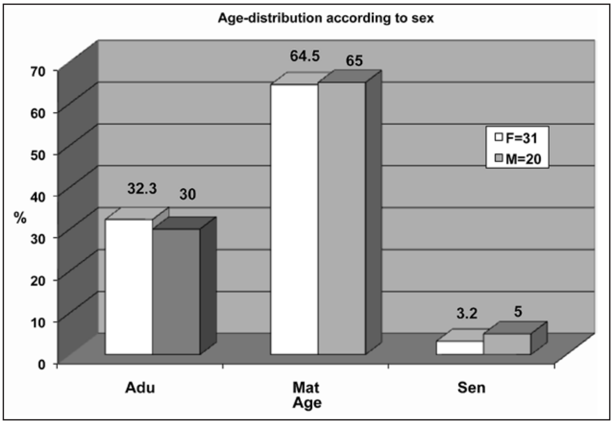

Figure 30 *Age-distribution according to sex among adult aged and sexed individuals at St Mary's. N=51. Adu=adultus (20–39), Mat=maturus (40–59), Sen=senilis (>60). (Chi-sq=0.12. df=2, P=0.94).*

The individuals in the three adult age groups have a similar distribution for both sexes. There is a slightly higher percentage of females (36.7%) than males (30%) in the adultus group (20–39), and a lower percentage of females (60%) to males (65%) in the maturus group (40–59). The senilis (>60) group comprises only two individuals, one of each sex.

There are no significant differences in age-distribution between adult males and females at St Mary's.

Table 8 shows the mean ages at death for each adult age group according to sex, with a mean age for each of the sexes and both sexes pooled. Mean age at death was calculated using the median for each of the adult age-groups as presented by Sellevold (1996; Sellevold 2001: 125; Kjellström 2005: 27). For purpose of comparison, the same median values have been applied. The age median in years for each group is: Adultus: 27, Maturus: 45.5 and Senilis 60.

	Adu	Mat	Sen	Mean
F	10	20	1	40
M	6	13	1	40.7
Total	17	31	2	40.0

Table 8 *St Mary's Church. Adult age-at-death among sexed individuals. N=51.*

Table 8 shows that the mean age-at-death for the female group was 40 years, the mean age for men is 40.7. The majority of the individuals, regardless of sex, fall within the oldest age groups. A calculation based on the mean age for each individual found no significant differences in mean ages between males and females (males: 42.0 years ±9.4 (SD), n=20; females: 42 years ±8.8 (SD) n=31; t=-0.08, df=49, P=0.94).

The mean ages for the individuals reaching adult age at St Mary's is higher than for all phases in the Sigtuna materials (32.9) (Kjellström 2005: 41), and for a selection of other Scandinavian and British materials, where mean ages have been adjusted according to the present method. The ranges in these materials are 31.9–40.7 (Sellevold 2001: 191); the upper ranges resembling the data from St Mary's. The mean ages in the Hamar Cathedral assemblage are high, ranging from 38.2 to 46.6, and there is a significantly higher mean age among women. At St Mary's, the mean ages-at-death at St Mary's must be considered high for both sexes.

Stature

Individual height and average stature reflect the ability of a population to fulfil its growth potential. This is strongly influenced by genetics, but depends to a certain extent on environmental conditions, the nutritional status of the individuals and disease pressure in a population. The stature in an assemblage may reveal information on the health status of the individuals which again may shed light upon the general living conditions in the medieval town.

As poor health is reflected through inhibited growth, one could expect the lower socio-economic strata in the population to be of lower stature. Individuals enjoying a nutritional surplus would most likely attain a higher stature. Thus, stature estimates do, to some extent, measure the well-being of a population.

The stature-estimates in this study are based on measurements of the long bones, preferably the left femur (thigh bone), substituted by the right when necessary. Based on the femur lengths, stature could be estimated in 18 individuals, 10 females and 8 males. When including humerus (upper arm) measurements, 27 stature estimates were achieved. The latter method is not ideal, because of variations in standard errors between the equations, but was necessary due to the limited size of the assemblage. Unless stated otherwise, all the mean stature estimates in the text include both femur and humerus measurements.

Table 9 shows the minimum, maximum and mean length of the femurs (mm) according to sex and for sexes pooled. The measurements of the left femur are included, substituted with the right when missing.

	Min	Max	Mean	SD	N
F	393	457	421.2	22.71	10
M	430	508	462	27.01	8
Total	393	508	441.6	24.86	18

Table 9 *St Mary's Church. Min and max femur lengths and the mean length of the femur according to sex and for sexes pooled. All measurements in mm. Sides pooled. N=19.*

The femoral measurements in table 9 show that the mean length in females is 421.2 mm, in males it is 462 mm. The mean femur length for the total assemblage is

441.6mm. The femur lengths are shorter than in the comparative materials from Lund, Sigtuna and Hamar. The differences in standard deviation show a larger dispersion in height among the males. The female heights are less varied. This is the situation both in Lund, and in Hamar in particular. In Sigtuna, the male statures are less dispersed.

Table 10 shows the difference in femur lengths between the males and females at St Mary's and in the comparative materials. All measurements are in mm. The difference is calculated from the mean femur lengths.

		F	M	SD	Mean diff	N
St. Mary, Bg.	c. 1150–1250	421.2	462	24.86	40.8	18
Hamar	c. 1100–1567	426.1	471.1	25.49	44.5	292
Sigtuna	c. 1100–1537	433.2	466.8	24.98	33.6	57
Lund	c. 990–1536	422	467	24.3	45	871

Table 10 *Mean femur length (M1) and mean difference in length between the sexes at St Mary's and in the comparative material. All measurements are in mm. Both sides pooled.*

The table shows that both the male and the female femur lengths at St Mary's are lower than in the comparative materials. The difference is particularly visible when comparing the males from Hamar and the women from Sigtuna. The sexual dimorphism in femur lengths, i.e. the mean difference in femur lengths between females and males, is lower than for Hamar and Lund, but higher than in Sigtuna. The Sigtuna material shows a considerably lower difference between the sexes than the other materials.

The diameter of the femoral head is often used as a criterion for sex determination (Stewart 1979: 120; Bass 1995: 231). Table 11 shows the minimum, maximum and mean diameter of all present femoral heads for each of the sexes and both sexes pooled.

	Min	Max	Mean	N
F	38	46	41.8	19
M	42	50	47.6	8
Total	38	50	43.5	27

Table 11 *St Mary's Church. Minimum, maximum and mean diameter of femoral head for each sex and for sexes pooled. Measurements in mm. Both sides pooled. N=27.*

Table 11 shows that the mean diameter of the femoral head in females at St Mary's cemetery was 41.8 mm. The mean diameter for men was 47.6 mm. The measurements are within the female and male standard ranges reported by Stewart (1979). This gives strength to the sex-determination in the sample.

Table 12 shows the stature estimates for females and males at St Mary's. The estimates are calculated according the two most commonly applied equations for stature-estimation. Both estimates are presented and referenced below. In the text, statures generally refer to the 'Sjøvold' estimates, except in comparisons with other materials, where methods are specified. The difference in stature estimates according to method is seen in shown. Height estimates from different assemblages are not comparable unless the methods for calculation are known.

	Sjøvold				T&G				
	Min	Max	Mean	SE	Min	Max	Mean	SE	N
F	152.4	175.1	160.0	4.49	151.2	167.9	159.0	3.72	10
M	162.4	183.5	171.2	4.49	163.8	182.3	171.1	3.72	8
Total	152.4	183.5	165.5	4.49	151.2	182.3	165.1	3.72	19

Table 12 *St Mary's Church. Mean stature according to sex. All estimates in cm. Stature equations by Sjøvold (1990) and Totter & Gleser (1952, 1958) based on the maximum length of the femur. Sides pooled N=19.*

The mean stature in females at St Mary's cemetery is 160 cm. Statures range from the lowest estimated stature at 152.4 cm to the highest estimated stature of 175.1 cm. The mean male stature is 171.2 cm. The estimate range is 162.4–183.5 cm.

	Sjøvold		Trotter and Gleser		
	F	M	F	M	N
St. Mary, Bg.	160.6	170.6	160.0	171.7	28
Hamar	/	/	159.7	175.3	242
Sigtuna	163.5	172.6	160.7	173.7	143
Lund	160.9	172.8	/	/	464

Table 13 *Mean height for men and women at St Mary's and in the comparative material. Measurements in cm according to the methods by Sjøvold (1990) and Trotter and Gleser (1958). The estimates for St Mary's represent the humerus and femur measurements pooled. N=28.*

Table 13 shows the mean female and male stature in the St Mary assemblage and for the comparative materials. Ideally, all stature estimates should be based on the length of the same long bone, preferably the femur or humerus. In order to achieve a maximum number of estimates in the sample these measurements have been combined. There are only slight differences compared with table 12.

The female stature at St Mary's (160.6 cm) is within the average ranges for Scandinavian medieval materials (Arcini 1999: 162; Kjellström 2005: 44). The mean stature in men (170.6 cm) is somewhat lower than expected, falling within the lower ranges in general for medieval materials (Kjellström 2005: 46). The female estimates at St Mary's are lower than in Sigtuna, but resemble the heights found both in Lund and Hamar. The main difference is found in the male heights, where the estimates for St Mary's turn out to be lower than both the Lund and Sigtuna materials and the Hamar material in particular. The Hamar statures are higher than the medieval average (Sellevold 2001: 137, 220).

The statures for women in the material from Bergen are similar or lower than the comparative materials; the statures for men are lower. The sexual dimorphism is lower when it comes to femur lengths at St Mary's than in Hamar and Lund, but higher than in the Sigtuna material. The male heights at St Mary's are more dispersed than the female heights, but less dispersed than for the Sigtuna males.

Skeletal pathology and trauma

The presence and absence of pathology and trauma was recorded in all individuals. This reflects, directly or indirectly, disease, accidents and violence in a society and is an indication on the general health status in a population. As general health in a society is related to socio-economic conditions, health is both a consequence of and an influence on lifestyle. One could say that health reflects the degree of well-functioning of a society. There is an interaction between the disease load in a society, the health and well-being in a population and the total socio-economic system (Roberts & Cox 2003: 2).

Recording pathology in the sample is an attempt to establish the prevalence of various diseases among the individuals and to relate the findings to aspects of health and medieval urban life. It is expected to find a higher evidence of occupational stress and signs of pathology among the lower socio-economic strata in the population. Another important pre-disposing factor for many diseases is age. Evidence of joint disease and periodontal conditions and tooth loss would be more common in the higher ages. Skeletal evidence of metabolic disruption and stress, and skeletal signs of infectious disease is often related to nutritional status and the exposure to infective pathogens and disease. Due to the sensitivity of children, conditions like enamel hypoplasia, cribra orbitalia and signs of infectious disease is expected to be more frequent in those not reaching adult ages.

Disease prevalence is the total number of cases displaying a disease in a specific population within a certain time unit. Disease incidence denotes the total number of new cases in a population. Only disease prevalence is measurable in archaeological assemblages (Roberts & Cox 2003: 20).

The prevalence of trauma and diseases is calculated according to:

- *the total number of individuals* in the assemblage (CPR=crude prevalence rate)
- *the total number of observed individuals* with the relevant bone elements available for study (i.e. the number of individuals potentially capable of displaying the disease), and
- *the total number of bone elements, teeth or joints available for study* of a specific disease (TPR=true prevalence rates).

The crude prevalence rate tends to underestimate disease prevalence, since the absence of skeletal pathology may be due either to the individual not being affected, or that the bone element is missing. As the crude prevalence rate does not account for any missing bone elements, thereby complicating comparative analyses on materials of varying preservation, true prevalence rates are given. The true prevalence rate counts the affected bone elements according to the total number of the specific bone element present in the material. The method, thus, accounts for the state of preservation of the material (Roberts & Cox 2003: 20, 29–30).

Dental disease

The presence of dental pathology was recorded in all individuals with the relevant teeth or bones present. Here, 18 females, 16 males and 3 individuals of undetermined sex were available for examination.

Table 14 shows the prevalence of dental disease at St Mary's cemetery. Conditions included are: ante-mortem tooth loss (AM-loss), dental abscesses (Abscess), calculus, caries and linear enamel hypoplasias (LEH). The category 'Abcess' may include both severe periodontal and peri-apical abcesses as well as a possible case of osteomyelitis. The number and percentages of the pathological conditions are demonstrated for both sexes. The percentages refer to true prevalence rates (i.e. calculated according to number of observable individuals and teeth). The number of affected individuals in the category of undetermined sex is given and included in the total frequencies. The last column shows the number of sub-adults affected. This number is not included in the total. The total frequencies include both calculations of prevalence according to the total number of individuals in the material, the number of observable individuals and the total number of observable teeth.

In total, 768 teeth were observable for observation, 373 for females, 314 for males, and 81 in the undetermined category. For the ante-mortem tooth loss, the calculation of TPR (% of observable element) is made from the number of tooth sockets (alveolae) available for observation. The total number of alveolae in the material is 1024.

	F		M		Chi	P	?	Total		M, F, ?		<20
	N	Ind%	N	Ind%			N	N	CPR%	Ind% (N=37)	Teeth%* (N=768)	n
AM-loss	6	33.3	5	31.3	0.02	0.90	0	11	18.0	29.7	8.6 (88)	0
Abscess	6	33.3	4	25.0	0.29	0.59	1	11	18.0	29.7	4.0 (31)	0
Calculus	14	87.5	12	80	0.04	0.85	3	29	47.5	78.4	33.3 (256)	5
Caries	2	13.3	2	12.5	0.02	0.90	1	5	8.2	13.5	1.3 (10)	0
LEH	0	0	2	6.2	-	-	0	2	1.6	5.4	0.8 (6)	1

Table 14 *St Mary's Church. Prevalence of dental disease among adults of both sexes, unsexed individuals and sub-adults (<20). Table shows:*

N=number of affected individuals
%=percentages of observable cases for individuals (Ind%), teeth (Teeth%) and (percentage affected of the total number of adults (CPR%). Percentages are given for adults only.
F=female, M=male. ?=undetermined.
Total number of adults: 61
Number of observable adults for teeth: F: 18, M: 16, ?: 3 ; Total: 37
Number of observable teeth - adults: F: 295, M: 314, ?: 90. Total: 768
Number of observable tooth sockets - adults: F: 470, M: 464 ?: 90. Total: 1024
Number of observable subadults for teeth: 10
Number of observable teeth - subadults: 218
** Ante-mortem loss is calculated from the number of observable tooth sockets in the material.*

Table 14 presents some indicators of dental health observed at St Mary's cemetery. Prevalence rates for ante-mortem tooth loss, dental abscesses, calculus, caries, periodontal disease, and enamel hypoplasia are listed. The conditions may represent various conditions such as infectious disease, metabolic stress and degenerative disease.

8.6% of the potentially present teeth were lost before death. The amount of individuals with teeth lost ante-mortem is high: 33.3% females and 25% males had lost one or several teeth. This most likely reflects the general age-distribution in the material, with a large number of middle-aged to elderly individuals. A similar prevalence, with an age-progressive character of the condition, but no sexual bias, is found in other Scandinavian and British medieval assemblages (Arcini 1999: 167; Roberts & Cox 2003: 262–263). In Lund, for instance, about one fifth of the young adults are affected while among the middle-aged more than half have suffered from tooth loss. The loss of teeth affects one's ability to masticate and may inhibit the intake of certain types of food. Tooth loss is seen both as a consequence of the intake of foods that are difficult to masticate or from poor dental health that causes severe gingivitis and destructive periodontal disease, but could be related to other disease, vitamin deficiency or high age (Alexandersen 2008: 380–81). The difference in prevalence of AM-loss between the sexes is non-significant on a 0.05 level.

Figure 31 *Severe attrition of the teeth in the mandible in a woman aged 60 + at St Mary's. BRM 0/76329 (ID 25). (Photo: K. Lorvik).*

Dental abscesses are found in 33.3% of the females and 25.0% of the males at St Mary's. The condition is found in individuals in the maturus (40–59) and senilis group (60+), and co-occur in several cases with AM-loss. The age-distribution corresponds with finds in other medieval assemblages and is most likely the cause of the high incidence at St Mary's. The Lund assemblage shows a corresponding female bias for the condition (Arcini 1999: 168; Roberts & Cox 2003: 259). So is the case in this material, with seven women and three men affected. The difference between the sexes is, however, not statistically significant on a 0.05 level. The number of alveolae (approx.) affected is 88. This shows a high representation of the condition per individuals. In some, several alveolae and extended parts of the jaw bone is affected. In ind. BRM0/75029 (ID 18) and BRM0/76331(ID 69), the condition may be related to a caries infection and the following death of the pulp (necrosis). A chronic peri-apical abcess, may have caused the risk of infection through the constant building up of pus in the cavity (cf. Figure 32). A differential diagnosis for BRM0/75014 (ID 10), an adolescent aged 14–16 years, is osteomyelitis – an inflammatory condition is developing from the interior part of the medullary cavity. This individual also showed pitting of the orbital roof consistent with cribra orbitalia. This could reflect an episode of poor health related to the severe dental infection. There was calculus on several teeth, indicating poor oral hygiene which in turn could be a consequence of the dental disease. Osteomyelitis is a serious and potentially lethal bacterial infection (Aufderheide 1998: 409), and may well have been the cause of death in this individual.

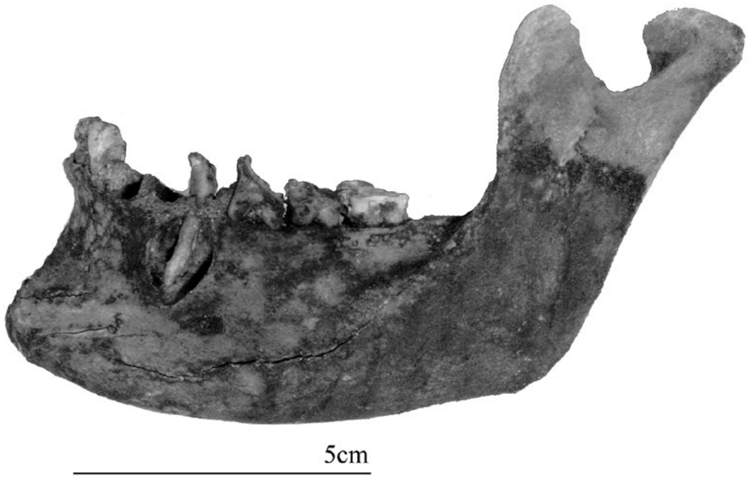

Figure 32 *Individual from St Mary's Church with a large perforation of the right mandible due to a peri-apical abscess (Photo: K. Lorvik).*

There is a high prevalence of calculus in the material (cf. Figure 33). 78.4% of the observable individuals have calculus present in one or several teeth. This means that 29 out of 37 adults had one or several affected teeth. There is no statistically significant difference in prevalence between the sexes (0.05 level). The amount of teeth affected is 33.3%, indicating that there was a tendency towards a distribution with one or a few affected teeth in many individuals, rather than severe generalized calculus in only a few individuals. Tooth loss may, however, have affected the percentages of teeth, and the prevalence rate of calculus by tooth is considered an underestimation. Ante-mortem loss, dental abscess and calculus co-occur in several individuals, both men and women. The high prevalence of calculus is common in medieval assemblages and most likely reflects poor oral health and an increase in dental complications with age.

Among the sub-adults six individuals of ten observable individuals have calculus (60%). Five have more that one tooth affected, ranging from 8–16 teeth. Interestingly, do the same five individuals also have cribra orbitalia and one has a possible case of osteomyelitis commented below. This could indicate poor health in general or that the individuals experienced a period of sickness prior to death.

One adolescent and one middle-aged man display dental alterations of the enamel consistent with dental hypoplasia. The youngest of the two is also affected with cribra

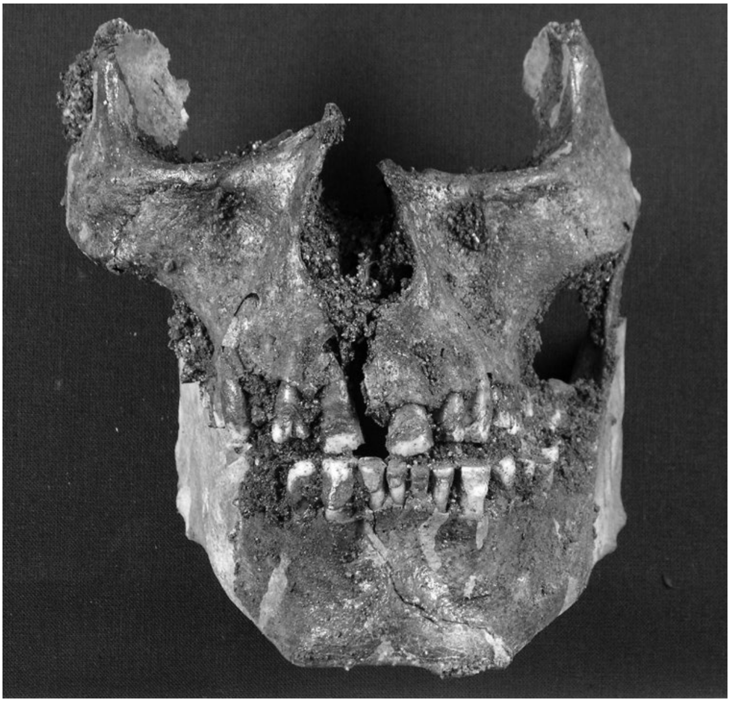

Figure 33 *Calculus in an adult probable male from St Mary's. BRM 0/75005 (ID 3). (Photo: K. Lorvik).*

orbitalia, an additional sign of stress. The frequency of enamel hypoplasia differs between adults and children at St Mary's where only 5.4% of the observable adult individuals but 10% of the total number of sub-adults display the condition. The total number of affected individuals is no more than three, making further interpretation difficult. The frequency is lower than in Lund, for instance, where the material shows an average prevalence of c. 15–26% in adults and 25–45% in sub-adults and a gradual increase through the Middle Ages (Arcini 1999: 181). One can conclude from this that there are no strong indications that the buried at St Mary's have undergone longer periods of disease and ill-health. There are few markers of stress and malnourishment to be found in teeth and bones. The dental complications found are of a kind that progress with age and are not necessarily a sign of a generally poor health.

The prevalence of caries in this material is also low compared to other materials. 13.5% of the individuals with teeth present had one or several caries lesions. Although it has been claimed that the incidence is higher in women in general (Arcini 1999: 85), there is no statistically significant difference between the sexes in this material (0.05 level). The prevalence of affected teeth is only 1.3%, a representative number for medieval materials. The low sugar-content in the medieval diet contributes to the low caries incidences commonly seen in medieval skeletal assemblages. In general, the dental pathology in the material is strongly associated with the general ageing process.

Joint disease

The presence of degenerative joint disease in the sample was recorded for all individuals with the specific joints available. The degenerative joint diseases may affect all joints in the body and are the result of cumulative and repetitive motions and the strains of habitual use of the muscoskeletal system. Studying the prevalence and distribution of joint diseases may enable us to understand life and work habits in the past, the sexual division of labour and the effects on people's quality of life (Steckel & Rose 2002: 44). Comparisons between communities on a geographical scale and over time may enable us to detect environmental and cultural variation (Rogers & Waldron 1995).

	F			M			F/M	F/M	Total >20			
	N	TPR Ind%	TPR Joints%	N	TPR Ind%	TPR Joints%	Chi-sq	P	N	TPR Ind%	TPR Joints%	CPR%
OAVertC	6	23.1	14.9	5	29.4	19.4	0.22	0.64	11	19	15.0	17.5
OAVertT	5	18.5	13.1	5	33.3	18.5	1.17	0.28	10	17.9	14.0	15.9
OAVertL	5	18.5	10.7	3	23.1	5.4	0.11	0.74	8	15.7	7.9	12.7
TotOAVert	6	22.2	13.3	6	35.3	16.3	0.90	0.34	12	20.3	13.1	19.4
OVB	13	44.8	28.1	5	27.8	18.0	1.51	0.21	20	37.7	18.6	25.6
SN	13	44.8	12.4	10	55.6	20.3	0.48	0.49	24	40.7	11.5	30.8
FusionVert	3	10.3	1.3	1	5.5	0.7	0.35	0.56	4	6.8	0.8	5.1
Spondylolo.	2	6.9	0.4	1	5.6	0.3	0.04	0.85	3	5.1	0.3	5.1
VertFrac	6	22.2	-	4	23.5	-	0.01	0.92	-	-	-	-
OAShoulder	5	20	6.9	1	7.7	5	0.97	0.33	6	12	5.3	9.5
OAElbow	3	13.4	3.4	2	12.5	2.7	0.003	0.96	6	11.1	2.3	6.4
OAWrist	0	0	0	0	0	0	-	-	0	0	0	0
OAHand	0	0	0	2	0	0	-	-	2	0	0	3.2
OAFingers	1	0	0	2	0	0	-	-	4	0	0	6.3
OAHip	0	0	0	4	26.7	11.8	-	-	4	7.3	3.2	5.1
OAKnee	2	13.3	3.9	0	0	0	-	-	2	5.6	3	2.6
OAAnkle	0	0	0	0	0	0	-	-	0	0	0	0
OAFoot	0	0	0	2	0	0	-	-	3	0	0	1.3
OAToes	0	0	0	0	0	0	-	-	0	0	0	0

Table 15 *The distribution of joint diseases at St Mary's. F=females, M=males. TPR=true prevalence rate, CPR=crude prevalence rate. N=number of individuals.*

Number of observable individuals for:
Cervical vertebrae: F: 26, M: 17
Thoracic vertebrae: F: 27, M: 15
Lumbar vertebrae: F: 27, M: 13
Shoulder (scapula/humerus/acromio-clav): F: 25, M: 13
Elbow: F: 23, M: 16
Hip: F: 24, M: 15
Knee: F: 15, M: 11

A high prevalence of degenerative skeletal changes in the sample could reflect the socio-economic status of the individuals, as those of lower social status would be expected to be more involved in hard physical labour, and thereby more prone to occupational stress.

Table 15 shows the distribution of joint diseases in the material from St Mary's cemetery. The prevalence is calculated for each of the vertebral compartments (OAVertC=osteoarthritis of cervical vertebrae, etc.) and for the whole vertebral column (TotOAVert), the large synovial joints (wrists, elbows and knees), and the smaller joints of the hands, feet, fingers and toes. Some individuals display changes in more than one vertebral compartment, this is corrected for in the total prevalence of the vertebral diseases.

Table 15 shows the prevalence of all degenerative joint diseases at St Mary's cemetery. The frequencies reflect the age-progressive aspect of the degenerative diseases. Degenerative changes of the spine are found in adults exclusively, the majority over the age of 40. While 35.3% of the men are affected by osteoarthritis of the vertebral joint facets in one or several vertebral compartments (cervical, thoracic and/or lumbar) (cf. Figure 34), only 22.2% of the women suffered from the condition (true prevalence rate). The difference is, however, not statistically significant on the 0.05 level. The condition seems to be less frequent in the lower back in both sexes. This is consistent with finds from Lund (Arcini 1999: 95). In British medieval assemblages joint diseases of the spine occur on average in one third of the total number of individuals in the samples (Roberts & Cox 2003: 281–282).

Figure 34 *Osteoarthritic changes of the vertebral joint factes in an individual from St Mary's Church. BRM 0/75040 (ID 30) (Photo: K. Lorvik).*

Spondylosis or marginal osteophytes (OVB=osteophytes of the vertebral bodies) and Schmorl's nodes occur in the disco-vertebral junctions of the vertebrae. 44.8% of the women and 27.8% of the men are affected contrary to the finds of vertebral osteoarthritis. This seems to deviate from finds in other archaeological assemblages (Kennedy 1989: 131). Although spondylosis is associated with osteoarthritis, it does not always represent disease, but is merely an accompaniment of ageing (Rogers & Waldron 1995: 25). The presence of osteophytes in the spine is promoted by an active lifestyle and heavy manual work, and may thus reflect the amount of mechanical stress experienced by a person (Manchester & Roberts 1995: 107). A fusion between vertebrae may occur in the excessive growth of osteophytes (Figure 35). This is present in three women and one man at St Mary's. The presence of spondylosis in Lund resembles the finds from St Mary's, but with predominance in men (c. 20%). The sex-differences observed for spondylosis and spinal osteoarthtitis at St Mary's could reflect differences in activity patterns between the sexes. The difference is, however, non-significant on a 0.05 level.

Figure 35 *Fusion of vertebral bodies due to extensive osteophyte growth. The condition could be the consequence of a malaligned fracture of the lower leg, see also figures 38 & 42. BRM 0/75066 (ID 24).*

A total of 25.6% of all adult individuals at St Mary's have the condition spondylosis. In comparison, the crude prevalence rates in all phases at Sigtuna (970–1536) is 9.2% and in the adult material from Lund (990–1536), the range is 0.8–5.5% (Arcini 1999: 175; Kjellström 2005: 50). The reason for the higher prevalence at St Mary's must be sought in the considerably higher proportion of middle aged and old individuals (50.0%) in the assemblage compared to Sigtuna (16.1%) and Lund (16.1%) (Arcini 1999: 160; Kjellström 2005: 40).

The occurrence of Schmorl's nodes (cf. Figure 36) is more balanced between the sexes (but the prevalence rate is very high; 40% of the adult individuals have experienced skeletal changes caused by the herniation of one or several vertebral discs. The condition is associated with prolonged physical stress and ageing or acute physical trauma to the back, and is common in both men and women, with a slightly higher representation in the men (44.8% to 55.6%). There is no significant difference between the sexes (0.05 level). The high prevalence of the conditions must be considered age-related. Schmorl's nodes often appear together with osteophytes on the vertebral bodies (OVB or Spondylosis). It is not known to what extent the condition is caused by ageing and to which degree by heavy physical strain (Bennike 1985: 131; Rogers & Waldron 1995: 25). The condition is common today, and has by some been attributed to sedentary

Figure 36 *Intervertebral indentations on a thoracical vertebra identified as Schmorl's nodes. Photo: K. Lorvik.*

Figure 37 *Spondylolosis in the throrax of a probable female aged 60+. Photo: K. Lorvik.*

work, and the condition does not always cause a lot of pain (Bennike 1985: 131–32). It has also been suggested that the herniation could be the result of an acute traumatic event, due to heavy axial loading (Fahey et al. 1998)

Spondylolosis has been found in three individuals, two women and one man. In one of the individuals, the condition co-occurs with fusion of two cervical vertebrae (Figure 37). The condition could be congenital or a result of trauma, perhaps a result of heavy physical strain or a fall to the back, but this has not been possible to establish. The sex-difference is non-significant.

Compressed fractures of the vertebra is yet another indicator of both ageing and prolonged physical stress – two factors often found to be co-occurring. The condition is found in both men and women, in 22.2% and 23.5% of the observable individuals respectively. The comparative materials do not list the occurrence of the condition, so comparing frequencies is not possible.

Among the individuals at St Mary's Churchyard, osteoarthritic change in the large synovial joints is found in the shoulder, elbow, hip and knee joints. The frequency of shoulder-OA includes both arthritic changes in the acromio-clavicular joint, on the humeral head and the glenoid cavity of the scapula, i.e. a large proportion of the articular surfaces of the shoulder joint. OA of the extremities is less frequent than in the spine at St Mary's. The condition was found in the shoulder, elbow, hip and knee joints. No hands, ankles or feet were affected, but several individuals displayed slight alterations of the finger joints that perhaps could be attributed to the initial stages of OA. The low prevalence of OA of the fingers may be a result both of a failure to record the presence due to lack of the identifying trait, eburnation, and the general under-representation of the finger-bones in the material.

Figure 38 *Middle-aged male with extensive arthritic changes of both hips (see also figures 35 & 42). BRM 0/75066 (ID 24). Photo: K. Lorvik.*

The prevalence for OA in the shoulder in women is 20%, while of the men only 7.7% are affected (one individual). OA of the elbow has a slightly higher representation in women at 13.4%, with 12.5% in men. The sex-differences for both conditions are, however, non-significant on a 0.05 level. Arthritic changes of the knee were present in two females only (13.3%), and OA of the hip was present in four males (26.7%) (cf. Figure 38). The frequencies for OA of the elbow and knee are higher than in Lund (Arcini 1999: 161; Kjellström 2005: 50), but similar to the averages from Sigtuna (c. 15%). Only for the prevalence of arthritis of the hip, do the frequencies from St Mary's stand out. The higher frequency in males is coherent with other medieval finds, but the prevalence in Lund and in comparative data on male farmers is considerably lower (c. 8%) (Arcini 1999: 105). The variations in distribution and location between the sexes could be related to differences in occupation and activities.

Infectious disease

By studying the age and sex-distribution of infectious disease one may reveal information on particular at-risk groups, population structure, age and sex-differences in distribution and on ecological and cultural factors influencing the predisposition to disease (Steckel & Rose 2002: 34–35). Following the discussion on the difficulties of identifying infectious disease in bone, the prevalence in the material is an estimate. The term periosteal reaction covers all cases of periosteal new bone formation and may include other bone lesions that are not the result of non-specific infection (periostitis). The prevalence of dental disease is presented separately but must be seen in relation to the other skeletal lesions possibly representing infectious disease.

Table 16 shows the prevalence of skeletal changes that may be related to non-specific infections and cribra orbitalia at St Mary's for sexes, unsexed individuals and sub-adults. The total number of observed individuals is fifty, thirty women and twenty men. These are all the sexed individuals in the material.

	F		M				Total			<20	?
	N	Ind%	N	Ind%	Chi	P	N	CPR%	TPR%	N	N
Periosteal reaction	6	20.0	3	15	0.20	0.65	9	18.0		0	2
Cribra orb*	5	16.7	3	15	0.03	0.88	8	16.0	26.3**	5	0

Table 16 *St Mary's churchyard. The prevalence of periosteal reaction that could be caused by non-specific infections and cribra orbitalia in adults of both sexes and sub-adults. N=50 (F: n=30, M: n=20, number of orbits: 60). Calculations according to the total number of sexed adults in the material and total prevalence for the observable individuals only.*

**=the percentage shows the crude prevalence rate, i.e. affected individuals according to total number of individuals in each group in the material*

***=percentage of affected orbits calculated from the total number of orbits in the material*

According to the data in Table 16 the frequency of periosteal new bone formation possibly caused by infection is 18% in adults, with a slightly higher appearance in females (15 to 20%.) The sex-difference is non-significant on a 0.05 level. One of the infants has signs of non-specific infections of the long-bones (BRM0/75032 ID 21)

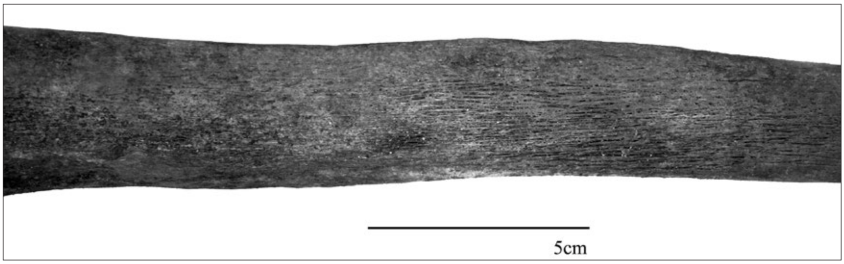

Figure 39 *Periosteal new bone formation – tibia.*

The number of individuals in the sample that suffered from infections could in fact be higher but the condition has left no traces in the skeleton. Even though a specific cause of death has not been possible to establish, one can not rule out that some individuals, and particularly the young ones without pathological lesions in the assemblage, may have died from acute infections.

Metabolic disease

Cribra orbitalia may reflect episodes of malnutrition or disease. About 30% of the total number if individuals under <20 were affected, but none younger than c. 12 years. The prevalence is lower than the general tendency for medieval assemblages (Isaksson et al. 1998: 106; Arcini 1999: 181). The prevalence of cribra is lower in the adults (c. 16%), and there are no sex-differences. This is lower than in other northern-European medieval assemblages where the average is 20–30% (Iregren 1994: 181; Arcini 1999: 181).

A combined case of cribra orbitalia is found in one of the double graves (BRM0/76350, ID 67 & BRM0/76348, ID 68). It is the grave of a middle-aged man and a teenager aged 15–18 both with porotic lesions of the orbits consistent with cribra orbitalia. The man also shows skeletal changes indicative of physical stress, arthtitic changes in the vertebrae column and activity-induced degenerative changes in both shoulders and arms. There is a possibility that the porosities are caused by a non-specific infection and not necessarily the result of a persistent anaemic condition. The cause of death is not established.

Trauma

The prevalence of skeletal trauma in a population may reflect levels of interpersonal conflict, activity and occupational related accidents and prolonged physical stress. The presence of trauma reflects to a certain degree health hazards in society. High frequencies of skeletal trauma in the assemblage is expected to reflect a conflictive environment and a high risk of being affected by accidents and violence and could in some cases enable the identification of assemblages of a special character, such as fallen soldiers and victims of war etc.

There are three possible cases of weapon-related trauma in the material. BRM 75005, ID 3: This is an adult, probable male from a double grave (buried with BRM/75045, ID 35) shows two lesions, both possible depressed fractures on the back of the skull (left parietal bone). BRM0/76342, ID 46 & BRM0/76327, ID 48 are both middle-aged males showing four and two similar cranial lesions respectively (Figure 40). The lesions may have been caused by several blows to the head with a blunt instrument either as an act of violence or in a fall (Larsen 1997: 129).

The other individual in the double grave is an adult female (ID35) placed directly underneath ID3. The woman has a deep cut on the left heel, possibly a weapon injury. The lesion cuts right through the posterior part of the calcaneus (heel bone) leaving less than one centimetre of bone intact on the opposite side. There is no bone formation consistent with healing in or around the lesion, indicating that the wound was inflicted peri-mortem around the time of death.

BRM 0/75229 (ID 42), middle-aged woman shows a sharp, non-healed cut on the left innominate bone possibly the result of sharp force trauma. No other pathology or trauma is observed (Figure 41).

BRM0/75045, ID 35: A young adult woman displays a lesion on the left calcaneus (heel) consistent with sharp-force trauma.

Apart from a high incidence of compressed vertebral fractures (23%) in the assemblage, the prevalence of trauma is low. The vertebral fractures are most likely age-related

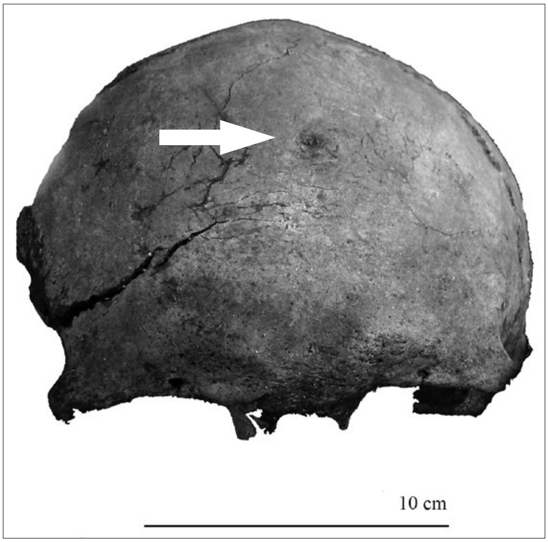

Figure 40 *Depressed fracture – skull. Possible cause is blunt force trauma either from an accident or physical violence. (Photo K. Lorvik).*

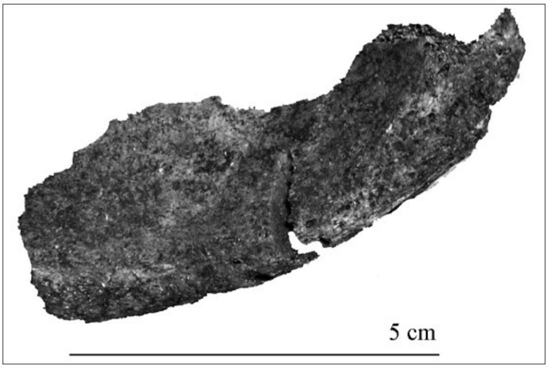

Figure 41 *Middle-aged female with possible weapon-related trauma to the pelvis. BRM 0/75229 (ID42) (Photo: K. Lorvik).*

Figure 42 *Male, 60+ with a healed fracture to the left lower leg. Same individual as figures 35 and 38. To the right; close-up of the fracture (Photo: Field documentation, Bryggen/ K. Lorvik).*

stress fractures and are commonly found in individuals past the age of forty. There are three incidences of other post-cranial fractures in the material.

ID24/ BRM0/75066: An older man displays a severe fracture of the lower leg (tibia and fibula), with an associated fusion of several vertebral discs. The fracture is healed and shows no sign of inflammatory response in the bone. Severe malalignment of the fracture has caused a shortening of the leg of about 5cm. This is most likely the cause of the back problems.

ID25 BRM0/76329, an individual aged 60+ (Figure 42) and ID 45 BRM0/76335, a woman aged 25–39 both have healed fractures of the let lower arm (ulna), a so-called Colles' fracture, probably from a fall on an extended wrist.

BRM0/76324, ID 54: This adult unsexed individual has most probably suffered from a twisting fracture of the upper shaft of the left femur causing major damage to muscle, tendons, nerves and blood vessels and possibly harming the femoral artery. The wound would then have caused massive blood loss and rapid death. There is no evidence of healing suggesting that the individual did not survive long after the incident. This does, however, not rule out the possibility of a different incident around the time of the fracture leading to the person's death.

Other graves worth mentioning are:

A multiple grave containing the skeletal remains of four adult and middle-aged women dated to the period 1170–1198. The individuals show no signs of trauma, indicating a possible reason for burying these four at the same time. The pathological lesions found are consistent with the general health picture in the material, age and/ or activity-related conditions, such as osteoarthritis, dental loss and dental abscesses.

Double grave: One grave contains two individuals BRM0/75011, ID 9 & BRM0/ 75018, ID 12, two adult women – one displays skeletal lesions indicative of infectious disease or other disease that have persisted long enough for it to be manifested as porosities in the orbits and long bones. The other woman seems to have compressed vertebrae, but no other pathological lesions.

The three double and multiple graves are all dated to the period of the civil wars, but the graves cannot with confidence be tied to these events or to the town-fires in the period.

Pathologies and trauma at St Mary's cemetery

Sub-adults

The pathological status of the sub-adults at St Mary's in general is characterized by inflammatory conditions in bones and teeth and signs of metabolic disturbance causing enamel defects (LEH). Among those who died between the ages 7–12, four out of five individuals showed periosteal lesions to the long bone diaphyses, indicating a chronic inflammation in the bone that may be a result of infections, trauma, cancer, vascular problems or vitamin-deficiencies. The same condition is seen in one of the juveniles, a possible male, past the age of sixteen. In general, the pathological conditions among the sub-adults are characterized by inflammations to bones and teeth and signs of metabolic disruptions, primarily enamel defects (LEH), cribra orbitalia, particularly among the older juveniles (12–19). There is also a case of compressed fracture to a vertebral disc and a case of arthritic destruction of the knee. These conditions could possibly point towards episodes of excessive physical strain experienced by the individuals. Among the older juveniles 16–18, four in seven possibly male, also display severe calculus depositions to the teeth. This indicates a period of poor dental health, perhaps related to the inflammatory conditions seen in the teeth and jaws of several individuals or indicating periods of illness, where food intake and dental hygiene was scarce.

Adults

The pathological status of the adults in the sample differs from the sub-adult group. Although inflammatory conditions and signs of metabolic disturbance do occur in the adults, the main complications are related to the effects of physical stress and ageing.

In total, c. 75% of the individuals in the sample display some sort of pathological condition or traumatic lesion. Not all conditions are lethal, however, some are a natural accompaniment to ageing, and others have developed as a result of long term wear and tear, and may tell us something about the level of physical strain in the population. The most common pathological conditions are either caused by physical stress, such as joint disease; such as joint disease; by ageing, like bone degeneration and dental disease; by metabolic stress, undernourishment or infections or by traumatic incidents, accidents or violence. There is no skeletal evidence that the buried at St Mary's have experienced violent episodes affecting a large proportion of the individuals and perhaps died as a result of this. This, despite living in a period where incidents related to an ongoing civil war may have affected the population in Bergen, for instance during the fights and the related fires known from Sverre's saga to have occurred in town at the end of the twelfth century.

Life and death in early urban Bergen

The finds from the osteological analysis throw light upon interesting aspects of the demographic composition and health status in the assemblage, representing a group of people buried at the church of St Mary's in the early High Middle Ages. To understand the finds in a wider perspective, as part of the history of urban medieval Bergen, the finds ought to be placed in a wider context, and viewed in light of other archaeological and historical sources.

Important aspects in the discussion of the character of the urban settlements are: migration, health variations between groups, gender-related issues and the presence of social hierarchies (Kjellström 2005: 68). Osteologically, these aspects may be reflected through the demographic composition of the assemblage, the prevalence of health indicators and the health status of the individuals and the location of the graves.
Important questions are:

- How do the skeletal data and the demographic profile of the assemblage reflect the character and composition of the town population?
- What does the presence of various health indicators among the individuals in this sample tell about the living conditions of the buried, and the quality of life for the

population in medieval Bergen? Do the finds in any way reflect social structures in the town?
- How do the finds correlate with information from other archaeological and historical sources?
- How do the finds contribute with new understandings on life in the medieval towns, and in Bergen in particular?

The demographic composition – men, women and children

Due to the function of the early medieval towns as centres for the administration, royal court, religious institutions, and commerce, it has been claimed that the town population had a characteristic demographic composition and were of mixed social and economic status. The town's functions attracted a variety of people to the new urban centres, both members of the royal court and the ecclesiastical community as well as merchants, people involved in handicraft and trade, servants and other labour-seeking groups. It also housed a large visiting, seasonally based community involved in trade and commerce (Helle 1982: 449–461).

Studies on the demographic composition in past and present towns show a general male bias in the population and in administrative positions, while women are in minority and associated with market and indoor household activities. Young people, and men in particular, represent low cost labour, as opposed to family groups, and the women working in towns tend to marry late and give birth to fewer children. This leads to a demographic structure with a high number of unmarried inhabitants and a low number of children (Øye 2005: 54–55). The towns attracted a large number young workers in the thirteenth century; men and women mainly arriving from the surrounding areas, and a large proportion of the population working in the towns probably represented independent, visitor workers. This implies a considerable degree of mobility in society, with a high level of migration, as many people left town or returned to their local communities at a later stage in life. Some authors claim that there were even proportions of men and women in the early towns. The sex-distribution, however, could have been strongly influenced by the function and character of the town. The function of Bergen as an administrative and royal centre, involved in trade and commerce, may have led to a male predominance in the urban population (Øye 2005: 56–57).

The skeletal sample from St Mary's cemetery shows an interesting sex-distribution

More than half of the young and middle-aged adults in the assemblage are women. This comprises two thirds of the total sexed individuals. The skewed sex-distribution in the assemblage is unusual in medieval archaeological assemblages, where there tends to be an overweight of men (Arcini 1999: 160; Sellevold 2001: 182). In the assemblage from Lund, there is accordingly a male bias in all phases from 990–1536 AD (Arcini 1999: 160).

At St Mary's there is a clear female bias in both the adultus (20–39) and the maturus (40–59) groups. Women are in majority among both the young and the middle-aged adults buried at the cemetery. The proportion of men to women is the same in both age-groups. The female bias is constant in the assemblage.

As for the age-distribution, the osteological analysis does not indicate that men or women of a particular age, for instance an overall presence of young individuals were buried on this part of the churchyard. This is contrary to what is seen in Scandinavian archaeological contexts, where there is a tendency towards a higher proportion of the young adult females as opposed to middle-aged and old at the cemetery (Iregren 1992a: 61; Sellevold 2001: 128; Kjellström 2005: 38).

There is no statistically significant difference in age-group distribution between the sexes at St Mary's. The more or less even distribution of ages between the sexes differs from the Hamar material, where as many as 84.1% of the women fell within the older age-groups as opposed to only 60.8% among the men. Sellevold interprets the high age-at-death, particularly among the women as an indication of a healthy, high status population, and explains the high ages of the women in the material with the possibility of these as representing corrodarians; lay people purchasing permanent residence in an ecclesiastical household. The author interprets this as a sign of the individuals' privileged status (Sellevold 2001: 221–223). In Sigtuna and Lund, there is an overrepresentation of women among the young adults (20–39) (Arcini 1999: 160; Kjellström 2005: 38). The age-distributions elucidate the differences among the cemeteries, with the Hamar assemblage representing a population from the upper social strata and the Sigtuna and Lund assemblages representing, to a larger extent, a cross-section of the town population. The age-distribution at St Mary's shows that almost two thirds of the adults individuals fall within the older age-groups. This resembles the finds from Hamar although the proportion of women is much higher at St Mary's (Sellevold 2001: 124–127, 221) The senilis group (60+) is represented with one individual for each sex at St Mary's cemetery. The high mean ages in the assemblage (40.1 years) is due to the high number of middle-aged individuals.

Do the finds reflect the true demographic composition of the town? Due to the assemblage being incomplete, and based on comparisons with other medieval assemblages, where there is a pre-dominance of men (Arcini 1999: 182; Sellevold 2000), this seems unlikely. Another possibility is that the mortality among women was higher than for men. This has been attributed to the potential health risks of childbirth, a major cause of death in eighteenth–ninteenth century Europe. The results from this study shows no indication that this should be the case here. The adultus category comprise to a large extent individuals in the upper range of the category (30–39), not predominantly among the younger women, a group where the frequencies of child-birth is expected to have been higher.

The female bias could, on the other hand, reflect the spatial organization of the cemetery. The low proportion of men may be due to a segregation of the cemetery according to sex, and may indicate that the men were buried elsewhere. The provincial laws of Borgarthing and Eidsivathing from the twelfth century, operating in eastern Norway and the Oslofjord area, presuppose a division of the cemetery according to social status. The latter states in addition, that men should be buried to the south of the church, women to the north. A segregation of the buried according to these principles is found at several Scandinavian cemeteries (Kieffer-Olsen 1993; Nilsson 1994; Sellevold 1999). In the medieval cemetery at Västerhus, Sweden, sexual segregation is almost total. The women found on the "wrong side", i.e. the south side of the church, are either believed to have died in childbirth or to have been buried in family graves (Jonsson 1999). This is not a likely explanation for the female bias in this study; neither age-distribution among the females, nor the large number of women buried to the south in the cemetery at St Mary's support this. Some authors have claimed that social class was the main structuring principle rather than sex. Lower social status for women would then be reflected in that more women were buried to the north (Nilsson 1994). This is, however, not always the case, particularly among the higher social strata, as seen at the Hamar Cathedral cemetery (Sellevold 2001). It is important that contrary to the other provincial laws, the law of western Norway, the Gulathing law, does not require a particular internal organization of the cemetery (Sellevold 2001: 64). It is possible that these organizing principles were never claimed in Bergen, but general practice may have deviated from the law. The fact that men, women and children are represented at St Mary's indicate that spatial organization according to sex was not practiced at St Mary's in the period c. 1150–1250. Because the cemetery of St Mary's is only partially excavated, it may, however, not be possible to determine whether other manners of segregation were practiced. The high proportion of women in the assemblage from St Mary's does, however, show that there may have been a marked presence of women in Bergen in the High Middle Ages.

It has been established that the distribution of adults deviates from what could be the expected representation of men and women and age-groups in medieval town populations.

The distribution of non-adults in the material is unusual. The total amount of sub-adults at St Mary's is 19%, all above the age of six. Compared with the age-distribution in other Scandinavian materials, this is within the lower ranges, where the number of sub-adults differs between 16.7–73.4%. Studies show that there is a lower presence of sub-adults in urban populations (Kjellström 2005: 42).[9] Even though there is a tendency for urban materials to display a lower number of infants than the corresponding rural, child mortality is believed to have been high in the Middle Ages, and the total absence of infants and children under the age of six at St Mary's is striking. The number of young children (<7) range from c. 15 to 30% in the comparative materials, with the highest proportion found in Lund. The exceptionally low proportion of small children could indicate that they were buried in separate parts of the cemetery. There is a chance that these graves were situated outside the excavated cemetery area. On the other hand, these results could be consistent with a theory that the early town of Bergen was in fact populated to a large extent by young, unmarried people, men in particular. The assemblage could then reflect the functions and character of the developing town in the twelfth and thirteenth centuries.

9 The results are previously published in Sellevold 2001; Arcini 1999; Benedictow 1993 and Dahlbäck 1982, and compiled in Kjellström 2005.

In a study on the archaeological representation of children in the material culture in Bergen, the majority of artefacts from the period can be related to children older than the age of 5–6 years, and boys in particular. This bias is associated with the patterns of mobility in the medieval towns as mentioned, where men of working age are thought to have been in majority (Mygland 2007: 66). These finds correspond with the skeletal data in this analysis.

Studies on the character of the town settlement in the period 1070–1170 interpret archaeological finds associated with women and young children (< age 7), such as children's shoes, food processing equipment and textile equipment, as indicators of the presence a well-established and permanent settlement in Bergen (Hansen 2005: 218–20). The skeletal remains from St Mary's cemetery, from the period about 1150–1250 fail to detect the young children. The older children, aged 7–11, may to some extent, have taken part in daily household duties or other physical outdoor labour, either as part of learning and growing up, or as a contribution to the family household. Many adolescents were probably engaged in regular work (Orme 2001: 68, 307–08). It has been suggested that the absence of young children is typical for the early urban development, where the town was characterized by the arrival of young entrepreneurs. This phase is believed to precede a phase where whole families were established. A similar low proportion of children is seen in the early phases of some of the Lund cemeteries (Kjellström 2005: 71; Arcini 1999: 68), and there is observed a general increase in the proportion of sub-adults in general in Scandinavian urban material (Kjellström 2005: 41). More sub-adults would normally give a larger number of young adults in an assemblage, and is not entirely consistent with the finds from St Mary's. The total absence of the youngest children in this sample could, on the other hand, be explained by the fact that it only represents a limited part of the cemetery, or that the graves belong to a specific group of people in the town, burying their dead in this particular area of the cemetery. There is thus a possibility of overlooking the presences of infants and children in the material.

In a study on the footwear from the Gullskoen site at Bryggen, attemps are made to link the shoe-sizes to the age and sex of the bearer. Size distribution frequencies show that the predominant sizes in the earliest period studied (pre-1170–1250) correspond with the dating of the graves in this sample. The study shows that in this period, almost all recorded shoe-sizes are represented with a peak in the sizes 37, 39 and 41. Taking into account that the body size and length of the foot has increased since the Middle Ages, the majority of the shoes lay within the large adult sizes commonest for men. The number of medium sizes that may have belonged to women and the young are also considerable (Larsen 1992: 73–75). The shoe-material from the period before the mid-thirteenth century indicates that the town was populated largely by adults, with a bias in men, but with a considerable presence of adult females, youths and children. The skeletal analysis reflects a similar sex- and age-group-composition, but with a stronger female bias. In the following period (1250–c. 1400), a strong increase in the shoes size 33–37, indicates a marked presence of women and youths relative to men in Bergen. Around this time there was a shift in population structures in town, mostly caused by the arrival of German tradesmen who rented premises in town and gained control of the foreign trade. As shown, according to archaeological data it is reasonable to believe that despite the increasing male dominance in the Bryggen area, until the mid fourteenth century, there must still have been a large proportion of local inhabitants in this part of town; not only men, but women, teenagers and children (Helle 1982: 376, 722; Larsen 1992: 76).

Health and living conditions

Archaeological and historical sources together with osteological data may provide new and interesting perspectives on medieval life. How do the skeletal remains from St Mary's cemetery throw light upon the health and living conditions in medieval Bergen – a town characterized by a growing population, with an increasing demand for hygiene and a new infrastructure for waste disposal, water supply and welfare? Do the skeletal remains show characteristics reflecting problems like increasing contamination, exposure to pathogens and disease, and higher mortality? Are there any differences between men and women in life-expectancy and disease prevalence? To what extent do the remains reflect hard physical work, and are there any differences between the sexes? Do the remains perhaps show the contrary, reflecting a population of high social status, and can this be inferred from the skeletal remains? These questions will be considered here in the light of the historical context and archaeological context of the remains.

The early High Middle Ages was a time of expansion in Bergen. The period was characterized by an increasing population and an increased population density within a fairly limited geographical area, and a mixed population of a local, permanently based community, immigrants and a large proportion of seasonal visitors. Archaeological investigations in the early settlement area of Bryggen show that the period from 1150 onwards was characterized by intensive building activity, both of secular and monumental character and an expansion of the town further out from the bay of Vågen. This marks Bergen's increasing importance as a centre of trade in the high medieval period and the economic growth and building activity must have gone along with a considerable population growth (Helle 1982: 117–169).

A range of factors influence people's standard of living and health status. The effect of urbanization on human living, with closer aggregation of settlements, population increase, and immigration is believed to have had a negative impact on people's living conditions in the Middle Ages. The urban environment may have led to a higher exposure to pathogens and an increased risk of contracting diseases (Roberts & Cox 2003: 228–248). A rough calculation on the population size in Bergen around 1250–1300 gives an estimate of between close on 10,000 inhabitants, without including the vast number of visitors in the summer sailing-season (Helle 2006). Bergen was a large town in the High Middle Ages, among the Nordic towns, possibly the largest. Sigtuna, in comparison, is estimated to have had a population of no more than c. 50–1400 in the Early Middle Ages (Kjellström 2005: 4).

Fundamental for human health and the effective protection against disease is the availability of a clean, unpolluted water supply. The most common contaminant of water supplies is sewage. Developing towns often experience problems with waste and sewage disposal causing contamination of water and the spread of diseases (Roberts & Cox 2003: 8). Similar situations may have occurred in the medieval towns. Finds of a number of privies/ latrines, some intended for common use and placed in public areas suggest that there was a public concern with the sanitary conditions in Bergen as early as the twelfth century (Herteig 1994: 287–99). But the remains of cess-pits and latrines in the housing areas in Bergen also show that people lived in close proximity to these potential health hazards. Dumping of household waste and other refuse was practiced in several open areas in town, and regulated waste disposal may not have been introduced until the urban legislation in the 1280s (Økland 1998: 30–49, 94–100; Øye 2004: 523).

Water supplies in Bergen came from surrounding rivers and the many wells documented archaeologically in the town centre. The intensive periods of rainfall characteristic of western Norway today was common in medieval times when temperatures were slightly higher and the climate more humid. The rain may have had a cleansing effect, and had a positive impact on sanitarian conditions in town. Dry periods may, however, have caused problems, and within the central town area, there was a risk of contamination (Øye 2004: 519).

Immigration and trade may lead to the introduction of new diseases in a community, a potential health risk (Roberts & Cox 2003: 9). In a medieval urban environment one can easily imagine how high population density, close contact between animals and man and poor hygiene could provide good conditions for the spread of infectious diseases. On the other hand the greater exposure to pathogens experienced in medieval times may have created immune systems that were stronger and better able to fight disease than today (Roberts & Cox 2003). Perhaps the pathogens affected the immigrant population more than the town's people.

As for the age- and sex-distribution among the individuals buried at St Mary's cemetery, the material shows an unusual composition. The age-distribution in the material has been discussed in relation to the character of the early town population and the representativity of the material. These aspects are also important in the study of the living conditions in the medieval town. Due to the complete lack of infants at St Mary's, the child mortality levels in the material are unusually low for a medieval context. Palaeodemographic studies show that there is a rise in childhood mortality with increased population density, but this is not observable in this analysis. There is a possibility that the youngest children are buried on other parts of the cemetery, hence the proportion of children that died in the population may have been larger. Another possibility, though difficult to prove, is that the material reflects the demographic composition in the early town – a society with an under-representation of children because the towns primarily attracted people in their working ages that did not form regular family groups. There is a chance that there were few children in general in early medieval Bergen. Not all of the young people in town were necessarily married with children, as the towns may have attracted a large number of not only young, single men, but also single women. These women may have been engaged as maid servants or in textile production, an important activity associated with women in the early medieval towns, before it was professionalized and to a larger extent came under the responsibilities of male trade and craftsmen. In Bergen, the household based textile production disappeared from the central Bryggen area in the fourteenth century (Øye 2005: 57).

The mean ages-at-death in the assemblage are high for both sexes. Most of the adults buried in the southern area of St Mary's cemetery had reached the age of forty years when they died. This could indicate that the individuals were of rather good health. Other health indicators must, however be examined to understand the full picture. A few of the individuals are past the age of sixty, but do not comprise a large proportion of the material. The majority of the individuals have attained a high age in a medieval context.

Body heights in a population may reflect health aspects, both genetically determined and socially and culturally induced. How are these conditions observable in the individuals from St Mary's? The statures of the individuals are within the average ranges for medieval assemblages. It would be of interest to know whether the people buried at St Mary's were born in town or arrived at a later stage in life, since this would give information on social organization and patterns of mobility, and could show whether the indicators of childhood health actually reflect local conditions. The geographical origin or ethnicity of the buried has not been possible to establish at this stage, but the statures show that the material is rather homogenous, with little height variation. The mean statures at St Mary's are not particularly high, but the female heights seem to correlate better with the comparative materials than the male heights which are lower. The heights at St Mary's are slightly more dispersed in men than in women. There are no exceptionally short or tall individuals in the material, but there is less dispersion in stature among the women, indicating that they represent a less diversified group. This is consistent with finds from Lund and Hamar, and may represent an urban trend, reflecting a greater mobility and thereby a genetic diversity in men. The individuals buried at St Mary's cemetery were in general shorter than in the main comparative material from Sigtuna, Lund and Hamar. The males have the lowest heights compared to other materials and the average stature in females is similar, but in the lower ranges of the other materials. The women at Hamar were considerably shorter than the men at the cemetery. It would be interesting to compare the finds from St Mary's with data from rural skeletal assemblages to examine whether this could be linked to migratory patterns in the population. The more dispersed stature estimates among men along with the large differences in mean stature between the sexes (sexual dimorphism) could indicate that the men represent a greater genetic variation than the women, thus indicating a larger mobility for one of the sexes, in this case, a higher rate of immigration and spread geographical background in the men. The considerably higher stature in men in the early urban phase in Lund is interpreted as an indication of a predominantly male immigration. The sexual dimorphism in stature at St Mary's is not high, but the homogeneity in the female group is an indication that this could be the case in medieval Bergen as well. This is as expected in a town with important ecclesiastical and administrative functions and an economy based to a large extent on trade.

Stature may reflect genetic relationships, but it is also a health indicator. Differences in body height between, for instance, men and women could be an indication of the nutritional status in the population and differences in access to foods and other goods. Large differences between the sexes, where men are considerably taller than women, may be a consequence of society investing nutritional surplus in the growth of men. If differences even out, this could reflect poor health conditions manifested in men, due to the higher degree of eco-sensitivity, i.e. the tendency in males to be more sensitive to socio-economic changes and nutritional stress than women (Arcini 1999: 74; Kjellström 2005: 73). Populations with unfavourable health conditions and poor nutritional status may experience inhibited growth in males. A high degree of sexual differences (dimorphism) in height would then be consistent with a healthy, well-nourished population (Kjellström 2005: 73). The sexual dimorphism at St Mary's, calculated from max femur lengths, falls between the ranges for Hamar and Sigtuna, the former representing a high status population. The differences in stature is similar to that for Lund material, where it is considered high and indicative of an early town population with access to a nutritional surplus. In Lund, the difference between men and women did, however, decrease over time, indicating a worsening of health conditions towards the late middle-ages (Arcini 1999: 74). The Hamar material shows the highest degree of sexual dimorphism among the comparative material, consistent with the idea that the assemblage represents a high status population (Sellevold 2001). Comparisons with rural assemblages indicate that the people in early medieval towns were better off health-wise than both the rural population at the time and the population in late medieval towns (Arcini 1999).

A higher survival rate in a population normally causes greater dispersion of body heights. This is because in a healthy population, the survival is higher even among the weakest individuals, identified, for instance by their lower mean heights. This causes a wider range of heights within the healthy, high status population. This is contrary to finds in lower status populations where the weakest individuals with the lowest heights are the first to succumb to health threats. These individuals will eventually disappear and the heights in the population even out. The mean statures in the two populations do not necessarily deviate much, but ranges of heights represented in the population do (Lynnerup et al. 2008b: 102).

What then with other health indicators like the signs of skeletal pathology and trauma? Do the finds correspond with what could be read from the ages and the statures in the material? An important clue to the health status in a population is found in the levels of mortality and degree of morbidity among the subadults. Children and adolescents are more sensitive to poor living conditions and exposure to disease than adults. Because of this, childhood mortality rates and the skeletal manifestation of infectious disease, growth disturbance and metabolic disruption, may reflect the level of well-being not only among the children, but in an entire population. The sub-adults at St Mary's show a low occurrence of signs of metabolic and infectious disease, but there are several incidents of cribra orbitalia, enamel defects and periosteal new bone formation in the group, particularly among the ones age 13 and above. One of the adolescents shows a co-occurrence of several parameters of childhood health, cribra orbitalia, and enamel hypoplasia; the latter reflecting events of severe stress around the ages 3–5. In this individual, the body stature is lower than expected for the age (BRM 0/75049 ID 61), another indicator of poor health. Despite a lower prevalence than in the comparative materials, there is evidence that the adolescents in this material from St Mary's were more vulnerable to disease. On the other hand, the higher number of teenagers in the material may reflect the actual demographic composition in medieval Bergen.

The prevalence of cribra orbitalia among the adults in the material is considerable taking into account that the condition is usually attributed to the sub-adult group. The lesions seen in the adults are not healed and can thus not be seen as reflecting overcome childhood disease. It may well be that the porosities observed in the orbits are caused by insufficient nutrition or chronic inflammation, perhaps of the eyes. The distribution of the lesion among adults shows no significant difference between the sexes.

The dental status of the individuals from St Mary's cemetery is varied. A large number of the individuals had experienced tooth loss, and several had suffered from severe and possibly lethal tooth infections. These conditions are not only an effect of poor health, but are increasingly common with age in medieval assemblages. In general, it is the middle-aged that show the majority of incidences at St Mary's. There is a tendency for the conditions to co-occur, reflecting a general deterioration in oral health with age (Roberts & Cox 2003: 262). The low presence of caries is not surprising. This reflects primarily a diet low in cariogenous substances, sugars and carbohydrates. There are no significant differences in caries distribution between the sexes indicating differences in diet or health between females and males in the assemblage.

The picture is somewhat different when it comes to joint diseases. A large proportion of the individuals buried at St Mary's suffered from degenerative joint diseases, primarily of the vertebral column, but also in the large joints of the appendicular skeleton. The conditions are known to be age-prevalent, with a higher frequency among those involved in hard physical labour. The prevalence of disease and the location may reflect occupational activities. A higher incident in men may indicate that men were more involved in hard physical activities than women. The overall prevalence for both sexes is high at St Mary's. A comparison of the prevalence of vertebral arthritis in general showed no statistical significance in distribution between men and women. There is a slightly higher prevalence of arthritis in the cervical vertebrae in women than in men, however. The majority of the men show changes of the thoracic vertebrae. The location of the lesions to the middle part of the back, point towards a different activity patterns for men. The cervical vertebrae are the most flexible part of the back, enabling flexion, bending and rotating, whereas the thoracic vertebrae are primarily involved in lateral bending and rotation. Finds may reflect a population where men to a greater degree than women were involved in labour causing a greater degree of movement of the body. Activities like construction work, carpentry and masonry, blacksmithing, carrying and lifting of goods in the warehouses and loading of vessels, etc. – all activities known from medieval Bergen – demanded a great deal of physical effort and movement. It is possible that the assemblage represents a group of people involved in similar labour in town. Prolonged exposure to heavy physical strain will create signs of wear and tear in the skeleton, but the aetiology of osteoarthritis is complex, and influenced by factors like disease and general health conditions, and not least, age. There are striking similarities between St Mary's and Hamar when it comes to the prevalence of joint disease. The expected high social status of the Hamar population may indicate that the conditions not necessarily reflect occupational stress, as one would expect the lower social classes to be more exposed to such conditions.

The frequency of spondylosis at St Mary's is higher than for osteoarthritic changes and slightly higher in women than in men. It has been suggested that hormonal changes could cause a dramatic increase in osteophyte-growth on the vertebral bodies of women after the ages of c. 50 (Sellevold 1990: 61). This is, however, not evident from in the finds from St Mary's since the difference between the sexes is not statistically significant. In two of the individuals, severe spondylosis, fusion of vertebrae and spondylolosis co-occur, hence the conditions could be related.

The presence of osteoarthritis in the smaller joints of the hands and feet is low in the material. This is unexpected, considering the large amount of women in the material, as it is reasonable to believe that at least the women were involved in manual work such as spinning, weaving and sewing, putting increased physical strain on the joints of the hands and fingers, through repetitive use. These were important activities in the early towns including Bergen. This is confirmed by the large representation of textile equipment from the Bryggen area, particularly dating to the period 1170–1332 (Øye 1988). Interesting in this context is the mentioned find of a loom-weight in a woman's grave. The woman – in her middle ages – did not display the changes mentioned above, but had severe osteophyte growth on the vertebral column (spondylosis) and a compression fracture in the lower back that could indicate activity-related stress. However, attributing this to specific activities such as textile production with certainty cannot be done. A study of the relationship between weaving and joint disease in an archaeological assemblage did, however, fail to establish a connection between the prevalence of the disease and occupation. The prevalence of the disease was more likely the result of advanced age (Waldron 1989). As the initial stages of the disease usually involve the small joints of the hands and feet (Rogers & Waldron 1995: 57), one would expect a higher prevalence at St Mary's taking into account the age-distribution in the material. The low prevalence could reflect an under-representation of the bones of the hands and feet in the material. This is often the case in archaeological contexts. The sex-distribution in arthritic changes of the large joint confirms a different activity-pattern for men than for women, where the knees and shoulders are affected in women only, and the hip in men. Both sexes have arthritic changes of the elbow joints, with no significant difference in distribution. Athritis of the elbow has been associated with activities involving the carrying of heavy loads with both arms and is common in masons and blacksmiths, and may also be related to activities such as net-casting and wood-cutting. The OA of the hip, found in the men, could be associated with carrying heavy weight loads, running and walking, and habitual squatting, i.e. sitting in a position with the knees bent, carrying the weight with the body (Kennedy 1989). The shoulder joint is involved in movements where the arm is subjected to force when it is in an extended position; a movement that has been associated in some populations with activities like clothing preparation and the scraping of skins (Merbs & Hawkey 1995). All the conditions described may be related to activities that most certainly must have taken place in twelfth and thirteenth century Bergen. The degenerative joint conditions found in the material may be activity-induced but with a certain age-progressive character.

There is a possibility that the environment in Bergen was not as hazardous to health as the situation must have been in the large and crowded late, medieval towns. The exposure to new pathogens and diseases in town, as a consequence of aggregated living and population growth, must have been a reality in Bergen in the High Middle Ages, but the skeletal remains from the church of St Mary's presents a more nuanced picture. A considerable amount of the buried lived well into their forties and fifties. The signs of skeletal stress in the individuals are not primarily related to the infectious diseases, malnutrition and trauma, but to activities consistent with hard work and advancing age. These individuals were marked by the activities they performed in life rather than the diseases they may have contracted by living in a crowded, unhygienic environment. By this is not meant that urban life did not have its downsides; the young adults, adolescents and children in the material bear witness of the presence of infectious diseases and dietary deficiency associated with urban medieval settings.

It is interesting that more evidence of weapon-related trauma in the material is not found. This was, after all, a period of conflict in Norway, with events related to the ongoing civil war reported to have taken place in Bergen on several occasions. Only one, possibly two cases of weapon-related lesions caused by sharp force trauma and four possible cases of blunt-force trauma to the scull could be identified in the material from St Mary's. Some of the latter may just also be the result of accidents. This is also the case for some of the fractures seen in the material that, apart from one, seem to have aligned and healed well. It should, however, be mentioned that some of the arthritic conditions observed in the upper extremities have been associated with archery and spear-throwing. That the conditions are only found in women does not entirely rule out the possibility of some of the individuals being involved in these activities, but other explanations may be just as likely.

Concluding remarks

The health and living conditions experienced by the population is reflected through mortality rates, mean ages-at-death, height and the prevalence of skeletal pathology and trauma. If child mortality is low, life-expectancy high, and there is little evidence of malnutrition, metabolic disruption or chronic infectious disease, there is a fair chance that the individuals or the population in question has experienced rather favourable living conditions. It is, however, difficult to infer life quality through these health parameters, as morbidity usually increases in the higher ages. This is often reflected through a higher prevalence of age-related diseases such as joint diseases, dental pathology and tooth loss with advancing age.

A study of the group of individuals buried at the cemetery of St Mary's in the High Middle Ages, a period of great expansion and population increase in Bergen, has found osteological evidence revealing interesting aspects of the lives and health of some of the town inhabitants. Among the group of individuals buried in the westernmost corner of the cemetery there was a high proportion of women, and the mean ages of both men and women were higher than usual. The individuals had attained an average height in life, the men somewhat lower than in the comparative materials. As for signs of poor health, there is a low prevalence of conditions associated with metabolic stress in the individuals, and the most common pathological changes are joint disorders, that may be related either to occupational activities or to a natural ageing process.

The presence of sub-adults among the buried indicates that there was a certain health risk associated with life in the medieval town. The proportion of children and adolescents is, however, low, and the total absence of young children either confirms the good state of health in the assemblage or may be attributed to other factors such as the function of the church and the spatial organization of the cemetery. There is also, as discussed, a possibility that there were few children in early urban Bergen.

Whether the conditions described here, the demographic profile of the assemblage, the life-expectancy, and the general health and activity-patterns observed are applicable to the population in Bergen as a whole, is difficult to answer. Although representing a minimal of the once-living population, and a partial area of the cemetery, the exceptional narrow dating enhances the value of the material considerably. The individuals from St Mary's represent approximately one hundred years of burial at the cemetery at a maximum. This represents a maximum of three generations buried at the cemetery. Almost all individuals are dated within periods of no more than 30–50 years. It is not an easy task to establish a picture of the social status or identity of the group in question. The analysis has, however, revealed information that the group may be of a mixed social status, where a large proportion of the men and women, and perhaps also some of the children, were involved in physical labour, perhaps we find some of the many contract workers that the new urban centre attracted, among the dead. Some of them had reached an acceptable, or even a rather high age by medieval standards, while others, most certainly some of the children, had succumbed to diseases and other risk factors characteristic of the developing medieval town. A few of the adults show evidence of trauma, some are non-lethal events related to accidents and others are of a more violent character. The skeletal evidence reflects varied aspects of medieval town life, living conditions and health.

Summary and conclusion

A study of the skeletal remains of 76 individuals from St Mary's cemetery in Bergen, dating to the period c. 1150–1250, has given interesting new insights into the lives of the inhabitants in the medieval town. The primary aim for this study was to make use of the data from an osteological analysis in combination with the available historical and archaeological sources to throw light upon health issues and living conditions in a medieval town in the High Middle Ages.

- How do the skeletal data and the demographic profile of the assemblage reflect the character and composition of the town population?

The group showed an interesting demographic composition, where the majority of the individuals had reached the age of forty years at death. There were a large proportion of females in the assemblage, comprising about one third of the total number of individuals and more than sixty per cent of the sexed adult individuals. The proportion of sub-adults was lower than expected in medieval assemblages, and there was a total absence of children under the age of seven.

The skeletal data and the demographic profile of the assemblage reflect a composition of the assemblage that is somewhat unusual so far in early urban contexts. The average demographic profile in medieval cemetery assemblages is a population of predominantly young individuals, the majority men, and a large proportion of the youngest children. This is due to the high mortality rates among children, or is explained as reflecting the group of entrepreneurs in the early towns. How could the character of this assemblage represent the structure and function of the early urban settlements, attracting large groups of human labour? Could the finds correspond with the idea that the urban environment was largely consisting of individuals seeking work in the town rather than regular family-groups?

- What does the presence of various health indicators say about the living conditions of the buried and the quality of life in medieval Bergen? Do the finds in any way reflect social structures in the town?

The prevalence of disease among the buried at St Mary's was lower than what is usually reported from medieval assemblages. In the adults, the observed pathological signs were most probably an accompaniment to ageing and the result of occupational stress, among the sub-adults, several bore evidence of infectious disease and signs of stress episodes that may have promoted an early death. However, the prevalence of such diseases is lower than in many other medieval assemblages. The individuals buried at St Mary's show a somewhat varied picture when it comes to health. There are differences between women and men and between the adults and the children. The high life-expectancy is consistent with good living conditions, but the prevalence of age and activity-related disease in the group reflects higher morbidity with age and occupational-related physical strain. Additionally, the pathology observed in the children reflects stress-related diseases and exposure to unfavourable health conditions, affecting a vulnerable part of the population. The prevalence of disease at St Mary's cemetery does not reflect a population of particularly poor health. It is more likely that it represents a group of people that are marked by the life they lived and the activities they were engaged in.

- How do the finds correlate with information from other archaeological and historical sources? Are the finds consistent with the traditional views on medieval towns?

The skeletal sample from St Mary's churchyard shows a demographic composition that is unusual in medieval assemblages. Both the age and sex-composition in the material deviate from the tendencies in other medieval cemetery assemblages, where there is often a bias of younger males, and a large proportion of the youngest children.

The stature, mean ages and the low prevalence of indicators of severe chronic health problems may point towards a part of the population that has enjoyed fairly good living conditions despite being involved in hard physical labour that led to strain related injuries that may have caused pain and discomfort. There is, however, no reason to believe that the group represents a population of particularly low socio-economic status. The unhygienic environment so often associated with the medieval towns may either be a later phenomenon and not characteristic for the early urban phase, or the individuals in the assemblage could for some reason, have enjoyed favourable living conditions in town, which rendered them less prone to contracting diseases. The presence of occupational and age-related disease in the adults and signs of infectious disease in the children does, however, indicate that the individuals had experienced their share of hardship, and that some did not survive the stress.

- How do the finds contribute with new understandings on life in the medieval towns, and in Bergen in particular?

The remains of the people of Bergen themselves have revealed the presence of women, men and children in the early town. The women are in majority in the assemblage All the sub-adults represented are past the age of seven. Together with a large group of middle-aged individuals, this indicates that there was a mixed population in the early town, however, not necessarily dominated by family groups.

The health status of the individuals is varied and there are no finds that are entirely consistent with the populations being of deprived health. There are signs of stress particularly in the more vulnerable children, and the adults, and there is a high occurrence of joint diseases not only reflecting the ages, but also the lifestyles of the individuals. A large proportion of the group could have been engaged in hard physical labour. The signs of activity-related stress in a large proportion of the individuals may indicate that despite a low representation of the more typical urban worker, the young adult men, these individuals may to some extent represent the working community in the early town. This analysis indicates that there was a marked presence of women and middle-aged people in the Bergen in the High Middle Ages. The results raise interesting questions on the demographic structure of the early town, and have given new insight into the activities, health and living conditions of the people that once lived in medieval Bergen.

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Original site documentation for the excavations carried out 1966–68, photos, plans and diary notes, kept in the Bergen University Museum archives; The Medieval Collection (Bryggen Museum).

The skeletal collection is stored at Bergen University Museum, The Natural History Collection (J.S. 1040).

Appendix

Main skeletal catalogue. St Mary's Churchyard, Bergen, Norway

ID	Accession no	Date	Phase	SQ	Arm	Sex	Age	Fem	Hum	StatSJ	LEH	Car	Abc	AMLoss	Cal	CO	OAVert	OA	Comp	Per	Trauma	W
1	75003	a.1198	3	Q2	B	M	Mat	508		183.5				•			•	•	•			
2	75004	1170-98	2	R2	B	M	Mat	468		172.7			•	•				•				
3	75005	1170-98	2	R2	D	M?	Adu	-	315	164.5					•						•	
4	75061	1170-98	2	R2	C?	F	Mat	457		169.7			•	•	•			•		•		•
5	75002	1170-98	2	R2	B?	F	Mat	-		-					•	•						
6	75013	b.1198	2	Q2	BC	-	Juv	481		176.2					•							
7	75007	1170-98	2	R2	C?	F	Mat	-		-				•								
8	75009	1170-98	2	R2	B	F	Adu	-		-			•		•		•					
9	75011	1170-98	2	R2	C	F	Adu	-		-									•			
10	75014	1170-98	2	R2	C	-	Juv	-		-					•	•				•		
11	75016	a.1198	3	Q2	B/C	F	Mat	(410)		157		•			•			•	•			
12	75018	1170-98	2	R2	C	F	Adu	-		-						•				•		
13	75019	b.1170	1	R2	B	M	Adu	435		163.7					•	•		•				
14	75021	1170-98	2	R2	C	?	Adu	-	308	161.3		•			•			•	•		•	
15	75022	b.1170	1	R3	BC	M?	Mat	-	333	172.8									•			
16	75023	a.1198	3	Q2	C	-	Inf II	-		-									•	•		
17	75012	b.1170	1	R3	C	F?	Sen	-		-							•	•	•			
18	75029	a.1170	3*	R3	B	M?	Mat	-		-		•	•		•	•				•		
19	75030	b.1248	3*	R2	-	F?	Mat	434		163.5						•				•		
20	75031	a.1198	3	Q2	C	-	Juv	443		165.9				•	•	•				•		
21	75032	1170-98	2	R2	C	-	Inf II	-		-										•		
22	75024	b.1170	1	R2	AB	M	Mat	-		-		•			•							
23	75034	1170-98	2	R2	-	M	Mat	458		170							•	•				
24	75066	a.1198	3	Q2	C	M	Sen	-	311	162.7							•	•	•		•	
25	76329	1170-1248	3*	R2	BC	?	Sen	439		164.3			•		•			•	•	•	•	
26	76325	b.1248	3*	R2	C	F?	Adu	-	240	157					•				•			
27	75039	1170-98	2	R2	C	M	Adu	(431)		162.7	•				•		•					
28	75038	1170-98	2	R2	B	F	Adu	(397)		153.4					•							
29	75036	b.1248	3*	R2	BC	F	Mat	-		-							•	•		•		
30	75040	1170-98	2	R2	D?	M	Mat	(489)		177.8						•	•	•		•		

ID	Accession no	Date	Phase	SQ	Arm	Sex	Age	Fem	Hum	StatSJ	LEH	Car	Abc	AMLoss	Cal	CO	OAVert	OA	Comp	Per	Trauma	W
31	75042	a.1198	3	Q2	B	F	Mat	417		158.9									•			
32	75041	a.1198	3	Q2	B?	-	Juv	-		-												•
33	75043	a.1198	3	Q2	BC	F	Adu	393		152.4												
34	75232	a.1198	3	Q2	n/a	-	Inf II	-		-												
35	75045	1170-98	2	R2	C	F?	Adu	-		-					•							•
36	75046	a.1198	3	Q2	-	F?	Mat	(439)		164.8								•				
37	75054	a.1198	3	Q2	B	-	Juv	-		-										•		
38	75067	b.1198	2*	Q2	BC	F	Mat	-		-							•	•		•		
39	75047	1170-98	2	R2	C	F?	Mat	-		-					•			•				
40	75060	a.1170	3*	R3	BC	F	Mat	-	327	170			•			•	•		•			
41	75050	a.1198	3	Q2	C	-	Inf II	-		-		•						•		•		
42	75229	1170-98	2	R2	B	F	Mat	-		-			•	•	•							
43	76326	b.1170	1	R2	B	F	Mat	-		-			•	•								•
44	76336	b.1198	2*	R2	B	-	Inf II	-		-												
45	76335	b.1170	1	R2	C	F	Adu	399		154					•		•			•	•	
46	76342	1170-1248	3*	R2	BC	M	Mat	-		-					•			•				
47	76344	1170-1248	3*	R2	C	?	Mat	-		-										•		
48	76327	b.1170	1	R2	BC	M	Mat	-		-							•	•		•	•	
49	76334	1170-1248	3*	R2	CD	M?	Mat	-		-	•			•	•		•	•				
50	76338	1170-98	2	R2	BC	F?	Adu	416		158.6												
51	76351	b.1170	1	R2	D	?	Mat	-		-					•							
52	76354	b.1198	2*	R2	n/a	?	>20	-		-												
53	76352	b.1198	2*	R2	n/a	?	Sen	-		-												
54	76324	b.1198	2*	R2	n/a	?	>20	-		-												•
55	76349	b.1198	2*	R2	n/a	M?	>20	-		-												
56	76330	b.1248	3*	R2	BC	M?	Mat	-		-												
57	76323	b.1248	3*	R2	C	-	Juv	-		-					•	•						
58	76322	b.1248	3*	R2	C	M?	Adu	-		-					•							
59	76328	1170-1248	3*	R2	B?	M	Adu	477		175.1									•			
60	76320	b.1170	1	R2	C	F?	Mat	-		-				•				•				

ID	Accession no	Date	Phase	SQ	Arm	Sex	Age	Fem	Hum	StatSJ	LEH	Car	Abc	AMLoss	Cal	CO	OAVert	OA	Comp	Per	Trauma	W
61	75049	1170-98	2	R2	B	-	Juv	-		-	•				•	•						
62	75058	a.1198	3	Q2	C	F	Adu	450		167.8					•							
63	76339	1170-1248	3*	R2	B	F	Mat	-		-				•	•							
64	76345	b.1198	2*	R2	n/a	?	>20	-		-												
65	76343	b.1198	2*	R2	n/a	-	Juv	-		-								•		•		
66	76347	b.1248	3*	R2	D	M?	Mat	-		-					•		•	•				
67	76350	b.1248	3*	R2	B	-	Juv	-		-					•	•						
68	76348	b.1248	3*	R2	C	M?	Mat	430		162.4			•	•	•	•	•	•				
69	76331	b.1248	3*	R2	CD	F	Mat	-	(307)	160		•	•		•						•	
70	76346	b.1248	3*	R2	B	F?	Mat	-	(331)	171,9				•	•		•	•		•		
71	76337	1170-1248	3*	R2	C	M	Adu	-	347	179.3					•							
72	76321	b.1198	2*	R2	n/a	?	>20	-		-												
73	76353	1170-1248	3*	R2	C	?	Mat	-	(284)	150.2									•			
74	76332	b.1198	2*	R2	B	F?	Adu	-		-												
75	76340	b.1248	3*	R2	n/a	-	Juv	-		-												
76	75010	a.1198	3	R3	n/a	F	Mat	-		-							•	•	•			

Legend:

ID Unique ID no.

Accession no. Museum accession no. under BRM 0, Bergen University Museum, the Medieval Collection.

Date Date of burial.
b.1170/1248 = before fire VI/VII in 1198/1248
1170–1198 = between fire VII and VI
1198–1248 = between fire VI and V
1198–a1248 = between fire VI and after, but close in time, to fire V

SQ Square (Bryggen grid system)

Arm Arm position (Redin 1976)

Sex F=female, M=male, ?=undetermined

Femur Max length of femur (mm). Left femur, right femur in brackets

Hum Max length of humerus (mm). Left hum., right humerus in brackets

StatSJ Stature according to Sjøvold (1990)

LEH Linear enamel hypoplasia

Car Caries

Abc Dental peri-apical abscess

AMloss Ante-mortem tooth loss

Cal Dental calculus

CO Cribra orbitalia

OAVert Osteoarthritis/ degenerative joint diseae, vertebra

OA Other osteoarthritis/ degenerative joint disease

Comp Compressed vertebrae

Per Periosteal reactio

Trauma Cranial and post-cranial trauma

W Weapon-related cranial and post-cranial trauma

NM Non metric traits

*=*could* be earlier, i.e. graves that are only given a before or after date are placed according to latest date.

A preliminary examination of the human remains excavated at Nonneseter, Bergen, in the late 1800s

Stian Hamre

In the latter half of the nineteenth century, the skeletal remains of a large number of individuals were exhumed from the medieval cemetery for the Nonneseter Convent in Bergen. These remains were, however, never examined anthropologically until 2006 when the author carried out some initial work on this material. This article will present the results of this preliminary anthropological examination. Some comparisons will also be made to the only other skeletal assemblage from Bergen which has been properly examined anthropologically to see if any differences are evident between the cemetery of the convent of Nonneseter and the material from the St Mary's cemetery at the northern part of the Bryggen area.

The excavations

This discussion of the Nonneseter excavations will mainly concentrate on the graves and the human skeletal remains unearthed at the site in 1872 and 1891, and is in its entirety based on the books by Bendixen (1893) and Lidén and Magerøy (1980). The Nonneseter site was first excavated by the architect Peter Blix in 1872 and later by architect Schak Bull in 1891 (Bendixen 1893). The area has also been subject to several excavations in more recent years (Dunlop 1996; Dunlop 1997; Dunlop 1998; Dunlop 1999), but these investigations revealed very little information about the burials at Nonneseter and will therefore not be discussed here. The last of the Nonneseter excavations was carried out in 2006 and revealed several more graves and skeletons. This material will, however, not be discussed in this paper either as the author has not had any part in the excavation or the analysis of this material (cf. Ekstrøm this volume).

A large number of graves were discovered during the excavations in 1872 and 1891. Graves were found on the north side (north-east), where the main graveyard was probably situated, on the south side (south-west) and on the inside of the church. The burials in the nave had a two and three layered stratigraphy. The topmost layer had been disturbed by previous construction work carried out at the site, but the bottom layers showed a well structured layout with burials placed in neat rows. Burials were also excavated in the chancel where 17 graves were found. In total, at least 100 graves were discovered inside the church. This number can, however, not be verified by Schak Bull and Peter Blix's drawings (Pl. I and II, in Bendixen 1893) or by Bendixen's descriptions of the graves, as only a small number of the burials are mentioned specifically. Bendixen states that quite a few graves were found to the north of the church and that the graves were unevenly spread out, but a cluster of graves were found close to the chancel walls. Only two graves were found to the south of the church. Thus, the exact number of burials excavated at the site is not known, but it ought to have been well over a hundred.

The exact dates for the Nonneseter burials are not known, but it is most likely that the inhumations took place during the period between 1150 and 1528 as this was the time when the site was in use as a convent. Judging from the three layered grave stratigraphy inside the church (Bendixen 1893), burials would have taken place over a significant time span.

The placement of the burials, as described by Bendixen (1893), gives some suggestions as to who was buried at the site. That most of the excavated graves were found either inside the church or in close proximity to the church walls suggests that these were people of high social rank. The low prevalence of enamel hypoplasias (see below) also supports that these people were not part of the poorer classes.

After the excavations at the Nonneseter site, all the skeletal material was stored in a few large crates and not boxed by individual. This was common practice at the time of excavation, but a lot of information gets lost when the skeletons are treated this way as the material becomes commingled and the individual skeletons can no longer be properly examined. In later years, the material had been split up and when this work started the skeletal material was stored in about ten boxes of various sizes (some wooden crates and some cardboard boxes) where the material was roughly sorted by skeletal element.

The anthropological examination

In 2006 and 2007, the skeletal material exhumed from the Nonneseter site in 1872 and 1891 was anthropologically examined by the author on the request of Anne Karin Hufthammer at Bergen Museum (Hamre 2006; Hamre 2007). At the time, the material had not been examined or registered, nor had an inventory been made. The main purpose of this examination was, thus, to register the material, make an inventory and record basic anthropological information about the remains, and basically prepare the material for further analyses and possible individualisation. Thus, the anthropological examination of the remains was by no means extensive, but the preliminary information obtained will be presented in the following.

Methods

As part of the examination of this material, information about age at death, sex, pathology and trauma was recorded in addition to metric data for the different bones. Accuracy when determining age at death and sex is dependent on preservation and it is preferable to have as much as possible of an individual available for examination. When dealing with commingled remains, as in this case, each individual is only represented by one skeletal element or fragment. This situation can possibly be improved by attempting to reassemble the remains. The methods available are, however, most effective when dealing with smaller samples (e.g. Adams and Byrd 2006; Snow and Folk 1970; Byrd and Adams 2003; London and Hunt 1998; London and Curran 1986; Adams and Konigsberg 2004; Hamre 2005), and thus the outcome of such an attempt to reassemble the Nonneseter material may not be as valuable as one could hope. At the present time, no attempt has been made at individualising the material and therefore, age at death and sex determination was made for single skeletal elements and not by individual. The age and sex information for this material was thus recorded in the following manner. Age was recorded for each bone on the basis of epiphyseal fusion. Bones with all epiphyses fused were recorded as adult and all other bones were recorded as subadult. Thus, the categories do not refer to an individual's age, but to the maturity of the individual skeletal elements. Sex was determined by metric means from measurements taken from the femoral heads. Living stature was also estimated from the femoral bones.

Pathological conditions are also best diagnosed when examining a complete individual as most diagnoses are impossible to make from a single bone. Some conditions have, however, been recorded: Enamel hypoplasias on the mandibular dentition, dental caries, calculus, and mandibular osteomyelitis and periodontitis. In addition to this, an example of leprosy was found and this will be discussed below.

Number of individuals

Due to the commingled nature of these remains, it is not possible to give an accurate account of the number of individuals exhumed from the Nonneseter Convent. At this point in time, the number of individuals in this sample cannot be estimated more accurately than to a minimum number of individuals (MNI). MNI is determined from the skeletal element, or part thereof, with the highest presence in the sample. In this case, the skeletal element with the highest adult presence was the femur with 84 right distal ends, 101 right shafts and 44 unsided shaft pieces. As some of the shafts could have been broken into several pieces and thus, some individuals may be counted more than once if using the shaft numbers, applying the distal femur ends would present a more accurate MNI estimate. However, both estimates are provided here to show that the actual number of individuals excavated from the Nonneseter site could be significantly higher than the conservative MNI estimated from the distal femoral ends. Thus, based on the right femoral distal end count, there were a minimum of 84 adult individuals in this sample, while an MNI based on shaft counts came to 101. The skeletal element with the highest number of subadults was also the right femur with 27 recorded specimens. It is therefore possible to conclude that there are at least 111 individuals present in the Nonneseter sample: 84 adults and 27 sub-adults.

Sex determination

To get an idea of the sex distribution in the material, the femora were sexed using the metric method developed by Stewart (1979) for sex determination of the femoral head. Among the 54 available femur heads, 16 fell into the female category and 21 into the male category. Of the remaining 17 femur heads, 9 fell into the intermediate category and were undeterminable while the other 8 were evenly distributed between the probably female and probably male groups (Table 1).

N	Male	Male ?	Ambiguous	Female ?	Female
54	21	4	9	4	16

Table 1 *Sex distribution based on the femoral head diameter*

Not many conclusions can be drawn from these results, except that there are both males and females present in the sample. The results may suggest that there are slightly more males than females in the Nonneseter material, but this is just as likely to be a result of sampling as actual fact.

It is clear that these results do not give a very accurate picture of the sex distribution at the Nonneseter graveyard, but it seems likely that there was no bias towards either sex even though the Nonneseter Convent was a nunnery for the majority of the time it was active.

Age at death

It is impossible to make reliable age at death estimates from a single bone and that is what commingled remains are: a collection of individual bones. However, the examination of these remains made it clear that the people buried at Nonneseter ranged from infants to older adults and the MNI distribution shows that there were at least 84 adults and 27 sub-adults in this sample.

Stature estimation

One can get a picture of the stature distribution in the Nonneseter material by studying the available femora in the sample. The reason for using the femora was that it was the skeletal element with the highest number of bones complete enough for length measurements to be taken; and, the femur is the skeletal element which gives the most accurate stature estimates.

The histogram in Figure 1 shows the distribution of femoral maximum lengths which ranges from 399mm to 492mm. This corresponds to a living stature of 154.90cm±4.52 to 179.36cm±4.52. As can be seen in Figure 1, there are two peaks in femur lengths and it is likely that these peaks represent the sexual dimorphism in living stature. The lower peak between 410mm to 440mm probably represents the bulk of the female population and 41% of the total sample falls within this range. The upper peak between 450mm and 480mm probably represents the bulk of the male population and 35% of the total sample falls within this range. If one accepts that the peaks in the histogram represent the sexual dimorphism in living stature in the sample, it can be suggested that the majority of females had a living stature between 157.79±4.52 and 165.68±4.52 while the majority of males in this population had a living stature between 168.31±4.52 and 176.20±4.52. All stature estimates are based on Sjøvold's regression formulae for estimation of stature for Caucasians independent of sex (Sjøvold 1990).

Comparing femoral maximum lengths data from Nonneseter to the data available for the St Mary's assemblage shows that there is only a slight difference between the sites. The femur lengths for St Mary's has a mean of 439.5mm (Lorvik, this volume) while the mean for the Nonneseter material is 445.8mm. This is an average difference of 6.3mm which is too small to show a difference between the two samples.

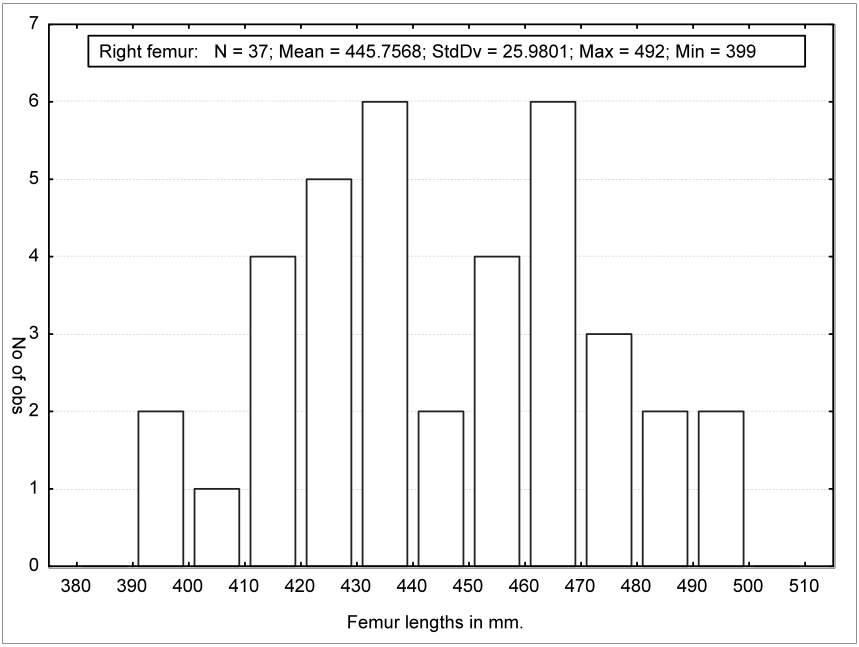

Figure 1 *Histogram showing the distribution of femur maximum lengths in the Nonneseter material.*

Health and pathology

During the examination of these remains, pathological changes were for the most part only recorded as either present or absent and no attempt was made to diagnose the conditions. However, some conditions were diagnosed and these will be discussed in the following.

There is one point that can be made about the general health and living conditions of the people at Nonneseter. The near absence of enamel hypoplasias suggests that these individuals grew up under fairly good circumstances, without serious episodes of disease and starvation. Enamel hypoplasias are the results of a severe metabolic assault to the body, an assault severe enough to be perceived as life threatening, so that the body diverts energy away from non-vital processes and redirects all its resources into processes which will ensure survival (Aufderheide and Rodriguez-Martin 1998). Thus, the growth of bone, teeth and other structures comes to a halt and enamel hypolasias may be the result. Situations which may be severe enough to cause hypoplastic enamel can be starvation and acute bacterial infection. Only one of the Nonneseter mandibles (cf.

Figure 2), displayed teeth with enamel hypoplasias and this suggests that the Nonneseter people grew up under relatively good conditions, shielded from starvation and life threatening diseases. This low prevalence of enamel hypoplasias is in correspondence with what was observed for the examined skeletons at Bryggen where only two individuals displayed hypoplastic enamel (Lorvik, this volume).

Figure 2 *The only mandible in the Nonneseter material which showed enamel hypoplasias (visible in the photo as transverse lines in the enamel).*

Leprosy

Although very few diagnoses could be made from the observed pathological changes on the skeletal material, there is one case which should be mentioned. One partial cranium showed osseous changes which are compatible with leprosy. As seen in Figures 3 and 4, this individual shows resorbtion of both the anterior and posterior walls of the alveolae for the incisors and canines, and pitting which has spread all across the hard palate and perforated the posterio-sagittal portion of it. Pitting is also present on the nasal floor (not visible in the figures). These changes are typical of facies leprosa as described by Møller-Christensen et al. (1952) and are unique for leprosy. More specifically, it can be said that this case is an example of advanced lepromatous leprosy. There are five forms of leprosy: (TT) tuberculoid leprosy, (BT) borderline toward tuberculoid, (BB) borderline, (BL) borderline toward lepromatous and (LL) lepromatous leprosy. The TT form of leprosy is mainly a peripheral neuropathic disease with very mild skin lesions while the lepromatous form causes destruction of skeletal elements of the face accompanied with nodular dermal facial lesions and possible involvement of the peripheral nerves.

The other three forms are intermediate forms of these. The only form of leprosy causing destruction of the maxilla and hard palate is the lepromatous form (Aufderheide and Rodriguez-Martin 1998) and it can, thus, be diagnosed that this individual suffered from lepromatous leprosy.

Figure 3 *Partial cranium showing atrophy of the anterior alveolar bone as part of lepromatous leprosy.*

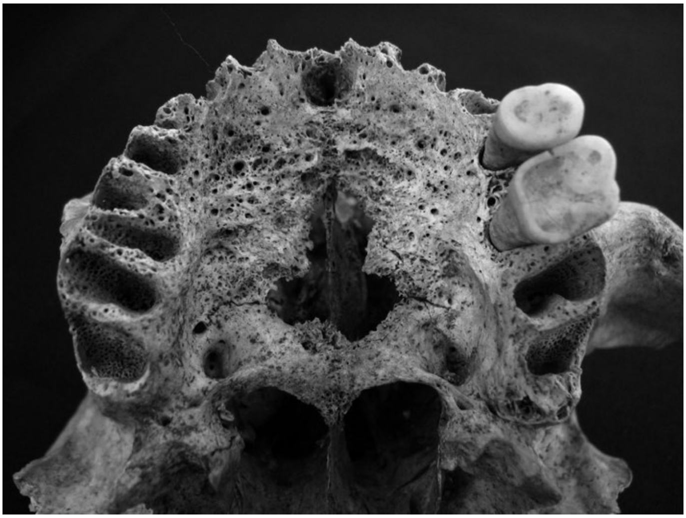

Figure 4 *Partial cranium showing atrophy of the posterior alveolar bone, pitting and perforation of the hard palate as part of lepromatous leprosy.*

Dental and oral health

Four different conditions were recorded with regard to dental and oral health: caries, periodontitis, osteomyelitis and calculus. Among the 78 mandibles, only 49 had any teeth present. The presence of teeth will have an effect on the diagnosis of three of the recorded conditions. The presence of caries and calculus cannot be determined without teeth present and as periodontitis is diagnosed from whether or not the alveolus has receded and exposed the roots of the teeth, this condition can be difficult to diagnose without any teeth present. Thus, all 78 mandibles were used to study the prevalence of osteomyelitis while only the 49 with preserved dentition were used for the other three conditions. The prevalence of the different conditions is presented in Table 2.

The different conditions will be discussed separately below and comparisons will be made to the material from St Mary's cemetery at Bryggen.

Medical condition	**N**	**Affected individuals (Nonneseter)**	**Percentage affected (Nonneseter)**	**Percentage affected (St Mary's)**
Osteomyelitis	78	9	11.5	5.7
Periodontitis	49	22	44.9	No data
Calculus	49	30	61.2	82.3
Carries	49	7	14.3	14.3

Table 2 *The prevalence of four medical conditions in the Nonneseter material with comparative data from St Mary's churchyard.*

Osteomyelitis

Osteomyelitis of the mandible, the most serious of the conditions, is caused by a bacterial infection of the pulp in the centre of the tooth causing a tooth abscess. The initial cause of such an infection can be severe attrition or trauma to the tooth which opens for bacterial access to the pulp. If the infection is not properly contained by the inflammatory and immune response system, a fistula will form between the abscess and the oral cavity, traversing the mandibular cortex (Aufderheide and Rodriguez-Martin, 1998). Thus, the pus is drained from the infected area into the oral cavity. Without antibiotic treatment, osteomyelitis of the mandible can be fatal because it is frequently associated with bacteraemia (ibid.). This would have been the case at the time when the Nonneseter graveyard and church were in use. Nine of the Nonneseter individuals suffered from osteomyelitis of the mandible. This is a prevalence of 11.54% which is about twice as high as the 5.7% presented for the material from St Mary's (Lorvik, this volume). One example of a mandible with osteomyelitis can be seen in Figure 5.

Periodontitis

Periodontitis is the result of the progression of gingivitis. When gingivitis is left untreated, the infection and inflammation spreads from the gums to the other parts of the periodontium (Aufderheide and Rodriguez-Martin, 1998). Thus, the periodontal ligaments, cementum and alveolar bone become involved. The most common initial cause of periodontitis is the accumulation of plaque at the base of the teeth. This causes inflammation of the gingiva which causes a pocket to develop between the gums and the teeth, which fills with plaque and tartar (ibid.). Soft tissue swelling traps the plaque in the pocket. Continued inflammation eventually causes destruction of the periodontium. Periodontitis is the most common cause of antemortem tooth loss in adults today and was also a common dental complication in antiquity. Twenty-two of the Nonneseter individuals showed signs of periodontitis. This is a prevalence of 44.90%.

Calculus

Calculus is mineralised plaque which is one of the main agents for the development of periodontal disease. Thirty of the mandibles showed calculus on one or more teeth which is consistent with the high number of mandibles showing evidence of periodontitis. The 61.22% of the mandibles showing calculus is somewhat lower than the 82.3% presented for the material from St Mary's (Lorvik, this volume).

Dental caries

Dental caries is a disease of the calcified teeth tissues characterised by demineralisation of the inorganic portion and destruction of the organic component of the teeth (Aufderheide and Rodriguez-Martin 1998). There are two types of caries: crown caries and root caries. The recording of this material made no distinction between the two types, but both types were present. The examples of root caries were situated in the cemento-enamel junction of the tooth. Crown caries is basically caused by the organic

Figure 5 *Mandible showing a dental abscess as part of the mandibular osteomyelitis.*

acids and proteases (any enzyme that catalyses the splitting of a protein) contributed to the oral fluids by bacterial metabolism. In sufficient concentration, the organic acids can dissolve the hydroxyapatite which is the component of the mineral portion of the enamel. The proteases are capable of digesting the organic portion of the crown in which the apatite crystals are embedded. Root caries is normally caused by the exposure of the tooth root by retraction or destruction of the gingiva (Aufderheide and Rodriguez-Martin 1998). Seven of the Nonneseter mandibles showed teeth with caries. This is a prevalence of 14.29% which is in correspondence with the 14.3% reported for the material from St Mary's (Lorvik, this volume).

Conclusion

This paper has presented the results of the preliminary anthropological examination of the skeletal material excavated from Nonneseter in 1872 and 1891. The skeletal material is completely commingled and this severely limits the information which can be drawn from these remains. In addition to this, as this was a preliminary examination of the material with the main purpose of preparing it for further research, this anthropological examination has by no means exhausted these remains. However, this paper indicates that males and females are equally represented in the material and that people of all ages were buried at the Nonneseter convent.

The health and pathological conditions in the Nonneseter material was limited to an examination of the available mandibles. Definitive conclusions about living conditions cannot be drawn from the study of enamel hypoplasias alone, but it can give some indications as to how it was growing up in Bergen in the Middle Ages. Only one of the mandibles from Nonneseter showed teeth with hypoplastic enamel and this suggests that these individuals grew up without experiencing life threatening diseases and starvation. Such a low prevalence of enamel hypoplasias is also in perfect correspondence with what was found in the study of the skeletal material from the St Mary's churchyard at Bryggen. The other oral and dental pathologies discussed, show that oral complications were quite common and that oral hygiene was not the best. A serious, and possibly fatal, condition like osteomyelitis was present in 11.5% of the Nonneseter mandibles while periodontitis and calculus had a high prevalence of 44.9% and 61.2% respectively. Carries was, however, a less common complication with only 14.3% of the individuals affected. The prevalence of osteomyelitis is about twice as high as for the material from St Mary's, but the presence of calculus is lower. It is difficult to say if these differences are evidence of any real differences between the two samples, and no conclusions can be made at this point.

Other pathological conditions were not specifically studied, but one diagnosis was made. One of the individuals buried at the Nonneseter convent suffered from lepromatous leprosy. This individual displayed an advanced stage of the disease and showed the defining features of facies leprosa.

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An osteoarchaeological analysis of the skeletal material from the Nonneseter Convent in Bergen uncovered in 2006

Hanne Ekstrøm

More than a hundred years after the first investigations of the Nonneseter Convent carried out by architect Schak Bull in the 1870s, a new archaeological excavation investigated the eastern part of the churchyard and some burials inside the chancel of the church of the medieval convent. This new investigation, carried out in the autumn 2006, was initiated by the building of a new transport system in Bergen. The Norwegian Institute of Cultural Heritage conducted the archaeological and osteoarchaeological investigations of the graves, and the osteoarchaeological analysis of the remains of the skeletons has been carried out by the author.

The burials

Altogether 31 graves were uncovered during the excavation, partly within the chancel of the convent church and partly outside in the churchyard. They demonstrate that the burial practice at Nonneseter was rather varied and that the graves had characteristic features somewhat different from other medieval cemeteries.

The graves were situated in the extended part of the chancel of the convent church; an extension probably from the second part of the thirteenth century (Lunde 1987: 104–105). The main part of the churchyard was probably situated north and northeast of the church, but many of the graves here have been destroyed or disturbed by road building during the last century.

Some of the more intact graves were rectangular or trapezoid in shape, but the majority had irregular shapes and were not clearly defined. In the majority of the graves, the corpses had probably been wrapped in cloth or buried in their own clothes. As many of the graves were poorly preserved it was difficult to verify whether the graves had contained coffins. Some of the burials revealed brown lines in the subsoil which could be remains of wooden coffins. In grave 11, a dark brown and orange layer was recorded in the bottom of the grave, probably the remains of a bier or coffin. Two graves, one trapezoid and the other rectangular shape, contained clearer remains of wooden coffins with eight iron nails respectively. Another trapezoid coffin also contained iron nails probably from the coffin.

Eight of the graves at the cemetery had a kind of stone construction. In two of the graves, the bottom was covered with stones like a kind of bier, one of them with flat stones in the footboard of the grave. Another grave had stones placed both in the bottom and around the skull. Five graves had curb stones and stones covering the body. These constructions probably served as coffins or grave markers.

Some graves were covered and filled with lime in between the stone-constructions or in the grave filling above the corpse. Similar graves were also found during the investigations in the end of the nineteenth century (Bendixen 1893). There are also other examples of such phenomena from other Scandinavian cemeteries. In one of the coffins inside the church of the Dominicans in Oslo, the corpse was wrapped in a cloth and placed in a layer of powdered lime (Ekstrøm 2006). The same is also registered at a churchyard in Åhus in medieval Denmark, where the bottom and the sides of the coffins were covered with lime (Lilja et al. 2001: 37). The lime fragments were obviously intentionally placed in the graves, possibly to prevent smell and to conserve the body.

Furthermore, charcoal was found in eight of the graves, probably intentionally placed there. It was found in relation to the long bones of the skeleton, the elbow and the shoulders, torso and the head. In half of the graves with charcoal, pathological changes on the skeleton were observed. Charcoal in graves has also been discovered at other medieval cemeteries. In Lund, for instance, graves with charcoal are registered in the bottom layer of coffins (Mårtensson 1976). As charcoal is a product of fire, it has been claimed that it could have a purification effect.

Although 31 graves were identified, only parts of 25 skeletons could be registered because of the varying preservation conditions and different soil conditions at the site (Table 1). Generally, the skeletons in the chancel were well preserved, partly because the area had been covered with stones. Most of the skeletons excavated at the churchyard were, however, in a poor condition, probably because the area had been used as gardens in later periods and water and air had penetrated the cultural-layers and minerals were probably washed out of the bones and micro-organisms added.

The osteoarchaeological analysis of the graves at Nonneseter

The osteological methods were only based on visual observations; there were no chemical or other scientific methods used in the survey of the skeletal material. The skeletons sex, age at death, height and some pathological conditions were analysed (Bass 1995, Brothwell 1981, Buikstra and Ubelaker 1997). The result of the osteological analysis of each skeleton was then combined with archaeological observations of the individual grave.

Six of the graves were C14-dated. In two of the graves, the dating material was wood from the coffins, the calibrated date in grave no 4 was AD 980–1155 and in grave no 12: AD 890–1025. Both tests showed datings earlier or about the time of the founding of the convent, probably due to several sources of error. The context of the test-material from grave no 12 is a.o. uncertain as the grave was only partly excavated.

Grave no, Skeleton no	Museum no (BRM)	Sex	Age of death (year)	Age group	Pathological changes	C14-dating
G1, S1	650/41	-	40–50	Maturus	-	-
G2, S2	650/10	-	30–60	Adultus/ Maturus	-	-
G3, S3	650/13	-	Adult	-	-	-
G4	-	-	-	-	-	AD 980–1155
G5	-	-	-	-	-	-
G6, S4	650/11	?	14–18/22	Juvenilis	-	-
G7, S5	650/12	-?	Adult	-	-	-
G8	-	-	-	-	-	-
G9, S6	650/9	-?	Adult	-	-	-
G10, S7	650/15	-	30–40	Adultus	X	AD 1005–1025
S8	650/16	-	-	-	-	-
G11, S9	650/63	?	30–40	Adultus	-	-
G12	-	-	-	-	-	AD 890–1025
G13, S10	650/36	-	30–50	Adultus/ Maturus	X	-
G14, S11	650/37	-?	30–50	Adultus/ Maturus	X	AD 1285–1300
G15, S12 (individual 1)	650/35	-	Adult	-	-	-
G15, S12 (individual 2)	650/35	-	Adult	-	-	-
G16, S13	650/34	-	Adult	-	-	-
G17, S14	650/38	-	30–50	Adultus/ Maturus	X	-
G18, S15	650/40	?	20–30	Adultus	-	AD 1310–1400
G19, S16	650/39	-?	30–40	Adultus	-	-
G20	-	-	-	-	-	-
G21, S17	650/64	-	20–30	Adultus	X	AD1215–1245
G22, S18	650/72	-	-	-	-	-
G23, S19	650/406	-	Adult	-	-	-
G24, S20	650/71	-	-	-	-	-
G25, S21	650/70	-	-	-	-	-
G26, S22	650/69	-?	30–40	Adultus	X	-
G27, S23	650/75	-	30–40	Adultus	X	-
G28, S24	650/73	-	30–40	Adultus	X	-
G29, S25	650/407	-?	30–50	Adultus/ Maturus	X	-
G30, S26	650/74	-	-	-	-	-
G31	-	-	-	-	-	-
G32	-	-	-	-	-	-
G33	-	-	-	-	-	-

Table 1 *Result of the osteological analysis, Nonneseter Convent 2006.*

In the other graves, dating was based on charcoal around the skeletons. The dating of these graves varies from AD 1005 to 1400. The charcoal was placed intentionally in the graves, but old charcoal could have been used.

The result of the osteological analysis revealed that two males and one female were buried in the chancel of the church, and a minimum of four males and eight females in the eastern part of the churchyard. Most of the buried were adults, between 20 and 50 years of age. Exceptions were a young individual between 14 and 22 years at the time of death and a male who was around 50–60 years old when he died.

The height has been estimated based on measurements of the femur. It was possible to estimate the height of eight skeletons; five females and three males. The female skeletons measured between 155 and 160 cm, and the masculine ones measured 169–181 cm.

Several skeletons had pathological changes on one or several bones. Five individuals had pathological changes on the skeleton of wear and tear which could have been a degree of osteoarthritis. Some skeletons had visible oral pathologies or osteological changes at the teeth or the jawbone. Some had traces of tumours and Periodontitis, an infection in the periodontal tissue around the teeth and the jawbone (Hillson 1998: 260). Several had lost one or more teeth *ante mortem*. The reasons for these conditions could be bad oral hygiene, irritations of the gum because of calculus or malnutrition (Brothwell 1981: 154). Three of the individuals, probably all women, had calculus on the chewing surface of the molars, indicating that they could only have consumed liquid in the last period of their lives (Arcini 1993).

Profiles of two of the buried individuals

Two graves; grave no. 14 and grave no. 21, were particularly interesting because of the construction of the graves and the osteological analysis of the skeletons.

Grave 14/ skeleton 11

Grave no. 14 with skeleton no. 11 was situated in the eastern part of the churchyard, in the north part of the site. The grave had an irregular shape that fitted the corpse. There were no remains of a coffin, but the grave was built up by stones (Figure 1). They were placed around the head down to the pelvis, and on the left side of the grave, behind the elbow of the skeleton, a big standing stone was located. On the right side of the grave there were many flat stones lying together with scattered remains of lime. There were also stones that covered the right side of the torso and partly the face. Several concentrations of charcoal were also found close to the skeleton. Charcoal was located outside and inside the left elbow of the skeleton, on the right elbow, upper and lower torso and under the skull.

Figure 1 *Grave 14/ skeleton 11. Photo by Hanne Ekstrøm.*

In the grave filling, about 7 cm above the skeleton there was found an unidentified artefact of bronze, measuring 2.5 x 4 cm, and 0.5–1 cm in thickness. The artefact could have been a type of fitting or perhaps a pilgrim badge.

The skeleton in grave no. 14 lay on its back with the face upwards. The right arm was resting on the lower torso, and the left arm above the pelvis. The skeleton was well preserved apart from some soft bones around the joints and a fragmented skull. The upper extremities were petite and feminine, while the lower part of the skeleton was more masculine in shape. The skeleton was most probably a female because of the shape of the skull and the petite features. The individual was adult, but because of its oral pathologies, it was difficult to decide the age of death. The person had lost the molars in the upper jaw and the third molars in the lower jaw during life. The jaw bone around the existing molars was resorbed and there was massive calculus on top of the teeth surface, which could indicate that the woman was bedridden in the final period of her life.

Grave 21/ skeleton 17

Grave no. 21 with skeleton no. 17 was situated in the chancel of the convent church, placed under the second phase of floors in the extended part of the chancel. Because of the limited excavation area, the skeleton was only partly revealed, and the tibia and the feet were still inside the profile. The grave was approximately rectangular in shape, and contained a trapezoid shaped wooden coffin with eight nails. Inside the coffin there were small and medium sized stones around the head and upper torso (Figure 2). In between the stones there were pieces of lime, especially around the skull. Similar to several of the skeletons at Nonneseter, there were remains of charcoal in the grave, placed in the southwestern corner of the coffin and on the left shoulder of the skeleton. It was C14 dated to AD 1215–1245 and may possibly be one of the first burials in the extended chancel. But it is also possible that the charcoal stemmed from earlier fires at the convent.

Figure 2 *Grave 21/ skeleton 17. Photo by Hanne Ekstrøm.*

The corpse was buried supine with the skull in the west part of the grave and the face turning slightly upwards to the north. The left arm rested on the lower part of the torso, and the right arm was lying over the left part of the pelvis. Under the right hand, over the left part of the pelvis, an unidentified item of iron was found. The artefact could match with one of the findings from grave no 14, a fitting or a pilgrim badge. The buried was of a young male, probably in his twenties when he died. The skull, the pelvis and the post cranial skeleton indicate an adult male. The height was estimated to around 169 cm alive.

The skeleton revealed several pathological changes. The most severe and special feature was a cavity in the hard palate. The bone-tissue around was almost spongy and had both micro and macro-porosity, and there were changes in the tissue around the molars. The hard palate was also deeper than normal (Figure 3). The young male had both caries and calculus, and had lost a premolar when he was still alive. Enamel hypoplasia was registered on the two incisors in front of the upper jaw. There were also transverse lines or bands of depressed enamel on the sides of the teeth crowns. The dental enamel hypoplasias can be caused by malnutrition, vitamin deficiencies and different kinds of paediatric diseases (Mays 1998: 156–158). In this case, tooth development was probably retarded at an early age, around three years of age.

Figure 3 *Grave 21/ skeleton 17; skull with a cavity in the hard palate. Photo by Hanne Ekstrøm.*

The young man had also a distortion in the facial skeleton, the right side of the face was slightly impressed and the left cheekbone was much bigger than on the right side. The deformation of the face in combination of the cavity in the hard palate could be the result of the same disease, possibly leprosy. Similar changes are seen in skeletons with leprosy from the monastery of Æbelholt in Denmark (Møller-Christensen 1958). But it could also be caused by cancer, a virus or bacterial infection, where it could have lead infected blood to the brain and vital organs.

Pathological changes were also registered on the postcranial skeleton, probably caused by an infection on the right collar bone, and there were changes in the joint of the elbow. These changes did not show signs of infection, and were probably caused by a congenital disease. It may have been a condition called Panner's disease, a phenomenon which affects boys between four and ten years of age (Aufderheide and Rodriguez-Martin 1998). This condition was not painful, and the deceased had probably not been aware that he had the disease.

Summary and interpretations

The osteoarchaeological analysis of the material has revealed new information about the burials at the Nonneseter Convent.

The analysis showed that a majority of adult females were located at the eastern part of the churchyard. This could therefore be a part of the churchyard where the nuns were buried. There is, however, a tendency that lay women of high rank could also be buried at nunneries, as it was attractive for the women in the higher levels of society to buy residence at convents and also be buried there. In 1306, at a meeting between the Archbishop of Nidaros, the bishops in Bergen, Stavanger and the Faroe Islands, rules were introduced for the convents and friaries in Norway. It was decided that only women could live in nunneries, and only men could apply for residence in abbeys (DN III, no 342). Some of the females buried at the cemetery at Nonneseter may have bought a residence in the convent, and a burial place in the churchyard was often a part of such an arrangement. There is also a possibility that some of the females had worked at the monastery, or belonged to social groups that were welcome to be buried in the churchyard. Some researchers even claim that it is possible that churches were socially organized rather than based on geographical distance to the church (Brendalsmo 2000: 35).

There is also a possibility that some of the buried at the convent might have been patients at the hospital nearby. One third of the skeletons had pathological changes, and several skeletons showed signs of severe illnesses that probably required nursing. The two males who are particularly mentioned in this survey had artefacts of metal in the graves. These could have been pilgrim-badges and they may have been pilgrims. The two males excavated in the chancel of the church could well have been priests or members of the clergy. There is also a possibility that they were benefactors to the monastery, noblemen or other individuals of high rank. Burials inside the church were originally reserved for the clergy or other prominent people in society.

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The Bryggen Papers present results based on the archaeological material from the excavations at Bryggen and other medieval and early sites in the town of Bergen. Known as an Episcopal see and regional royal administrative and residential centre, Bergen developed in the twelfth and thirteenth centuries into the first truly international trading centre of Scandinavia and one of the most important ports of northern Europe, at the same time becoming the first capital of the Norwegian kingdom. The Hanseatic League established one of its four main trading stations or *Kontor* in Bergen around 1360, lasting into the latter part of the eighteenth century.

This volume of the Supplementary Series of the Bryggen Papers deals with life and death in medieval Bergen as witnessed by human remains, *in casu* skeletons. Three osteoarcheaological studies from medieval Bergen are presented: one in-dept analysis of skeletons from the graveyard belonging to the oldest surviving church in Bergen, St Mary's, and two more limited studies of the skeletal remains from the Nonneseter convent. These contributions represent the first analyses of osteoarcheaological material from Bergen, and shed new light on the living conditions in the early medieval town – issues related among others to health, diseases and life expectancy.

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