A COMPARATIVE STUDY OF THE HUMAN SKELETAL MATERIAL FROM LATE FIRST AND EARLY SECOND MILLENNIUM SITES IN THE NORTH-EAST OF ENGLAND

by

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A thesis submitted for the degree of Master of Philosophy
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ABSTRACT

Seven cemetery populations from the North-East of England, ranging in date from the Anglian to the Late Medieval periods, were studied. Aspects of ageing, sexing, physical appearance, continuous traits and odontology were considered. Age, sex and stature distributions were found to differ very little between the populations, but groupings based on cranial metric and non-metric traits could be made. A study of dental pathologies showed an increase in caries, abscesses and tooth loss through time. Slight differences in the populations were discussed in relation to their temporal and spatial distributions. Pathological study of most of the sites is unfortunately incomplete at present, and the reader is referred to case studies by Calvin Wells on some of the more interesting cases from two sites (Jarrow and Monkwearmouth). The work should add a physical dimension to the archaeological interpretations of the sites which could otherwise only take into account social and cultural aspects of daily life.

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DECLARATION

The material in this thesis is the result of research carried out in the Department of Archaeology, University of Durham, between December 1986 and December 1989. It has not been submitted for any other degree, and is the author's own work, except where acknowledged by reference.

INTRODUCTION

The original research design for this project involved the study of the human skeletal remains from three sites located in the North-East of England and excavated by Professor Rosemary Cramp of the Department of Archaeology in Durham. These sites were the two Saxon and Medieval Monastic Cemeteries from Monkwearmouth, Sunderland and Jarrow, Tyne and Wear, and the churchyard of a small medieval church at The Hirsel near Coldstream.

In the course of time, the research involved in this study has grown to encompass four other sites from the Newcastle and Cleveland areas. These are as follows: Blackfriars, Newcastle; Blackgate (Castle), Newcastle; Norton, Cleveland; and Guisborough Priory, Cleveland. The sites are discussed in more detail in Section 1 on the cemeteries.{PARA}The layout of the thesis, from Section 3 onwards, follows that of a conventional archaeological human bone report involving the study of age, sex, stature, metrical and non-metrical skeletal characteristics and dental analysis. The reasoning behind this is discussed in Section 2, which reviews past and recent work on skeletal populations and the way in which they are studied and published.

In each section beginning at Section 3, methodologies for each field of study are discussed and some of the more recent work is reviewed. It is hoped that this will give an insight into more specialised forms of research being carried out in each field, some of which may eventually replace existing techniques of analysis. In almost every case the present author has used the simplest methodologies currently available, often due to the fact that these are less time consuming and more economically viable, but sometimes also because they are the best we have at present. Since funds were not available for more specialised research to be carried out on these skeletal collections, it was felt to be more reasonable to compare them using the 'everyday' techniques which would be found in a normal skeletal report, rather than to use no comparative analysis at all.

The research has involved the comparison of all seven sites in all the fields of study mentioned above, as far as was possible from the evidence available. However, the two north-eastern monastic sites of Jarrow and Monkwearmouth have populations which are almost contemporary, of the same monastic order, and relatively close together. These are therefore the perfect choice for such a comparison, and although other sites in the area will be considered, these two will probably yield the most useful information due to their spatial and temporal proximity. The Hirsel group is the largest one which was available for study, and also the one most likely to contain a different population stock. For these reasons, the three sites originally included as part of this research project have often been given more prominence in this work. No apologies are made for this, as it is felt that comparisons with other sites are not invalidated by it, since they can to some extent be seen as a control when differences and similarities between the three main sites are considered in detail.

Work on all the groups has yielded important insights into the way of life of late first and early second millennium inhabitants of the North-East of England, some of which would not have been noted without a comparison between the sites. However, it must be remembered that interpretations based on skeletal evidence alone cannot be regarded as pure fact. Although this may reduce the importance of comparative analysis, since the results of skeletal studies on individual groups may not be reliable, it is felt that the fact that all these groups have been analysed by the same worker(s) will lessen the impact of this problem to some extent. However consistency, when it involves consistently incorrect results, is obviously not a virtue, and it will be necessary in the next few years to reconsider the techniques applied to a number of fields within skeletal research if valid comparisons are to be made both within and between skeletal populations. The problems and difficulties associated with erroneous conclusions are discussed within each section of the thesis, especially with respect to techniques of ageing (see Section 3.1), which have recently been shown to be hopelessly inaccurate. At present, as with many other problems in skeletal research, there seem to be no positive solutions, and it is a case of either not studying skeletons at all or studying them to the best of our ability and hoping that they will stay above ground long enough for revisions to be made where possible. With this in mind, it can be seen that the techniques applied to the seven skeletal groups considered here are probably the best which could have been utilised given the time and resources available.

SECTION 1
The Cemeteries: Description and Evaluation

The seven cemetery sites to be considered in this thesis are all located in the North-East of England, and range in period from early Saxon to late medieval. All have been analysed (either fully or in part) by the present writer. The sites are as follows:-

a) *The Hirsel*, Coldstream: Excavated by Professor R.J. Cramp, Durham University, 1979-84. This ecclesiastical site has been dated to the 9th-late 14th centuries, starting with a small chapel. The church was extended in the 10th and 12th centuries, and some of the burials to the west of the church were cut by the extended west end. Four burials seen by the present writer have been dated, two at the west end (Sk. 247, c.1205 ± 100 a.d.; Sk. 239, 1245 ± 55 a.d.), one at the east end (Sk. 26, 1200 ± 125 a.d.), and one just to the north of the last (Sk. 14, 1365 ± 60 a.d.). In addition two of the skeletons excavated in the first year were dated, but not analysed (Sk.1, c.1210; Sk. 3, 1110 ± 20 a.d.) The span of use of the cemetery was probably 11th-13th century, with a few burials from the early 17th century.

Little is known from textual evidence, but it is assumed that the skeletal population from The Hirsel represent a fairly static rural community. The people were likely to have been of British stock, but since the site is just within the territory of Lindisfarne it is possible that there were some Anglo-Saxons. On the whole, however, the population is thought to be native, and probably had little admixture from the Iron Age to the Medieval period. A large proportion of child burials were recovered from this site. The minimum number of individuals was estimated at 334.

b) *Jarrow*, Tyne and Wear: Excavated by Professor R.J. Cramp, Durham University, 1963-75 (Cramp, 1969). The building of the monastery at Jarrow was started in 682. There is evidence from Bede for c.600 brethren at Jarrow and Monkwearmouth combined by the year 716. After the Viking attacks on the Northumbrian coast in the 9th century, the site was abandoned for a time, but was revived in 1072 and became a dependent cell of Durham in 1083. At the Dissolution the church remained in use. The Pre-conquest cemetery was situated at the south-west of the church, and the medieval cemetery was to the west of this. Burial continued in the churchyard into post-medieval times (18th century).

The Jarrow skeletons have been divided into three groups by broad time period as follows: "Preconquest-Early Medieval" (or Saxon), incorporating all those skeletons believed to be of Saxon or earlier date, with a few which may possibly extend into the early part of the medieval period; "Medieval", incorporating all those skeletons dated between the eleventh and sixteenth centuries, i.e. early medieval proper, medieval and late medieval; and "Post-Medieval", including those few skeletons thought to be of 17th century date or later. The post-medieval skeletons will not be considered in the present study since there were so few of them.

Both Jarrow and Monkwearmouth were likely to have had fluctuations of population. The foundation of Saxon monasteries suggests the appearance of a small elitist group, and monks taking over a populated area with tenants and rents. At both sites there is a possibility of burials earlier than the foundation dates of the monasteries. Between the 7th and 9th centuries the monasteries served as foci for the surrounding population. There is however a problem in that there is no clearly defined division of lay and religious burial in either cemetery, either temporally or spatially. There are distinct groups but it is not always possible to take these into account, due to the difficulty in distinguishing them and the resulting reduced size of the skeletal sample. Both sites were open to raids and violence since they were situated on the coast.The estimated minimum number of individuals from the sample analysed was 380, although the actual number of burials excavated was nearly double this figure. Many of the skeletons were analysed by Dr. Calvin Wells, but the site was not completed before his death. Any skeletons which he did not see, and which had not been reburied (a total of c.98 individuals), were analysed by Anderson and Birkett (1988).

c) *Monkwearmouth*, Tyne and Wear: Excavated by Professor R.J. Cramp, Durham University, 1961-74 (Cramp, 1969; 1976). The history of this monastic site is closely tied up with its sister foundation at Jarrow. Building of the monastery began in 674, and like Jarrow the site was abandoned in the 9th century, revived in 1072, and later became a small cell of Durham. There was an extensive Christian cemetery to the south of the west porch, which probably remained in use up to the 12th century. The earliest burials may predate the church of 674. Many of the skeletons were disturbed by later burials and building, and this made the estimation of a minimum number of individuals very difficult. A figure of c.200-230 was eventually arrived at. Many of the skeletons from this site also were studied by Wells, and the remainder were seen by Anderson and Birkett (Wells, 1988?; Wells *et al*, forthcoming).

d) *Norton*, Cleveland: Excavated by Cleveland County Archaeology Unit, 1984. The discovery of a 6th century Pagan burial in 1982 resulted in the survey and subsequent excavation of a cemetery containing 120 burials (117 inhumations and 3 cremations). The site was broadly dated to 540-610, from the large and rich assemblage of grave goods. The cemetery was situated on the sand and gravel terrace on the north edge of the Tees estuary. There are no other known pagan Anglo-Saxon remains in Norton parish, and no other known sites of the period in Cleveland north of the Tees. The human remains were analysed by Anderson and Marlow (Marlow, forthcoming). The estimated minimum number of individuals was 126.

e) *Blackfriars*, Newcastle: Excavated by R. Fraser, Newcastle Archaeology Unit, 1983-86. The excavation of this medieval friary was carried out under rescue conditions, and many of the interments identified had to remain unexcavated. A total of 36 individuals were recovered from both the cemetery to the north of the church and from within the church itself, 29 being from the chancel. There was also a large amount of redeposited bone. The method of excavation may account for any sample bias, such as the small number of juvenile skeletons recovered. The skeletons were analysed by Anderson (forthcoming).

f) *Blackgate*, Newcastle: Excavated by B. Harbottle, Newcastle Archaeology Unit, 1977-8. This cemetery site was situated at the base of the castle mound in Newcastle. The few related finds dated the start of the cemetery to c.700A.D. Most burials were sealed below the clay of the castle rampart of 1080, although a few were dated to the late 11th century or later. The cemetery was probably closed in 1168. Only bones appearing to be in situ and with some signs of articulation were kept. The interments were all very disturbed, due to the digging of new graves and the castle ditch, 17th-19th century occupation, houses, shops, etc. and the construction of the railway viaduct in the mid 19th century. Orientation was approximately W-E, and the lack of grave goods was evidence for the Christian nature of the site. The other half of this cemetery population, from around the base of the castle mound, is awaiting analysis. The estimated minimum number of individuals from the first part was 140.

g) *Guisborough Priory*, Cleveland: Excavated
by D. Heslop, Cleveland County Archaeology Unit, 1985-86. Excavations were carried out within the church of this Augustinian Priory, and 47 skeletons were recovered. The priory dates from the 12th to 16th centuries and was dissolved in 1540.

All the sites except two (Norton and Blackgate) were associated with an ecclesiastical building, and all the burials were inhumations (with the exception of three cremations from Norton). All are within the ancient kingdom of Northumbria, although the cemeteries at Blackfriars and Guisborough did not exist at the time of this political division.

Details for each site are summarized in Table 1.1 below.

Site	Abbrev.	Date Range	Type	MNI
The Hirsel	HIR	11th-13th c.	Church	334
Jarrow	JA	Sax-16th c.	Monastic	380
Monkwearmouth	MK	Saxon	Monastic	200
Norton	NEM	c.540-610	Pagan	126
Blackfriars	BF	Medieval	Monastic	36
Blackgate	BG	c.700-1168	Christian?	140
Guisborough	GP	12th-14th c.	Monastic	47

Table 1.1.

On average, preservation of skeletal remains at all the sites was fair, although it is possible to grade them from best to worst as follows: GP, BF, HIR, BG, JA, MK, NEM. It is unfortunate, but not uncommon, that the larger populations are generally the worst preserved.

SECTION 2
The Present State of Population Evaluation

The field of human skeletal research has evolved over the last twenty years into a multidisciplinary subject, in much the same way as archaeology. Although originally composed of the two separate branches of palaeopathology and physical anthropology, the subject now involves techniques not only of medicine and human biology, but also those more often used in geology, chemistry, computing, demography, and social history. Palaeopathology itself may occasionally involve the study of art and literature to provide evidence for disease occurrence in the past.

2.1 A Short History of Human Skeletal Research

An account of the present state of research in any field must of necessity include a brief review of past methodologies. The fields of palaeopathology and physical anthropology, which are now almost always merged as one study area, both have a long history, and it is not the intention of the present work to look at this in detail. However, a short background study of the subject may provide a greater understanding of the reasons for the current state of research.

One of the first men to study human skulls was Vesalius (1513-1564). He made a comparison of the cranial forms of Genoese, Turks, Greeks and Germanic people. Little other work was done in the 16th-17th centuries, and the real beginnings of human osteological research can be dated to the late 18th and early 19th centuries.

Blumenbach (1752-1840) was the first to record the shape of the skull and face. He published a description of his large collection of skulls under the title ‘Decas collectionis suae craniorum diversarum gentium illustrata’ (1790-1820). Others followed in his footsteps. Tiedemann, for example, first determined cranial capacity in 1836 by the weighing of the amount of millet seed that a skull would hold (Haddon, 1910). Retzius (1796-1860) is credited with the invention of the methods of cranial measurement which are still in use today. He also invented the cephalic index so that skulls could be organised by form, rather than classified into race.

Grattan (1800-1871), an Irishman, believed that 'No single cranium can per se be taken to represent the true average characteristics of the variety from which it may be derived. It is only from a large deduction that the ethnologist can venture to pronounce with confidence upon the normal type of any race,' (Ulster Journal of Archaeology, 1858). This at least represented a move away from the tradition of assigning individual skulls to a race type, even if not completely away from racial classification. Grattan adopted the most useful measurements of previous workers, and devised new ones of his own.

The Hungarian, Professor V. Török advocated the use of 5000 measurements for every skull. Fortunately, most of his contemporaries did not agree with such excessive recording. Even now, with the use of electronic callipers and computer analysis, collecting such a vast quantity of data would be extremely time consuming, and would in all probability yield meaningless or incomprehensible results.

Haddon (1910) states that ‘Though for a time craniology was hailed as the magic formula by which alone all ethnological tangles could be unravelled, measurements of other parts of the body were not ignored by those who recognised that no one measurement was sufficient to determine racial affinities’. However, although he quotes a number of workers in the field of anthropometry, there is no reference to anyone involved in the measurement of the bones of the post-cranial skeleton.

At around the time of Darwin’s *Origin of the Species* (1859) a new interest was growing in establishing the antiquity of man. Although to a large extent this involved searching for artefacts, there was an interest in human bone. Skulls were collected and measured in an attempt to establish some form of racial affinity with invading groups, and this branch of anthropology became distinct from the study of human evolution. Research was confined to the skulls of prehistoric man, as can be seen from the examples above. In America, the earliest known work was Warren’s ‘Account of the Crania of some of the Aborigines of the United States’ (1822). A number of similar studies were made by other Americans and Europeans. Thurnam and Davis, for example, wrote 'Crania Britannica' in 1856. Three of the most famous physical anthropologists of the early 20th century, Hrdlicka, Morant and Pearson, also produced a vast amount of work on cranial osteology.

At around the same time, interest in mummies from Egypt was growing considerably, and mummy unwrapping sessions were even open to the general public. This in turn led to an increased interest in the pathology of these individuals, and also to an interest in pathological specimens from prehistoric skeletal material. Wood-Jones’ work in Nubia produced a large number of mummies which were studied by the anatomy professor Elliot Smith (1910).

Palaeopathological studies had been carried out previously. Perhaps one of the earliest was that of Von Walther (1825), ‘Ueber das Alterthum der Knochenkrankheiten’. In America the earliest notable work in the pathology of pre-Colombian human remains was that of Jones (1876), ‘Explorations of the Aboriginal Remains of Tennessee’. However, before the work of Elliot Smith, no great attention was paid to detail in recording of physical anthropological data, pathology and anomalies of the complete skeleton (or in this case, mummified remains).

These two rather narrow fields of interest ensured that the only human remains kept from archaeological excavations of the period were skulls and obvious pathological specimens. By the beginning of the 20th century, however, more interest was beginning to be shown in the potential information to be gained from the measurement of all the bones of the skeleton. American anthropologists in particular were devising new measurements and attempting to estimate living stature of individuals. Palaeopathologists began to take more notice of the evidence of disease provided by the whole skeleton. Ruffer and Moodie were the two main pioneers in the field in the early part of the century, and much of the more recent work is based on their beginnings.

The thirty years after c.1935 were fairly barren as far as osteological work in America was concerned. In 1965 a symposium was held in Washington D.C. in an attempt to bring a new vitality to human palaeopathology (Jarcho, 1966), and in 1967 Brothwell and Sandison edited Diseases in Antiquity, with the intention of 'palaeopathological stock-taking and pooling of recently collected data'.

Although little work had been done in America in these 30 years, the work of Calvin Wells, Don Brothwell and Andrew Sandison in Britain did a great deal towards advancing the science of osteology. Wells, trained in both medicine and anthropology, saw a need for co-operation between the two disciplines, although he was reluctant to accept that anthropological training was of useful in pathological diagnosis. A great romanticiser, he brought the bones to life, sometimes at the expense of pure fact (e.g. Wells and Hawkes, 1975b). However, as many archaeologists would have to agree, there are no real facts in a subject which deals in the main with artefacts created by cultures which are long dead, and interpretations are really all that can be hoped for when dealing with skeletal remains. Wells produced many papers and cemetery reports in his career, and his appearances on television helped to popularise the subject of palaeopathology in much the same way as Sir Mortimer Wheeler had done for archaeology. His book, *Bones, Bodies and Disease* (1964e) was a useful summation of methods and theories in current use.Brothwell has used various methods in his studies of skeletal material. He has produced papers on palaeodemography, statistical analysis, teeth, biological variation and palaeopathology. His book, *Digging up Bones*, now in its third edition (1981), has become the standby of the cemetery excavator.

Sandison, trained in pathology, applied his knowledge and expertise to both skeletal remains (e.g. 1968, 1980) and Egyptian mummies.The methods of both Brothwell and Wells are employed in the production of many recent skeletal reports. Brothwell's tooth wear classification is used with varying accuracy by most osteologists, and Wells' general report layout is usually followed. Since Wells' time, however, a number of new techniques have been evolved for use in forensic and physical anthropology. An attempt has been made to standardise the techniques used in ageing and sexing of human remains by the Workshop of European Anthropologists (1980), and many new books and papers on palaeopathology have been produced, particularly in America. These techniques will be covered in more detail in the relevant chapters of this thesis.

2.2 Skeletal Reports

Few osteologists have produced as many skeletal reports as Wells, who wrote a total of 40 during the period 1955-1978, the year of his death (a number of his reports and papers were published posthumously). For this reason it is probably not surprising that so many other reports follow the same general pattern of recording skeletal remains, although possibly with less emphasis on pathology. Many of his reports were lengthy and included catalogues of all the burials in the cemetery (for example, North Elmham, 1980b). It is often the case today that skeletal reports are not published in full if they are considered by the excavator to be over long. Unfortunately, in the eyes of the osteologist, pottery, stonework and other artefacts tend to get pride of place in a report, often taking up many pages with catalogues which are denied to the student of human bone. Skeletal reports are all too often pushed to the back of the report on microfiche, or even never published at all and are instead held at the Ancient Monuments Laboratory. This seems to negate the importance of skeletal material in a cemetery dig, since the only time that the full results of skeletal analysis are published is when there are few other finds on the site.

Since, as Brothwell states in the Introduction to *Digging up Bones* (1981), 'no social reconstruction can be complete without examining the physique and health of the community', the reason for the undervaluation of skeletal information is unclear. As Sir Mortimer Wheeler claims in a much quoted passage from Archaeology from the Earth (1954), ‘the archaeological excavator is not digging up things, he is digging up people.’ It is true that the cemetery is often analysed in great detail, and burial positions, grave goods and so on are recorded in depth (e.g. Boddington, 1987a), but although this tells us a lot about the social aspects of a society, it tells us nothing of their physical characteristics, and without that information the picture is incomplete.

2.3 Skeletal Remains and Archaeology

It may now be pertinent to consider the information which can be obtained from a study of the skeletal remains of a population. Firstly, there is population demography, which involves the assignment of an age and sex to each skeleton whenever possible. Provided that the population is large enough, such information can be used for the construction of life tables and estimations of the size of population which the cemetery served, as well as life expectancy at various ages, average age at death of adults of each sex, and sex ratios can be calculated. Such analysis does of course have its problems, and these will be considered in the appropriate section.

Skeletons also provide the only non-artistic information we have about the physical appearance of people in the past. Stature can be calculated for most adult skeletons, and the various cranial and post-cranial measurements can be used for comparison between sites. They are still used, with slightly more reservation, in attempts to assign a racial type to a population, although this is a rather more complicated and dangerous occupation than perhaps some archaeologists would like to think. It is possible to suggest some degree of distance between populations based on their cranial measurements using multivariate statistics, however, and this may yield some useful information when comparing a number of large groups within a small area.

The three other main areas of study in archaeological osteology are non-metric traits, the dentition, and pathological changes. The first can provide possible information on genetic variation and relationships within and between cemeteries, and the second can give some idea of eating habits, age and disease. The third is useful for studying the prevalence of a particular disease in a population, or its occurrence in a particular individual.

A number of factors may reduce the amount of information which can be gleaned from the bones. Henderson (1987) has made a study of these, suggesting that they include the treatment of the body immediately after death, the method of burial, the burial environment, the method of excavation, and post-excavation treatment. After each stage it is almost certain that some information will be lost, and that the sample will be biased as a result of this. If the osteologist is not involved from the start of an excavation, there is very little that he or she can do about this, since osteological analysis is at the very end of the chain of destruction. The careful excavation and labelling of each burial is of vital importance if the archaeologist hopes to gain any worthwhile knowledge from the employment of a human bone specialist. Of course, some sites, in particular medieval churchyards, are often in such a state of chaos before the archaeologist even puts his trowel to the ground, that there is really very little he can do to remedy the situation, other than careful recording of the position of each bone if possible.

2.4 British Skeletal Reports before Wells

There have been a number of reviews of American work in this field (e.g. Buikstra and Cook, 1980; Jarcho, 1966), although mainly based on pathological reports and papers. In Britain, it is difficult to find osteological reports written before or around the time of Wells, without an extensive search through past journals. Those which are available are generally of poor quality by today's standards.

Duckworth, in whose memory the Cambridge skeletal collection was named, produced a number of reports (for example, Duckworth, 1906 and 1927; Duckworth and Pocock, 1909), which although claiming to be studies of human bones are generally concerned only with the skulls of the skeletons excavated. Martin produced *Prehistoric Man in Ireland* in 1935, a racial classification of skulls found in Ireland and dating from the early prehistoric to the Norse periods. Other contemporary specialists, such as Myers (1896), produced similar work.

One of the best reports written during the time of Wells’ dominance in this field was that on the Romano-British cemetery at Trentholme Drive, York (Wenham, 1968). The skeletal remains were reported on by Warwick, Professor of Anatomy at Guy’s Medical School. Although perhaps not of quite the same standard as Wells’ reports, it covered all aspects of skeletal morphology which are considered today, but with slightly more emphasis on racial affinities than is usual in modern reports. The pathological report was not particularly detailed, but the large dental report, including both dental variation and pathology (Cooke and Rowbotham), and the photographic plates compensate for this to some extent.

2.5 Skeletal Reports by Wells

As mentioned above, Wells produced a vast number of reports in his career, both on inhumations and on cremations, the latter being a field in which little work had been done previously. Much of his work was done on populations in Norfolk, where he lived. The sites of North Elmham (Wells & Cayton, 1980), Red Castle, Thetford (1967e), Caistor-by-Norwich (1973h) and Burgh Castle (unpublished; Anderson and Birkett 1989) were the main ones from that area. Other major cemetery sites included Portway Down, Andover (Wells & Henderson, 1985), Cirencester (1982), Skeleton Green (1981b), Iona (1981b) and Kingsworthy (Wells & Hawkes, 1983). The two sites of Monkwearmouth and Jarrow which are to be considered here were also seen by Wells, but were unfinished and are still awaiting publication (but see Wells et al, forthcoming; Anderson and Birkett, 1988). Whenever sites yielded interesting pathological specimens, Wells usually published them in medical or archaeological journals, thus ensuring that this information at least could be used by other workers. (A full list of Wells' publications can be found in Hart, 1983.)

Wells' work has served as an inspiration to many recent osteologists, and his sites are often used for comparison in modern reports, despite recent changes in methodology. Pathology, for example, is more usually described than diagnosed now. This is partly because many osteologists come from an anthropological or archaeological background and accept that they do not have the medical knowledge necessary for in-depth discussion of differential diagnosis, and partly because medically-trained palaeopathologists are recognising that diagnosis of disease from skeletal changes alone cannot be justified when it is often difficult enough to diagnose disease in the living patient.

Despite this, the descriptions of pathological conditions in Wells' papers and reports often bring a feeling of vitality and realisation of individual suffering, thus adding to our picture of the daily life of our forebears. Such description is lacking in many recent reports, due to the lack of space allowed for publication, and also due to the wish of many archaeologists and osteologists for the report to appear less fanciful and more factual than is perhaps the case with Wells.

2.6 Recent British Skeletal Reports

Many reports in the last ten years have been short, and confined to microfiche, giving little detail of individual skeletons (e.g. Dawes, 1986). Admittedly, a catalogue of skeletons does not make interesting reading, but such work should perhaps be more easily available to the specialist for whom a simple summary is not enough. The main report (i.e. everything except the catalogue) should be published in full in any archaeological report for which skeletons have been analysed, in order that the data may be compared with other sites.

Only two British cemetery sites have been given volumes almost entirely dedicated to the skeletal remains in recent years. The better known of the two is that of Dawes and Magilton (1980) on St. Helen-on-the-Walls, York. This report does not follow the usual layout made popular by Wells, and it can be very difficult to extract information from it. Much of the information is given in the form of pie charts, which although useful for comparison, do make it more time consuming to find the actual figures required. However, once the appropriate section is located, there is a vast amount of useful information included in the report, and the size of the cemetery makes it a useful comparison site. The pathological report is rather limited, however.

The other large report is that by White (1988) on St. Nicholas Shambles, London. This follows a more conventional layout and provides much information on all aspects of the population, although in less detail than Dawes' report.

Other fairly large sites to have been analysed recently include Guildford Dominican Friary (Henderson, 1984), Blackfriars Street, Carlisle (Henderson, 1986?), Great Chesterford, Cambridgeshire (Waldron, 1988), the skeletons from the Mary Rose (Stirland, forthcoming), and Fishergate, York (Stroud, forthcoming).

However, none of the recent skeletal reports is comparable in size and detail to many German publications, one of the best being the complete volume dedicated to the human remains from Manching (Lange, 1983). This covers a wide range of subjects within human skeletal biology, and includes large amounts of data, even down to the recording of individual skulls in photographs. It is apparent from this that more funding is available to German osteologists, and that consequently the impetus is provided for more detailed consideration of skeletal remains.

2.7 Possible Future Developments

Osteologists and palaeopathologists are beginning to question the assumptions made by past and indeed present workers in this field. As Ann Stirland and Janet Henderson have claimed in recent meetings of the Palaeopathology Association, the usefulness of disarticulated and incomplete skeletons is fairly limited. Ageing techniques have had to be reviewed in the light of the work done on the Spitalfields population, and the use of single bones in both ageing and sexing is, and should be, discouraged. Stirland feels that archaeological skeletal populations are probably not in general representative of the population of England at the period, and should not be seen as such. She has also questioned the use of lifetables and demographic analysis of such populations, and disagrees with the use of any statistical analysis on populations smaller than 50 individuals (Meeting of the Palaeopathology Association British Section, May 1989). Techniques used on populations from different sites need some kind of standardisation if these groups are to be compared. Palaeopathological reports should be based on current clinical terminology, and descriptions should be made under broad categories of change. All statements must be consistent with the available evidence.

A meeting is planned for the end of 1989 so that some form of standardisation of techniques can be agreed upon. The use of cranial and post-cranial measurements, for example, will be discussed, with a view to cutting down on the number of measurements which are taken at present, and which are considered by many workers to provide us with little more than large lists of numbers. The publication of the Spitalfields report should provide some impetus for the reviewing of ageing techniques. The use and misuse of presently available methodologies will be discussed under the relevant sections of this thesis.

2.8 Subdivisions in this Thesis

As stated above, Wells divided his reports into sections based on age, sex, physical characteristics, teeth and pathology. These sections, with the exception of the last, will be used in this thesis as a convenient way of presenting the data, so that it can be compared with the work of other osteologists. It is felt that, although all the subjects are inter-related to varying extents, these are probably the best subdivisions which can be made given the current state of research.

SECTION 3.
Palaeodemographic Analysis

Brothwell (1981) states that ‘there are...three primary areas of human demography that can be considered in relation to earlier peoples: a) population growth and decline; b) the composition of communities; c) the distribution of populations in space and time’. The first and third areas are not within the scope of the present work, but the composition of communities will be considered. For such a study it is necessary to determine age at death and sex for each skeleton within a population. Methods and problems involved in these determinations will be discussed in Sections 3.1 and 3.2. Aspects of fertility will be considered in Section 3.3 on parturition.

Palaeodemographic surveys have been carried out based on various regions (e.g. Brothwell, 1972; Hedges, 1982) and on single cemeteries (Boddington, 1982, 1987c). These studies have involved the construction of life tables and sex ratios based on data from research on the skeletal populations. The imprecision of ageing techniques will undoubtedly render the results of these life tables inaccurate, if not completely useless, although sex ratios should be fairly certain. However, as Acsádi and Nemeskéri (1970: 72) point out, ‘Historical investigations in the field of both the biological and social sciences must often rely on demographic information. The necessity of palaeodemographic research is justified by the lack of any other source supplying such information’. In other words, if we hope to find out anything of value about people in the past, it is useful to know age and sex distributions at the very least.

The use of life tables involves a number of assumptions, not the least being that age estimations for the population are at least reasonably reliable. The problems involved in ageing skeletal remains are such that, in the case of adults, there may be a bias towards younger individuals. Older individuals cannot be excluded from the complete table, but they will probably be underaged. Without some form of correction factor, such biased tables cannot be compared with life tables of modern populations.This fundamental problem, which would appear to invalidate the use of life tables in the study of skeletal populations, may be overcome by the use of some more accurate ageing techniques in the future. At present, however, if any analysis of age at death of skeletal populations is to be carried out, it may be of use to construct life tables and graph expectation of life, survivorship rates and probability of death, at least for those populations with a large number of buried individuals and a large proportion of juvenile remains.

Bocquet-Appel and Masset (1982) found a high correlation between age structure of reference populations for various ageing methods and age structure of populations aged using those particular methods. From their study, they suggest that scarcely anything positive can be deduced about the demography of ancient populations. ‘Early mortality of adults, over-mortality of women, lack of old people in these populations, whether prehistoric or medieval: all these hackneyed notions were born from the misinterpretation of data. As they are in no way vindicated, we must get rid of them.’ (1982: 329). However, Buikstra and Konigsberg (1985), although noting other problems with palaeodemography, showed the suggested correlation of study group ages with reference group ages to be incorrect.

Moore *et al.* (1975) consider some of the assumptions made in the use of life tables in palaeodemographic analysis. They list the main problems as being infant underenumeration, population growth and small sample size, but do not examine inaccuracy of ageing a skeletal population. Acsádi and Nemeskéri (1970) list six requirements pertaining to a population to be analysed palaeodemographically, these being (i) completeness of the series, or lack of it, should be known, (ii) accuracy of estimation of age and sex, (iii) information on the series, such as chronology of burials, (iv) the population should be unchanging, no migration, etc., and representative, (v) suitable demographic methods should be used depending on the aim, and (vi) uniformity of analytical work throughout the procedure. None of the populations studied in the current work, or indeed anywhere in the world, can be thought of as complete, and their migratory patterns and representativeness are unknown. However, Acsádi and Nemeskéri carried out extensive studies on a large number of archaeological and historical populations from Europe, and Hungary in particular, and have concluded that ‘the cemeteries of historical populations, forming part of the same people and having been under identical social, economic and cultural conditions, usually correspond to one another in respect of essential demographic characteristics. There may be certain minor local features which differ and these can be explained by the low number of elements in the sample, and so the computed results can be generalized even if only a few series are taken into account’ (1970: 58).

In the current work, graphs and life tables are presented with weighted adult ages (as well as the original age estimates), on the assumption that 50% of the individuals within each adult age group have been underaged by ten years. It is of course likely that a different proportion of adults in each age group could have been under- or even overaged, but it seems possible that the various inaccuracies may be evened out when age groups of ten years are being utilised. For example, if 60% of the individuals in the age group 35-45 years were underaged and a number corresponding to 10% of this group were overaged in the group 45+, a weighting factor of 50% would produce the same result. Without further evidence from known populations, such as Spitalfields (which is not available at the time of writing) it is impossible to be certain of the proportions of individuals in each age group who are likely to have been assigned wrongly. For this reason, a figure of 50% was chosen in order to show the effect such an error would have on the life table of three populations (HIR, MK and JA). These tables and figures are included and studied in detail in section 3.1 on age.

It may be possible to prove with further work that the inaccuracy of age estimation in adult skeletons does not affect the general picture produced from life table calculations. For this it will be necessary to have some indication of the level of inaccuracy, probably from work such as that done on the Spitalfields population. On the other hand, the number of assumptions involved in using these tools of demography on ancient populations may render the whole process invalid.

3.1. Estimation of Age

3.1.1. Methods and Problems

A number of methods of determining the age of a human skeleton are currently in use, some more accurate than others. Methods range from visual, through metrical, to microscopic. In general, human osteologists tend to concentrate on the first when writing reports, with use of the second where necessary. The reason for this is that the last is extremely time consuming, is not available in most centres, and also involves destruction of part of the bone by slicing it into thin sections.

Examples of ageing techniques which fall into the first group include the general appearance of the bones, for example presence of signs of old age (osteoarthritis, osteophytosis, etc.), the appearance of the pubic symphysis, or the stage of wear of the teeth. In the case of a child, the stage of calcification and eruption of the teeth is more appropriate, as well as the stage of fusion of the epiphyses to the long bones. The second group of methods generally involves measuring the long bones of children in order to determine their approximate age. This method is almost as accurate as the stage of eruption of their teeth, but both methods will only give an estimate of biological developmental age, not chronological age.

Microscopic methods of determining age from adult bone include that pioneered by Kerley (1965), which involves the counting of the number of osteons, fragments of osteons and non-Haversian canals in a given area of the femur or tibia. This method (with recent revisions, Kerley and Ubelaker 1978) is probably a far more accurate way of ageing adults, but unfortunately, as stated above, it would take far too long to do this for every skeleton in a group, which makes it unlikely that it would be used in a normal osteological study. It has also been suggested by Ortner (1975) that dietary and environmental factors could influence the histological appearance of the bone, which may reduce the accuracy of the method.

Another microscopic method has been devised for use on thin sections of teeth, in particular the canine (Gustafson, 1950). This involves the study of six features of the sectioned tooth: attrition, periodontosis, secondary dentine deposition, root resorption and transparency of the root. A standard curve is used to estimate age from points allotted to each feature. This method seem to yield accurate results, but are time-consuming and expensive, and are therefore not practicable for most archaeological bone specialists. The assessment of periodontosis (recession of the gingival margin) is in any case difficult in archaeological populations (Hillson, 1986).

Unless one of the microscopic methods is used, the chances of ageing an individual accurately once he/she has reached the age of 25 are very slim. Most bone specialists, nevertheless, give an approximate age range within which the individual would fall with 80-90% probability, although this estimate of accuracy has had to be revised in the light of the evidence from Spitalfields.

The main techniques in use will now be considered in more detail. Those utilised in the ageing of children are considered first, followed by those applicable to adults.

3.1.1.1. Child Age Evaluation

Probably the most accurate method of ageing a child is to inspect the stage of calcification and eruption of the teeth. This involves deciding which teeth are present in the jaw, which are deciduous and which are permanent, and the relative length of the root of each tooth. A scheme based on large numbers of individuals (Ubelaker, 1978) which can be used to determine the age to within a few months in the case of a very young child, or a couple of years in the case of an older child or adolescent, has been recommended by the Workshop of European Anthropologists (1980). This chart was originally prepared from a study of the teeth of modern American children, and we have no way of knowing if the dentition of ancient populations reached the same stage at a similar age as that of the modern child. Although the state of eruption of the teeth is the easiest method to use, since it does not involve radiographic analysis, most osteologists believe that calcification is a more accurate age determinant (Ubelaker, 1987). This is due to the fact that calcification is a more consistently occurring phenomenon than eruption in most populations, since the latter tends to vary from individual to individual.

If no teeth are present, either because the child is too young or because conditions of burial have been unfavourable, another method of determining the age of a child, from six months to 14 years, is to measure the lengths of the shafts (diaphyses) of the long bones. The lengths are then compared with a standard chart (Workshop Eur. Anth., 1980), based on an old Slavic population with an average stature of 171cm for men and 161cm for women (Stloukal and Hanáková, 1978). The problem with this method is that it is based on a small number of individuals of unknown age, and it is therefore recommended that a broader age estimate is given when this method is used. It also assumes that individuals who died as children were not greatly affected by growth disturbing diseases. Sundick (1978:232) presents evidence to suggest that 'the subadult skeletons which are present in our archaeological collections are not very different from those who survived in terms of their size. They may just have succumbed to a relatively stressful situation that lasted for a short period of time'. Presumably, also, children of populations of similar time periods were in general dying for similar reasons, unless some localized epidemic occurred. However, since the method is widely used, it does at least allow for comparison between sites, and when used in conjunction with other estimates of juvenile age it provides greater confirmation of age determinations. Scheur *et al* (1980) have produced regression equations for ageing foetal and perinatal skeletons based on a modern population.

Both methods can be used up to the age of 14-15 years, after which all the adult teeth have erupted (except the third molar, which may not always erupt, and could then only be used in radiological studies of calcification stage), and the bones become a less accurate guide due to divergence between sexes, and the wider range between children of the same age and sex.

From age 14 to 25 the best method to use is the fusion of the epiphyses of the long bones. These are attached to the diaphysis of the long bone by cartilage, which eventually ossifies, at which point the bone no longer grows in length. Approximate ages of fusion for each bone are known, since this process does not occur in all parts of the skeleton at the same age. The state of ossification, or size of the epiphyses, can give an estimate of age (Brothwell, 1981). It is best to consider more than one bone if possible, since this will narrow the range of ages considerably. This method will usually give an accuracy of 3-5 years, based on a modern population.

There are, however, problems in the ageing of child skeletons. Johnston (1969:336) states that the normal range of variation for age at menarche in girls is 6.5 years, and 'an age difference of four years is not at all uncommon between two like-sexed individuals who display the same degree of skeletal maturity'. This suggests that once a child has reached the age of puberty, an estimation of chronological age will be far less accurate than previously. From the age of ten years onwards any age estimate based on skeletal maturation in juveniles or sub-adults may be out by as much as 5+ years.

3.1.1.2. Adult Age Evaluation

After the age of c.21, all the teeth are usually present, and tooth wear can be considered. This is not always an accurate indication, since it is largely dependent on the type of food being eaten by an individual. It is best to consider all the teeth in the population as a whole, as this will usually provide a better guide to the amount of attrition to be expected. The molar attrition charts of Miles (1963a,b) and Brothwell (1981) have been widely used in ageing of adult skeletons in recent work. The research done on the Spitalfields population suggests that this method of ageing adult skeletons is not really valid. It is possible, however, that underageing of this population was caused by the consumption of softer foods than would have been available to the earlier populations for which the charts were originally produced. There is little or no evidence on which to base such a suggestion, since there are no Anglo-Saxon or Medieval burial populations with known age and sex. The work of Cayton (1980) suggests that Anglo-Saxons were reaching a greater age than is suggested by their dental attrition, but this was based on documentary evidence and usually involved individuals from the upper echelons of that society. Lovejoy (1985) presents work on the Libben population of American Indians, suggesting that dental wear has a high correlation with age, and, if used in a multifactorial determination of age, should yield good results up to the age of around 50 years. Dental attrition may yet emerge as a valid method of age estimation, since new methods, based on the complete dentition, are being developed and tested on populations of known age (Pot, 1988; Bouts and Pot, 1989). It will, however, never be possible to prove how much wear occurred at specific ages in a Saxon or Medieval population, and a ten-year estimate is probably the best that can hoped for using this method.

Another method of ageing adults is to consider cranial suture closure. This method is less widely used now, since it has been found to be less accurate than any other visual technique (Brothwell, 1981). Work on a documented collection of Dutch crania has suggested that cranial suture closure is fairly reliable up to the age of 50, but after this there was a large number of skulls which still had open sutures (Perizonius, 1984). This would make it likely that a skull belonging to an old age group would be placed in a younger category if sutural closure was the only ageing method available. Meindl and Lovejoy (1985) suggest that the use of ectocranial suture closure is a valid method of ageing when used in conjunction with other factors, although in their test (Lovejoy, Meindl, Mensforth & Barton, 1985) its correlation with actual age was only 0.53.The occipital sphenoid suture has been found to be fairly reliable, but tends to close around the age of 21 when it is really of least use as an age determinant. The main vault sutures (coronal, sagittal and lambdoid) almost invariably close on the endocranial (interior) surface first, followed by the ectocranial side a few years later, and in the order sagittal, coronal, lambdoid. This order can usually be relied upon, and therefore suture closure can be used for a relative estimate of age, even if not an absolute one. It will give an approximate guide to the accuracy of tooth wear in younger individuals, for example (although if the individual was old and still had unfused sutures and little molar attrition, this method would not be of much help in estimating his age at death). However, Singer (in Vallois, 1960) notes that sutures can be reopened by the action of dilute acids, and this needs testing in relation to acidic soil, since it would suggest a younger age by this technique (although most skeletons from acidic soil tend to be in very poor condition anyway).

The most widely used ageing technique in forensic science, when the skeleton alone is being considered, is the changing surface of the pubic symphysis of the pelvis (Todd, 1920; McKern and Stewart, 1957; McKern, 1976; Hanihara and Suzuki, 1978; Meindl, Lovejoy, Mensforth & Walker, 1985; Katz and Suchey, 1986). The last two studies both found the Todd system to be the most accurate, and produced modified scales based on this work. However, unless a series of archaeological skeletons is very well preserved, it is unlikely that more than a few individuals will be found to have this bone intact and uneroded. In any case, this method can only be used with any reliability on male skeletons, since changes in childbirth can radically alter the pubis in females (Gilbert and McKern, 1973; Gilbert, 1973; Suchey, 1979). Suchey (1979) found the 1973 Gilbert and McKern system for the ageing of the female skeleton from the Os pubis to be highly unreliable. The accuracy of the technique for male skeletons is well attested in the forensic world for individuals under c.50 years of age, but it is difficult to use on badly eroded bones from archaeological sites, and may be different in ancient and modern specimens.

A similar problem is encountered in the use of a method for estimating age from changes in the sternal rib (Iscan et al, 1984, 1985, 1986a, 1986b). In this method, the sternal end of the rib is studied and assigned to one of nine phases related to change with age. The accuracy of this method is thought to be as good as that obtained in the use of the pubis. The fragility of the ribs, however, means that the ends, if not the whole bone, are often lost in the ground, thus making it almost impossible to use this method in the majority of archaeological populations.

Lovejoy, Meindl, Pryzbeck & Mensforth (1985), noted the higher preservation rate of the auricular surface of the ilium, and have devised a new method involving the metamorphosis of this joint facet in the determination of adult age at death. The authors claim that the technique is highly replicable, although admitting that it is ‘somewhat more difficult to apply’ than pubic symphyseal ageing, with which they compare it favourably. Unlike the pubis, changes still occur after the age of 50 years, making it a valuable tool in the estimation of age throughout adult life. Its greater preservation potential may mean that this joint will eventually prove to be more useful than the pubis in estimating age in archaeological populations. The authors do however advocate the use of as many techniques as possible in assigning ages to skeletal populations, since a multifactorial approach yields better results.

If there is an opportunity for radiological analysis, a number of methods have been established for estimating age at death from changes in the internal bone structure (e.g. Acsádi and Nemeskéri, 1970), especially of the humeral head, the femoral head and the clavicle (Walker and Lovejoy, 1985). This last study found that the clavicle was the best indicator of age in radiographic study. However, to use this method on most skeletal populations would be time-consuming and costly, and it is therefore infrequently used. It is also likely to be of little use in female skeletons since hormonal changes after the menopause mean that bone loss is not a steady phenomenon.

One other method which can be used in conjunction with the above, or alone if all else fails, is the presence or absence of signs of old age. As we get older, bony changes occur especially at the major joints, and cartilage may become ossified. Ligamentous ossification may also occur, especially on the anterior of the patella, the posterior surface of the calcaneus, and the proximal end of the ulna. Osteophytic lipping may be present on the vertebrae and the main joints, especially the hips, knees, elbows and shoulders. If the individual is affected by osteoarthritis there is probably a good chance that he was mature, although we cannot be sure that this disease did not affect our ancestors at an earlier age than is normal today. However, problems with this method include the fact that absence of these pointers does not necessarily mean that the individual was young (although it is more likely). Calcified cartilage will be one of the first things to be lost after the decay of the soft tissues, so it is only found in skeletons which are preserved in good condition. Osteoarthritis may be present on a joint secondary to another lesion, especially trauma, such as dislocation of the hip or shoulder. If this joint is the only part of the skeleton to be preserved (as is sometimes the case) it is extremely difficult to estimate the age of the individual, and an age should probably not be assigned to such a skeleton.

Such are the problems of ageing a skeleton, and it may now be realised why it is sometimes impossible to classify an individual into a smaller age range than ‘young’, ‘middle-aged’ or ‘old’. Even relatively narrow ranges such as ‘25-35’ may not appear very accurate to the archaeologist. However, it must be remembered that if such a range is given, there is no absolute guarantee that the individual in question died between those ages. It is only the most likely range into which his age at death may fall.

Stirland, at the Meeting of the Palaeopathology Assoc. in May 1989, has suggested that we should not attempt to age skeletal material more precisely than the categories young adult (20 - mid 20's), adult (late 20's - 40's) and old adult (40+), and that any estimates should be based on the entire skeleton only. Although this may be a little over cautious, it is certain that skeletal ageing techniques are not as accurate as has been assumed in the past, and it may be misleading to quote an age range of five or ten years for individuals thought to be over 25 years of age.

3.1.2. Methods applied to the Study Populations

3.1.2.1. Juveniles

The methods of ageing children at the sites considered in this study were the three major ones, i.e. the calcification and eruption stages of the teeth, the lengths of the diaphyses of the long bones and the stage of epiphyseal union. In the work both the formation and the eruption of the teeth of juveniles were considered in each dentition wherever possible. Ages estimated from the teeth were found to show a high correlation (in the Hirsel population at least, correlation coefficient = 0.98, see Fig. 3.1) with those estimated from long bone lengths, the standards for which were originally calculated using tooth *calcification* (Stloukal and Hanáková, 1978).

The histograms presented as part of Figure 3.1 show the numbers of Hirsel children in each age group aged by teeth and long bones, firstly of the children for whom age was estimated using the teeth, and then for the children aged by long bone length. The white sections of the bars in both cases includes those children for which both methods could be used (but plotted according to the age given by the method under consideration only), and the hatched sections show those children who could only be aged by one method. The distributions are similar, but there are slightly more infants aged by long bone length than by teeth. This is probably because the small tooth buds of tiny children are easily lost on excavation or by the processes of erosion.

Tables 3.1 and 3.2 show the numbers of children aged by each method at Jarrow, Monkwearmouth and The Hirsel. It should be noted that the Jarrow and Monkwearmouth figures do not include the children aged by Wells, since the methods used for particular individuals are not recorded in his work.

	Ageing Techniques			
Site	Teeth	Bones	Epiphyses	Other
JA Sax	8	6	1	1
JA Med	7	10	0	0
MK	9	15	1	1
HIR	97	97	4	0

Table 3.1

	No. of Methods			
Site	1	2	3	Total
JA Sax	12	2	0	14
JA Med	7	5	0	12
MK	13	5	1	19
HIR	39	78	1	118

Table 3.2

This suggests that the age determinations of Hirsel children are likely to be more accurate than those of the Jarrow and Monkwearmouth children, since more of the Hirsel estimates are based on two methods of ageing than on one, and on teeth as much as long bones. However, the children represented in this table are only a small sample of the children from Jarrow and Monkwearmouth, and they were in general less well preserved than those seen by Wells.

It is probably reasonable to assume that the estimated ages for the children in these populations are as accurate as possible given the condition of the remains, the time and resources available for the analysis, and the current state of research.

3.1.2.2. Adults

Age was estimated using the tooth wear charts of Brothwell (1981), occasional use of the pubic symphysis (Katz and Suchey, 1986), and visual examination of the condition of the bones was used for some attempt at confirmation. Cranial suture closure was noted for the same reason, although it is recognised that this last method is less than accurate. In most cases, although the less accurate ageing pointers were noted, the individual was aged from the most reliable techniques available, since averaging based on all the methods is likely to lead to greater inaccuracy.

Tables 3.3 and 3.4 record the numbers of each technique used in the ageing of adults from Jarrow, Monkwearmouth and the Hirsel. The adults aged by Wells are not included since methods of individual age estimations were not recorded in his notes.

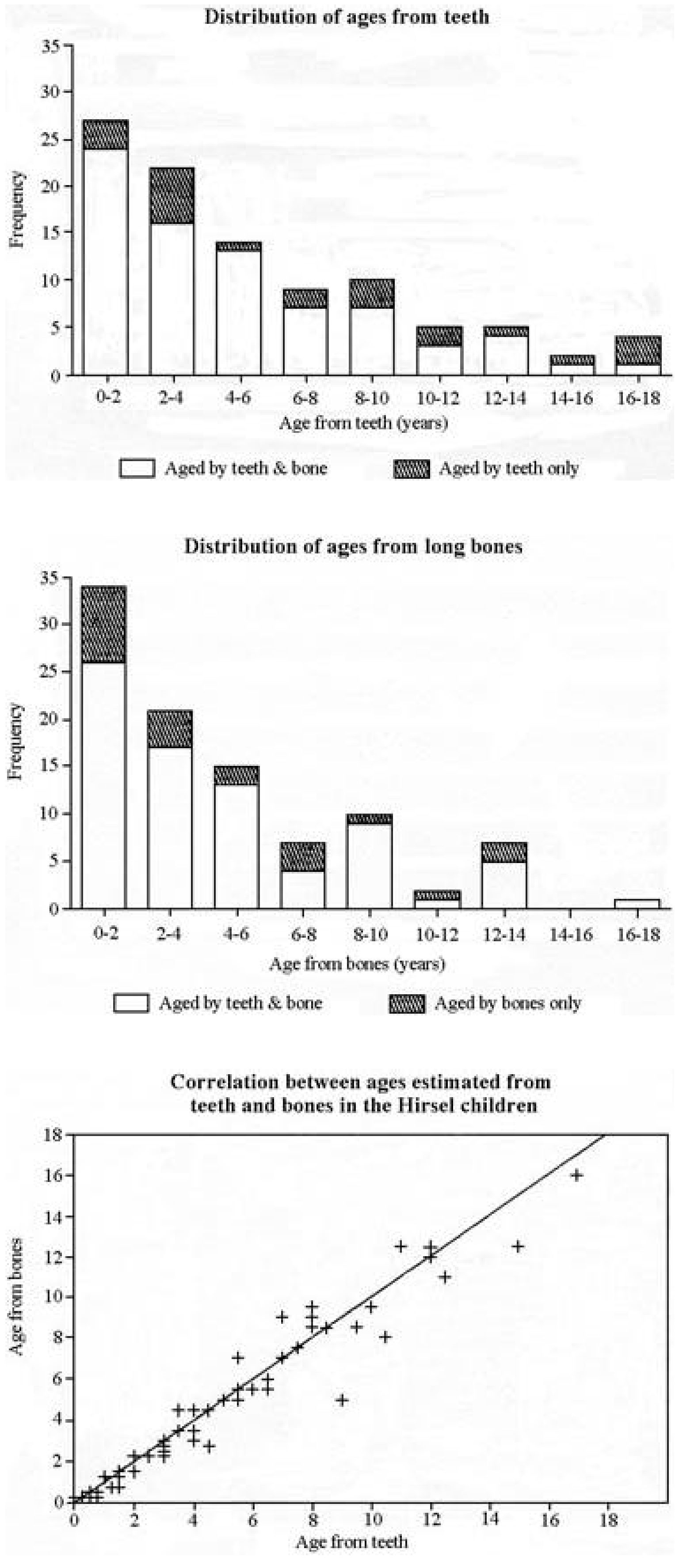


Figure 3.1. Correlation between age from teeth and bones in children from The Hirsel.

Site	Method of Ageing				
	Tooth Wear	Pubis	Bone Condition	Suture Closure	Epiphyses
JA Sax	8	1	3	5	1
JA Med	9	4	5	7	4
MK	21	3	16	12	4
HIR	130	29	73	126	26

Table 3.3

This shows that molar attrition, cranial suture closure and general condition of the bone were the most frequently used methods of ageing adults in these populations. There was no great difference between the sexes, except at The Hirsel where twice as many men as women were aged by the pubic symphysis.

	Number of Techniques					
Site	1	2	3	4	5	Total
JA Sax	4	3	1	0	1	9
JA Med	4	7	1	2	0	14
MK	16	6	5	2	0	29
HIR	25	62	45	22	2	96

Table 3.4

Most of the skeletons from The Hirsel were aged by two or more techniques, which gives the estimates slightly greater credibility. The Jarrow and Monkwearmouth figures are really too small to draw conclusions.

It is thought unlikely that the estimation of adult age at death in the populations considered here can be viewed as giving an accurate picture of mortality in Anglo-Saxon and Medieval England. The inadequacy of skeletal ageing techniques has been considered above, but such techniques have been applied to these populations because no alternative methodologies were available at the time of study.

3.1.3. Age Distribution and Palaeodemography in the Study Populations

Having explained this, it is now possible to look at some examples, and make comparisons between sites. Since all the cemetery populations considered in this study have been analysed using the same methods, and are broadly contemporaneous, it seems reasonable to assume that a valid comparison of results can be made, as long as the inaccuracy of adult age estimation is continually borne in mind. Wells' figures for Jarrow and Monkwearmouth are included in this analysis, since the populations would be too small for statistical study otherwise. Work on Jarrow (Anderson and Birkett, 1988) has shown that the results obtained by Wells and the present writer are similar.

At Jarrow, of the 380 individuals, 163, or 42.9%, were less than 18 years of age at death. At Monkwearmouth there were fewer juveniles - 116 (35.5%) out of 327 "individuals". However, it must be remembered that the burial ground at Jarrow was used over a longer period than that at Monkwearmouth, and when Jarrow is divided into the loose categories "Saxon" and "Medieval" (see Section 1), it can be seen that 73 (42.9%) juveniles belong to the Saxon period and 74 (39.2%) to the Medieval (the rest being post-medieval). The Saxon figure is still much higher than that of Monkwearmouth, but the medieval period is only slightly higher. However, the cause of this difference is unknown. It is possible that living conditions at Monkwearmouth were better, or that the children living there were better nourished or cared for. It may simply be due to different burial customs, or different use of the churchyard, or may even have occurred as the result of a single epidemic. It is impossible to say which of these, if any, may be correct from the data available.

At The Hirsel 153 (45.8%) out of 334 individuals were juvenile. This figure is slightly higher again than that of Jarrow, although whether this was due to some environmental factor or another phenomenon, or even simply due to chance given the small size of the difference, is unknown.

Table 3.5 provides a summary of the numbers and percentages of children found at each of the seven sites studied in this work.

Site	No. of Individuals	No. of Children	% of Children
The Hirsel	334	153	45.8
Jarrow (Sax)	170	73	42.9
Jarrow (Med)	189	74	39.2
Monkwearmouth	327	116	35.5
Norton	126	34	27.0
Blackgate	140	36	25.7
Guisborough	47	7	14.9
Blackfriars	36	3	8.3

Table 3.5

The low proportions of children at Norton, Blackgate, Guisborough and Blackfriars are suggestive of a biasing factor. Possible causes include lack of preservation of fragile child skeletons, differential burial practices, or lower child mortality. This last is the least likely, particulary at the two earlier sites (Norton and Blackgate). Blackfriars and Guisborough were probably prestigious burial grounds and this would account for the small numbers of juveniles buried there.

The average age at death (calculated from the medians of age ranges) of the children at Monkwearmouth was 4.2 years, whereas for the Jarrow Saxon children it was nearer 7 years. The medieval juveniles at Jarrow had a slightly lower average age of 5.5 years. At The Hirsel the figure was 4.5 years. The distribution of juvenile ages at death for each site is shown in Fig. 3.2. The pie charts show the greatest similarity between distributions at The Hirsel and Saxon Jarrow.

Monkwearmouth also has a similar distribution. Medieval Jarrow shows the most difference, which is probably not surprising, since the other groups are of a more similar time period, although The Hirsel dates from the 11th-15th centuries and covers both periods. It may have had a more backward community, however, since it was more rural than either Jarrow or Monkwearmouth, and might therefore present a similar picture to urban Saxon sites. Table 3.6 records the actual figures in each age group for all the sites in this study. The percentages in the 'Total' column are proportions of aged children out of the total population.

Site	0-2	2-6	6-10	10-14	14-17	Total
HIR n	51	44	28	14	8	145
%	35.2	30.3	19.3	9.6	5.5	43.4
JA n	18	18	10	6	5	57
Sax %	31.6	31.6	17.5	10.5	8.8	33.5
JA n	10	23	19	16	4	72
Med %	13.9	31.9	26.4	22.2	5.6	38.1
MK n	52	20	19	12	5	108
%	48.1	18.5	17.6	11.1	4.6	33.0
NEM n	4	3	12	8	6	33
%	12.1	9.1	36.4	24.2	18.2	26.2
BG n	11	9	7	5	4	36
%	30.6	25.0	19.4	13.9	11.1	25.7
GP n	3	2	0	2	0	7
%	42.9	28.6	-	28.6	-	14.9
BF n	1	0	1	1	0	3
%	33.3	-	33.3	33.3	-	8.3

Table 3.6

The last four sites have too few juveniles to be included in the statistical and palaeodemographic analyses.

The distribution of deaths below the age of two years is shown in Table 3.7. The totals are slightly lower than the figures given for the 0-2 age group in the previous table, because in some cases it was impossible to age these children more closely than 'infant'. The percentages in the 'Total' column show the proportions of aged infants to the rest of the juveniles.

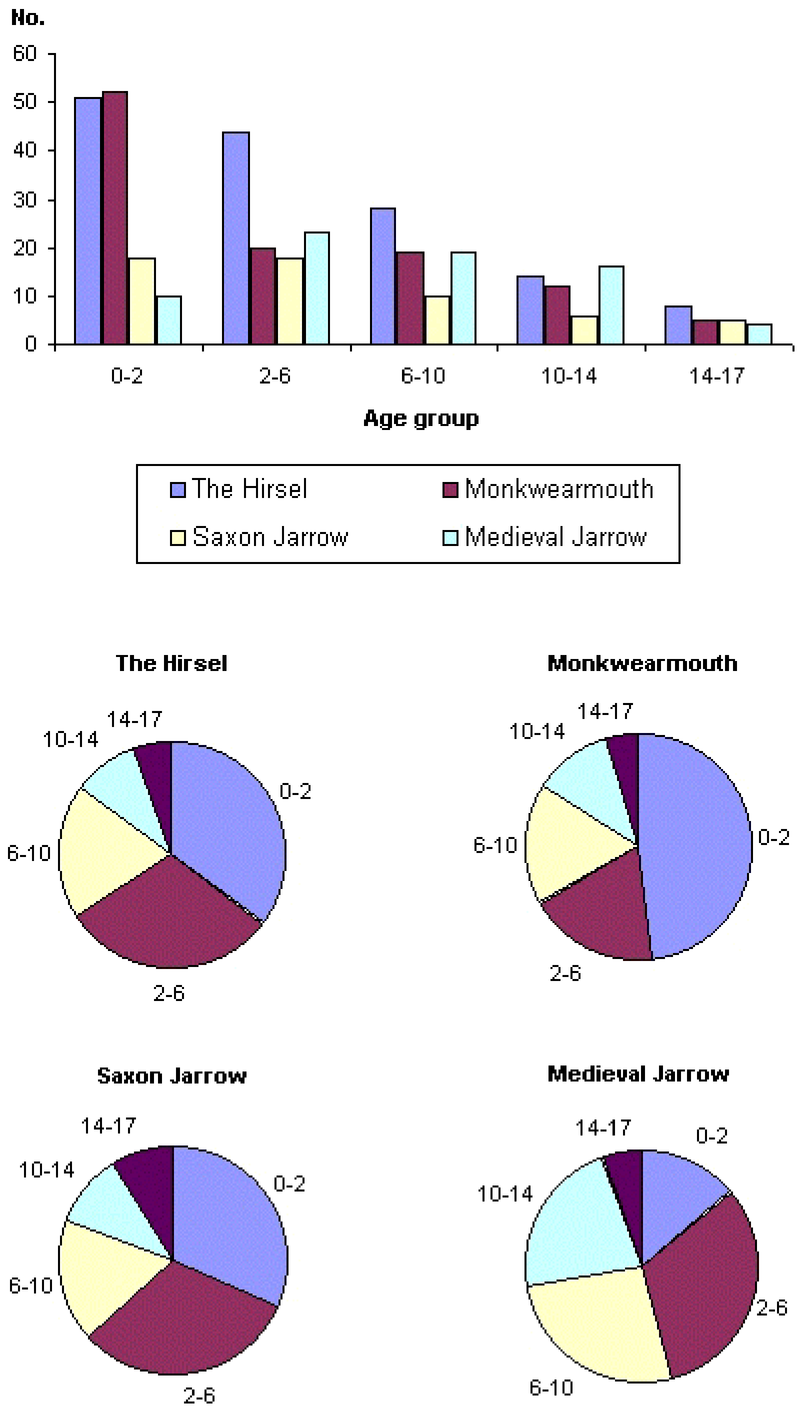


Figure 3.2. Bar and pie charts of actual numbers and percentages of children by age group.

Site	<1m	<6m	<12m	<18m	<24m	Total
HIR n %	12 25.0	12 25.0	8 16.7	12 25.0	4 8.3	48 31.4
JA n Sax %	5 27.8	4 22.2	7 38.9	0 -	2 11.1	18 24.7
JA n Med %	2 22.2	2 22.2	3 33.3	0 -	2 22.2	9 12.2
MK n %	20 17.2	14 12.1	5 4.3	2 1.7	8 6.9	49 42.2

Table 3.7

It can be seen from this that the largest proportion of infants were buried at Monkwearmouth, followed by The Hirsel, Saxon Jarrow and finally Medieval Jarrow. This would suggest that babies were healthier at Jarrow than Monkwearmouth or the Hirsel, although again the figures may be due to different burial practices (i.e. whether there was a designated area of the cemetery for infants), or even differential preservation between the two sites.

At The Hirsel, infant mortality was fairly evenly spread between newborn and 18 months. At Jarrow the greatest mortality appears to have occurred when the children reached the age of one year. At Monkwearmouth the greatest frequency of infant death was around the time of birth. This suggests that different factors were involved in the determination of infant mortality at the three sites. Perhaps at Monkwearmouth the mothers were less healthy, and consequently the babies tended to die most often soon after birth. At Jarrow, the most frequently occurring deaths at the end of the first year of life could be accounted for by some form of infection. The Hirsel figures would suggest generally poor health when compared with the other populations, but the percentage of infant mortality in the whole juvenile population was less than that at Monkwearmouth. It is difficult to know the true reasons for the differences in spread of infant deaths at these populations, especially as they occurred over a number of centuries. Chance may be an important factor, especially in the excavation process, but illness and malnutrition cannot be ignored as possible causes.

An average age at death was not calculated for the adult skeletons, since the results obtained are felt to be misleading due to the anticipated underageing of a fair proportion of the adult individuals. The percentages of adults in each age group from all the sites are presented as pie charts in Fig. 3.3. The pie charts show that there is most similarity between Monkwearmouth and Jarrow, and that Guisborough and The Hirsel are also fairly similar in adult age distribution.

Life tables (Figs. 3.4-3.8) have been calculated for each of the three larger populations in this study. The smaller populations were not used due to the small proportions of child remains, and in the cases of Blackfriars and Guisborough, due to small sample size. Some of the problems of using these tables with skeletal data have been considered in the introduction to this chapter. However, the large sample sizes of the populations from Jarrow, Monkwearmouth and the Hirsel, and the large proportion of children at each, means that fewer assumptions have to be made in the construction and analysis of the life tables based on them.

Life tables have been calculated, as stated above (in the introductory section of this chapter), both for the estimated age distributions as calculated from the study of the skeletal remains and for the weighted adult ages on the assumption that half of each age group was underaged by ten years. The results of e(x) (life expectancy), l(x) (survivorship) and q(x) (crude probability of death, after Boddington 1982) were plotted against age in each case (Figs. 3.9-3.11). The curves obtained for the two sets of data do not seem to differ greatly. Life expectancy is slightly higher throughout life, which is not really surprising since the weighted figures assume a maximum age of 70 years rather than 60. The difference is at most one of five years, but the general appearance of the curve changes very little. The probability of dying is slightly reduced , most noticeably at age 17, but otherwise both this and the graph of survivorship are little altered. These results seem to indicate that conclusions made on the basis of life table calculations are likely to be generally correct, at least in these three major fields of data. It is obvious, however, that if the assumption of 50% individuals underaged is invalid and the various age groups show markedly different proportions of individuals wrongly aged, that the curve obtained will not be quite so similar to the original. The testing of this in full will unfortunately have to await the results of the analysis of a known population with consistent under- or over-ageing of adult individuals.

The estimation of population size at each of the sites is based on a standard formula (Boddington, 1982), and has been corrected to include those individuals who were present in the skeletal remains but who could not be aged with enough accuracy to be included in the life table. In every case the population size given is likely to be greatly underestimated, partly due to the fact that it has been impossible to look at complete populations. At all three sites the excavation of the entire burial ground was not possible, although at The Hirsel it is likely that the vast majority

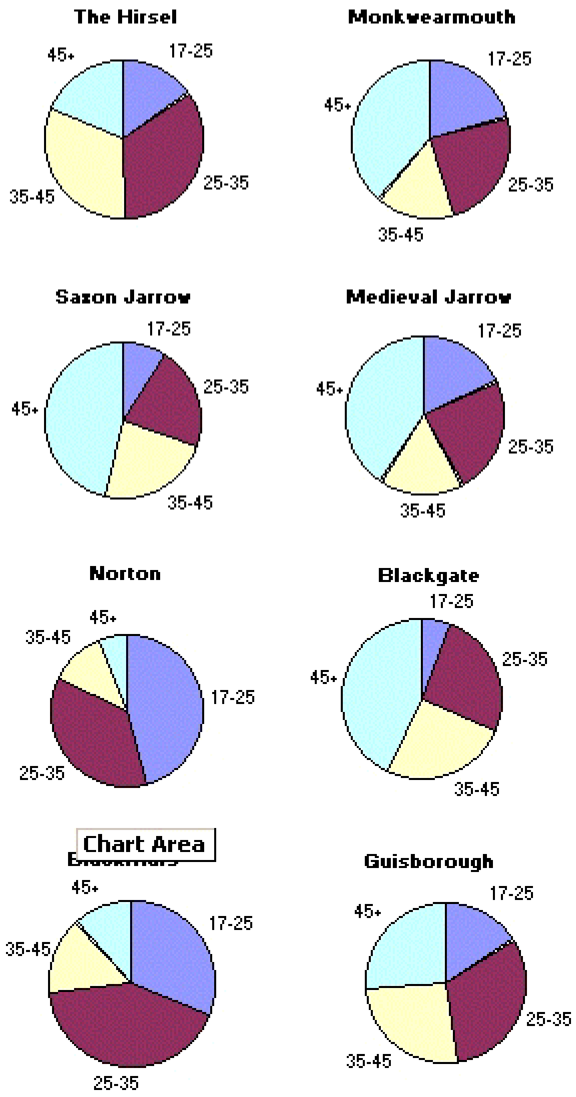


Figure 3.3. Pie charts of percentage age distribution of adults at each site.

Number of individuals: 307 (91.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
0	51	16.6	100.0	183.4	2141.0	0.17	0.083	21.4	8.6
2	44	14.3	83.4	304.9	1957.7	0.17	0.043	23.5	14.2
6	28	9.1	69.1	258.0	1652.8	0.13	0.033	23.9	12.0
10	14	4.6	59.9	230.6	1394.8	0.08	0.019	23.3	10.8
14	8	2.6	55.4	162.2	1164.2	0.05	0.016	21.0	7.6
17	25	8.1	52.8	389.6	1002.0	0.15	0.019	19.0	18.2
25	55	17.9	44.6	356.7	612.4	0.40	0.040	13.7	16.7
35	52	16.9	26.7	182.4	255.7	0.63	0.063	9.6	8.5
45	30	9.8	9.8	73.3	73.3	1.00	0.067	7.5	3.4

Estimated maximum age: 60 years

Crude Mortality Rate: 46.71

Estimated length of cemetery use: 200 years

Estimated population size: 33
(Corrected for total excavated remains: 36)

Weighted adult ages
Number of individuals: 307 (91.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
0	51	16.6	100.0	183.4	2385.5	0.17	0.083	23.9	7.7
2	44	14.3	83.4	304.9	22.2.1	0.17	0.043	26.4	12.8
6	28	9.1	69.1	258.0	1897.2	0.13	0.033	27.5	10.8
10	14	4.6	59.9	230.6	1639.3	0.08	0.019	27.4	9.7
14	8	2.6	55.4	162.2	1408.6	0.05	0.016	25.4	6.8
17	25	4.2	52.8	405.2	1246.4	0.08	0.010	23.6	17.0
25	40	13.0	48.5	420.2	841.2	0.27	0.027	17.3	17.6
35	53	17.3	35.5	268.7	421.0	0.49	0.049	11.9	11.3
45	41	13.4	18.2	115.6	152.3	0.73	0.073	8.3	4.8
55	15	4.9	4.9	36.6	36.6	1.00	0.067	7.5	1.5

Estimated maximum age: 70 years

Crude Mortality Rate: 41.92

Estimated length of cemetery use: 200 years

Estimated population size: 37
(Corrected for total excavated remains: 40)

Figure 3.4. Life Tables: The Hirsel.

Number of individuals: 190 (58.1% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ꝗ(x)	e(x)	C(X)
0	52	27.4	100.0	172.6	1927.6	0.27	0.137	19.3	9.0
2	20	10.5	72.6	269.5	1755.0	0.14	0.036	24.2	14.0
6	19	10.0	62.1	228.4	1485.5	0.16	0.040	23.9	11.8
10	12	6.3	52.1	195.8	1257.1	0.12	0.030	24.1	10.2
14	5	2.6	45.8	133.4	1061.3	0.06	0.019	23.2	6.9
17	17	8.9	43.2	309.5	927.9	0.21	0.026	21.5	16.1
25	20	10.5	34.2	289.5	618.4	0.31	0.031	18.1	15.0
35	13	6.8	23.7	202.6	328.9	0.29	0.029	13.9	10.5
45	32	16.8	16.8	126.3	126.3	1.00	0.067	7.5	6.6

Estimated maximum age: 60 years

Crude Mortality Rate: 51.88

Estimated length of cemetery use: 300 years

Estimated population size: 12
(Corrected for total excavated remains: 21)

Weighted adult ages
Number of individuals: 190 (58.1% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ꝗ(x)	e(x)	C(X)
0	52	27.4	100.0	172.6	2112.9	0.27	0.137	21.1	8.2
2	20	10.5	72.6	269.5	1940.3	0.14	0.036	26.7	12.8
6	19	10.0	62.1	228.4	1670.8	0.16	0.040	26.9	10.8
10	12	6.3	52.1	195.8	1442.4	0.12	0.030	27.7	9.3
14	5	2.6	45.8	133.4	1246.6	0.06	0.019	27.2	6.3
17	9	4.7	43.2	326.3	1113.2	0.11	0.014	25.8	15.4
25	18	9.5	38.4	336.8	786.8	0.25	0.025	20.5	15.9
35	17	8.9	28.9	244.7	450.0	0.31	0.031	15.5	11.6
45	22	11.6	20.0	142.1	205.3	0.58	0.058	10.3	6.7
55	16	8.4	8.4	63.2	63.2	0.67	0.067	7.5	3.0

Estimated maximum age: 70 years

Crude Mortality Rate: 47.33

Estimated length of cemetery use: 300 years

Estimated population size: 13
(Corrected for total excavated remains: 23)

Figure 3.5. Life Tables: Monkwearmouth.

Number of individuals: 100 (40.2% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ꝗ(x)	e(x)	C(X)
0	18	18.0	100.0	182.0	2123.5	0.18	0.090	21.2	8.6
2	18	18.0	82.0	292.0	1941.5	0.22	0.055	23.7	13.8
6	10	10.0	64.0	236.0	1649.5	0.16	0.039	25.8	11.1
10	6	6.0	54.0	204.0	1413.5	0.11	0.028	26.2	9.6
14	5	5.0	48.0	136.5	1209.5	0.10	0.035	25.5	6.4
17	4	4.0	43.0	328.0	1073.0	0.09	0.012	25.0	15.4
25	9	9.0	39.0	345.0	745.0	0.23	0.023	19.1	16.2
35	10	10.0	30.0	250.0	400.0	0.33	0.033	13.3	11.8
45	20	20.0	20.0	150.0	150.0	1.00	0.067	7.5	7.1

Estimated maximum age: 60 years

Crude Mortality Rate: 47.09

Estimated length of cemetery use: 300 years

Estimated population size: 7
(Corrected for total excavated remains: 18)

Weighted adult ages
Number of individuals: 100 (40.2% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ꝗ(x)	e(x)	C(X)
0	18	18.0	100.0	182.0	2306.5	0.18	0.090	23.1	7.9
2	18	18.0	82.0	292.0	2124.5	0.22	0.055	25.9	12.7
6	10	10.0	64.0	236.0	1832.5	0.16	0.039	28.6	10.2
10	6	6.0	54.0	204.0	1596.5	0.11	0.028	29.6	8.8
14	5	5.0	48.0	136.5	1392.5	0.10	0.035	29.0	5.9
17	2	2.0	43.0	336.0	1256.0	0.05	0.006	29.2	14.6
25	7	7.0	41.0	375.0	920.0	0.17	0.017	22.4	16.3
35	9	9.0	34.0	295.0	545.0	0.26	0.026	16.0	12.8
45	15	15.0	25.0	175.0	250.0	0.60	0.060	10.0	7.6
55	10	10.0	10.0	75.0	75.0	1.00	0.067	7.5	3.3

Estimated maximum age: 70 years

Crude Mortality Rate: 43.36

Estimated length of cemetery use: 300 years

Estimated population size: 8
(Corrected for total excavated remains: 19)

Figure 3.6. Life Tables: Saxon Jarrow.

Number of individuals: 148 (57.1% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ꝗ(x)	e(x)	C(X)
0	10	6.8	100.0	193.2	2357.8	0.07	0.034	23.6	8.2
2	23	15.5	93.2	341.9	2164.5	0.17	0.042	23.2	14.5
6	19	12.8	77.7	285.1	1822.6	0.17	0.041	23.5	12.1
10	16	10.8	64.9	237.8	1537.5	0.17	0.042	23.7	10.1
14	4	2.7	54.1	158.1	1299.7	0.05	0.017	24.0	6.7
17	14	9.5	51.4	373.0	1141.6	0.18	0.023	22.2	15.8
25	18	12.2	41.9	358.1	768.6	0.29	0.029	18.3	15.2
35	13	8.8	29.7	253.4	410.5	0.30	0.030	13.8	10.7
45	31	20.9	20.9	157.1	157.1	1.00	0.067	7.5	6.7

Estimated maximum age: 60 years

Crude Mortality Rate: 42.41

Estimated length of cemetery use: 500 years

Estimated population size: 7
(Corrected for total excavated remains: 12)

Weighted adult ages
Number of individuals: 148 (57.1% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ꝗ(x)	e(x)	C(X)
0	10	6.8	100.0	193.2	2584.5	0.07	0.034	25.8	7.5
2	23	15.5	93.2	341.9	2391.2	0.17	0.042	25.6	13.2
6	19	12.8	77.7	285.1	2049.3	0.17	0.041	26.4	11.0
10	16	10.8	64.9	237.8	1764.2	0.17	0.042	27.2	9.2
14	4	2.7	54.1	158.1	1526.4	0.05	0.017	28.2	6.1
17	7	4.7	51.4	391.9	1368.2	0.09	0.012	26.6	15.2
25	16	10.8	46.6	412.2	976.4	0.23	0.023	20.9	15.9
35	16	10.8	35.8	304.1	564.2	0.30	0.030	15.8	11.8
45	21	14.2	25.0	179.1	260.1	0.57	0.057	10.4	6.9
55	16	10.8	10.8	81.1	81.1	1.00	0.067	7.5	3.1

Estimated maximum age: 70 years

Crude Mortality Rate: 38.69

Estimated length of cemetery use: 500 years

Estimated population size: 8
(Corrected for total excavated remains: 13)

Figure 3.7. Life Tables: Medieval Jarrow.

Number of individuals: 248 (48.8% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
0	28	11.3	100.0	188.7	2263.3	0.11	0.056	22.6	8.3
2	41	16.5	88.7	321.8	2074.6	0.19	0.047	23.4	14.2
6	29	11.7	72.2	265.3	1752.8	0.16	0.041	24.3	11.7
10	22	8.9	60.5	224.2	1487.5	0.15	0.037	24.6	9.9
14	9	3.6	51.6	149.4	1263.3	0.07	0.023	24.5	6.6
17	18	7.3	48.0	354.8	1113.9	0.15	0.019	23.2	15.7
25	27	10.9	40.7	352.8	759.1	0.27	0.027	18.6	15.6
35	23	9.3	29.8	252.0	406.3	0.31	0.031	13.6	11.1
45	51	20.6	20.6	154.2	154.2	1.00	0.067	7.5	6.8

Estimated maximum age: 60 years

Crude Mortality Rate: 44.18

Estimated length of cemetery use: 700 years

Estimated population size: 8
(Corrected for total excavated remains: 16)

Weighted adult ages
Number of individuals: 248 (48.8% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
0	28	11.3	100.0	188.7	2472.4	0.11	0.056	24.7	7.6
2	41	16.5	88.7	321.8	2283.7	0.19	0.047	25.7	13.0
6	29	11.7	72.2	265.3	1961.9	0.16	0.041	27.2	10.7
10	22	8.9	60.5	224.2	1696.6	0.15	0.037	28.1	9.1
14	9	3.6	51.6	149.4	1472.4	0.07	0.023	28.5	6.0
17	9	3.6	48.0	369.4	1323.0	0.08	0.009	27.6	14.9
25	23	9.3	44.4	397.2	953.6	0.21	0.021	21.5	16.1
35	25	10.1	35.1	300.4	556.5	0.29	0.029	15.9	12.2
45	36	14.5	25.0	177.4	256.0	0.58	0.058	10.2	7.2
55	26	10.5	10.5	78.6	78.6	1.00	0.067	7.5	3.2

Estimated maximum age: 70 years

Crude Mortality Rate: 40.45

Estimated length of cemetery use: 700 years

Estimated population size: 9
(Corrected for total excavated remains: 18)

Figure 3.8. Life Tables: Saxon and Medieval Jarrow.

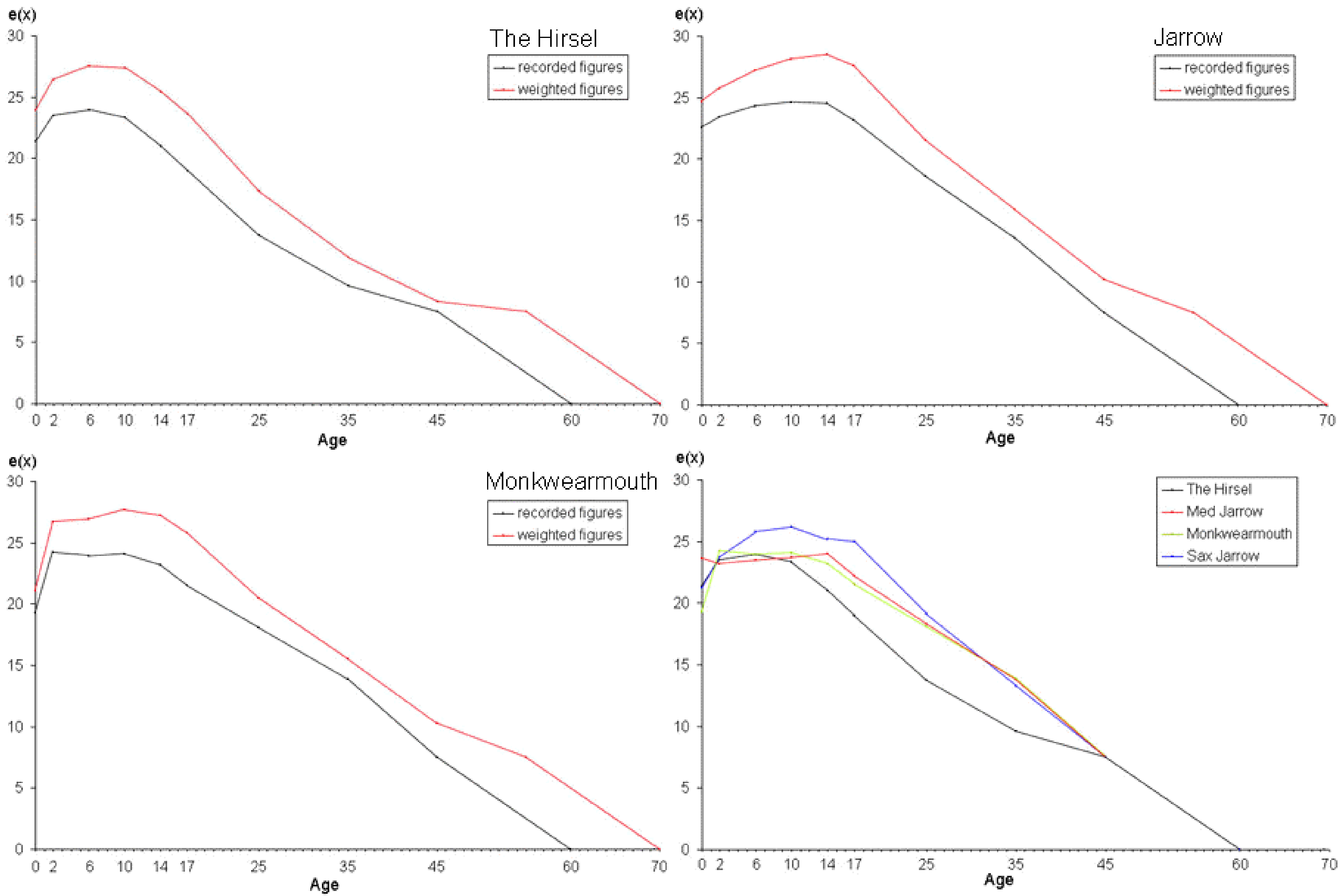


Figure 3.9. Graphs of life expectation.

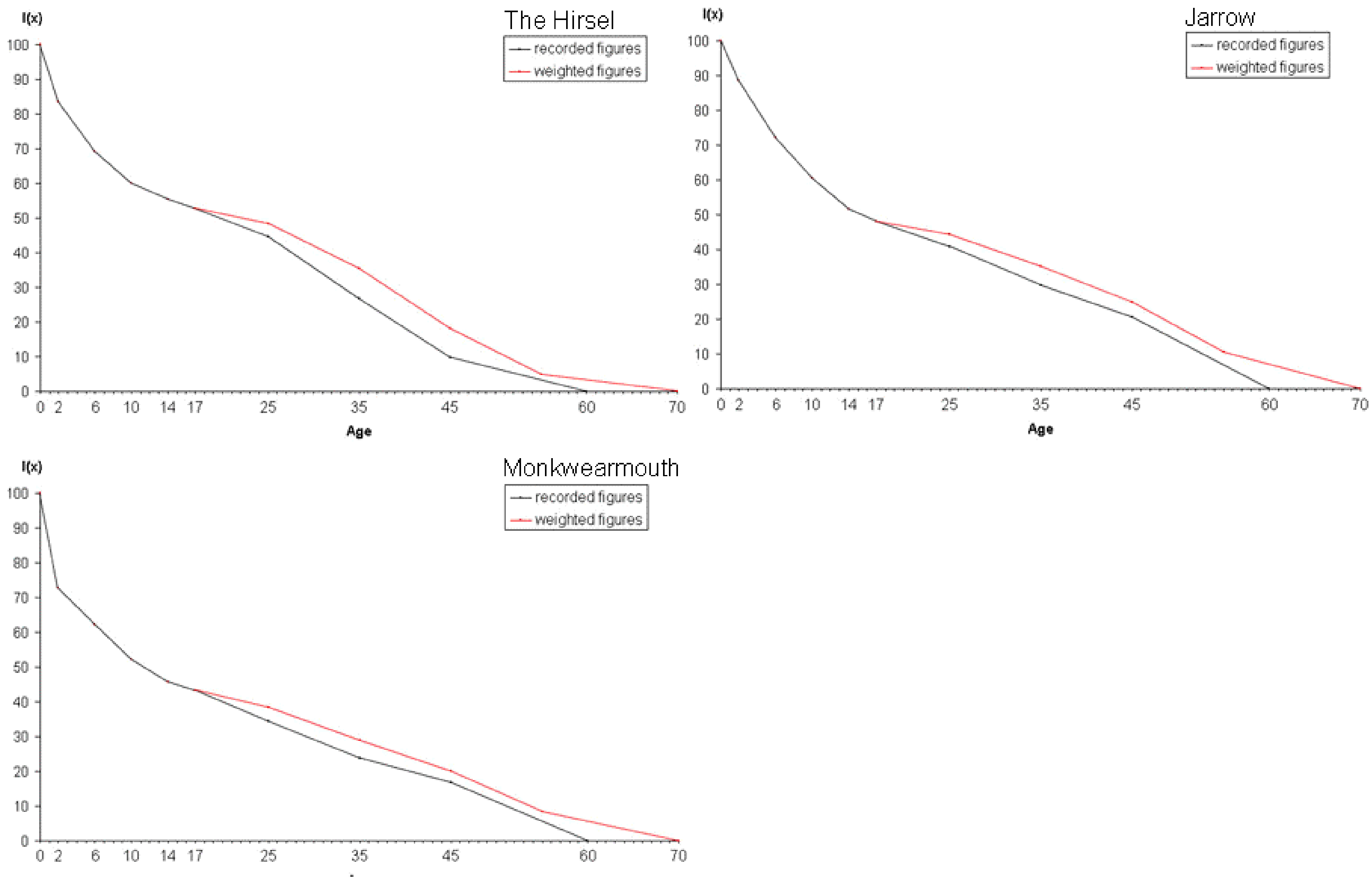


Figure 3.10. Survivorship curves.

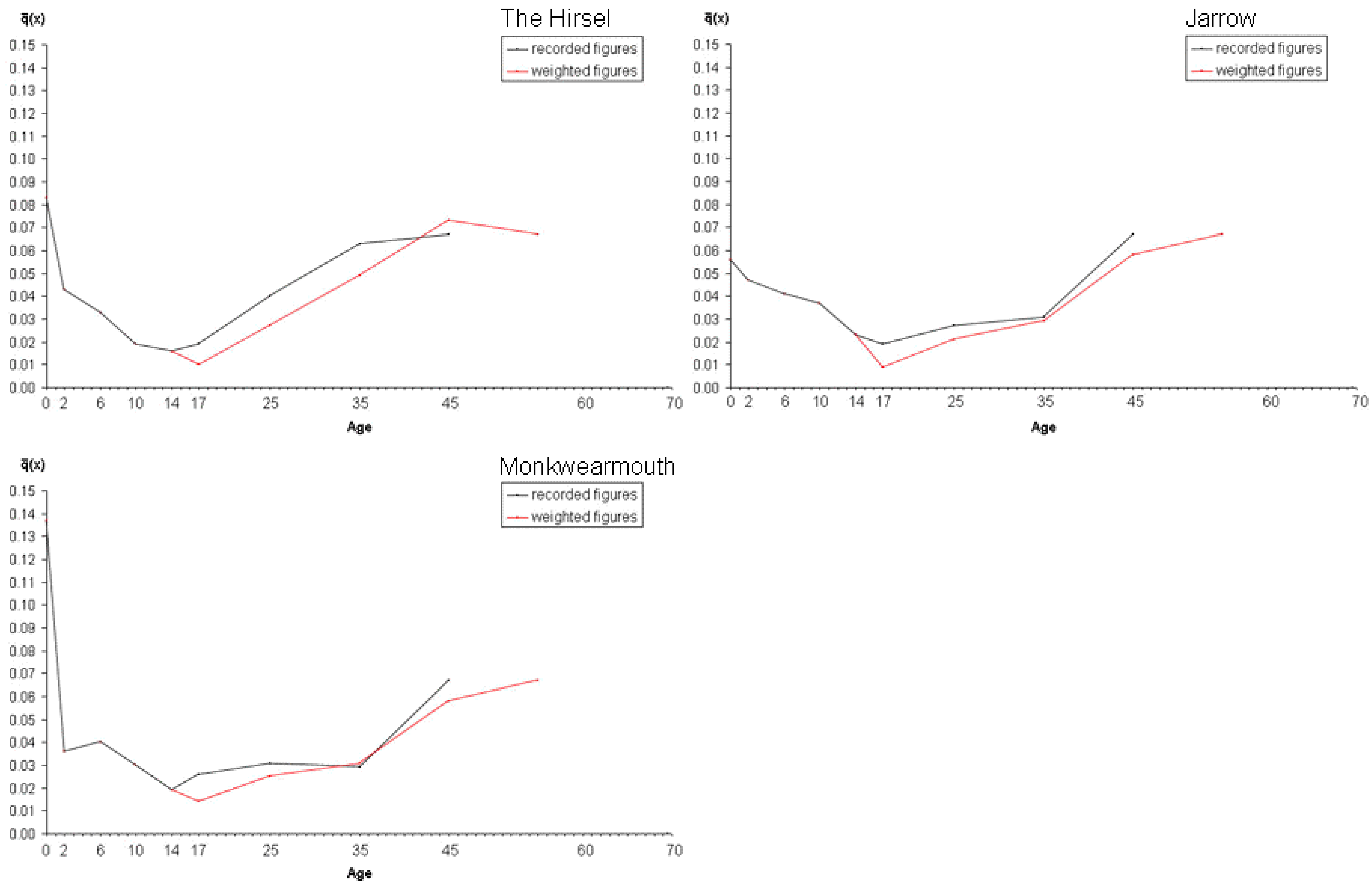


Figure 3.11. Graphs of crude probability of death.

of individuals originally buried were recovered. Other factors which may affect the population represented in the cemetery are not taken into account by the population estimation statistic, including burial at another site and loss of skeletal remains for various reasons (see Section 2.3). The figure given should therefore be seen as the absolute minimum number of individuals required to sustain the *cemetery* population at its estimated level.

The life tables and graphs of the three populations will now be considered in more detail. The figures for Jarrow are given for the two time periods separately and combined, but are graphed on the combined figures. This assumes an even spread of use of the cemetery throughout its functional life, which makes it more comparable with the other two sites. The life expectancy at birth is higher at Medieval Jarrow than in the other groups, but at age 2 it is highest at Monkwearmouth. Life expectancy is in general fairly similar throughout the groups, however, with the exception of The Hirsel, where it starts to reduce in an earlier age group (17-25 as opposed to 25-35).

The survivorship curves are all broadly similar, although the percentage survival at Jarrow at age 45 is somewhat higher than at The Hirsel. The crude probability of death curves show the greatest divergence between the groups, with the greatest probability of death in infancy at both The Hirsel and Monkwearmouth, but at age 45 at Jarrow. The difference is due to the smaller percentage of infants in the medieval period at Jarrow, possible reasons for which were discussed above.

Fig. 3.12 presents the data for the distribution of age at death (D(X)) in the three populations. From these histograms it can be seen that of the adults more people survived past middle-age than the proportion dying young at both Jarrow and Monkwearmouth. At The Hirsel a larger proportion died in middle age. Assuming that the Hirsel individuals were not underaged due to different tooth wear patterns, or that the patterns are not at variance due to the different methods used by the present author at The Hirsel and by Wells at Jarrow and Monkwearmouth (both of which are possibilities), this suggests some form of environmental influence affecting individuals who reached the age of around 30. Wells suggests in the Jarrow report (forthcoming) that monastic life could help in providing high nutritional standards at Monkwearmouth and Jarrow. He says ‘Perhaps the example of an industrious and beneficent abbey served to inspire a high level of husbandry in the surrounding villages. Perhaps the proximity of the sea offered unusual (and most essential) protein ration with fish, molluscs and various kelps’.

Fig. 3.13 shows the percentages of each age group at the three main sites in bar chart form for ease of comparison. The general distribution obtained is similar to the histograms. The picture for each group is fairly similar, with most deaths occurring at 0-2 years and 45+, although at Medieval Jarrow the pattern is changed to 2-6 and 45+, and at the Hirsel it is 0-2 and 25-35 years.

Although in some populations a bias is found with respect to the lack of infant and child burials, when a life table is constructed there may be some bias in the opposite direction due to the greater ease of assigning an age at death to juvenile skeletons, even those in comparatively poor condition. Boddington (1982) found that the greater the proportion of unaged adult burials, the greater the effect on the calculated expectancy of life at birth (e(0)). Figure 3.14 shows the proportions of aged and unaged adult burials at The Hirsel, Monkwearmouth and Jarrow. Table 3.8 shows the numbers and percentages of unaged adult and child burials for comparison. It can be seen from this that The Hirsel is likely to be the population least affected by biasing. The large proportion of unaged Monkwearmouth adults is due to the poor preservation of skeletal material at that site, and a similar problem is apparent at Saxon Jarrow. Boddington suggests that such biasing can underestimate e(0) by as much as 5 years, and this is in addition to any effect that inaccuracy of adult ageing may have had. However, the estimation of maximum age in the population can also have an effect on e(0) and it is possible that the increase in e(0) seen in the weighted figures is due to the increase of maximum age from 60 to 70 years.

	Adults			Children		
Site	No.	Unaged	%	No.	Unaged	%
HIR	181	19	10.5	153	8	5.2
MK	211	129	61.1	116	8	6.9
JA Sax	97	54	55.7	73	16	21.9
JA Med	115	39	33.9	74	2	2.7
JA Both	212	93	43.9	147	18	12.2

Table 3.8

In conclusion, it can be said that the closest of the three populations, as far as age is concerned, were Monkwearmouth and Saxon Jarrow, as might be expected (especially as they were both aged by Wells). However, none of the populations were greatly different from other contemporary sites in different parts of the country. The adult figures from North Elmham, Norfolk (Wells, 1980b), for example, are very similar. Early populations had a much larger proportion of juvenile deaths than at present. This is not surprising when the poor standard of living (compared with our own) and the lack of modern medical knowledge are taken into account.

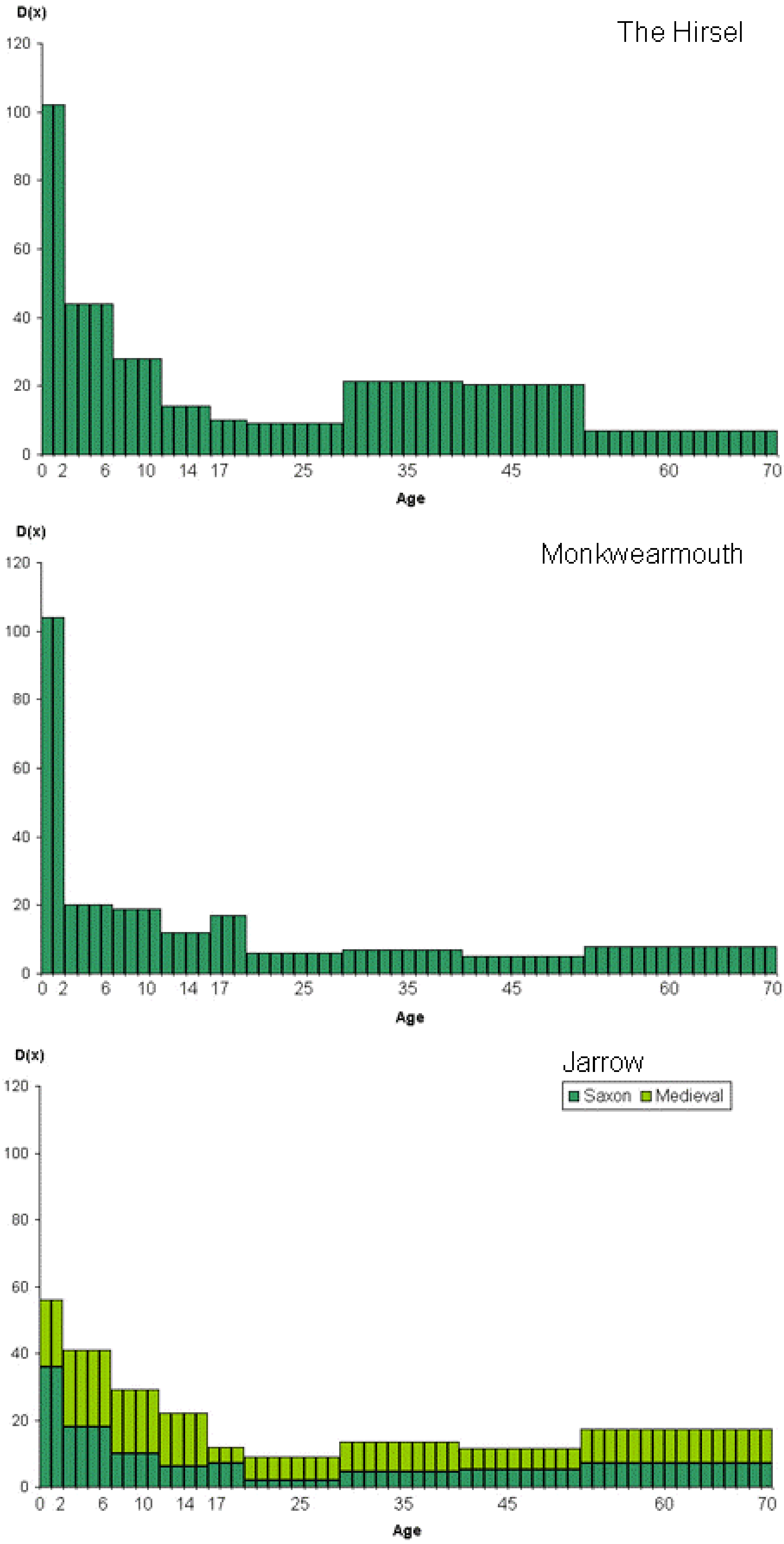


Figure 3.12. Histograms of distribution of age at death.

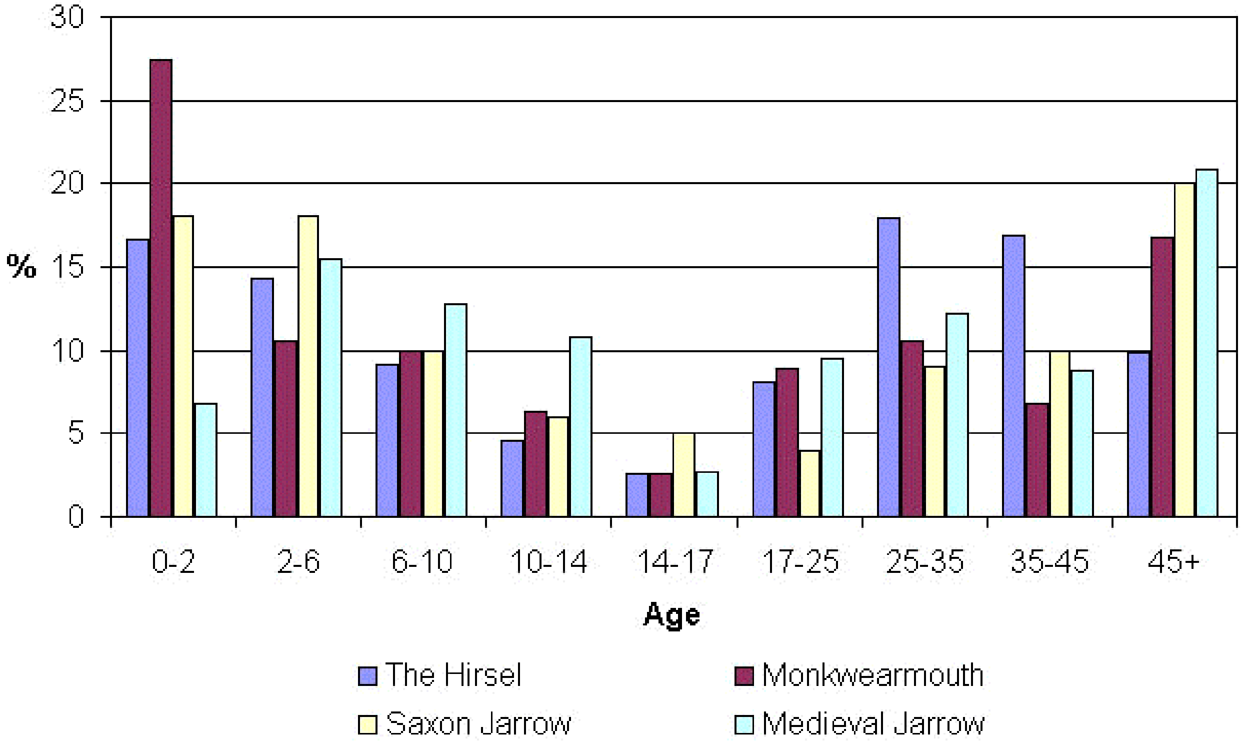


Figure 3.13. Percentages of age groups at main sites.

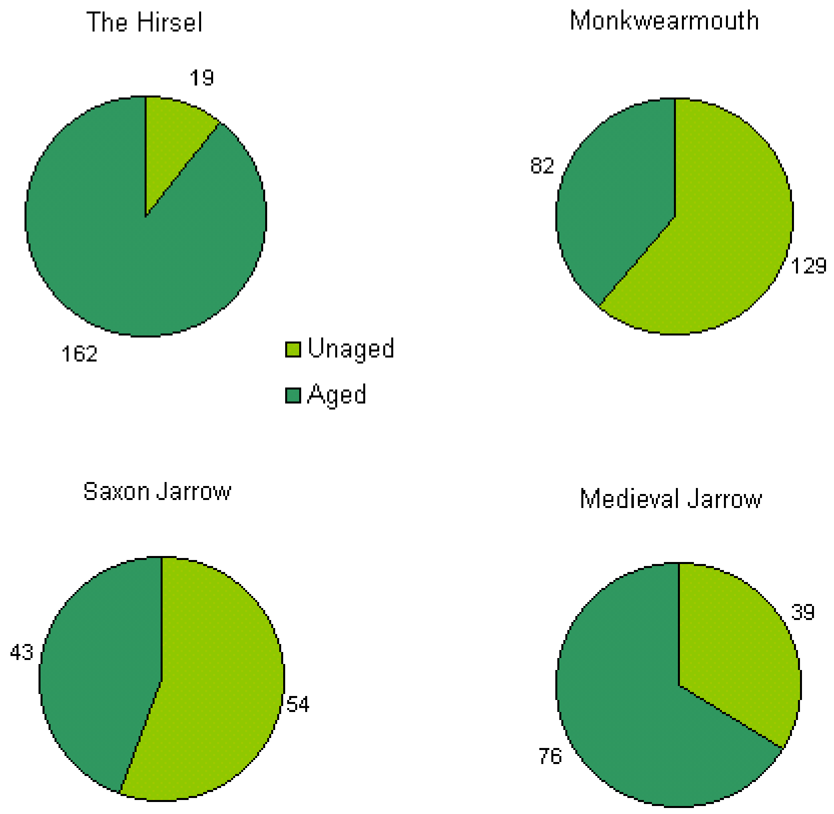


Figure 3.14. Proportions of aged and unaged adults.

3.2. Determination of Sex

3.2.1. Methods and Problems

Although sexual dimorphism is usually quite well marked in the human skeleton, it is often difficult to decide whether an individual was male or female. The problem of masculine women and effeminate men is one which occurs in all populations, and problems of sexing are not simply confined to poorly preserved remains. However, given a large population of adult skeletons it is usually possible to provide a sex distribution with far greater confidence than is the case with age determination.

Unfortunately, it is almost impossible to sex the skeleton of a child with present methods, since the sexual characteristics found in adult bones are not developed in the child until about 14-18 years of age, following puberty. For this reason, none of the children from the sites studied in this paper have been sexed.The most reliable indication of sex in the adult human skeleton is the size and form of the pelvis. In the female, the pelvis is generally wide and bowl-shaped, due to one of its major function in life, to hold the foetus in pregnancy. It has wide sciatic notches and a sub-pubic angle which appears greater than 90º (although when the notch is traced and the angle measured, the female sciatic notch is found to be around 65º and that of the male around 40-50º on average). The pelvis of the male is more robust and larger than that of the female, but it is comparatively narrower and taller, with narrow sciatic notches and an acute sub-pubic angle.

Several workers have attempted to produce less subjective sexing techniques based on the morphology of the pelvis. Phenice (1969) suggested a visual sexing technique for the Os pubis, based on three features, the ventral arch, subpubic concavity and the medial aspect of the ischio-pubic ramus. He claimed an accuracy of greater than 95% using this method. Kelley (1978) tested the method on an unknown population and concluded that it provided a good sexual discriminator. Lovell (1989) found an accuracy of c.83% on a dissecting room population, and concluded that this lower figure was due to the larger number of older individuals in her population than in the original study, since accuracy appears to decrease on older specimens. The method is widely used, but in most archaeological populations the same problem will be found as that applying to age determination from the pubic symphysis, namely that the bone is often lost or damaged by post-mortem erosion.

If the pelvis is not present, or is fragmentary, as often happens in archaeological material, the next most useful group of bones to study are those making up the skull (Workshop of European Anthropologists, 1980). The major differences between male and female crania, apart from the overall size, are the size of the supra-orbital ridges, the mastoid process and the nuchal crests, and the sharpness of the orbits. In the male, the first three are generally larger, and the last is more blunt than those of the female.

In the absence of either the skull or the pelvis, the size of the long bones can be used as a guide, especially if the diameter of the femoral head or humeral head can be measured. For both of these measurements the mid-point is around 45mm. Below this is usually female, and above is probably male. However, this mid-point is only an average and can vary with different populations. There is also the problem of those skeletons with a femoral/humeral head diameter of exactly 45mm. If no other criteria are available for study, it is almost impossible to sex such an individual.

If all else fails, the robusticity of the bones can be used to sex the individual, but there can be problems with this method as well. In ancient populations there may not be such a distinct difference between the sexes as is seen in modern peoples. The women may have used their muscles almost as much as the men, and the size of their bones may be larger than expected due to this. The Australian Aborigines, for example, show very little difference between the sexes.

Black (1978b) proposed a method of sexing based on the midshaft circumference of the femur, for which he claimed an accuracy of 85%. This method is difficult to use, however, since the irregular contours of the linea aspera make it almost impossible to take accurate measurements. MacLaughlin and Bruce (1985) attempted to rectify this problem, and also that of not being able to use the method with incomplete femora due to the ensuing problem of inability to determine the exact midpoint of the shaft. They suggest instead that the maximum antero-posterior diameter of the femoral shaft should be used. This yielded a high consistency of about 90% with sex determinations based on pelvic and cranial morphology in a Scottish prehistoric population.

Sexual dimorphism has also been noted in the formation patterns and overall size of the teeth. Black (1978a) suggests a method of sexing children based on tooth crown diameters of the deciduous teeth, but found discriminant functions less effective in sexing children than in adults. Although sexing of juveniles by tooth size has been seen as a possibly useful technique (Hillson, 1986:241), it probably should not be used alone, since even in adult remains there is greater certainty of allocating the correct sex to an individual if more than one sexing technique is applied. Brace and Ryan (1980) found that 'human dental sexual dimorphism was greater during the Upper Paleolithic than at any subsequent time and that it is at its least in some modern human populations'. The Workshop of European

Anthropologists (1980) state in their recommendations that 'In recent populations...there is a broad overlapping of male and female measurements. Therefore, sex diagnosis really cannot be based on the teeth.'

The most reliable method of sexing the skeleton is to use a combination of all these skeletal features. Using the whole skeleton can produce an accuracy of 95-100% according to some sources (Krogman, 1978; Shipman et al. 1985), with the pelvis yielding 90-95% accuracy, and the skull slightly less (87-92%). These are all based on morphological studies.

Statistical methods of sexual differentiation, in particular based on discriminant function analysis, have also been proposed, but in general these have been found to be less accurate and more time consuming than visual techniques. Seidler (1980) and Day and Pitcher-Wilmott (1975) have produced schemes for the sexual diagnosis of innominate bones, but these are based on measurements of the whole bone, which is often not available in many archaeological populations. Giles (1970) and the Workshop of European Anthropologists (1980) have recommended discriminant function techniques based on various bones of the skeleton. These involve a number of osteometric points which are often very eroded or lost in the majority of individuals from archaeological sites. Pons (1955) even suggested a discriminant function based on the sternum, a bone which is singularly conspicuous by its absence in many populations. At Guisborough Priory, the most well-preserved series in this study, for example, only 5 males and 2 females had fragments of sternum surviving.

A recent study by Meindl, Lovejoy, Mensforth and Carlos (1985) based on 100 known skeletons from the Hamann-Todd Collection in America has suggested that females are less likely to be wrongly sexed than males, thus contradicting the assertion of Weiss (1972) that there is a systematic bias in skeletal sexing towards males. The authors recommend that the best determination of sex can be made from the complete pelvis. They studied the use of discriminant function sexing methods and compared them with simple morphological techniques, and concluded that '[their] own numerous attempts to resolve metrically the sex of those very few cases in which the pelvic morphology is indeterminant have never proved more successful than ordinary observational methods' (1985:84). They also suggest that archaeological populations tend to be more sexually dimorphic and genetically homogeneous than the mixed samples used in most forensic studies.

Some useful metrical sexing criteria have been developed for use on various parts of the pelvis. Kelley (1979c) developed the sciatic notch/acetabular index, but MacLaughlin and Bruce (1986) have shown this to be a poor discriminator of sex in two European populations. The ischio-pubic index and the sacral index are lower in males than in females, but in poorly preserved series they are virtually useless, since these parts of the pelvis are most susceptible to post-mortem erosion. The ischio-pubic index is also very difficult to use because there are often problems in defining the appropriate osteometric points. They have been used very little in this study for these reasons. It is also felt that metrical analysis simply applies figures to visual impressions, thus making observations seem more impressive than they are.

3.2.2. Methods applied to the Study Populations

The techniques used in determining the sex of the adult individuals in the study populations basically fall into the category of morphological methods, although some metrical characteristics were also recorded. The following morphological traits were considered:

Cranial features: general size and robusticity,
size of supra-orbital ridges,
size of mastoid process,
relief of nuchal crests,
shape of occipital protuberance,
sharpness of orbital border,
size and appearance of mandible.
Pelvic features: size and shape of obturator foramen,
angle and shape of sciatic notch,
presence of pre-auricular sulcus,
sub-pubic angle,
form of iliac crest,
reconstructed appearance of pelvis.
Long Bone features: general appearance and robusticity.

Metrical analysis involved the sacral and ischio-pubic indices on the few occasions when it was possible to take these, and the sizes of the femoral and humeral heads were also noted.

Table 3.9 shows the number of individuals sexed according to each technique at the three main sites and Blackgate. The Jarrow and Monkwearmouth figures do not include Wells' data. (N.B. Inclusion of an individual within a certain methodological category does not imply that it was possible to look at every morphological criterion within that category. For example, only the mandible and occipital of the skull may be present, but an individual could still theoretically be counted in one of the skull categories.)

	HIR		MK		JA		BG	
Method	M	F	M	F	M	F	M	F
Cranium (1)	5	8	2	1	2	0	3	3
Pelvis (2)	0	0	1	0	0	0	0	0
L.Bones (3)	4	0	3	2	4	7	15	5
(1) & (2)	0	0	2	0	0	0	0	0
(1)(2) & (3)	43	61	3	3	4	8	17	12
(1) & (3)	12	10	3	0	3	1	9	6
(2) & (3)	14	7	5	1	3	4	14	14

Table 3.9

Most Hirsel skeletons were sexed using all three methods, implying that the determinations are fairly reliable, although individual sexing was in fact often problematical. Many individuals considered to be female from their pelves had extremely masculine skulls, for example.

The Blackgate figures show that 75% of those sexed by long bones alone were male or possibly male. This may suggest some biasing in the technique, especially if the whole population was fairly robust, or it may be that there were more males on the site and that these stood a better chance of becoming disarticulated. The females sexed on all criteria or pelvis and long bones did not appear to be particularly robust.

There were not really enough individuals from Jarrow and Monkwearmouth to make any conclusions, but most Jarrow adults were sexed using all techniques, or long bones only. “All” obviously gives better results, although at least one skeleton from Jarrow could not be sexed based on all criteria. Basically the table gives an idea of preservation of the material at each site. More individuals sexed on all criteria suggests better preservation of skeletons.

Table 3.10 shows the distribution of individuals by number of sexing methods.

Number of	HIR		MK		JA		BG	
Methods	M	F	M	F	M	F	M	F
1	9	8	6	3	6	7	17	8
2	26	17	10	1	7	5	23	20
3	43	61	3	3	4	8	17	12

Table 3.10

Figures 3.15 to 3.17 show the metrical analyses of the adult femora from The Hirsel which are thought to be related to sex. The most sexually dimorphic characteristic, in this population at least, would appear to be the femoral head diameter, with a cut-off point of around 45mm, as suggested above. The robusticity index suggests a modal value of around 13 for the males and 12 for the females, but the overlap is too great for this to be used as a sexual indicator on its own. MacLaughlin and Bruce (1985) found a sectioning point of approximately 27mm for sexing on the maximum femoral antero-posterior diameter. The modal value of the females at The Hirsel is 27mm, which would tend to suggest that the sectioning point would have to be higher in this population, possibly between 28 and 29mm. Since MacLaughlin and Bruce only had 8 female individuals, it is possible that the results from The Hirsel represent a more normal population. This last method would appear to be less sexually dimorphic than femoral head diameter, but more so than femoral robusticity, at least at The Hirsel.

Figure 3.18 shows the distribution of sciatic notch angles measured for the Hirsel population. The method of measurement followed Dawes and Magilton (1980), and involved the tracing of the sciatic notch onto paper in order to measure the angle. This method is very subjective, and it is possible that the general appearance of the sciatic notch gives a better overall impression of the sex. The bar charts appear fairly dimorphic, however, and suggest a sectioning point of around 45º.

3.2.3. Sex and Palaeodemography in the Study Populations

Table 3.11 and Figure 3.19 show the distributions of sexes in the study populations, and the ratios of men to women.

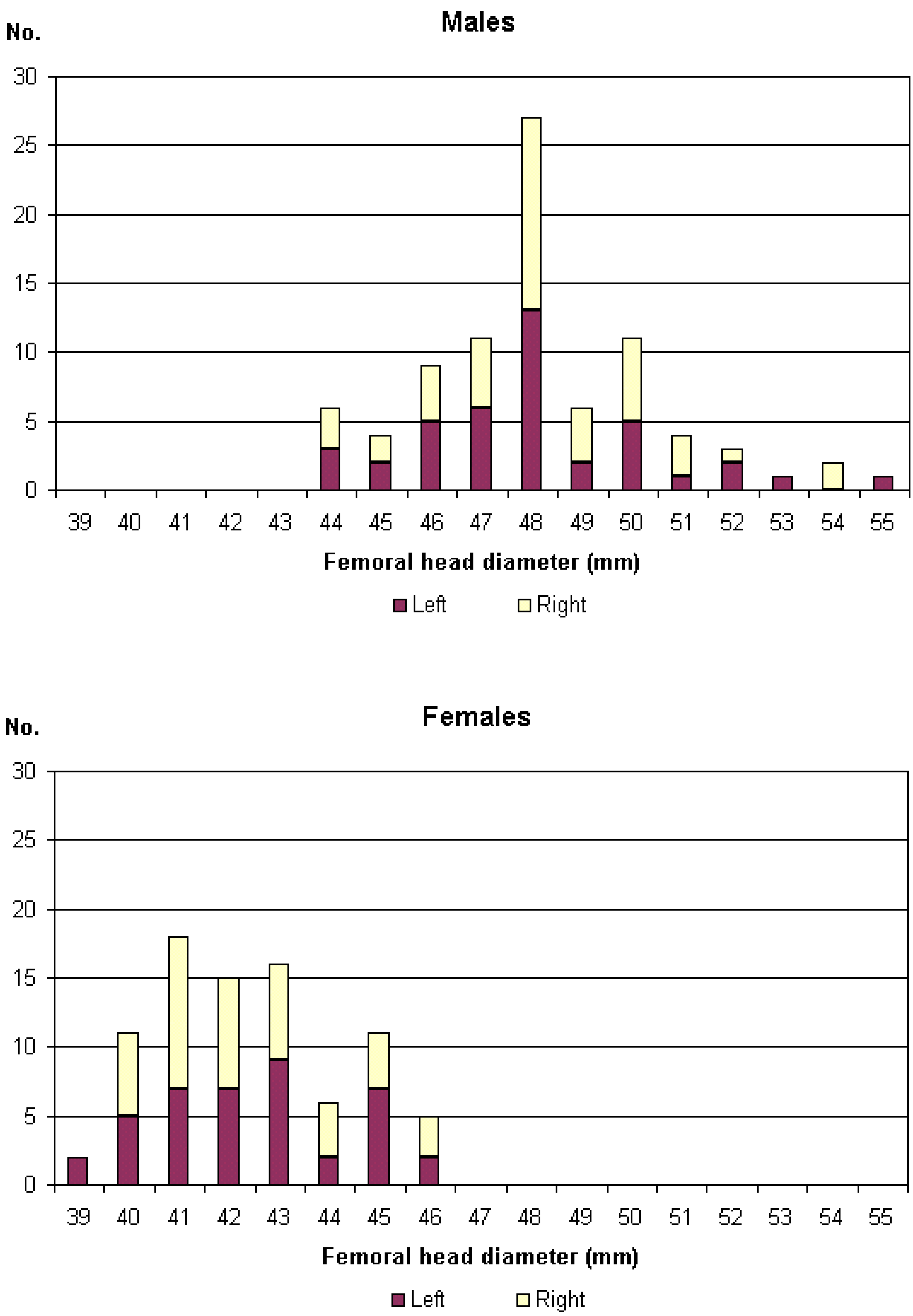


Figure 3.15. Femoral head diameters at The Hirsel.

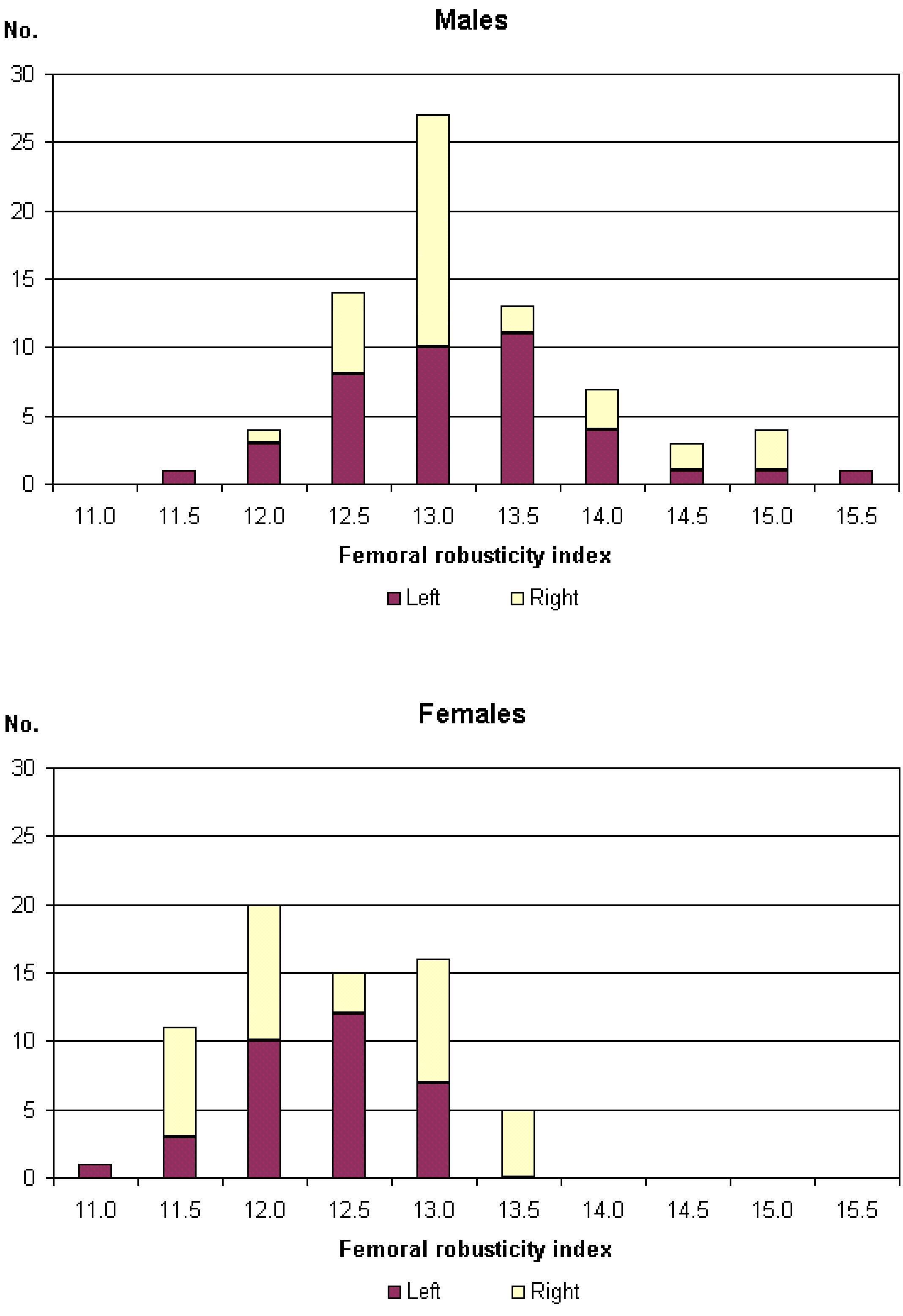


Figure 3.16. Femoral robusticity at The Hirsel.

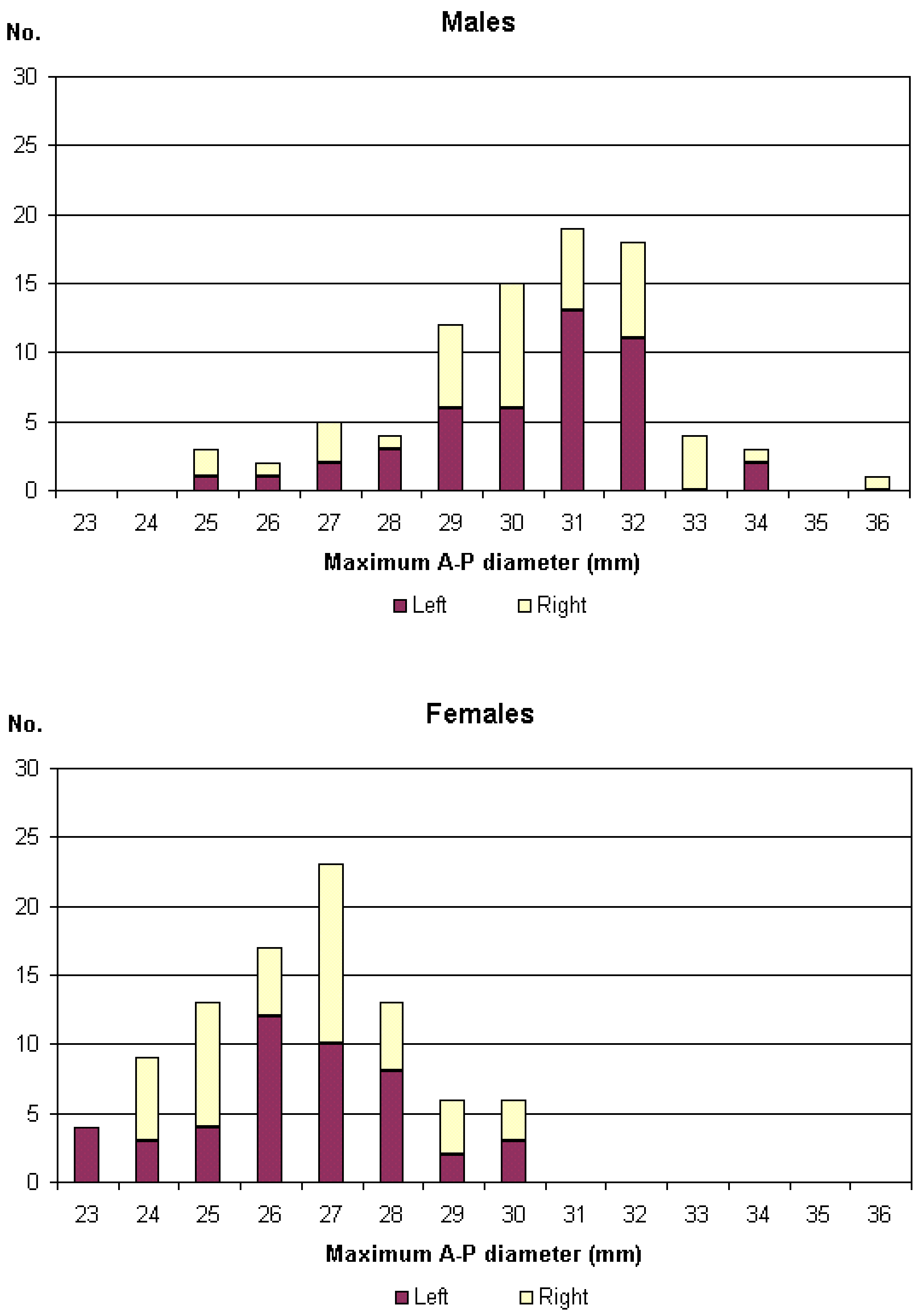
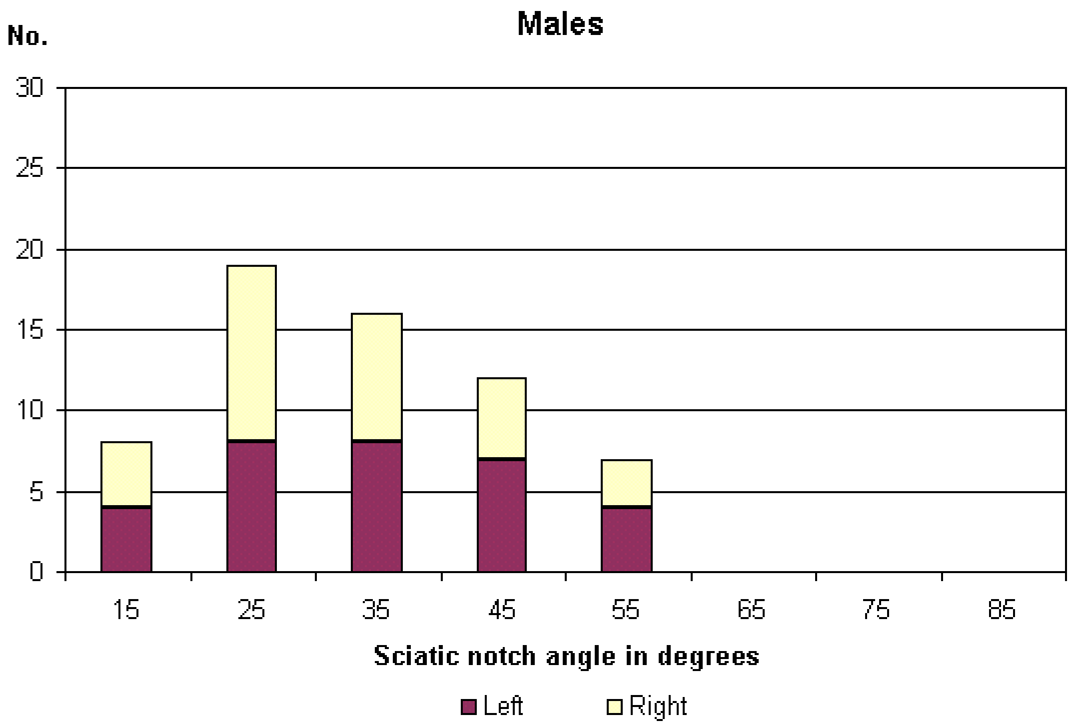


Figure 3.17. Femoral A-P diameter at The Hirsel.



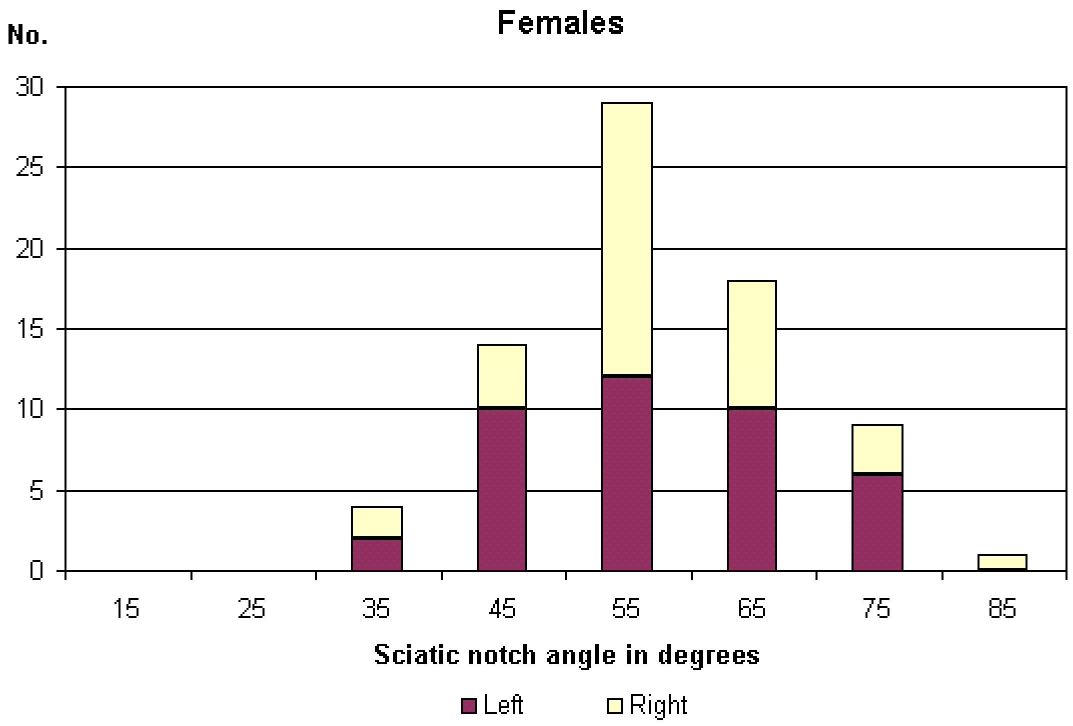


Figure 3.18. Sciatic notch angles at The Hirsel.

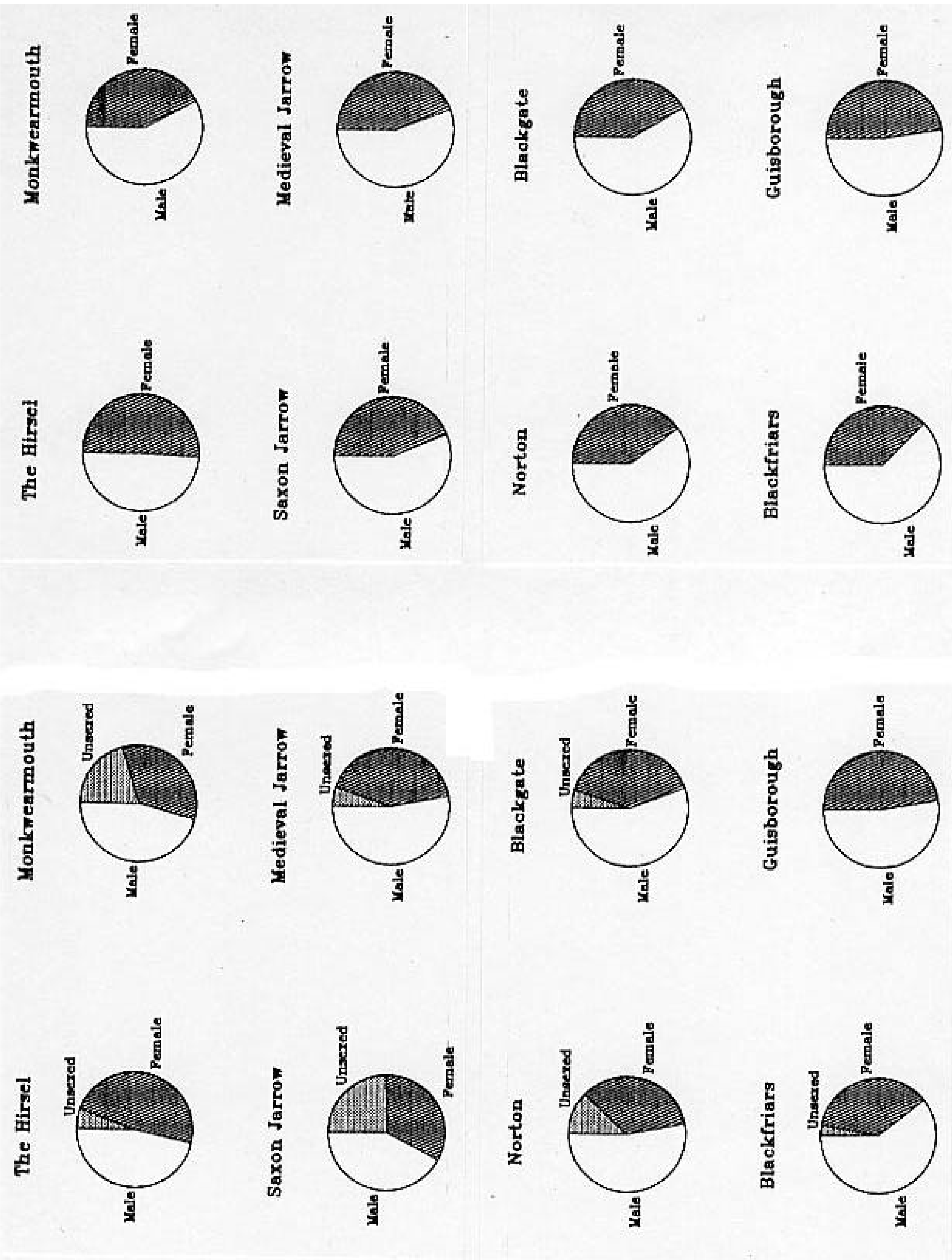


Figure 3.19. Proportions of sexed and unsexed adults.

Site	Male	Female	Unsexed	Ratio
HIR	84	87	10	49:51
MK	97	71	43	58:42
JA Sax	41	32	24	56:44
JA Med	61	48	6	56:44
GP	21	19	0	53:47
BG	58	41	5	59:41
BF	20	12	1	63:37
NEM	44	29	10	60:40

Table 3.11

In a demographically normal population it is usually expected that the ratio of men to women will be roughly 50:50. At all of these sites except The Hirsel the male:female ratio was biased in favour of males. This is probably due to the fact that most of the sites were monastic cemeteries, serving both the spiritual and the temporal communities, although at Norton and Blackgate this was unlikely to have been the case. It is possible, however, that some older females have been lost (or rendered unsexable) as a result of their lighter, more porous bones being more susceptible to erosion and disintegration. As Acsádi and Nemeskéri (1970) point out, however, the sex ratio obtained from the skeletal remains must not be regarded as the sex ratio of the entire population which the remains 'represent'. They state that 'Determination of the sex ratio is necessarily inaccurate because of the difficulties involved in determining the sex of children's skeletons, and its validity covers only the members of juvenile or older age groups, but not the whole population' (1970:66). They also note that if the sex ratio of a cemetery population is 1:1 but the age at death of males is higher, then 'it is obvious that more men than women were living at the same time in the community using the cemetery' (1970:66).

Bennet (1973) tried to overcome the problem of child sexing to some extent in his study of a prehistoric American series. He simply assumed a ratio of 50:50 boys and girls in each age group, and used these figures in his life tables by sex. Given that adult sex ratios are very rarely 50:50 in archaeological populations, however, it seems unlikely that child ratios will be, and this method will not be used here.

The life tables for the adults for each site by sex are presented in Figures 3.20 to 3.24. The life expectancies for Jarrow, Monkwearmouth and The Hirsel are shown graphically in Figure 3.25. Although in general life expectation for women appears to be lower than that for men at all the sites, at Monkwearmouth after age 17 women could expect to live slightly longer than men. Life expectancies at age 17 are fairly similar throughout the groups, although at Norton it was generally quite low, and both the Guisborough and Blackfriars women had a very low expectancy, probably caused by the small numbers of individuals rather than any other factor.

At Saxon Jarrow and at Monkwearmouth more women than men died young, but at Medieval Jarrow this was reversed. One possible reason for this is that the women were having babies at a later age in the later period, although it must be noted that reasons other than childbirth have been postulated for early death of females in the past, most of which involve poor nutrition. As it has already been suggested earlier in this section that the people of Medieval Jarrow were not malnourished, it is possible that the high percentage of deaths in females between 25-35, if this figure can be relied upon, was caused by pregnancy, although it is impossible to say for certain.

3.3. Fertility and Parturition Scars

It has been suggested by a number of workers that scars found in the bony pelvis can be used to determine the number of pregnancies per woman in a skeletal group. These scars are formed at the sacro-iliac joints and the dorsal surface of the pubis due to pregnancy stresses of the muscle and tendon attachments. However, similar grooves are also seen in men which has caused some authors (e.g. Houghton, 1974) to classify such scars into two groups, those which occur in both sexes and are therefore unrelated to pregnancy, and those which are thought to be caused by the stresses of childbirth.

In recent years a number of studies have tested the validity of the original theories that the pre-auricular sulcus and pubic dorsal pitting are related to pregnancy (Stewart 1970b) and that the number of children borne by each woman could be estimated from forms of the pit (Ullrich, 1975). Suchey et al (1979) tested the theories on a group of modern American women with known reproduction rates. They found a statistical association between the number of full-term pregnancies and the degree of pitting of the pubic bone, but the correlation was not strong. In a number of cases nulliparous women were found to have medium to large pits and multiparous women were found to have none. The size of pitting appeared to increase with length of time since the last pregnancy in some women. Scars seemed to be correlated both with age and with pregnancy, but they could not really be used to predict the number of pregnancies for an individual female.

The Hirsel: Males
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ɋ(x)	e(x)	C(X)
17	7	9.0	100.0	764.1	2078.2	0.09	0.011	20.8	36.8
25	24	30.8	91.0	756.4	1314.1	0.34	0.034	14.4	36.4
35	31	39.7	60.3	403.8	557.7	0.66	0.066	9.3	19.4
45	16	20.5	20.5	153.8	153.8	1.00	0.067	7.5	7.4

Estimated maximum age: 60 years

The Hirsel: Females
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ɋ(x)	e(x)	C(X)
17	17	21.5	100.0	713.9	1717.1	0.22	0.027	17.2	41.6
25	30	38.0	78.5	594.9	1003.2	0.48	0.048	12.8	34.6
35	19	24.1	40.5	284.8	408.2	0.59	0.059	10.1	16.6
45	13	16.5	16.5	123.4	123.4	1.00	0.067	7.5	7.2

Estimated maximum age: 60 years

Monkwearmouth: Males
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ɋ(x)	e(x)	C(X)
17	7	16.7	100.0	733.3	2197.6	0.17	0.021	22.0	33.4
25	11	26.2	83.3	702.4	1464.3	0.31	0.031	17.6	32.0
35	8	19.0	57.1	476.2	761.9	0.33	0.033	13.3	21.7
45	16	38.1	38.1	285.7	285.7	1.00	0.067	7.5	13.0

Estimated maximum age: 60 years

Monkwearmouth: Females
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ɋ(x)	e(x)	C(X)
17	9	26.5	100.0	694.1	2113.2	0.26	0.033	21.1	32.8
25	8	23.5	73.5	617.6	1419.1	0.32	0.032	19.3	29.2
35	2	5.9	50.0	470.6	801.5	0.12	0.012	16.0	22.3
45	15	44.1	44.1	330.9	330.9	1.00	0.067	7.5	15.7

Estimated maximum age: 60 years

Figure 3.20. Life Tables by sex: The Hirsel and Monkwearmouth.

Jarrow (Saxon): Males
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
17	1	4.5	100.0	781.8	2611.4	0.05	0.006	26.1	29.9
25	5	22.7	95.5	840.9	1829.5	0.24	0.024	19.2	32.2
35	5	22.7	72.7	613.6	988.6	0.31	0.031	13.6	23.5
45	11	50.0	50.0	375.0	375.0	1.00	0.067	7.5	14.4

Estimated maximum age: 60 years

Jarrow (Saxon): Females
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
17	2	11.1	100.0	755.6	2477.8	0.11	0.014	24.8	30.5
25	3	16.7	88.9	805.6	1722.2	0.19	0.019	19.4	32.5
35	5	27.8	72.2	583.3	916.7	0.38	0.038	12.7	23.5
45	8	44.4	44.4	333.3	333.3	1.00	0.067	7.5	13.5

Estimated maximum age: 60 years

Jarrow (Medieval): Males
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
17	8	22.2	100.0	711.1	2336.1	0.22	0.028	23.4	30.4
25	6	16.7	77.8	694.4	1625.0	0.21	0.021	20.9	29.7
35	4	11.1	61.1	555.6	930.6	0.18	0.018	15.2	23.8
45	18	50.0	50.0	375.0	375.0	1.00	0.067	7.5	16.1

Estimated maximum age: 60 years

Jarrow (Medieval): Females
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
17	4	10.8	100.0	756.8	2236.5	0.11	0.014	22.4	33.8
25	11	29.7	89.2	743.2	1479.7	0.33	0.033	16.6	33.2
35	9	24.3	59.5	473.0	736.5	0.41	0.041	12.4	21.1
45	13	35.1	35.1	263.5	263.5	1.00	0.067	7.5	11.8

Estimated maximum age: 60 years

Figure 3.21. Life Tables by sex: Saxon and Medieval Jarrow.

Jarrow (Saxon & Medieval): Males
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	$\bar{q}$(x)	e(x)	C(X)
17	9	15.5	100.0	737.9	2440.5	0.16	0.019	24.4	30.2
25	11	19.0	84.5	750.0	1702.6	0.22	0.022	20.2	30.7
35	9	15.5	65.5	577.6	952.6	0.24	0.024	14.5	23.7
45	29	50.0	50.0	375.0	375.0	1.00	0.067	7.5	15.4

Estimated maximum age: 60 years

Jarrow (Saxon & Medieval): Females
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	$\bar{q}$(x)	e(x)	C(X)
17	6	10.9	100.0	756.4	2315.5	0.11	0.014	23.2	32.7
25	14	25.5	89.1	763.6	1559.1	0.29	0.029	17.5	33.0
35	14	25.5	63.6	509.1	795.5	0.40	0.040	12.5	22.0
45	21	38.2	38.2	286.4	286.4	1.00	0.067	7.5	12.4

Estimated maximum age: 60 years

Figure 3.22. Life Tables by sex: Jarrow combined periods.

Norton: Males
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
17	15	34.9	100.0	660.5	1439.5	0.35	0.044	14.4	45.9
25	11	25.6	65.1	523.3	779.1	0.39	0.039	12.0	36.3
35	15	34.9	39.5	220.9	255.8	0.88	0.088	6.5	15.3
45	2	4.7	4.7	34.9	34.9	1.00	0.067	7.5	2.4

Estimated maximum age: 60 years

Norton: Females
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
17	11	39.3	100.0	642.9	1392.9	0.39	0.049	13.9	46.2
25	7	25.0	60.7	482.1	750.0	0.41	0.041	12.4	34.6
35	8	28.6	35.7	214.3	267.9	0.80	0.080	7.5	15.4
45	2	7.1	7.1	53.6	53.6	1.00	0.067	7.5	3.8

Estimated maximum age: 60 years

Blackgate: Males
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
17	1	2.5	100.0	790.0	2421.2	0.02	0.003	24.2	32.6
25	12	30.0	97.5	825.0	1631.2	0.31	0.031	16.7	34.1
35	12	30.0	67.5	525.0	806.2	0.44	0.044	11.9	21.7
45	15	37.5	37.5	281.3	281.3	1.00	0.067	7.5	11.6

Estimated maximum age: 60 years

Blackgate: Females
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
17	4	9.8	100.0	761.0	2193.9	0.10	0.012	21.9	34.7
25	8	19.5	90.2	804.9	1432.9	0.22	0.022	15.9	36.7
35	20	48.8	70.7	463.4	628.0	0.69	0.069	8.9	21.1
45	9	22.0	22.0	164.6	164.6	1.00	0.067	7.5	7.5

Estimated maximum age: 60 years

Figure 3.23. Life Tables by sex: Norton and Blackgate.

Blackfriars: Males
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	$\bar{q}$(x)	e(x)	C(X)
17	2	10.5	100.0	757.9	1942.1	0.11	0.013	19.4	39.0
25	8	42.1	89.5	684.2	1184.2	0.47	0.047	13.2	35.2
35	5	26.3	47.4	342.1	500.0	0.56	0.056	10.6	17.6
45	4	21.1	21.1	157.9	157.9	1.00	0.067	7.5	8.1

Estimated maximum age: 60 years

Blackfriars: Females
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	$\bar{q}$(x)	e(x)	C(X)
17	4	33.3	100.0	666.7	1437.5	0.33	0.042	14.4	46.4
25	4	33.3	66.7	500.0	770.8	0.50	0.050	11.6	34.8
35	3	25.0	33.3	208.3	270.8	0.75	0.075	8.1	14.5
45	1	8.3	8.3	62.5	62.5	1.00	0.067	7.5	4.3

Estimated maximum age: 60 years

Guisborough: Males
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	$\bar{q}$(x)	e(x)	C(X)
17	0	0.0	100.0	800.0	2442.9	0.00	0.000	24.4	32.7
25	7	33.3	100.0	833.3	1642.9	0.33	0.033	16.4	34.1
35	6	28.6	66.7	523.8	809.5	0.43	0.043	12.1	21.4
45	8	38.1	38.1	285.7	285.7	1.00	0.067	7.5	11.7

Estimated maximum age: 60 years

Guisborough: Females
Number of individuals: 78 (92.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	$\bar{q}$(x)	e(x)	C(X)
17	5	27.8	100.0	688.9	1577.8	0.28	0.035	15.8	43.7
25	6	33.3	72.2	555.6	888.9	0.46	0.046	12.3	35.2
35	5	27.8	38.9	250.0	333.3	0.71	0.071	8.6	15.8
45	2	11.1	11.1	83.3	83.3	1.00	0.067	7.5	5.3

Estimated maximum age: 60 years

Figure 3.24. Life Tables by sex: Guisborough and Blackfriars.

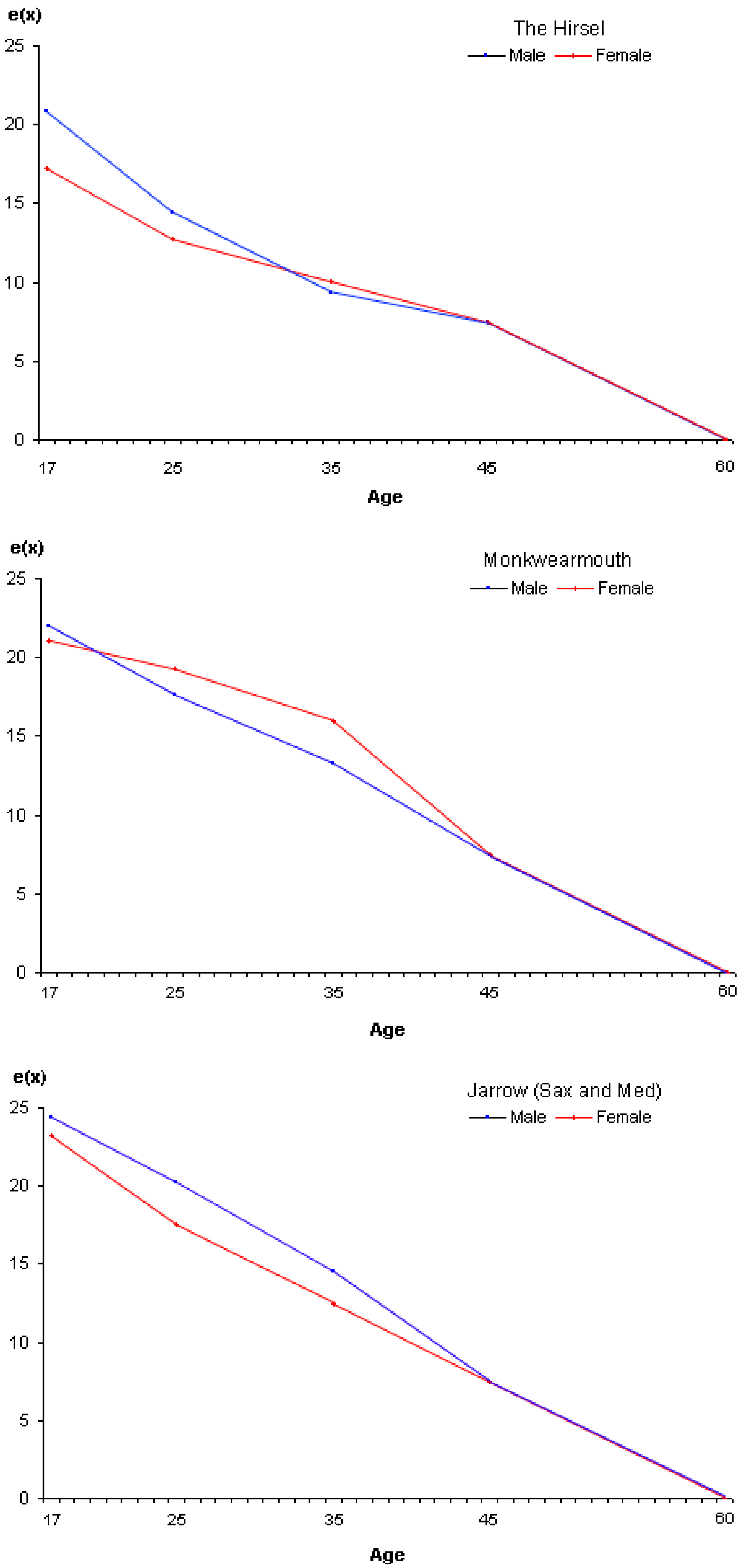


Figure 3.25. Expectation of life by sex.

Bergfelder and Herrmann (1980) found similar results in pubic bones from a modern group. A small exostosis on the superior edge of the pubic bone, the Tuberculum pubicum, was found to be an indicator of several births, and cavity formation on the dorsal surface of the pubis did appear to increase with the number of births. The features suggested by Ullrich (1975) to predict fertility were not found to be connected with number of births.

Most recently, Cox (1989) has found that the formation of pits and grooves on the pelves of women from Spitalfields has no correlation with the number of pregnancies. She has suggested (at the Conference on Archaeological Sciences, University of Bradford, Sept. 1989) that the length and width of the pre-auricular sulcus is associated with pelvic measurements. Large female pelves seem to be inefficient, causing cortical resorption and remodelling at the ligamentous attachments. If this is the case then female pelves must be more unstable than male since there is no correlation of scars with size in males, and there is no pubic pitting in males. Cox suggests that the so-called scars of parturition are actually formed as a consequence of the size and shape of the pelvis, with oestrogen production also being a factor.

Although these results may be disappointing in some respects, it is perhaps not surprising that bones, which often provide such ambiguous information when considering age and sex, cannot provide detailed information about parturition either. The most that can be stated at present is that a female skeleton with large pits or grooves on her pelvis is more likely to have borne children than one without. The preauricular sulcus is perhaps a better indicator of sex than of fertility, and in this study it has has only been used as a sexing characteristic (as noted in Section 3.2.2.).

SECTION 4.
Stature and Metrical Skeletal Characteristics

This chapter will deal with the information which can be gained from the metrical analysis of skeletal remains. Measurement of the lengths of the long bones is most useful for the estimation of living stature of an individual. Measurements of the skull are used to calculate cranial indices which can be used in the comparison of skeletal populations. A few indices, such as the Meric and Cnemic, are calculated from long bone measurements.

All measurements taken in this study follow the methods described in Brothwell (1981).

4.1. Stature

4.1.1. Methods and Problems

The only living statistic which can be estimated with any accuracy from the skeleton is stature. According to Brothwell (1981:100), factors controlling this physical characteristic are c.90% genetic and only 10% environmental. This obviously has to be taken into account in the interpretation of mean stature estimates. Various regression formulae for calculating height have been compiled in the past, based on a number of different populations. For example, small groups of French skeletons were studied by Rollet (1888), Manouvrier (1892-3) and Pearson (1899). In 1898-1902 Hrdlicka (1939) measured the long bones of American whites and negroes, with known cadaver heights, and calculated long bone/stature ratios. Dupertius and Hadden (1951) also worked on American whites and negroes with known cadaver heights (Todd Collection). They tested the validity of Pearson's formulae, which they found to give a consistently shorter stature than their own. Telkkä (1950) studied a small group of Finnish skeletons, mostly male, and calculated regression equations.

The most useful and extensive study to be carried out so far is that of Trotter and Gleser (1952, 1958, Trotter 1970). They used the skeletons of World War II dead, the Terry Collection, and later the Korean War dead, all of whom had a known living stature. Different formulae were calculated for the three major race types (white, negro and mongoloid), since it was found that the relationship of stature to length of long bones differed between them.

The method utilised is as follows. The maximum length of each complete long bone in the skeleton is measured (except for the tibia, for which the total length is used). The formula for the bone(s) with the least standard deviation is then chosen according to which bones are present. It is best to use the femur and tibia if these two bones are available. The long bones from the legs are undoubtedly of more value in this respect than those of the arms, since the former contribute more to stature than the latter.

Trotter and Gleser proposed a correction factor for individuals over the age of 30 years. The correction is to subtract 0.06cm for every year over the age of 30, and therefore an accurate age is required. This is not used with archaeological skeletal populations due to the difficulty of accurately determining age. The estimated living stature of an individual quoted in an archaeological skeletal report is taken to be the approximate greatest height attained by that individual during his or her lifetime.

Male and female skeletons require different formulae, due to the difference in bodily proportions between the two sexes. For this reason, if an individual skeleton cannot be sexed, it cannot be allocated an estimated height.

Although the Trotter and Gleser formulae were calculated from an American population, they have been used on various ancient European populations. This is because it is felt that they are more accurate than some other formulae which have been calculated from European populations. For example, Breitinger (1937) worked out formulae based on 2400 living males from Germany. Trotter (1970:71) states that in this case 'The clear advantage of stature being measured on the living subject was unfortunately offset by the limited accuracy with which bones can be measured from bony prominences palpated through the skin'. Other earlier formulae (Pearson, Telkkä, Dupertius and Hadden, etc.) were in general calculated from skeletal groups numbering 200 or fewer individuals.

Huber (1968) points out that Trotter and Gleser measured bones in conditions varying from moist to dry, and bone lengths decrease slightly with drying. Assuming that limb bone proportions are the same in archaeological populations, stature will probably err on the short side, if at all, because of this. He also states that even if limb bone proportions are shown to be similar in modern and ancient populations, we know nothing about the possible relative changes in the trunk size.

L.H. Wells (1960) estimated the statures of some neolithic skeletons from West Kennet long barrow and Dark Age skeletons from S.E. Scotland using the formulae of Trotter and Gleser, Pearson, and Dupertius and Hadden. He found that both the 1952 and 1958 formulae of Trotter and Gleser gave widely discrepant estimates from different long bones of the same skeleton (a difference of as much as 27mm), whereas those from Pearson, and Dupertius and Hadden, were much closer (only 5mm and 14mm difference respectively). He says 'Although all the discrepancies are well within the standard errors of estimate of the Trotter-Gleser formulae, it seems justifiable to conclude that Anglo-Saxons as a group had appreciably longer arms than modern White Americans, but were identical in mean limb proportions with the nineteenth century French series upon which the Pearson formulae were based' (1960:139). He suggests that this could be due to the more vigorous use of the upper limbs in the lifestyles of these populations when compared with modern populations.

Huber and Jowett (1973) have used the measurements taken by Trotter and Gleser and compared them with a population of early medieval Alamannic Germans. They found that bodily proportions of American whites and the medieval population were not significantly different, and concluded from this that it was reasonable to use the Trotter and Gleser formulae for such a group.

In his 1968 paper, Huber states that 'mean lengths of the long bones of the males from Weingarten [i.e. Alamanns] are no greater than those from any other early Medieval series from Northern Europe...and they are essentially the same as those of the Anglo-Saxons' (1968:80). He suggests that, as far as stature is concerned, they can be regarded as a homogeneous population. If this is the case, then the Trotter and Gleser formulae should be just as appropriate for estimating stature in the current study groups as it appears to be for the Alamanns, especially, as he points out later (1968:83), since 'the American white population was predominantly descended from the older Northern European and British populations, and...there is no reason to assume that the formulae for stature prediction do not apply to them'.

It should be noted that, at present, it is only possible to estimate the stature of adult skeletons. There has been no study on a known population of children, and since sexing is so difficult there may also be a problem here. Smith (1939) used diaphyseal lengths of foetal long bones to calculate foetal length, but the validity of this is questionable, and its use in archaeological populations is limited by the lack of foetal skeletons normally discovered. Since the main use of this method is to estimate the age of a skeleton, and given that the variability of height within a certain age group is likely to be fairly large, then it is doubtful whether stature by age can be estimated for children who are aged from the lengths of their long bones.

Steele and McKern (1969) and Steele (1970) suggest a method of estimating stature from fragmentary long bones (humerus, femur and tibia), based on 117 prehistoric American Indian skeletons, but since this only adds greatly to the error already involved in calculating stature it is not generally attempted. Its main use is in forensic anthropology, when the height is a useful criterion in identification.

Musgrave and Harneja (1978) have calculated regression formulae for estimating stature from metacarpal lengths, based on radiographs of the hands of 166 mainly white adults. They found a high correlation between stature and metacarpal length. However, if no long bones are present in an archaeological skeleton, it is doubtful whether there would be enough of the skeleton left to sex it confidently, or even if the metacarpals would have survived in a condition good enough to be measured.

4.1.2. Methods used in this Study

The Trotter and Gleser formulae are the most widely used today. In this study the 1970 American white formulae are used throughout (Wells' studies on the Jarrow and Monkwearmouth populations utilised the 1952 and 1958 formulae, but the statures have been recalculated for these two groups to make them more comparable with the others in this study). The 1970 formulae are actually the 1952 formulae, with the omission of those formulae involving a mixture of arm and leg bones, since these were felt by the authors to be less accurate. It is felt that the 1952 formulae are preferable to the 1958 formulae for male individuals for use with an ancient population, because they are based on an older group (from the Second World War and earlier, rather than the Korean War) and are therefore less affected by the demonstrable increase in height which has occurred during this century.

In this study only the complete long limb bones of adult male and female skeletons have been utilised, although broken or slightly eroded bones have been used if the majority of the bone was present. Since any estimation of stature can have an error of between 2 and 4cm when a bone is complete, it was felt that a slight inaccuracy in the measured length of the long bone would not greatly affect the estimated height.

Tables 4.1 and 4.2 show the numbers and percentages of the methods which were used for estimating stature at Jarrow, Monkwearmouth and The Hirsel.

Method	HIR		MK		JA Sax.		JA Med.	
MALES	N	%	N	%	N	%	N	%
Fe+Ti	33	53.2	17	40.5	5	26.3	14	43.8
Femur	16	25.8	9	21.4	8	42.1	8	25.0
Fibula	2	3.2	1	2.4	0	-	0	-
Tibia	3	4.8	7	16.7	1	5.3	5	15.6
Humerus	6	9.7	5	11.9	4	21.1	2	6.3
Radius	2	3.2	2	4.8	1	5.3	1	3.1
Ulna	0	-	1	2.4	0	-	2	6.3

Table 4.1.

Method	HIR		MK		JA Sax.		JA Med.	
FEMALES	N	%	N	%	N	%	N	%
Fe+Ti	37	64.9	10	55.6	3	25.0	16	42.1
Fibula	2	3.5	0	-	1	8.3	2	5.3
Tibia	2	3.5	4	22.2	1	8.3	7	18.4
Femur	11	19.3	3	16.7	4	33.3	7	18.4
Radius	2	3.5	1	5.6	1	8.3	4	10.5
Ulna	1	1.8	0	-	1	8.3	0	-
Humerus	2	3.5	0	-	1	8.3	2	5.3

Table 4.2.

The bones recorded under 'method' are in order of lowest to highest standard error for each sex. In almost every case the formula with the lowest error (Fe + Ti) has been used the most, so that the estimates of stature from these three sites should be fairly reliable.

4.1.3. Stature Estimates in the Study Populations

The average estimated statures in centimetres (from all bones) of the population groups in this study are as follows:

Site	Period	Sex	n	Mean	Range
NEM	Anglian	M	15	173.5	164.2 - 182.8
		F	14	163.7	148.3 - 176.1
BG	Saxon	M	35	171.8	162.5 - 179.6
		F	27	157.8	140.5 - 167.8
MK	Saxon	M	42	171.9	151.9 - 188.4
		F	19	159.5	145.9 - 169.2
JA	Saxon	M	19	171.0	160.9 - 184.4
		F	12	159.1	148.8 - 166.6
JA	Medieval	M	32	171.0	158.0 - 186.2
		F	38	159.7	152.2 - 168.0
HIR	9th-15th c.	M	62	167.7	154.4 - 177.2
		F	57	158.8	147.0 - 169.7
BF	Medieval	M	15	173.5	163.6 - 181.9
		F	8	162.5	154.6 - 176.6
GP	c.1100-1540	M	17	170.6	160.7 - 181.6
		F	13	162.7	153.0 - 170.6

Table 4.3.

The distribution in heights between the sexes is shown in figures 4.1 - 4.7. These bar charts show that there is a fairly similar spread of heights at all the sites, with the possible exception of Blackfriars. This last site had two male modes, possibly due to the small size of the sample rather than to any particular trend. Figure 4.8 shows the mean and range for each site graphically and by broad time period. It shows that all the means and ranges are within normal limits.

Table 4.4 shows the modes (in cm) of the various sites which are presented graphically in Figures 4.1-4.7, for ease of comparison. This shows that the sites are all fairly similar in general trend, with the exception of the Jarrow females and the Hirsel males, both of whom have a lower mode than the others.

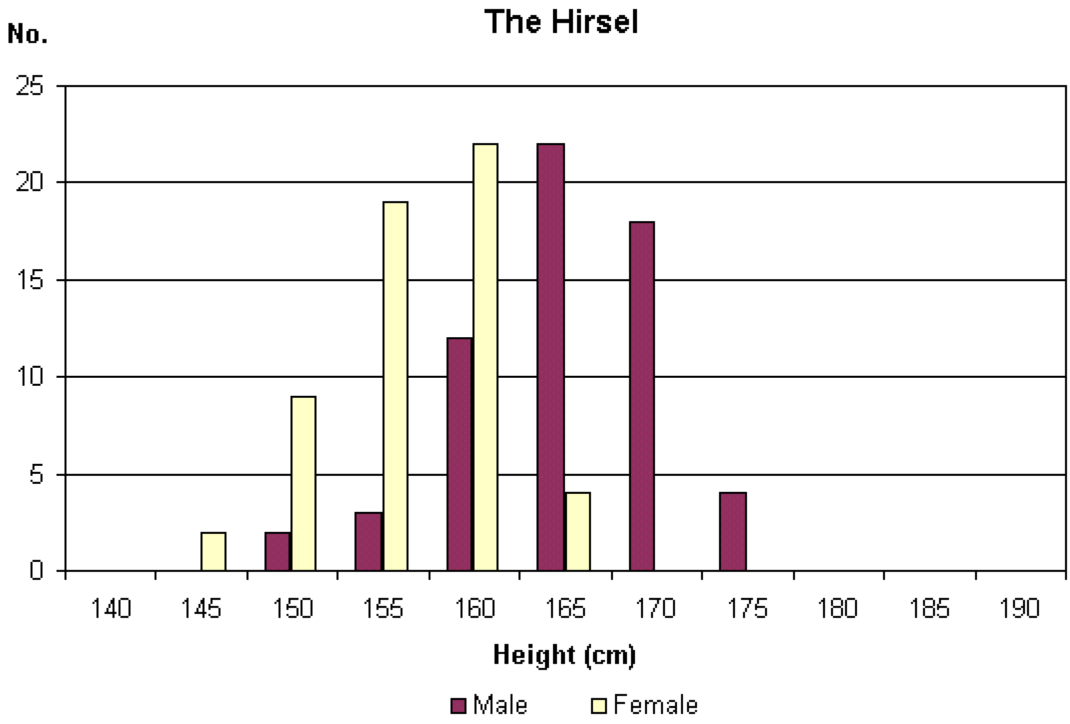


Figure 4.1. Stature distributions at The Hirsel.

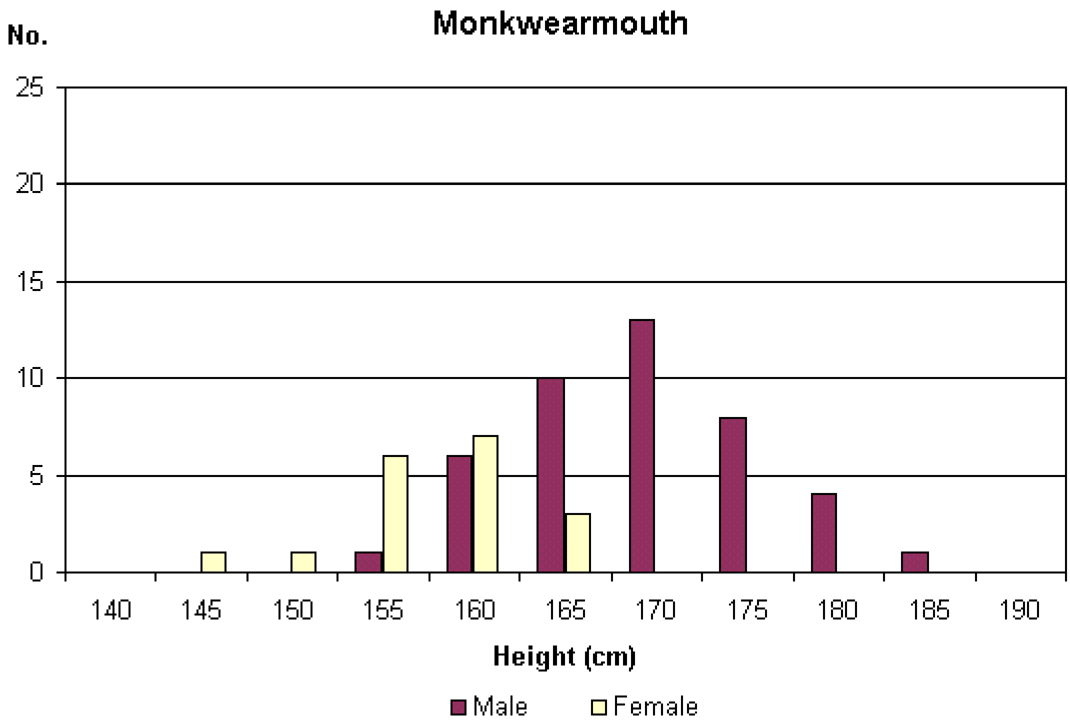


Figure 4.2. Stature distributions at Monkwearmouth.

Figure 4.3. Stature distributions at Jarrow.

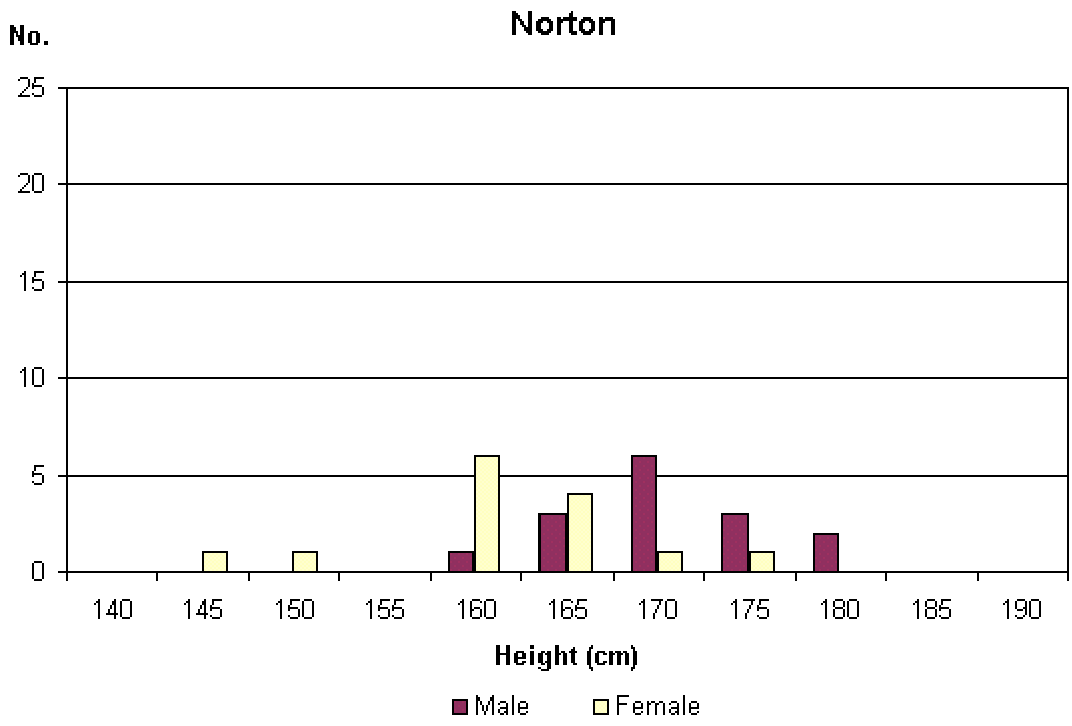


Figure 4.4. Stature distributions at Norton.

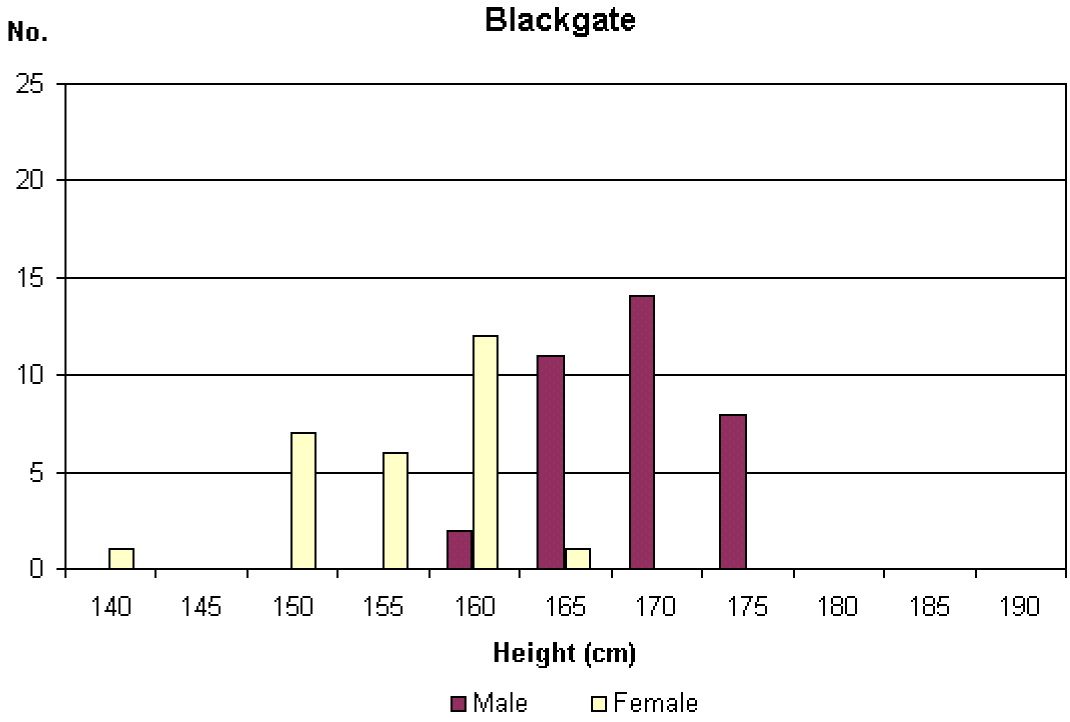


Figure 4.5. Stature distributions at Blackgate.

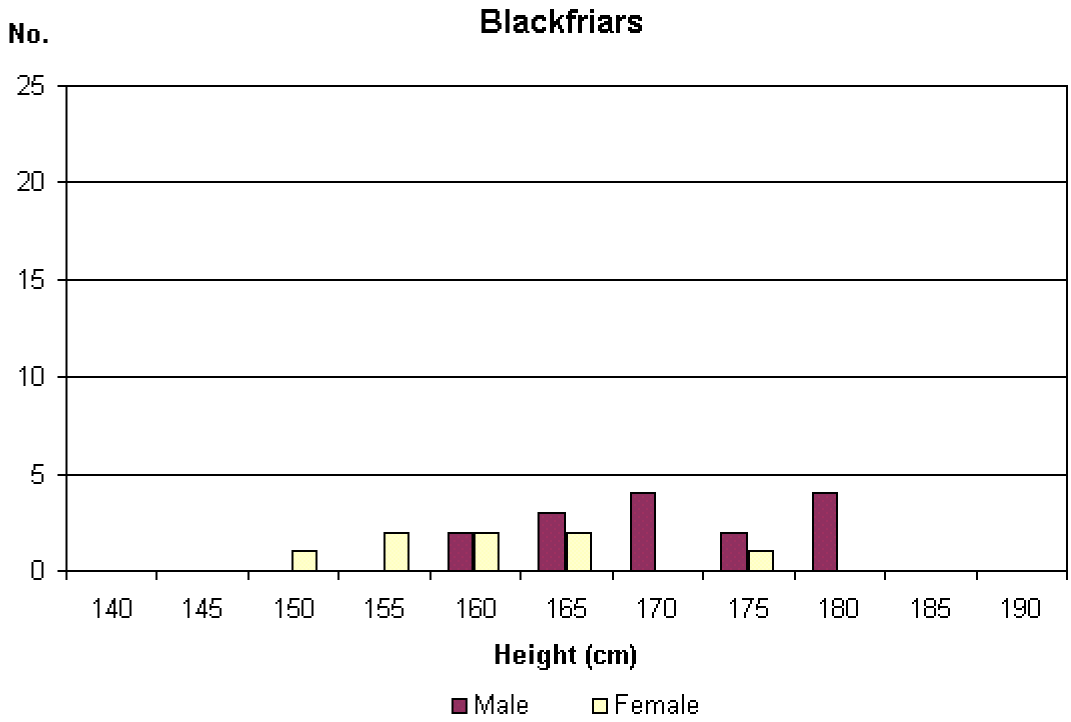


Figure 4.6. Stature distributions at Blackfriars.

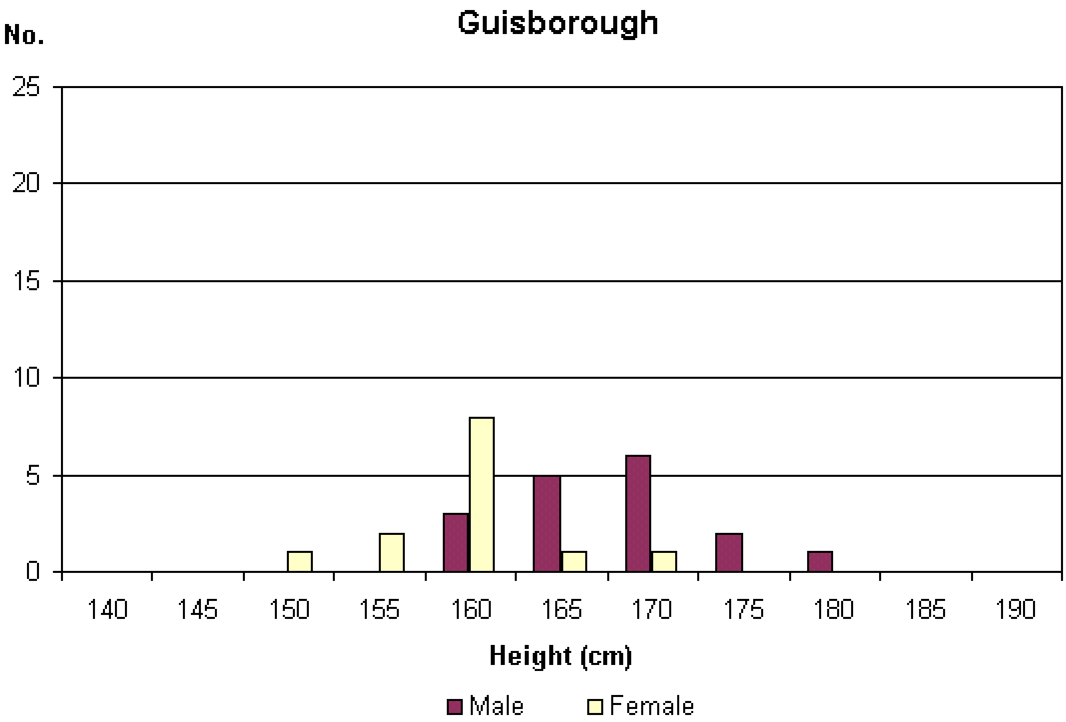


Figure 4.7. Stature distribution at Guisborough.

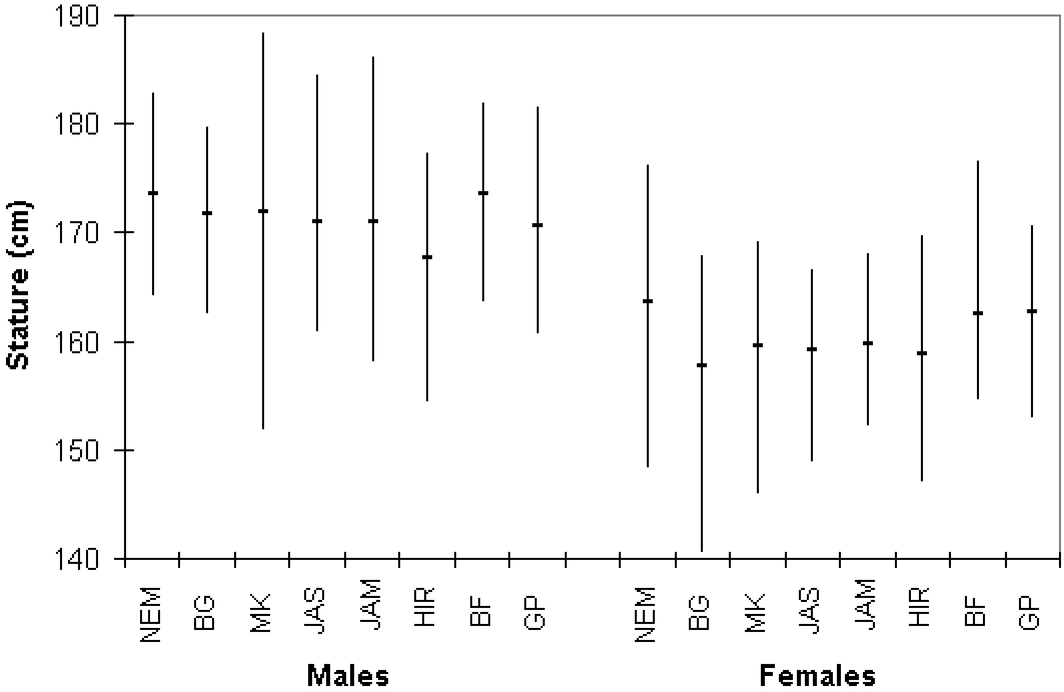


Figure 4.8. Means and ranges of stature by broad time period and site.

Site	Male	Female
HIR	165	160
MK	170	160
JA	170	155
NEM	170	160
BG	170	160
BF	170/180	160?
GP	170	160

Table 4.4.

It has been found, in all the populations in this study, that stature estimated for individuals with only arm bones is often noticeably greater than that of individuals for whom leg bone measurements can be used, especially in the females. This is in support of L.H. Wells' theory that the Anglo-Saxons and other early peoples had longer arms in proportion to their legs than do the modern Americans.

Tables 4.5 and 4.6 show the numbers, means and ranges of the statures (in cm) estimated from the leg bones only, for Jarrow, Monkwearmouth and The Hirsel. Table 4.5 includes those estimates based on the formula with the lowest error in both sexes (i.e. Femur + Tibia), and Table 4.6 includes estimates based on all the leg bone formulae. The results for all except the Jarrow males are very similar.

Site	Sex	N	Mean	Range
MK	M	17	171.8	160.5 - 183.3
	F	10	159.8	153.9 - 162.8
JA	M	19	169.9	160.8 - 183.1
	F	19	159.1	152.2 - 166.6
HIR	M	33	168.3	159.4 - 177.2
	F	37	158.9	149.3 - 166.1

Table 4.5.

Site	Sex	N	Mean	Range
MK	M	34	170.9	159.1 - 184.0
	F	17	159.9	145.9 - 169.2
JA	M	40	174.0	158.0 - 183.1
	F	41	159.3	148.8 - 168.0
HIR	M	54	167.8	155.2 - 177.2
	F	52	158.5	147.0 - 169.7

Table 4.6.

Mean statures were calculated from all the long bone types available at The Hirsel, in order to find out how great the variance is between the various estimates. The results are shown in Tables 4.7 (males) and 4.8 (females). Both sexes have a difference of 5.2cm (2") between the highest and lowest mean estimate. However, this is well within the standard errors of 2.99cm and 3.55 for the best regression formulae (Fe+Ti), suggesting that it is reasonable to use all stature estimates when calculating the mean, rather than having to limit the calculations to those skeletons which had intact femora and tibiae. In some skeletons the estimate was actually very close. Sk. 198 (male), for example, had three estimates of 173.9 (from Fe+Ti, Fem, and Tib) and one of 170.9 (Rad). This is not to say that the stature estimate for this skeleton is any more accurate than the others. It only suggests that it is closer to the American white population.

Formula	Mean	N	Range	s.d.
Fe + Ti	168.3	33	159.4 - 177.2	4.66
Femur	167.4	49	155.2 - 177.2	4.68
Fibula	166.6	19	162.1 - 170.8	3.03
Tibia	169.8	38	160.0 - 177.4	4.26
Humerus	170.5	37	154.4 - 181.3	5.68
Radius	169.8	38	154.5 - 179.2	5.50
Ulna	171.8	30	158.8 - 179.5	4.75

Table 4.7.

Formula	Mean	N	Range	s.d.
Fe + Ti	158.9	38	149.3 - 166.1	3.89
Fibula	157.5	16	150.1 - 162.8	3.56
Tibia	160.2	41	152.3 - 166.9	3.92
Femur	157.5	49	147.0 - 169.7	4.42
Radius	161.0	32	152.3 - 171.5	4.88
Ulna	162.7	23	155.3 - 171.3	4.29
Humerus	160.2	38	148.4 - 175.2	5.22

Table 4.8.

L.H. Wells (1960) found a variance of 27mm between stature estimates on the Humerus, Radius, Femur and Tibia of a male Anglo-Saxon Series, using Trotter and Gleser's formulae. Using his method of estimating mean stature from the mean long bone length, The Hirsel male population produced a variance of 35mm. Although this seems to give a better result than the mean calculated from estimates of stature derived from each individual skeleton, it is probably more accurate to produce a mean by the latter method.

As stated previously, Huber (1968) considers that Alamanns and Anglo-Saxons are very close in stature. He quotes a mean stature of 173.2cm for both (172.8 if Trotter's 1970 formulae are used). L.H. Wells quotes a similar figure of 172.3 (or 171.8 with the 1970 formulae). Both are higher than the majority of populations in this study, both Anglo-Saxon and Medieval. In Table 4.9, the mean lengths of long bones for Alamanns and Hirsel males are compared.

	Alamanns			The Hirsel		
Bone	N	Mean	s.d.	N	Mean	s.d.
Hum.	53	332	21.0	58	325	16.9
Rad.	30	249	14.9	53	241	13.7
Fem.	71	465	23.7	83	444	19.3
Tib.	48	377	22.5	37	361	17.9

Table 4.9.

This shows that the long bones of the Alamannic males were consistently longer than those of the Hirsel men. However, if the Trotter and Gleser formulae can be proved to be of use for Alamannic groups because the proportions of the limbs are similar to the American whites, then it is proportionality not actual size which is important. If the Humero-Radial length is divided by the Femoro-Tibial length and converted to a percentage, the Alamannic ratio is 69.0 and that of The Hirsel is 70.3. The sites in this study were combined to form two groups, Saxon (JA Sax, MK, BG and NEM) and Medieval (JA Med, BF, and GP). A ratio was calculated for the right limbs of each of these two groups to see if there was any great difference. The results, together with those of The Hirsel, the Alamanns, Pearson, Dupertius and Hadden, and Trotter and Gleser (combined series) are recorded in Table 4.10.

Group	Male	Female
Saxon	71.5	70.0
Medieval	69.9	67.2
The Hirsel	70.3	69.9
Alamanns	69.0	-
Pearson	70.5	68.6
Dupertius & Hadden	69.8	68.3
Trotter & Gleser	69.2	69.0

Table 4.10.

The results suggest a fairly similar proportionality within all the groups. The small differences account for the variance seen when estimating stature from one of the formulae with a greater standard error. As L.H. Wells suggested (1960), the upper limbs of Saxon men and women may be slightly longer in proportion to their legs than those of the Medieval period, although the difference is slight.

Wells also suggests that Teutonic migrations were producing a shift towards taller stature in Western Europe. Table 4.11 records the mean statures (in cm) of a few Anglo-Saxon series for comparison with those studied here.

Site	Author	Male	Female
North Elmham	C. Wells (1980)	172.1	157.5
Red Castle	C. Wells (1967)	169.7	158.1
Burgh Castle	Anderson (1989)	175.9	163.2
Nazeingbury	Putnam (1978)	175.3	168.2
Kingsworthy	Wells/Hawkes (1983)	173.6	161.3

Table 4.11.

These sites, all in the South-East of England, have a fairly high average stature. Most of the Saxon sites in this study are fairly close to the lowest two means, but The Hirsel is well below, and none of the populations reach anywhere near the mean heights attained by the Burgh Castle population. Even if Burgh Castle is exceptional, and the other sites are the norm for an Anglo-Saxon population (which seems likely), then the North-Eastern populations are still on the short side. Perhaps Northerners were less well-nourished than their southern counterparts in this period and were therefore not reaching their maximum potential height. The other alternative seems to be that these populations were more localised, and had a greater proportion of native peoples amongst them. However, it is dangerous to make assumptions about ethnic groups based on stature and long bone measurements alone. Cranial observations may provide more evidence (see Section 4.3), but it is unlikely that a distinction between environmental and genetic factors in these groups can be made based on present knowledge.

4.2. Indices Calculated from Long Bone Measurements

Although many indices have been invented by various workers in the past, and especially in the early days of physical anthropology, only a few are used regularly today. Ashley-Montagu (1951) lists four, namely the Radio-Humeral index (R/H x 100), the Pilastric index (taken at the midshaft of the femur, AP/ML x 100), the Meric and the Cnemic indices. Bass (1971) mentions a few more: the claviculo-humeral (useful for the indication of the relative development of the chest); the humero-radial (the same as Ashley-Montagu's radio-humeral); the robusticity of the clavicle, humerus and femur (to show the relative size and thickness of the shaft, and often used for sex determination); and of course, the platymeric and platycnemic indices. These last two are the most well-known and well-used indices in any osteological study, despite the fact that they are still not fully understood or explained. There is a growing feeling amongst a number of workers that such indices are merely measured because they are there.

The Meric index measures the antero-posterior flattening of the femoral shaft, and is taken just below the lesser trochanter (AP/ML x 100). The Cnemic is a similar measure of the medio-lateral flattening of the tibia, and is taken at the nutrient foramen (ML/AP x 100). They are usually classified into four categories each, as follows:

Meric Index		Cnemic Index	
Hyperplatymeric	x - 74.9	Hyperplatycnemic	x - 54.9
Platymeric	75.0 - 84.9	Platycnemic	55.0 - 62.9
Eumeric	85.0 - 99.9	Mesocnemic	63.0 - 69.9
Stenomeric	100.0 - x	Eurycnemic	70.0 - x

The larger the index, the broader the shaft of the bone in both cases.

Wells, in his report on the Jarrow skeletons (forthcoming), states that the fact that the two conditions of platymeria and platycnemia are more common in early and present-day primitive peoples than in advanced civilisations has caused them to be ascribed to the habit of squatting. He feels that this theory is difficult to sustain. As he says, 'in many populations femoral and tibial flattening vary independently of each other, and in known squatters both may be absent, or in non-squatters either may be found'. He also mentions a number of other theories concerning the conditions, such as the idea that platymeria is a response to unusual stresses on the femoral shaft, or that it is caused by various pathological processes, or that it is a physiological economization in the use of minerals for bone formation. Platycnemia has been claimed to be dependant on the degree of retroversion of the tibial head. Wells does not think that any of these theories are correct, and suggests a multifactorial origin for both conditions.

Lovejoy *et al* (1976) analysed the biomechanics of bone strength as applied to platycnemia. They state that 'higher cnemic indexes are more common among populations associated with neolithic and urban economies...[and] the triangular shape of the tibia is a more recent phenomenon' (1976:490). Like Wells, they discard the theory that a particular posture (i.e. squatting) could determine the form of the shaft, since 'the shape of an adult long bone results from a highly complex process of deposition and resorption, not simply by differential rates of growth'. Having studied the torsional strength of the tibia as a whole, they conclude that platycnemia is caused by a specific pattern of mechanical loading which is distinct from that producing eurycnemia. They suggest that a eurycnemic tibia is more adapted to all strain-inducing modes than the platycnemic, which is better equipped for more antero-posterior bending strain. However, what this means in terms of the archaeological and anthropological interpretation of the Cnemic index is unclear.

Andermann (1976) has studied the Cnemic index and found it to be greatly affected by the random variation of the position of the nutrient foramen. He studied 104 tibiae from the Dickson Mound collection of prehistoric American Indians, and concluded that a better measure of antero-posterior flattening could be taken at one-third the length of the tibia (proximal end). He found this index to be more consistent and comparable than either the cnemic index or the midshaft index, the latter being affected by biomechanical forces originating from the distal end of the shaft, and therefore of less use than the new index when considering the traits which influenced the original Cnemic index. However, as he himself admits, specimens which are incomplete or broken, for which the length cannot be measured, could not be used in the new index, since the measurement has to be taken at exactly one-third distance from the proximal end. It is also impossible to make comparisons with past work if the new index is used.

Lavelle (1974a) studied the femora of a number of British populations ranging from the bronze age to the present. He used measurements, indices and multivariate analysis. Both multivariate and simple statistics showed varying patterns of contrast between populations. After standardization of linear measurements against length, a progressive increase in size was seen from the bronze age to the present, and form was also seen to change by metrical analysis. Before standardization, however, there was little to choose between univariate and multivariate statistics as a method of biological distancing (see Section 4.3.1). Unfortunately he makes no conclusions about changes or otherwise in the meric index specifically.

4.2.1. Work on the Study Populations

Three long bone indices were calculated for the study populations, the Meric and Cnemic indices, and the index of femoral robusticity (Bass, 1971). This latter, as measured at The Hirsel, has been discussed in Section 3.2 on Sex.

An attempt was made to see if any correlation existed between the meric and cnemic indices in the adult population from The Hirsel. Scattergrams of one plotted against the other showed no specific trend, and the correlation coefficient calculated for the male L. meric against L. cnemic was very low (0.2375). There would appear to be very little relationship between the two, other than that determined by the sizes of the bones.

4.2.1.1. The Meric Index in the Study Populations

The means and ranges of the meric index (combined for left and right sides) at each of the study groups are recorded in Table 4.12.

	Male			Female		
Site	N	Mean	Range	N	Mean	Range
HIR	91	76.9	63.2-93.8	99	75.4	62.2-104.3
MK	47	75.9	64.1-87.5	28	72.5	62.9- 87.1
JA Sax	25	77.9	54.7-88.3	14	72.1	60.2- 83.0
JA Med	56	77.1	59.5-99.7	60	80.0	61.4- 93.4
NEM	37	72.1	60.5-83.3	31	72.3	60.0- 93.3
BG	53	76.8	67.5-91.4	51	73.6	62.9- 83.3
BF	31	82.3	71.1-93.3	22	87.1	74.2-104.3
GP	33	82.2	66.7-94.3	23	78.1	67.6- 90.0

Table 4.12.

This suggests that the earlier populations had proportionately thinner femora than the later ones, and that at all but Medieval Jarrow and Blackfriars, the females had a smaller index than the males. Brothwell (1981) states that various authors have claimed that platymeria is more common in females, and more frequent in earlier peoples, and the figures from this study would seem to bear this out. He also suggests that the left femur is often more platymeric than the right. In these populations this is true of the majority of groups (JA Med, NEM, BF females, GP, BG and HIR females), but in all cases there was very little difference between the means of the two sides.

Almost all of the mean meric indices recorded in the table fall into the platymeric range. The females of Monkwearmouth and Saxon Jarrow and both sexes from Norton are in the hyperplatymeric group, and the Blackfriars females are in the eumeric category.

Figures 4.9 to 4.12 present the distributions over the categories at all the sites, in the form of pie charts. These show a marked similarity between both sexes from The Hirsel and Medieval Jarrow, and the Blackgate and Monkwearmouth males. The females from Norton and Guisborough are also fairly close to these. The females from Monkwearmouth, Saxon Jarrow and Blackgate, and the Norton males, seem to form another distinct group.

The males from the two medieval sites of Guisborough and Blackfriars have a similar distribution, but the Blackfriars females show a distribution different from any of the other groups, possibly due to the small size of the

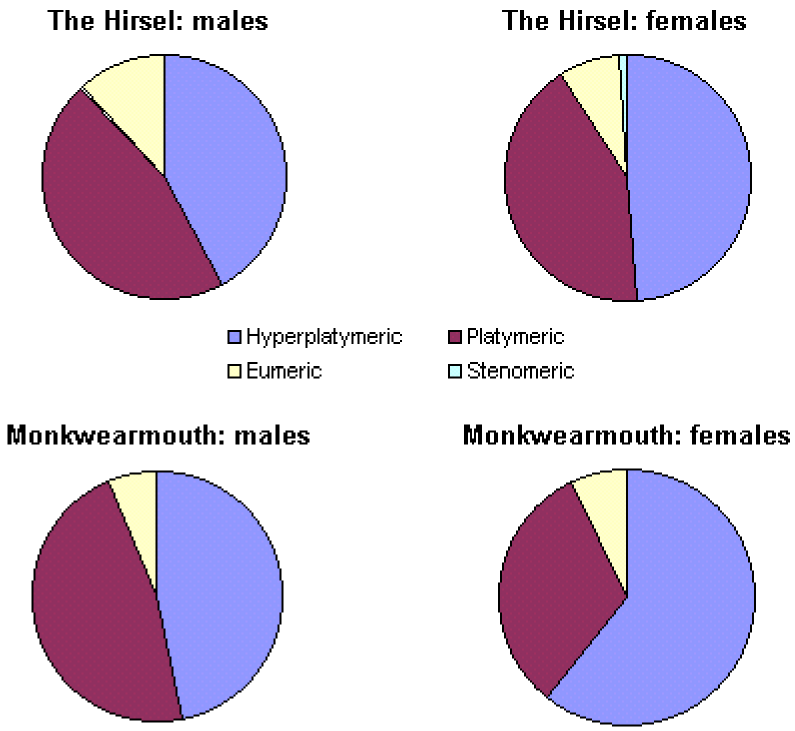


Figure 4.9. Meric index distribution: The Hirsel and Monkwearmouth.

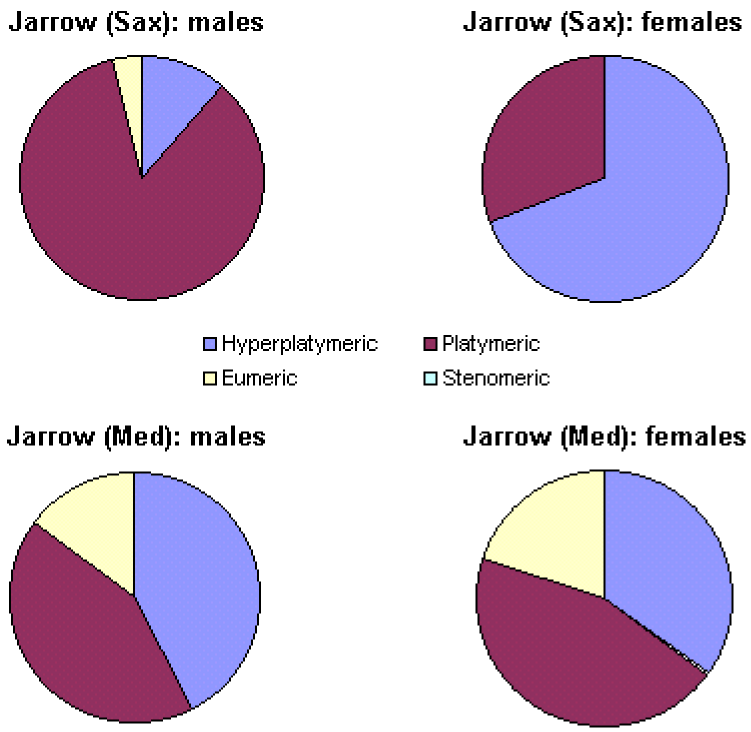


Figure 4.10. Meric index distribution: Jarrow

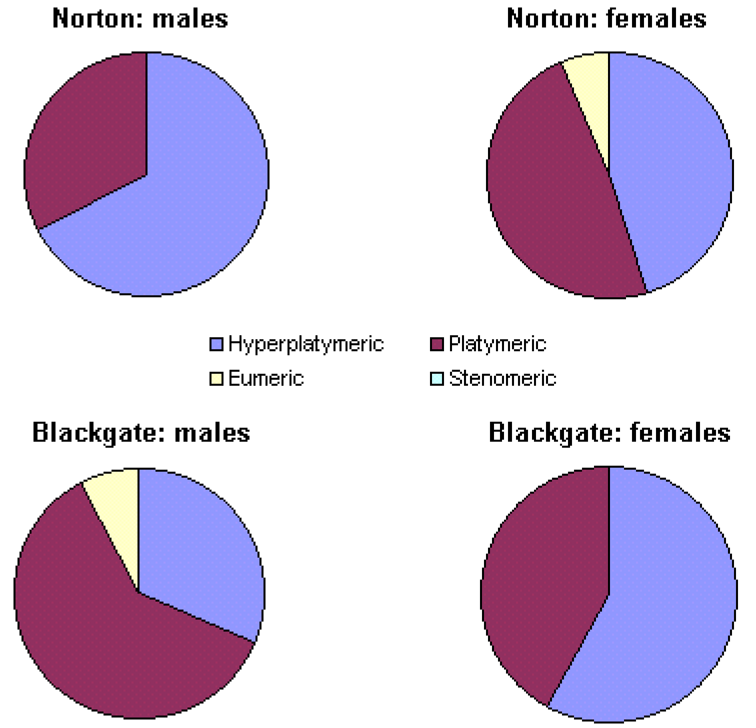


Figure 4.11. Meric index distribution: Norton and Blackgate.

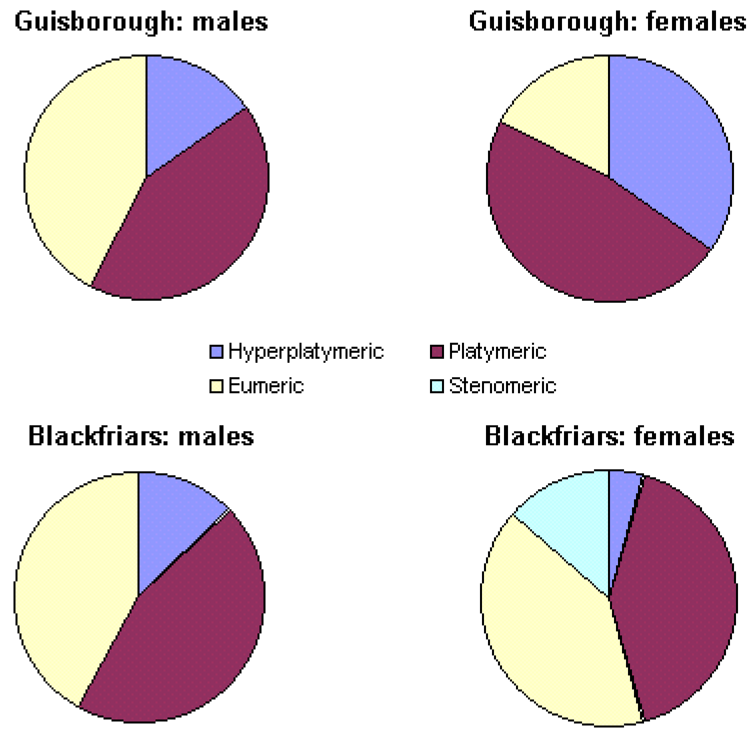


Figure 4.12. Meric index distribution: Blackfriars and Guisborough.

sample. The Saxon Jarrow males also have a strange distribution, with a large proportion of platymeric femora. If the Meric index does differ through time, which it certainly seems to at these sites, then the observed grouping of the Saxon females can be easily explained. The grouping of the Saxon males from Monkwearmouth and Blackgate with two medieval populations is less simple to understand, although it may be that the males were changing towards the medieval type at a greater rate than the females, or that they had a larger input into the genetic change in later periods than females. Since the reasons behind the flattening of the shaft of the femur have not been adequately explained it is difficult to reach any conclusions concerning these patterns.

4.2.1.2. The Cnemic Index in the Study Populations
The means and ranges of the Cnemic indices calculated for the study populations (for combined left and right sides) are recorded in Table 4.13.

	Males			Females		
Site	N	Mean	Range	N	Mean	Range
HIR	92	67.2	55.0-88.0	93	70.7	52.9-92.3 3
MK	46	66.3	52.5-78.9	25	70.4	60.7-91.9 3
JA Sax	22	67.4	54.7-87.5	17	70.7	56.6-81.6 3
JA Med	43	71.8	59.6-82.6	49	72.2	57.6-81.3 3
NEM	39	70.6	56.1-81.8	31	73.1	64.5-91.7 3
BG	46	66.4	57.5-82.4	28	69.4	55.3-80.6 3
BF	26	71.9	64.9-82.9	16	75.1	67.6-83.3 3
GP	32	68.9	56.1-85.3	20	69.1	62.5-80.0 3

Table 4.13.

In this case, the earlier sites have a slightly lower mean than the later in every case, except Norton. All the female means are greater than those of the males. All the group means fall into the Mesocnemic (HIR male, MK male, JA Sax male, BG and GP) and Eurycnemic (HIR female, MK female, JA Sax female, JA Med, NEM and BF) categories.

Figures 4.13 to 4.16 provide a graphic representation of the distribution of the indices into categories at each of the sites. There is a similarity between the distributions at The Hirsel and Saxon Jarrow, and Monkwearmouth and the males from Blackgate, Guisborough and Norton are also quite close. The Norton females show a similar pattern to the females from Medieval Jarrow, and the Guisborough and Monkwearmouth females are fairly close to each other. The Blackgate females and both sexes from Blackfriars do not correlate well with any of the other groups. In the case of the Cnemic index there does not appear to be much correlation with time period in the distribution patterns seen at these sites, but how this should be interpreted is unknown.

4.3. Cranial Measurements and Morphology

4.3.1. Techniques of Cranial Analysis in Current Use

For the purposes of most (British) osteological reports, the cranial measurements recommended by Brothwell (1981) are generally used. Indices are calculated from the main measurements, such as cranial length, breadth and height (for cephalic, height/length and height/ breadth). Krogman (1978), Ashley-Montagu (1951) and others give lists of the major indices and their category divisions. Other measurements are usually recorded in the hope that they will be useful for future research.

At the other end of the scale in craniometric research, particularly in America, and occasionally in Europe (e.g. Brothwell and Krzanowski, 1974; Tattersall, 1968a), complicated statistical methods are employed to compare biological distances between populations.

Hursh (1976) produced a survey of the techniques of measuring and analysing cranial form. As well as conventional methods of measurement with sliding and spreading callipers, he considers various analytical tools such as stereocontouring and even holography. He sees these 'hi-tech' procedures as the way forward in the field of analysis of cranial form, although he admits that they are obviously expensive, and that, in the case of stereocontouring, 'the most serious question is what to do with the contour lines once you have them'! (1976:475).

As well as considering measurement techniques, Hursh summarises statistical methods in current use. Under the heading of 'Univariate Measures', he lists three problems associated with the use of 'simple' statistics. 'First, as many will freely admit of themselves, statistics are not very well understood by a significant number of people in the field....Second, they are sometimes not complex enough to test the proposed model....Third, there may be a significant discrepancy between the implications of the statistical model and the assumptions of the evolutionarily directed culture of the contemporary biological scientist' (1976:481). If univariate statistics are subject to misuse

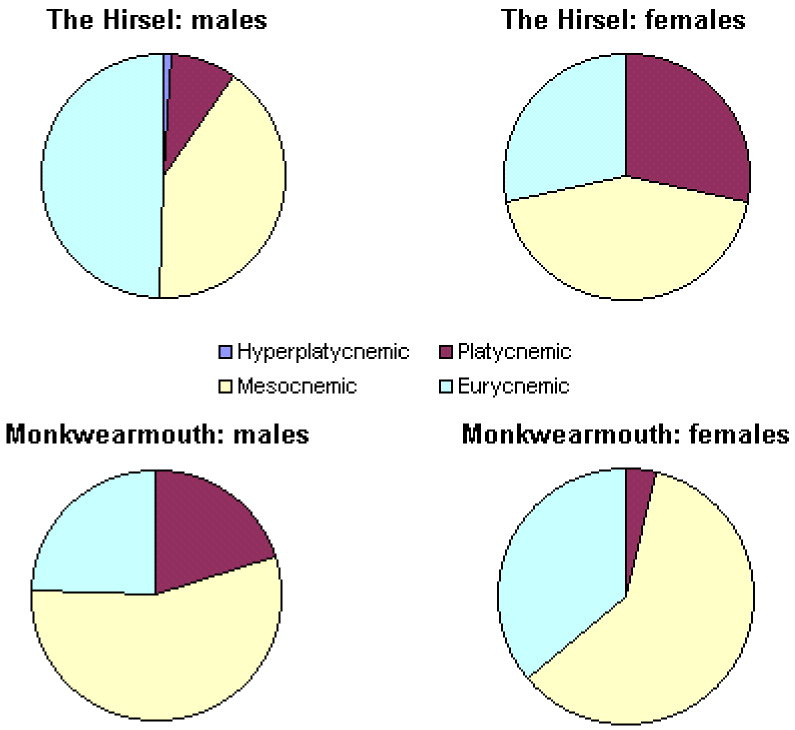


Figure 4.13. Cnemic index distribution: The Hirsel and Monkwearmouth.

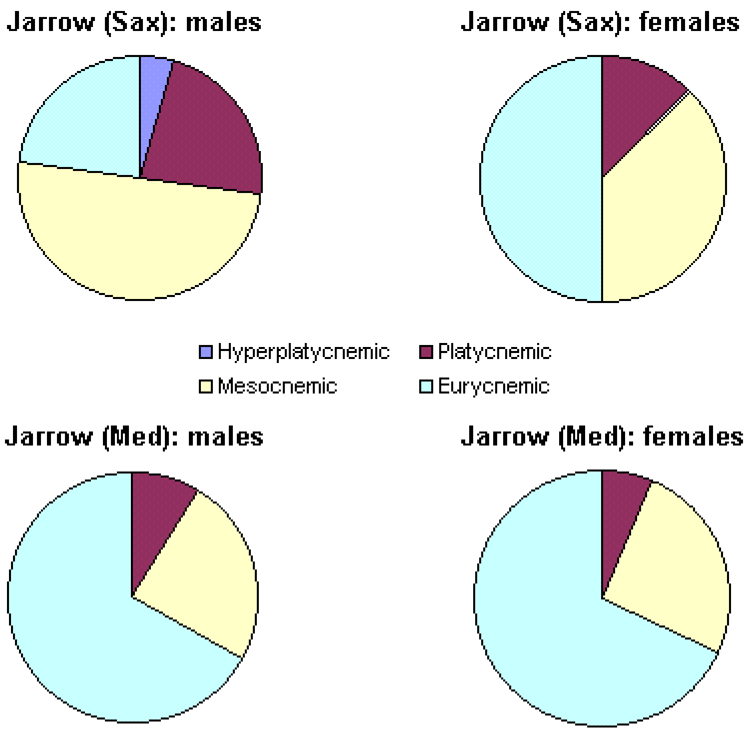


Figure 4.14. Cnemic index distribution: Jarrow.

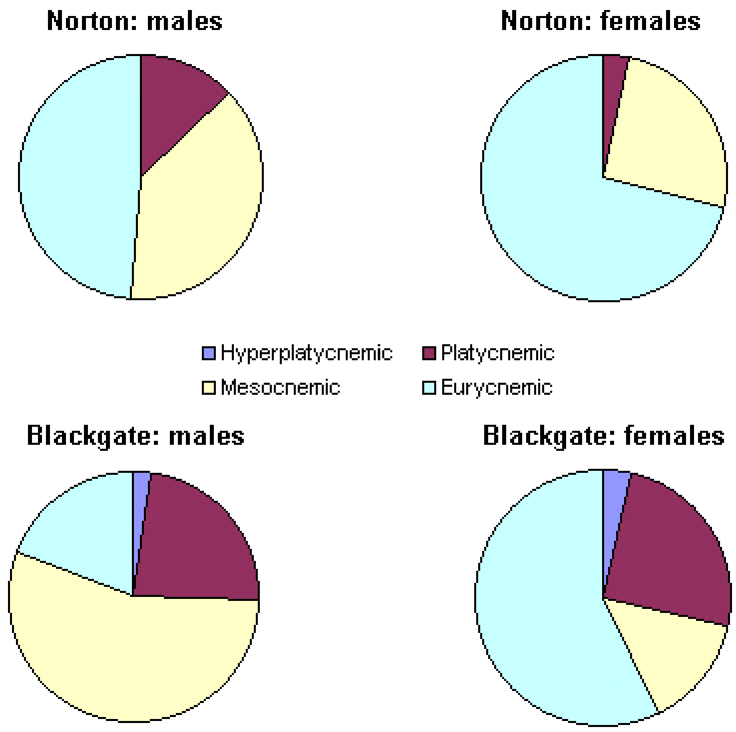


Figure 4.15. Cnemic index distribution: Norton and Blackgate.

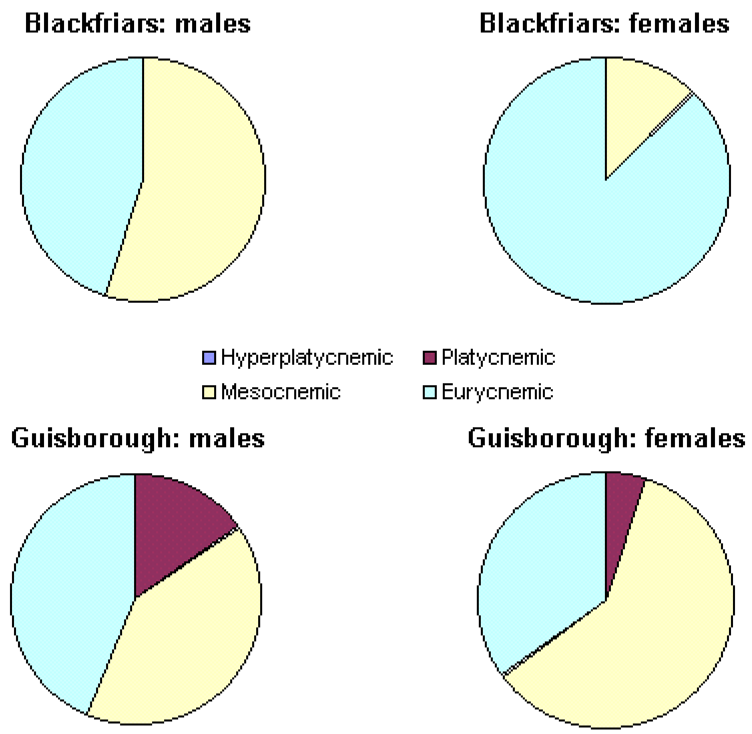


Figure 4.16. Cnemic index distribution: Blackfriars and Guisborough.

and error due to a lack of understanding, then it follows that the more complicated procedures of multivariate analysis will be even more incomprehensible to most osteologists.

Hardy and Van Gerven (1976) tested the effect of size variation on indices calculated from cranial measurements. They concluded from their results that 'body size contributes substantially to morphological differences quantified from standard craniometric techniques' (1976:82). Because of this, they recommend the use of principal components analysis followed by analysis of covariance to avoid the statistical problems of use of indices.

As early as 1923, Morant stated that 'the cephalic index alone is quite incapable of discriminating between fundamental types or of distinguishing relationships between races which are known to be allied. Furthermore, no single character which has yet been suggested can fulfil either of these purposes and it is extremely unlikely that one will ever be found' (1923:194). He used Pearson's 'Coefficient of Racial Likeness' in the analysis of several population groups (e.g. Tibetans in the study of 1923). However, he also says that 'it seems at present to be highly probable that differences in size are of relatively little importance; resemblance between the shapes of heads is the real criterion of relationship and this we are able to measure with angles and indices' (1923:212).

A more recent study by Brown (1973) uses multivariate techniques to look at covariation in Australian Aboriginal skulls. She found it to be a useful method of craniometric research, since the collective analysis of a set of variables is more objective than analysis by conventional statistical techniques.

As mentioned earlier, Brothwell and Krzanowski (1974) have looked at a number of British skeletal groups using multivariate methods. At least 2000 skulls from 53 samples were used, varying from Neolithic to Medieval in date. The statistical tests tended to cluster the groups of similar time periods, and distance them from those of others, as would probably be expected. Brothwell says that some of these distinctions are probably biologically meaningful, and that there is some evidence for regional micro-evolution. Such an analysis may be useful when attempting to decide whether a group of skeletons are likely to belong to a certain period.

Jantz (1973) studied Arikara (American Indian) crania by multivariate methods. He also feels that variables should be considered together rather than individually. He suggests that many metrical variables are inherited to a large extent, even if 'genetic and environmental aspects of morphological variation are still inadequately understood' (1973:15). In his analysis he found that cranial length and breadth, the two variables used in the cephalic index, contributed very little to his canonical variates, and that variables from the face contributed the most. Thus, 'the face tends to display more significant interpopulation variation than the cranial vault' (1973:20). The reason for the predominant use of the cephalic index by most workers is that the face is unfortunately more susceptible to decay than the cranial vault, making it impossible to carry out any in-depth studies into facial indices in the average archaeological population.

Because of this, many workers in Europe have continued to use the cephalic index, due to its ease of calculation and the fact that it usually allows for a larger sample of skulls to be considered. Wiercinski (1974) studied brachycephalisation in various populations, mostly in Europe, and concluded that the process of increase in the cephalic index (brachycephalisation) was genetically rather than environmentally determined. Necrasov (1974) did a similar study on Rumanian populations, looking at the process of brachycephalisation through time and using it to suggest genetic affinities between skeletal groups. Alekseeva (1974) used some simple indices to differentiate between Slavs and Germans. His indices and measurements appear to show a reasonable difference between population groups.

Giles and Elliot (1962) have produced a set of discriminant functions for the identification of race from cranial measurements. This is of most use in forensic identification, since it is based on the differences between Whites, Negroes and American Indians. It may be possible to use a similar method to distinguish between closer populations in archaeological contexts, as Jantz (1973) and McKern and Munro (1959) attempted on American Indian groups. However, Hursh states that 'discriminant function analysis will find differences even when they are not there. This does not actually mean that it creates differences, but that it is so good at detecting differences that it will be able to discriminate with high levels of accuracy on differences which are not attributable to causal origins, but rather to happenstance' (1976:484). If this is the case, then it may not be a good idea to use the method on population groups which are very similar in time and space.

Utermohle *et al* (1983) have drawn attention to three other factors which might affect cranial measurements in both statistical analysis and simple comparisons of populations. They showed that there was a difference in measurements taken by different observers on the same set of skulls, that there was a difference between measurements taken at various time periods by the same observer on the same group of skulls, and that measurements were affected by varying levels of humidity. Although the differences in all these factors were at most about 3mm, they suggested that this would produce a large error when the measurements were used in multivariate statistics. Discriminant functions were calculated which could distinguish between measurements taken by the three observers to a reasonable degree. In their conclusion they state that 'the potential inappropriateness of conclusions involving data collected by different observers is not a comforting prospect for a scientific discipline' (1983:92). However, it is well known that in many branches of science errors are expected to occur most of the time, and these are generally taken into account in the final analysis.

4.3.2. Methods applied to the Study Populations

In the study of these population groups, craniometric techniques have been confined to the simple measurements and indices described by Brothwell (1981). There are three main reasons for this.

Firstly, Ubelaker (1978) suggests that a sample of 100 or more adults from each group being compared should be used in the estimation of biological distance by multivariate techniques. This would rule out all of the skeletal populations considered in the present study, since none of them has a large enough group of complete skulls.

Second, the more complex statistical techniques involve large and time consuming calculations, which, even if carried out by a computer, still need to be analysed by the observer. They are thus beyond the range of the current work, since they would need to have been done almost to the exclusion of the analysis of any other data. In other words, such a study is almost large enough for a thesis in itself.

Thirdly, it is not yet clear which methods would be most appropriate for small series, and the research involved to determine this is outside the scope of this study.

Although the craniometric study carried out on the study populations is of the simplest type, it was thought valid to include the data, since it is still comparable with other recent studies of British skeletal populations. Ubelaker states that 'the potential of skeletal analysis for resolving archaeological problems involving biological hypotheses cannot be realized until the genetics of bone development is better documented' (1978:88). Since this is undoubtedly the case, it seems unnecessary to rule out the possibility that cranial vault and face indices are able to provide useful information in this field.

The most recurrent theme in all of this work on statistical analysis of cranial measurements is that they can show a difference between populations. However, unless we are able to gain a better understanding about the biological background of these people, and learn more about the heritability of metrical traits, the results are very difficult to interpret. It is noticeable that, even after all the analysis has been carried out, most workers are only able to say that one population is closer to/more distant from another in their survey. It is equally possible to show this with even simple statistics. The problem which now has to be faced is that of obtaining possible biological or environmental causes for such distinctions.

4.3.3. Results of the Craniometric Analysis

The means and ranges of the cephalic index for all the populations are recorded in Table 4.14. Other indices were calculated on the cranial vault and face, but the sample sizes involved are so small that it is felt that they may give a misleading or biased picture. As can be seen from the table, the numbers involved in the calculation of the cephalic index at most of the sites were very small.

Site	Sex	N	Mean	Range
HIR	M	29	79.0	73.9 - 88.2
	F	32	77.9	71.8 - 86.0
MK	M	6	69.8	65.3 - 72.8
	F	8	72.7	66.6 - 79.9
JA Sax	M	5	75.3	70.4 - 79.8
	F	3	74.3	70.6 - 77.0
JA Med	M	7	78.7	72.2 - 82.4
	F	5	76.4	74.3 - 77.9
NEM	M	5	72.0	67.7 - 79.9
	F	8	74.0	68.8 - 76.1
BG	M	5	73.1	68.8 - 78.0
	F	3	75.0	72.0 - 76.7
BF	M	9	77.7	68.5 - 88.4
	F	4	82.5	80.7 - 83.3
GP	M	15	79.7	75.1 - 84.5
	F	7	76.1	72.6 - 79.4

Table 4.14.

It would seem to be fairly pointless to attempt to sort these groups into the categories of the cephalic index, but from the means there does seem to be a trend towards broad, rounded (brachycephalic) crania from the earlier to the later sites. This is shown graphically in Figure 4.17.

Figures 4.18-4.20 show the spread of the three main cranial indices at The Hirsel. Unfortunately, due to the small numbers of measurable crania at the other sites, it is not possible to make any conclusions about this data in comparison with that of the other groups in this study, other than to say that there are more brachycranial individuals in the later sites and more dolichocranial (long-headed) individuals in the earlier ones. At The Hirsel, there was very little difference between the sexes in the cephalic and height/breadth indices. The most noticeable difference was in the height/length index, where the greatest proportion of males fall into the mid-range category, whilst the majority of females are in the lowest group.

One other simple index was calculated for the males of these populations, to compare them with the European groups used by Alekseeva (1974) in his study of Slavs and Germans in the Middle Ages. He used an index based on the three major cranial dimensions to differentiate Germans and Western, Southern and Eastern Slavs. This is calculated as follows:

$$\frac{\text{Cranial Height}}{(\text{Length + Breadth})/2} \times 100$$

Unfortunately, his other three indices involve measurements which are only taken rarely, when preservation allows, and it was not possible to use them in this study. The results of the analysis are given in Table 4.15 below.

Group	Mean
Monkwearmouth	78.4
The Hirsel	79.1
Jarrow (Medieval)	79.6
Blackgate	80.1
South Germans	80.9
Middle Germans	81.4
Guisborough	81.5
Burgh Castle	81.9
West Scandinavia	81.9
Jarrow (Saxon)	82.0
Blackfriars	83.6

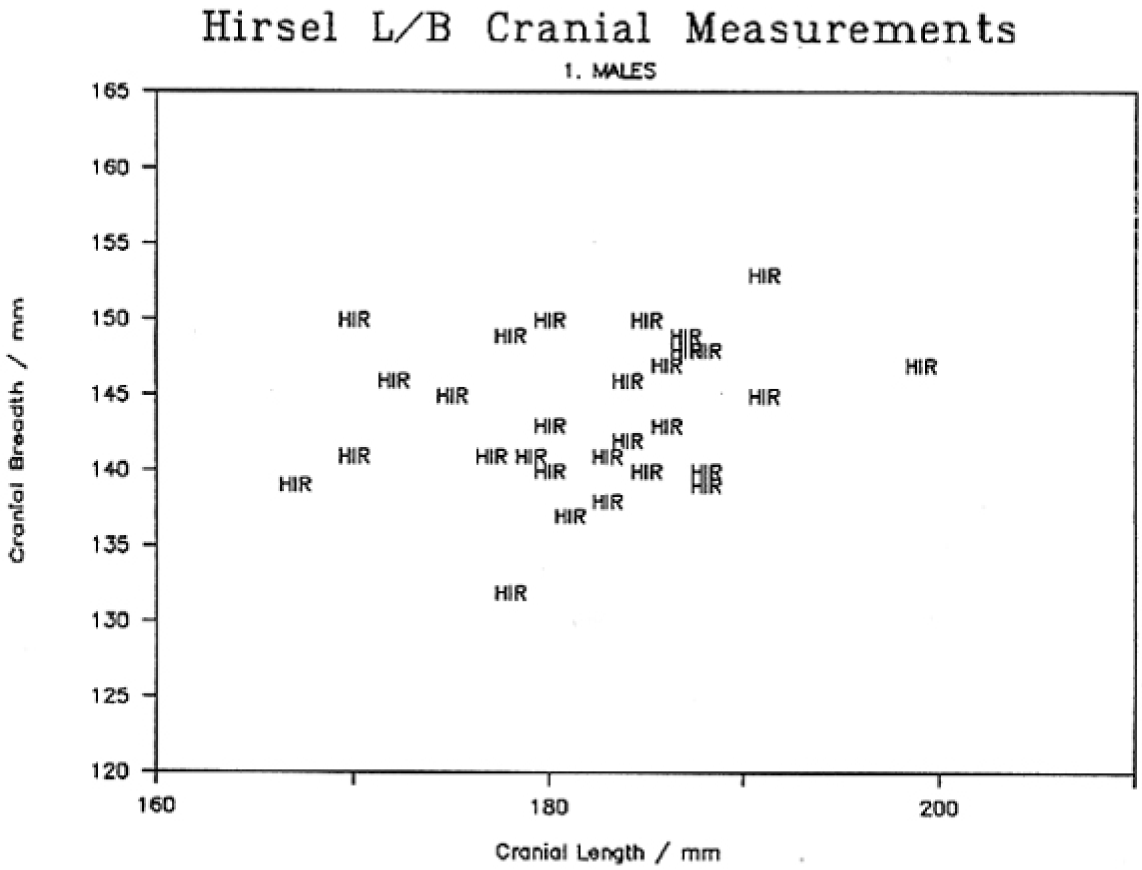
Table 4.15.

The results seem to indicate that the populations of Blackfriars and Saxon Jarrow were at the greatest distance from Monkwearmouth and Medieval Jarrow. This is very unlikely, since they are similar groups of a similar time period and belonging to a very small area. The reason for this discrepancy is probably the small sample sizes from Blackfriars and Saxon Jarrow, rather than any major morphological difference. The most reliable results are probably those from The Hirsel, Guisborough and Burgh Castle, since all are based on quite large samples. The difference of The Hirsel from the Germanic populations and the similarity of the latter two with Germanic and Scandinavian groups is quite striking. This index is probably quite a useful method of distinguishing between population groups, but should probably only be used to make final conclusions when larger sample sizes than these are available for study.

A similar study was carried out by Brothwell on the Bronze Age people of Yorkshire (1960b). As well as using the multivariate technique of Penrose distances, he also plotted various populations using the cephalic index against basi-bregmatic height. This produced a pattern in which the Bronze Age and Neolithic groups were all fairly close together. In Figure 4.21 the same technique is applied to the populations in this study, together with some of those listed in Table 4.15 from Alekseeva's study.

From this analysis it can be seen that the males from Saxon Jarrow (JAS) are the same as the South Germans (SG), that the Middle Germans (MG), Blackgate, Norton, West Scandinavians (WS) and Burgh Castle (BC) form a distinct group, Medieval Jarrow (JAM), Guisborough and Blackfriars form a looser group, and The Hirsel and Monkwearmouth seem to be very different from all the other groups. The females show a different pattern, with Jarrow and The Hirsel appearing fairly close, Blackfriars being at a distance, and the rest forming a fairly loose group. In both the males and the females, a horizontal dividing line can be drawn between the Saxon and Medieval groups, although in the females this division is less distinct.

Further analysis of the figures obtained in the metrical analysis of these sites will have to await a study by someone with a greater understanding of statistical techniques than the present author. However, considering the small number of cranial measurements available, it is unlikely that any complex statistical test would be valid on most, if not all, of these populations.



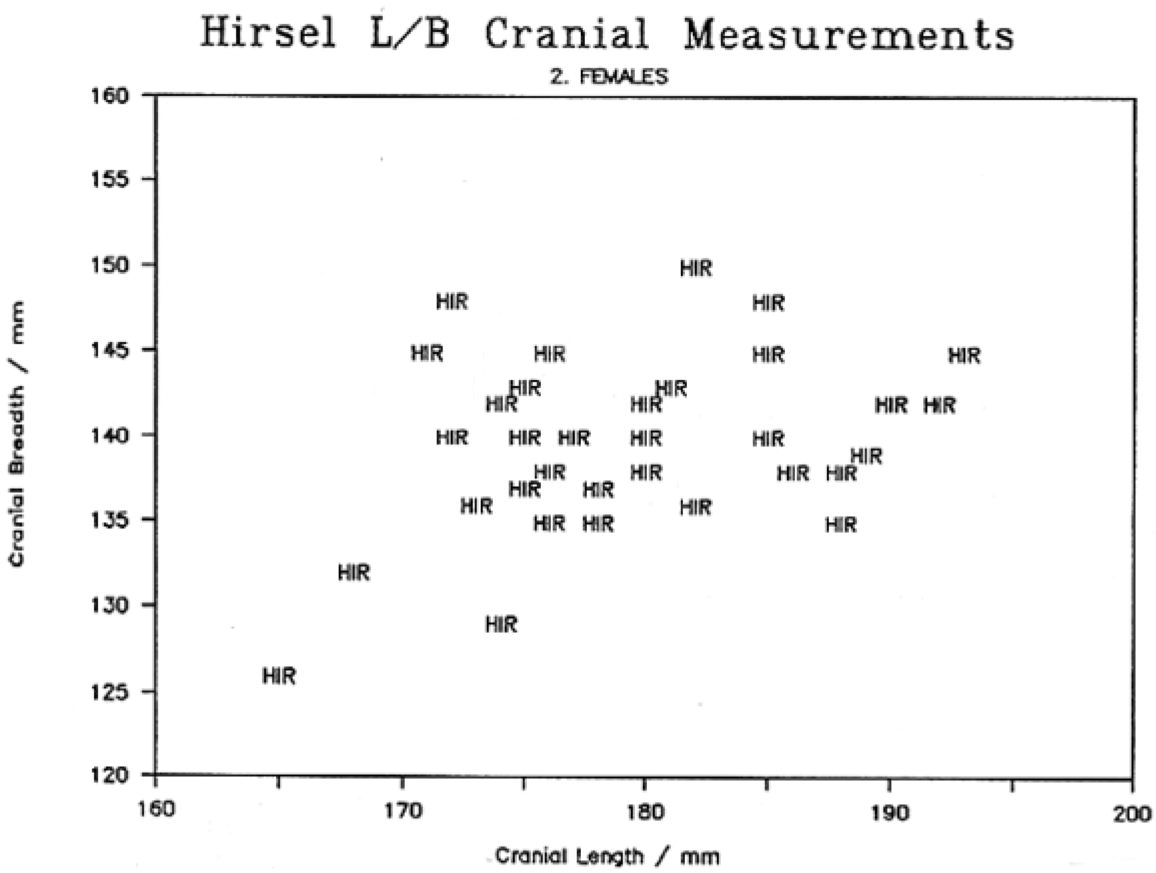
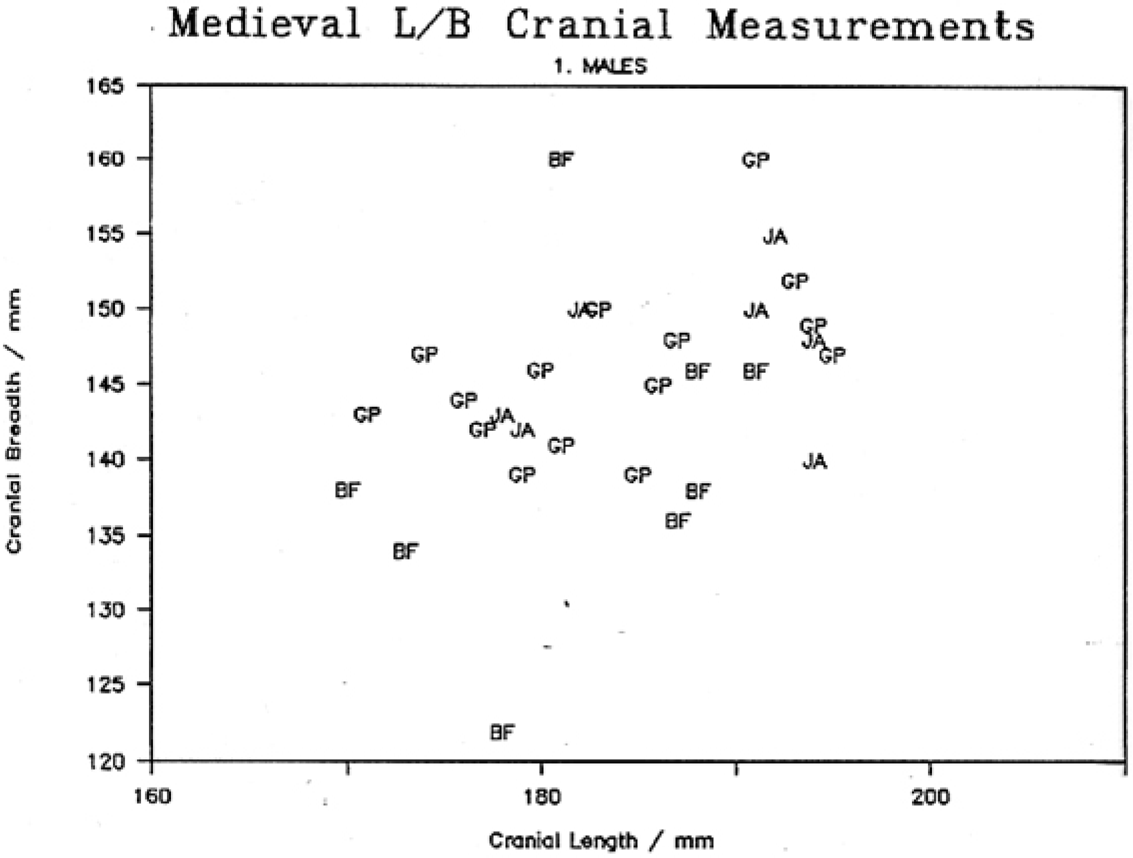
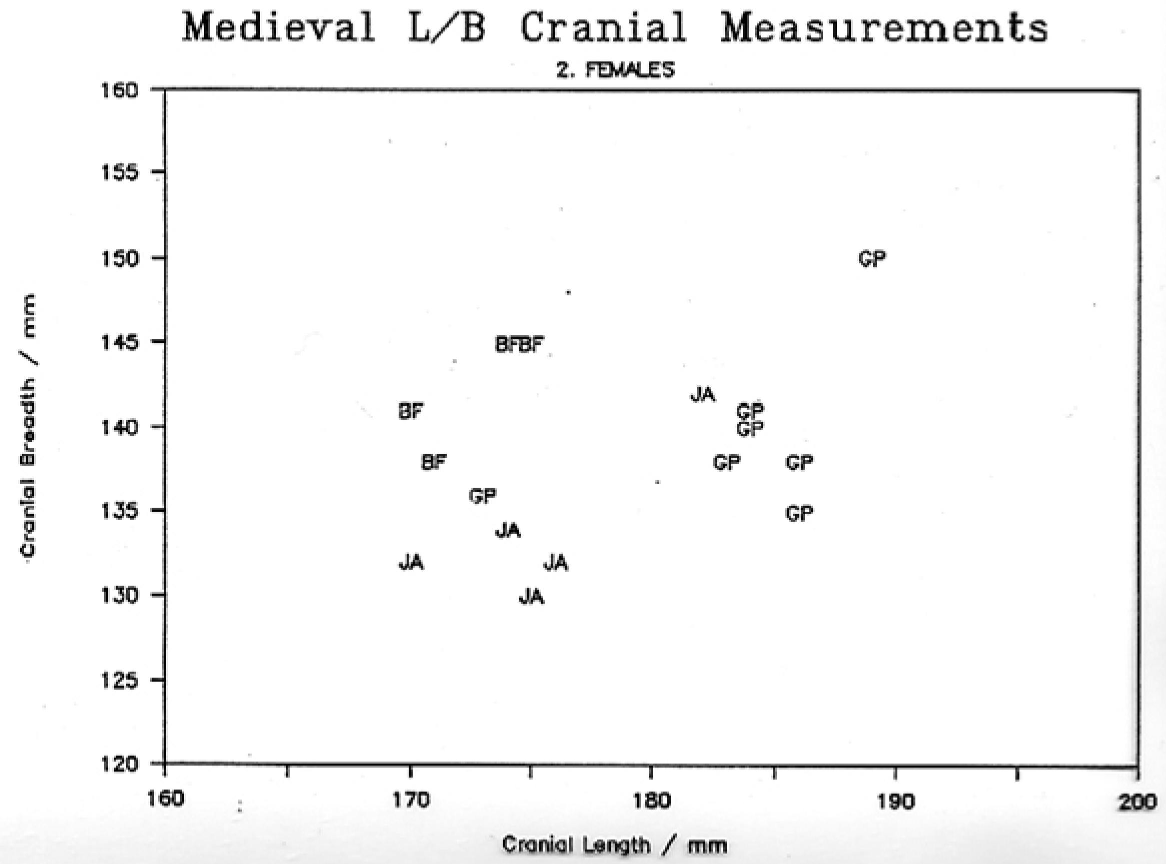


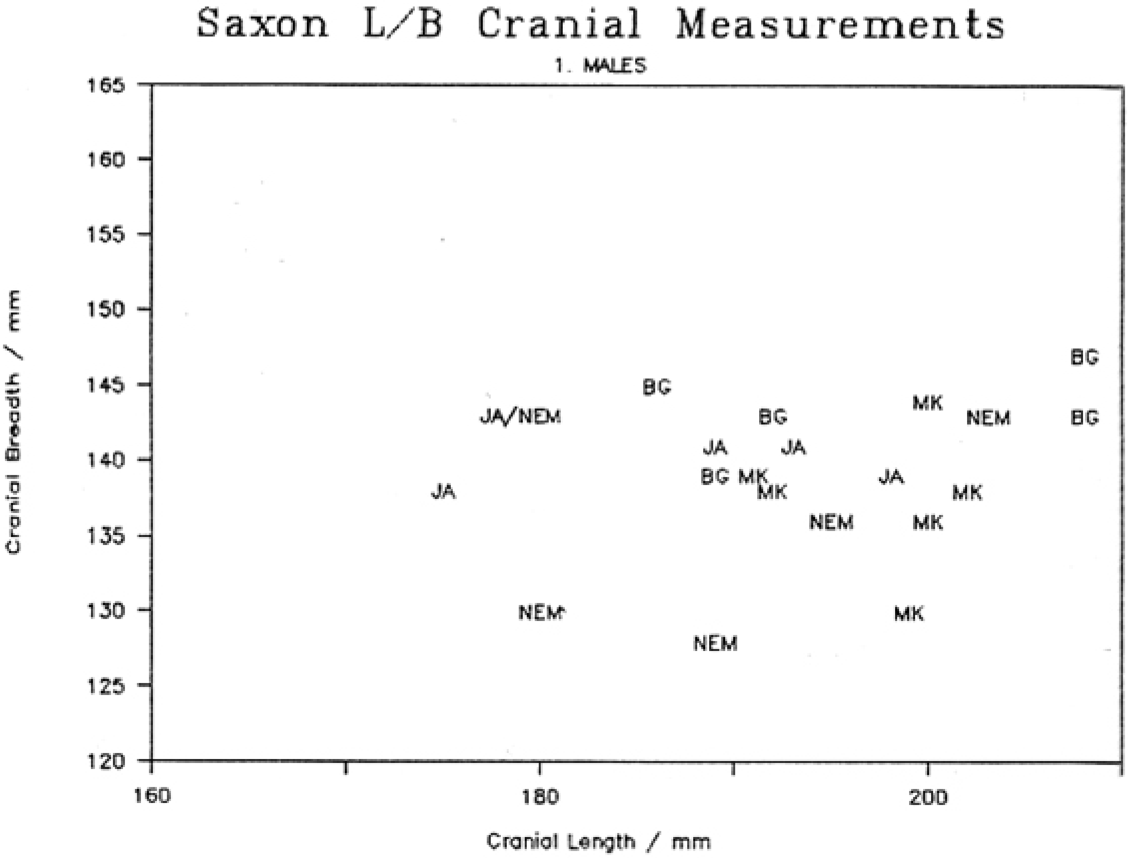
Figure 4.17a. Scattergraphs of L/B cranial measurements (The Hirsel).

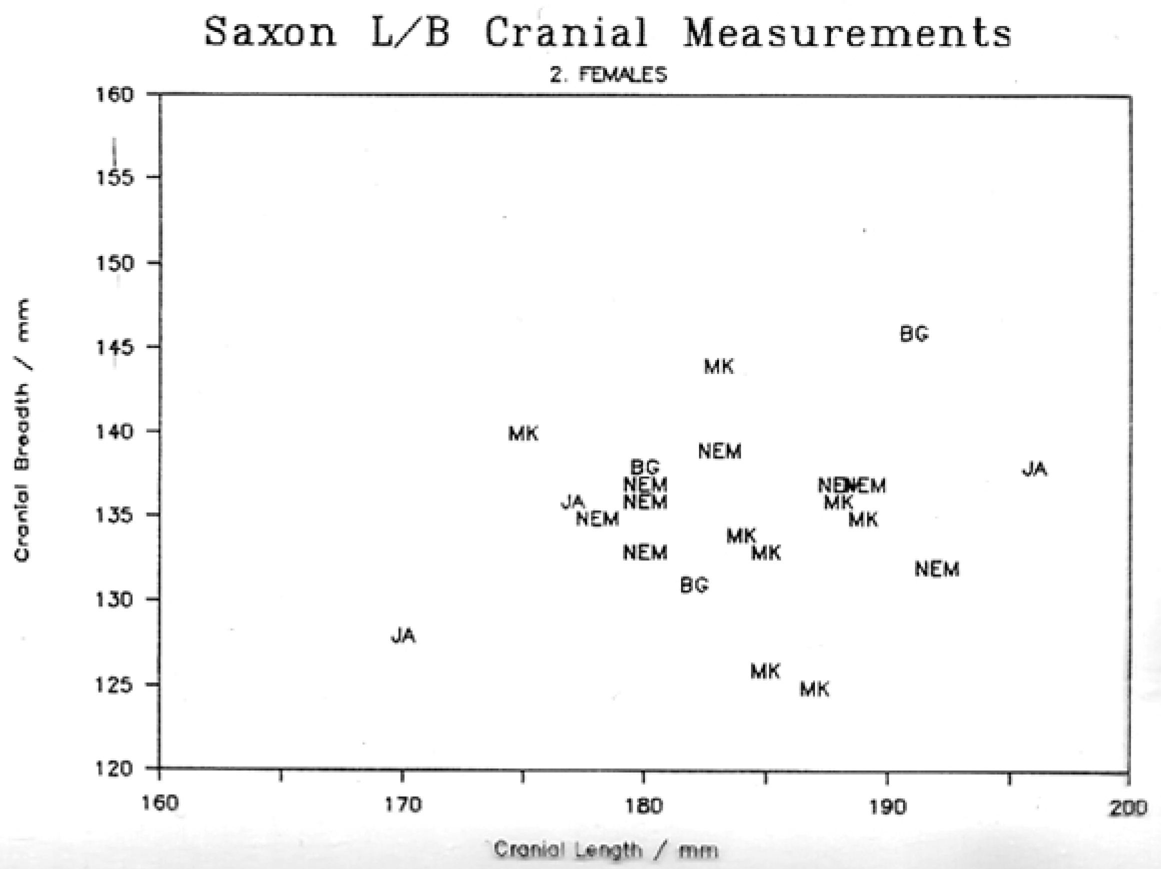




4.17b.

Scattergraphs of L/B cranial measurements (Medieval sites).





4.17c.

Scattergraphs of L/B cranial measurements (Saxon sites).

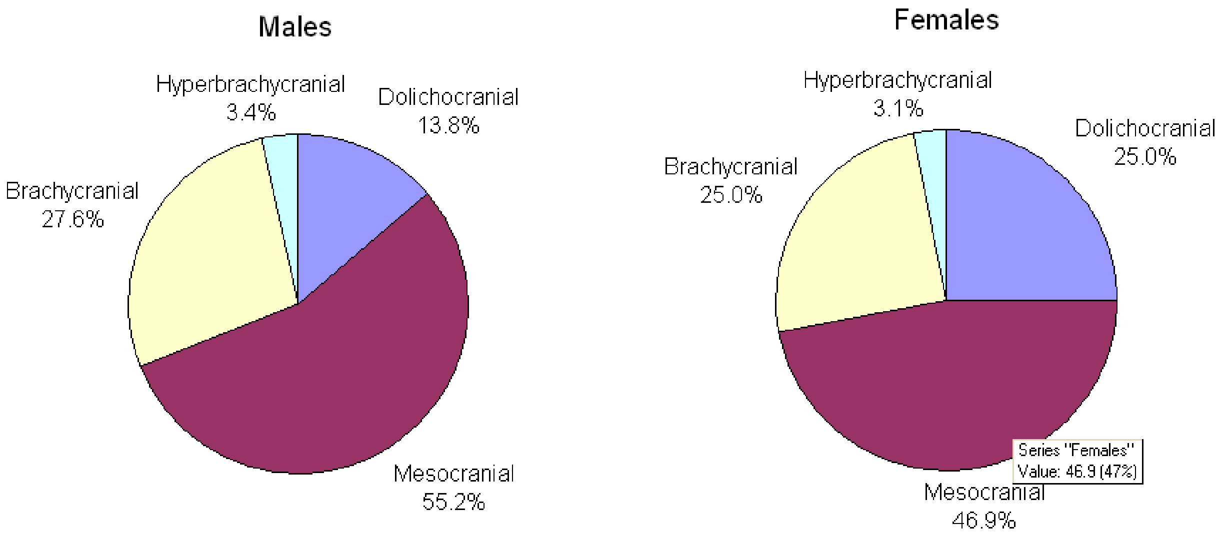


Figure 4.18. Cephalic index distribution at The Hirsel.

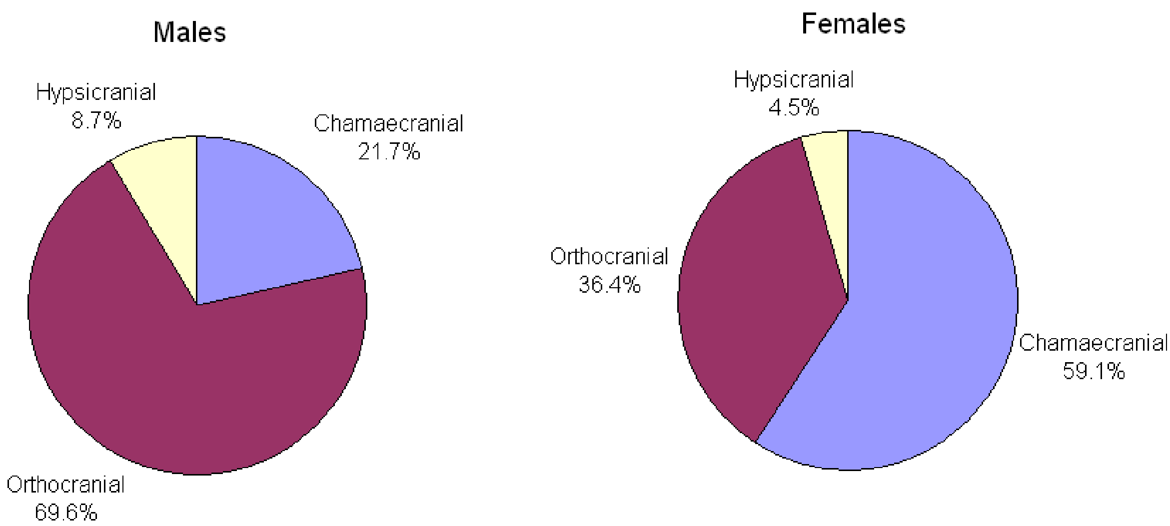


Figure 4.19. Height/length index at The Hirsel.

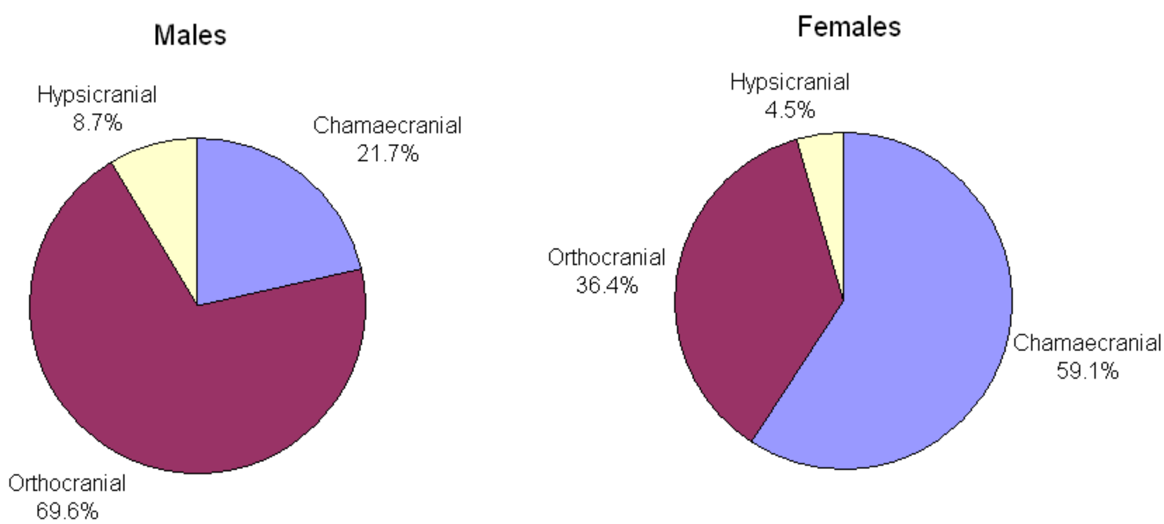


Figure 4.20. Height/breadth index at The Hirsel.

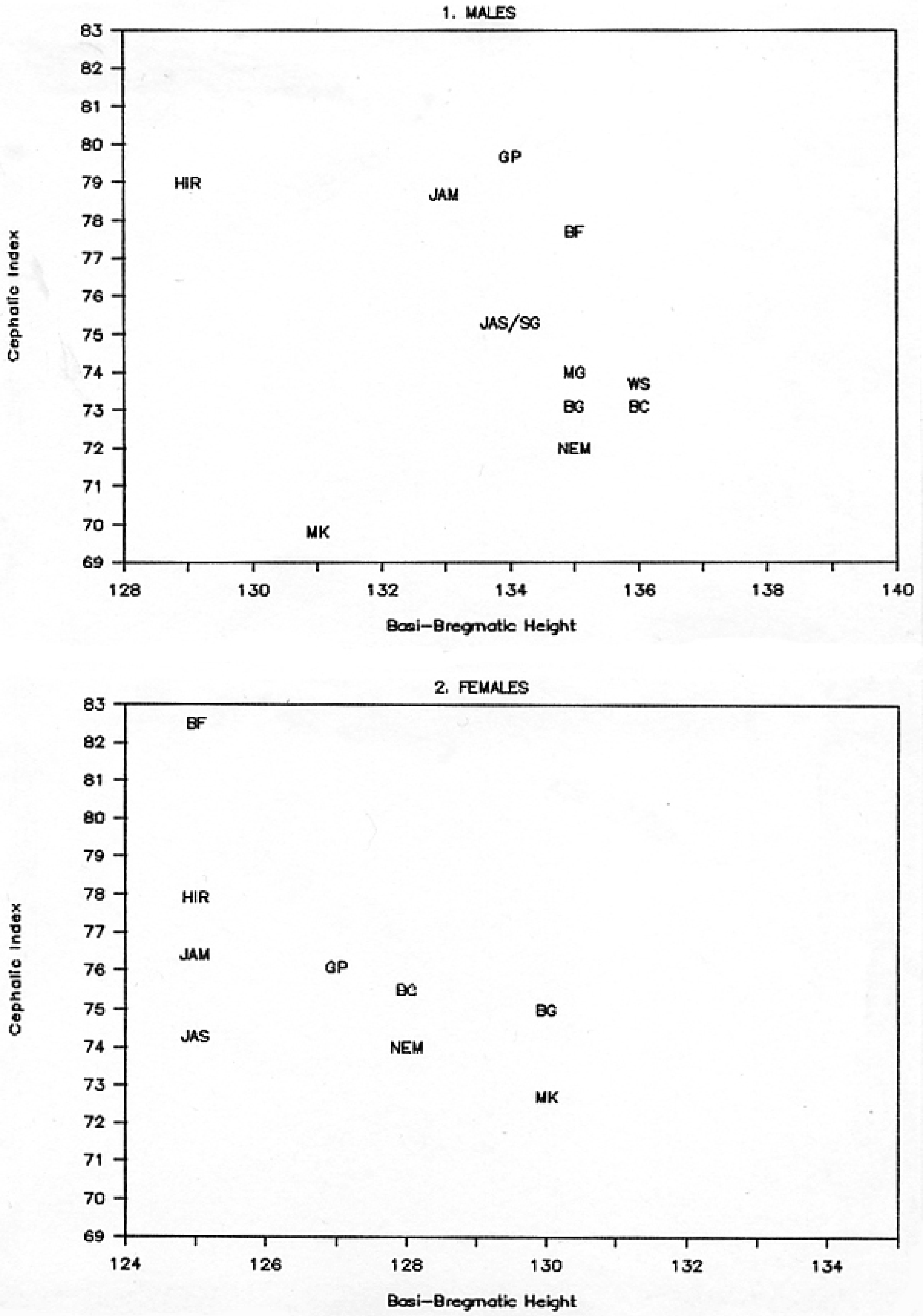


Figure 4.21. Cephalic index against vault height for various groups.

SECTION 5.
Non-Metric Traits

Non-metric, discontinuous, or discrete, traits are anomalies in the normal anatomy of the skeleton. They are not measurable and are simply recorded on a present or absent basis. In most cases they are thought to have a genetic origin, and for this reason a reasonable amount of attention has been devoted to them in the hope that relationships both within and between groups might be postulated.

Although these features are usually fairly obvious to the observer of the skeletal remains (although some can be easily overlooked if a systematic approach to their study is not adopted), the original owner of the bones would not have been aware of the majority of such 'abnormalities'. They are not generally considered to be pathological in origin, although in the case of some sutural variations, such as the presence of wormian bones, it has been thought possible that cultural practices may play some part in their appearance.

The traits most commonly noted in most archaeological bone reports are those which are found on the skull. This is probably because more time and effort has been devoted to their study in the past, and consequently more documentation is available on them. However, a few traits have been recorded in the post cranial skeleton, and these, together with some cranial traits, are summarised by Brothwell (1981).

5.1. Methods and Problems

The most notable work carried out in this field in recent years has been that by Berry and Berry (1967) on the various traits of the cranium. This paper brings together the most important and frequently occurring discrete cranial traits and describes them in detail. It also looks at the genetic inheritance of such traits as compared with a similar study carried out on the skeletons of mice. Traits were recorded in various populations from Egypt, America, the Far East and Palestine, and multivariate statistical analyses were carried out to establish distances between the groups. The Egyptians appeared to be stable through the ages, but were distinct from the Palestinians for example. Since the study gave good results as far as distinguishing between groups was concerned, and because no difference was found in sex and age (although juveniles were not considered), the authors suggest that the use of such traits is superior to the use of metrical data in the reflection of genetic differences.

Since Berry and Berry made this statement, a number of other workers have looked at the inter-relationship between cranial metric and non-metric variation. Pietrusewsky (1978) studied some early metal age crania from Thailand, and found that there was a difference between the groupings based on each of the two methods, although some similarities also occurred. He suggests that this difference may be caused by the tendency for craniometric data to reflect size rather than genetic variation.

Corruccini (1974, 1976) tested the relationship between non-metric and metric characters and found statistically significant associations between them. However, as he says, 'It is impossible to infer causation from correlation statistics alone. Either variation may be the impetus for variation in the other, or they may be functionally independent but both dependent on another, unrecorded stimulus.' (1976:291). He also found significant age and sex differences between traits studied in the Terry collection. In the white group, 19 out of 61 traits differed significantly by sex in a chi-square test, and the age differences were of a similar magnitude, although affecting different traits. Berry and Berry, as mentioned above, did not find any differences between the sexes. Corruccini attributes this to the fact that they combined their population groups to test sexual divergence, and states 'if different sexes must be separated to test population differences, it is obligatory to separate different populations to test sex differences' (1974:428). Although he says that discrete as well as metric traits seem to be determined genetically, he claims that at present this is untestable in man (although good results have been obtained from work on rodents, e.g. Berry, 1968). However, he does not mention the fact that the genetic component of metrical characteristics is also largely unknown, and although he suggests that there are age differences in the appearance of traits, this is also true of metric traits, and these are not separated into age groups in population studies.

Rightmire (1976) studied metric and discrete traits in African skulls. He used multivariate statistics and found a better correlation between the expected group separations and metrical characters than with non-metric characters. He therefore disagreed with Berry and Berry's conclusion that discrete traits were a better indicator of population divergence than measured characteristics. However, he does say that 'for the most part, unfortunately, one has little grasp of the meaning of the results obtained; samples of widely divergent groups of man are shown to be different, and that is not unexpected' (1976:385).

Carpenter (1976), like Corruccini, carried out a study of metric and non-metric traits in the Terry collection, based on 317 crania. He claims that non-metric traits are actually more difficult to score than metric, which at variance with the Berrys' statement to the opposite effect. He found that metric variables were significant sex and race discriminators, and non-metrics were slightly significant for age. Like Corruccini, he concludes that non-metric characters should be used as a supplement to other observations rather than alone.

The study by Molto (1979) would seem to confirm Carpenter's contention that non-metric features are difficult to score. He looked at intraobserver error by scoring the same skeletal group twice with a two-year interval. Although he found that 8 traits had unacceptable levels of recording error, 80% of his traits actually had a correlation of 0.9 or more between the two scoring sessions. However, if the 8 unacceptable traits are included when looking at mean measures of divergence, then groups expected to be biologically close are shown to be dissimilar, whereas if they are excluded the groups have 'more meaningful and consistent relationships' (1979:340).

Berry (1979) admitted that 'there is undoubtedly a fair amount of subjectivity in the scoring of some variants' (1979:675), and that it would be useful to have agreed criteria for the classification of all variants. However, he does not seem to think that this is necessary with data collected and used by a single worker. Since Molto found that there was a greater divergence in results obtained over long periods of scoring various series, it is probably just as important for individuals to consider their scoring criteria before they begin an analysis. As Berry suggests, a workshop of active workers would be useful to establish a widely agreed scheme.

Molto (1985) looked at Berry and Berry's contention that non-metric traits are unrelated to each other and can therefore be used in distancing techniques. He concluded that 'intercorrelations between discontinuous traits, while low, seem strong enough to influence biological distance coefficients and their significance levels' (1985:64). He recommends that samples of more than 300 crania should be used to detect intertrait correlation, that this should be determined separately for males and females, and that if this is impossible due to small sample size, then the use of accessory ossicles should be avoided because of their high intercorrelation. However, he does not attempt to suggest causes for this intercorrelation, and it may be that if traits are intercorrelated it is because a fairly small gene pool exists within a population. If this is the case, these traits may actually be more useful for assessing population differences than Molto's study implies.

Other workers have considered the significance of sex, age, race, size and shape, and skeletal side in the study of non-metric traits. Cheverud et al (1979) suggest that size can have an effect on the presence or absence of a non-metric trait. They feel that the correlations between metric and non-metric characteristics 'are largely determined by the growth and development of the soft tissue and functional spaces of the cranium' (1979:196). Because of this, they suggest that there is no biological reason to favour either type of trait in population studies, and that both kinds of trait should be used whenever possible.

Hertzog (1968) found associations between various non-metric variants in adjacent regions of the skull, although there was considerable racial variation in this. Such associations seem to suggest some correlation with the form, and possibly the size, of the skull. Benfer (1970) tested these associations by multivariate analysis, however, and found that three of the traits were largely independent of each other.

Berry (1975) studied non-metric traits in 186 crania of known age, sex and date of birth from St. Brides, London, following Corruccini's criticisms of Berry and Berry's 1967 paper. She found few sex differences, and those that were present were different in various populations. Age dependency was only found in one trait (Hschke's foramen), and other factors such as year of birth, presence of rickets, and spina bifida occulta showed little influence on the incidence of variants. Family studies unfortunately proved inconclusive due to the small number of related individuals who could be identified.

Bilateral traits have been studied for correlation between sides of the skeleton by various authors. Trinkaus (1978) showed that asymmetry of bilateral non-metric traits is not rare. He concluded from this that environmental factors (nutrition, climate, biomechanical stress) are relatively important in controlling the appearance of such traits, since if the traits are strictly under genetic control both sides should be affected equally. However, Perizonius (1979b) claims that since Trinkaus only counted symmetrical positive scores as symmetry, and neglected bilateral symmetrical absence, his conclusion that asymmetry is common can be discounted.

Green *et al* (1979) tested 16 traits for bilateral correlation in the crania of prehistoric Californian Indians. They found fairly good correlations between sides, although tests for differences between side frequencies showed significant difference in 5 out of the 16 traits. They consider three methods of recording bilateral traits: firstly to count the total number of times the trait occurs on either side and divide by the observable number of sides; secondly to record the trait as present if it occurs on one or both sides of the skull, even if the skull is damaged and only one side is available, and divide by the number of observable skulls rather than sides; thirdly to consider one side only. They recommend use of the first method since it will provide the most accurate estimate of trait frequency.

Korey (1980) considers that the second method suggested by Green et al is the best, although he recommends the exclusion of unpaired sides. To support this, he studied a single cranial trait, the supraorbital foramen, and reported on its bilateral and unilateral incidence. He found no difference between the sexes, but there was an increase of unilateralism with age. This, he felt, was in support of the use of cranial sampling rather than sampling by side, because age would introduce a bias into the latter. However, he also says that we are left with 'a disagreeable choice between a sampling strategem which almost certainly introduces genetically extraneous information and one which risks excluding genetically salient information' (1980:22). He advocates sampling by crania to mask these effects.

Ossenberg (1981) looked at two bilateral traits, the absence of the third mandibular molar and the mylohyoid bridge, and concluded that 'computing the frequency of a discrete trait on the basis of total left and right sides quantifies the genetic potential in the population better than does the individual count' (1981:478). She admits that there is a problem with this method because of artificial inflation of sample size, and advocates calculating the frequency in total sides n but entering n/2 in the distance formula.

Cosseddu *et al* (1979) looked at both sex and side differences in non-metric variants in a group of Sardinian skulls. Their results, using the mean measure of divergence, suggested almost no difference between the sides or the sexes, and any that did exist were always non-significant.

Perizonius (1979a) looked at sex and age differences based on 49 discrete traits in 254 Amsterdam crania of known age and sex. Although sex difference occurred for some traits (16%), age difference was non-existent. Recalculation of Corruccini's figures for the Europeans of the Terry collection, based on the suggestion that his chi-square values for bilateral traits were twice as high as they should be, resulted in a sex difference of only 8%, rather than the 31% of the original paper.

Ossenberg (1976) points out that archaeological samples are unfortunately often small, and that 'error in very small male and female subsamples may be greater than the distortion due to sex component in pooled samples' (1976:705). She found high correlations between sex in three large samples, and states that pooled samples will probably not be greatly distorted by a component due to sex.

Riggs and Perzigian (1977) found only 5 out of 27 traits significantly associated with sex in two American Indian groups, and only one trait was significantly associated by side. Saunders (1978) found that on a grouped-trait basis side differences are minimal for most traits, and, like Korey, that recording trait presence by side may tend to exaggerate age differences in unilaterality and bilaterality. He also found significant multivariate distances between age and sex, and that 'excess' bone traits are more common on the right side, more common in males and generally increase in frequency with age.

Berry (1968) presented a statistic for the comparison of non-metric characteristics between populations. This has been modified by later authors (e.g. SjPvold, 1973; Green and Suchey, 1976; Finnegan and Cooprider, 1978), and is most useful for large population groups and high trait frequencies. Finnegan and Cooprider tested a number of variations on the original statistic and concluded that there was very little difference between them in terms of results obtained.

Kaul *et al* (1979) used the mean measure of divergence suggested by Berry in a study of four populations from India. They found that the statistic yielded good results for the most racially divergent groups, but that related groups were arranged 'in a curious pattern'. They state that this is 'rather the opposite of the typical situation with non-metric skeletal analysis, where local demes are often well-separated while continental racial populations appear illogically related' (1979:697).

Strouhal and Jungwirth (1979) used a graphical method to determine the divergence of some late Roman-Early Byzantine cemeteries at Sayala in Egyptian Nubia. They obtained satisfactory results using non-metric traits to test biological difference, but state that the measure of divergence would have to be used to test significance of the results.

A.C. Berry (1974) studied the population movements of Scandinavians by non-metric cranial traits. She found that estimates of divergence generally accord well with population movements accepted by history and language study. Schreiner's calculations of the Coefficient of Racial Likeness in Norwegian skulls (based on metrical analysis) were little correlated with the estimates of divergence found by Berry, whereas work on blood groups has suggested a similar pattern to hers. She therefore concluded that the non-metric method is a useful aid in the study of population movements.

Most of the above studies have been based on cranial traits. A few workers (e.g. Anderson, 1968) have studied and described post-cranial traits, but there has been little or no attempt to use these in the same way as cranial traits. It seems that anthropologists are still suffering from overemphasis of cranial traits in this particular branch of the field.

Despite the suggestions of Corruccini and a few others to the contrary, it seems that non-metric traits can yield useful results in terms of biological distancing studies. Whether they are better than metrical traits in this respect really depends on their genetic affinity, and more work needs to be carried out on this aspect before any conclusions can be reached. Until this is possible, it is probably best to consider both metric and non-metric features of the skeleton whenever possible, since both have obvious advantages and disadvantages in almost equal proportions.

5.2. Studies of Specific Traits

There is a vast number of papers on the subject of particular non-metrical characteristics of the skeleton, many of which date to the last century or the early part of the present one. Many of these dealt with the more obvious traits, such as wormian bones, torus palatinus and tori mandibulares. A small selection of the available literature will be reviewed here in order to give a cross-section of the sort of work done.

Perhaps the most well-known anatomical variant is the wormian bone. These small sutural ossicles are so common in many populations that they cannot really be called abnormalities, since more individuals are found with them than without. Early studies (e.g. Hess, 1946; Torgersen, 1951) suggested that the presence of these ossicles was highly correlated with the retention of the frontal suture (see below) and asymmetry of the skull. Hess quoted a number of pathological conditions in which the bones were found, such as hydrocephaly and chondrodysplasia. Since many of these diseases involve disorders of bone growth it is perhaps not surprising that wormian bones should be seen frequently in the skulls of affected individuals.

Bennett (1965) disagrees with Hess and Torgersen concerning the association of wormian bones with metopism and cranial asymmetry. He suggests that they are caused by some form of physical stress in the late foetal and early perinatal periods, with genetics also playing some, unknown, role.

El-Najjar and Dawson (1977) studied the effect of the cultural practice of cranial deformation on the wormian bones in the lambdoid suture. They found non-significant differences in the incidence of wormian bones between deformed and undeformed skulls, suggesting that stress is not a major factor in their formation. They also found that 11.3% of the foetal skulls studied had wormian bones, from which they postulated that artificial cranial deformation and stress have little effect on the presence or absence of ossicles, and that there is probably a high genetic component in their formation. However, they found that artificial deformation does appear to influence the number of bones present in the lambdoid suture, if not the actual predisposition to their formation.

Gottlieb (1978) came to a similar conclusion in his study of artificial cranial deformation. He suggests that deformation has a direct effect of increasing the complexity of the pars lambdica of the lambdoid suture, and of increasing the number of wormian bones if they are present at all. From this he proposed a genetic cum environmental causation of wormian bones, with stress influencing their appearance, but with an underlying genetic predisposition.

Johnson *et al* (1965) looked at the Mandibular torus, a bony exostosis on the lingual surface of the mandible. From a study on a living population, they found that there was a less than one in 100,000 chance that the trait is not familial. They also found a greater incidence in females, with a sex ratio of males to females of 70:100. From this study, there does not appear to be any doubt of the genetic association of this trait.

Wells (1974d) studied over 100 skeletons from Iona, the great majority of which were female and probably a conventual population. Parts of 25 mandibles survived from this population, and all 25 had well-marked tori either unilaterally or bilaterally. A hundred-percent incidence of mandibular tori is completely unknown anywhere else in the world. The normal frequency for a European population is in the region of 1-5%. Wells suggests that the Iona group represents a closely inbred enclave, or a group drawing on a fairly restricted gene pool. The possible arrival of Eskimos (for which there is some literary evidence) and the introduction of a dominant gene for torus mandibularis is one theory which could be considered to explain this phenomenon. If this were the case, then the usefulness of this trait at least in the estimation of biological distance can be seen.

Sellevold (1980) considered the mandibular torus in two populations from Greenland, a medieval Norse series and a group of 14th-17th century Eskimos. Both populations had high frequencies of the trait, but tori occurring in the Norse population were larger. This argues against masticatory stress causing the torus, since the Norsemen probably had a softer diet than the Eskimos, and no correlation has been found between dental attrition and the degree of torus development. He concludes that ‘while the role of the environment cannot be disregarded as a factor in determining the presence of the trait, the present results indicate that genetic factors play a major role in determining the morphology of the mandibular torus' (1980:572).

Another type of torus, the torus auditivus, has been studied by Mann (1986). He states that two types of tori are found around the auditory meatus, one being a superficial, lobulated osteoma, and the other being a fairly large exostosis deep inside the meatus. This latter is explained as a consequence of swimming in cold water, but it is the former which is usually recorded as a non-metric trait. Mann claims that it is simply a benign tumour 'with some hereditary factors in its formation'. It is possible that this feature cannot be regarded as a non-metric characteristic in the truest sense, since it is extremely rare in most European populations, suggesting that if it has any genetic component then this is fairly small.

A few post-cranial traits have been identified (Brothwell, 1981), but there does not seem to have been a great deal of time devoted to their study. Saunders and Popovich (1978) looked at a vertebral trait, atlas bridging, and found good evidence for its heritability in Canadian families. Barkley (1978) considered vertebral arch defects in ancient Egyptians, including spondylolysis (separation of the vertebral arch from the body, which may be environmentally determined), which seemed to have a high incidence in one of the populations.

The humerus has also attracted some attention. Benfer and McKern (1966) studied the correlation of the septal aperture with bone robusticity. They found a slight correlation between the minimum midshaft diameter of robust bones and the absence of septal aperture. The trait was found to be slightly more common in women.

Cavicchi *et al* (1978) also studied the septal aperture and its relationship with humeral and ulnar measurements. Their work suggests a greater incidence of the trait in males than in females (exactly the opposite conclusion to Benfer and McKern), a difference between sides, and a negative correlation between humerus size and presence of the trait. They suggest a genetic association for the trait, since it does not seem to be dependent on robustness in their study.
The above review does not claim to be comprehensive; it merely covers some of the major traits observed in the present study. Other cranial and post-cranial traits are listed in Berry and Berry (1967), and Brothwell (1981), where short descriptions and location diagrams can be found.

5.3. Traits recorded in the Study Populations

Ossenberg (1976) states that c.200 variants have been identified on the human skull, some of which are of dubious value. Obviously it would be impossible to consider all of these in the analysis of a skeletal population, even if one could remember what they all are. The decision as to which ones to use is largely arbitrary. Many workers follow Berry and Berry's (1967) 30 traits, but others opt for a shorter list based on these or Brothwell's. Ossenberg suggests a new list, but these were chosen for use in a comparison study of American Indians, Eskimos and Negroes, and they are not necessarily the correct group of traits for consideration of a European population.

A list, decided upon basically for ease of recording over large skeletal series, consisting of 19 non-metric traits was used in the study of most of the groups considered here. Occasionally other traits were recorded, and the list has grown through time to encompass 26 traits which are now scored during the analysis of a population. Unfortunately, since some of these were not scored in some of the first groups to be analysed, and since the list of traits chosen by Wells for the Jarrow and Monkwearmouth groups were very different, comparisons between the groups has been difficult. This only serves to emphasise the need for a workshop to decide upon a standard group of 20 or more traits which should be scored in every population, if only to allow realistic comparisons within and between workers.

The 19 traits, with abbreviations for use in the following section, scored in all the groups in this study (except Jarrow and Norton) are as follows:

Persistence of the metopic suture (metopism)	M
Presence of parietal foramina	PF
Wormian bones: coronal suture	CW
sagittal suture	SW
lambdoid suture	LW
Epipteric bone(s)	EB
Parietal notch bone(s)	PN
Inca bone (may be bi- or tri-partite)	IB
Asterionic bones	AB
Torus palatinus	TP
Maxillary tori	MT
Mandibular tori	TM

Torus auditivus	TA
Double hypoglossal canal	DHC
Post-condylar canal	PCC
Septal aperture of humerus	SA
Third trochanter of femur	TT
Atlas double condylar facet	ADF
Acetabular crease (innominate)	AC

Other traits scored in some populations include: precondylar tubercle (PCT), double occipital condylar facet (DCF), six sacral segments (6S), sacralisation of the L5 vertebra (SL5), Poirier's facet and/or plaque formation (PF1/2) at the head of the femur (not always easy to distinguish from each other), and multiple mental foramina of the mandible (MMF). Some traits were only seen (and therefore scored) in one population. For example, though not really a part of this study, the squameparietal ossicle was only observed in the Burgh Castle group. In general, foramina on the base of the skull were not scored because of the difficulty of locating them from drawings.

5.4. Non-Metric Traits in the Study Populations

5.4.1. Between-group Study

Table 5.1 below gives the actual figures and percentages for all traits scored at each site for combined sexes. The abbreviations for traits are given in Section 5.3 above

The figures given in Table 5.1 are not divided into sexes because, like Perizonius and others mentioned above, the present author has found no great difference in the incidence of traits between male and female skeletons. Frequencies of non-metric variants from The Hirsel, Blackgate and Guisborough were tested for significant difference between sexes using the chi-square statistic published by Perizonius (1979) and Green et al (1979). At The Hirsel only three of the 19 traits (15.8%) showed a significant difference at the 5% level, none being significantly different at the 1% level. At Blackgate only one (parietal foramen) of the 23 traits (4.3%) was significant, and at Guisborough 3 out of 27 (11.1%) were affected, all of which were post-cranial (atlas double condylar facet, septal aperture, plaque formation at the femoral head). Perizonius found a similar percentage difference to that calculated for The Hirsel (16%), and concluded that sex was not a major discriminator in non-metric features. The traits found to be different at The Hirsel were the parietal notch bone, the double hypoglossal canal and the septal aperture of the humerus. Neither of the first two were significant in Perizonius' study, and he did not consider the third. This last has been found to be significant in other populations, however, and as mentioned previously (Section 5.2) it does seem to have some correlation with sex and robusticity. The trait does show a large difference in incidence in the populations studied here, though, ranging from 3.6% at Blackfriars to 46.7% at Norton. It is thus a more useful discriminator of population groups than of sex, and it is probably valid to use it in the combined sex incidence.

Table 5.1 presents the actual data from each site, but it is limited in its usefulness since it does not allow for ease of comparison between traits and populations. Figure 5.1 shows the results graphically by plotting the mean percentages of each trait for each site (except Jarrow). It can be seen that for each trait the sites vary in their relative position and distance from each other. The Mean Measure of Divergence statistic used by Berry and Berry (1967) and subsequent workers solves this problem to some extent, and it was applied to five of the populations in this study plus Burgh Castle for this reason

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Trait	HIR	MK	JA	BG	NEM	BF	GP
M +	7/126	2/44	4/104	5/40	7/47	2/21	4/36
%	5.6	4.5	3.8	12.5	14.9	9.5	11.1
PF +	89/127	29/58	72/108	16/33		14/22	23/37
%	70.1	50.0	66.7	48.5		63.6	62.2
CW +	9/116	1/42	3/72	3/30	1/33	1/23	24/35
%	7.8	2.4	4.2	10.0	3.0	4.3	68.6
SW +	11/115	1/29	1/50	6/29	1/33	0/23	6/36
%	9.6	3.4	2.0	20.7	3.0	-	16.7
LW +	68/120	18/36	26/85	22/30	9/33	17/23	27/35
%	56.7	50.0	30.6	73.3	27.3	73.9	77.1
EB +	11/76	1/40	0/41	1/10	1/9	0/17	8/25
%	14.5	2.5	-	10.0	11.1	-	32.0
PN +	3/84	1/4		2/11		1/17	6/23
%	3.6	25.0		18.2		5.9	26.1
IB +	4/119	2/33	2/62	7/37	2/33	2/23	1/36
%	2.1	6.1	3.2	18.9	6.1	8.7	2.8
AB +	8/91	3/24	4/38	1/9		2/23	4/30
%	8.8	12.5	10.5	11.1		8.7	13.3
TP +	21/100	2/10		4/21	1/17	3/19	10/31
%	21.0	20.0		19.1	5.9	15.8	32.3
MT +	13/105	1/10		4/28		6/23	4/29
%	12.4	10.0		14.3		26.1	13.8
TM +	1/115	0/32		14/47	2/53	0/24	2/32
%	0.9	-		29.8	3.8	-	6.3
TA +	1/127	0/33		1/40	0/?	0/17	0/35
%	0.8	-		2.5	-	-	-
DHC +	18/74	3/24	15/111	11/27		7/21	8/26
%	24.3	12.5	13.5	40.7		33.3	30.8
PCC +	17/73	5/26	30/55	2/22		0/21	3/18
%	23.3	19.2	54.5	9.1		-	16.7
PCT +		1/25	4/100	4/29		1/21	2/24
%		4.0	4.0	13.8		4.8	8.3
DCF +			1/76	1/27		2/21	0/25
%			1.3	3.7		9.5	-
MMF +		1/52	4/174				
%		1.9	2.3				
SA +	5/111	6/56	16/188	10/54	21/45	1/28	3/26
%	4.5	10.7	8.5	18.5	46.7	3.6	11.5
TT +	16/113	14/46	44/159	20/55	7/47	12/30	7/26
%	14.2	30.4	27.7	36.4	14.9	40.0	26.9
ADF +	10/72	2/39		5/30		5/20	3/20
%	13.9	5.1		16.7		25.0	15.0
AC +	10/96		20/95	14/37	1/24	1/25	7/25
%	10.4		21.1	37.8	4.2	4.0	28.0
6S +		3/18		5/11		1/10	3/11
%		16.7		45.5		10.0	27.3
SL5 +				3/29			1/22
%				10.3			4.5
PF1 +						2/28	0/30
%						7.1	-
PF2 +						0/28	5/30
%						-	16.7

Table 5.1.

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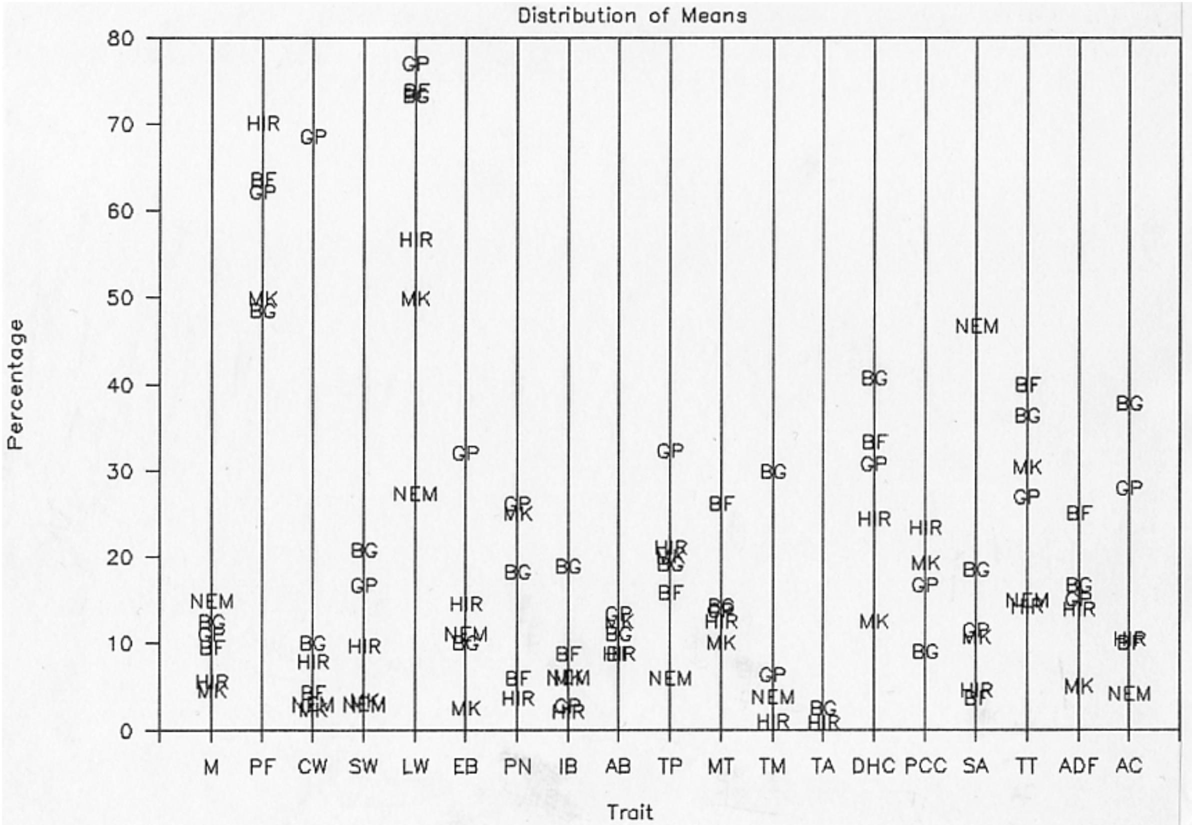


Figure 5.1. Distribution of means of trait scores.

Table 5.2 gives the results of this study (calculated from the formulae given by Thoma, 1981). The figures above the main diagonal are the mean measures of divergence, and those below are the variances. The closer the mean measure is to zero, the more alike the two populations are.

Site	HIR	BG	GP	BC	BF	MK
HIR		0.126	0.086	0.035	0.045	0.022
BG	0.005		-0.001	0.091	0.085	0.082
GP	0.005	0.008		0.087	0.110	0.061
BC	0.003	0.006	0.005		0.119	0.026
BF	0.006	0.009		0.008	0.006	0.020
MK	0.006	0.010	0.009	0.009	0.014	

Table 5.2.

The distances obtained by this method of biological differentiation are almost completely different to those obtained in the comparison of cranial measurements. For example, by this method The Hirsel and Monkwearmouth are the third closest groups, whereas in Figure 4.21 (cephalic index against vault height) they appeared to be at a large distance from each other. On the other hand, Burgh Castle and Blackgate, the two closest groups in the metrical study, are only the twelfth closest in the non-metric analysis. The non-metric analysis places Guisborough and

Blackgate at the smallest distance from each other, and this seems to be an unlikely pattern considering their dates and geographic locations. On the whole, the metric analysis seems to give a picture which is in all probability more correct for these populations.

An attempt is made to present these figures graphically in Figures 5.2 to 5.5. The scattergraphs are not really comparable with the one produced for metrical divergence owing to the nature of the mean measure of divergence. Sites are plotted at the meeting point of their two measures of divergence from the sites named on the axes. These were chosen with a view to testing relationships based on geographical distance, closest non-metric measure of divergence, and greatest distance from the metrical measure of biological distance. Although the results appear very different at first glance, it is apparent from closer inspection that Blackgate and Guisborough always occur close together (reflecting the small measure of divergence between the two) and that there are varying degrees of clustering between the other sites. It is very difficult to decide which of these pictures provides the best pattern of divergence between the sites, or even if this is a valid method of representing the data at all.

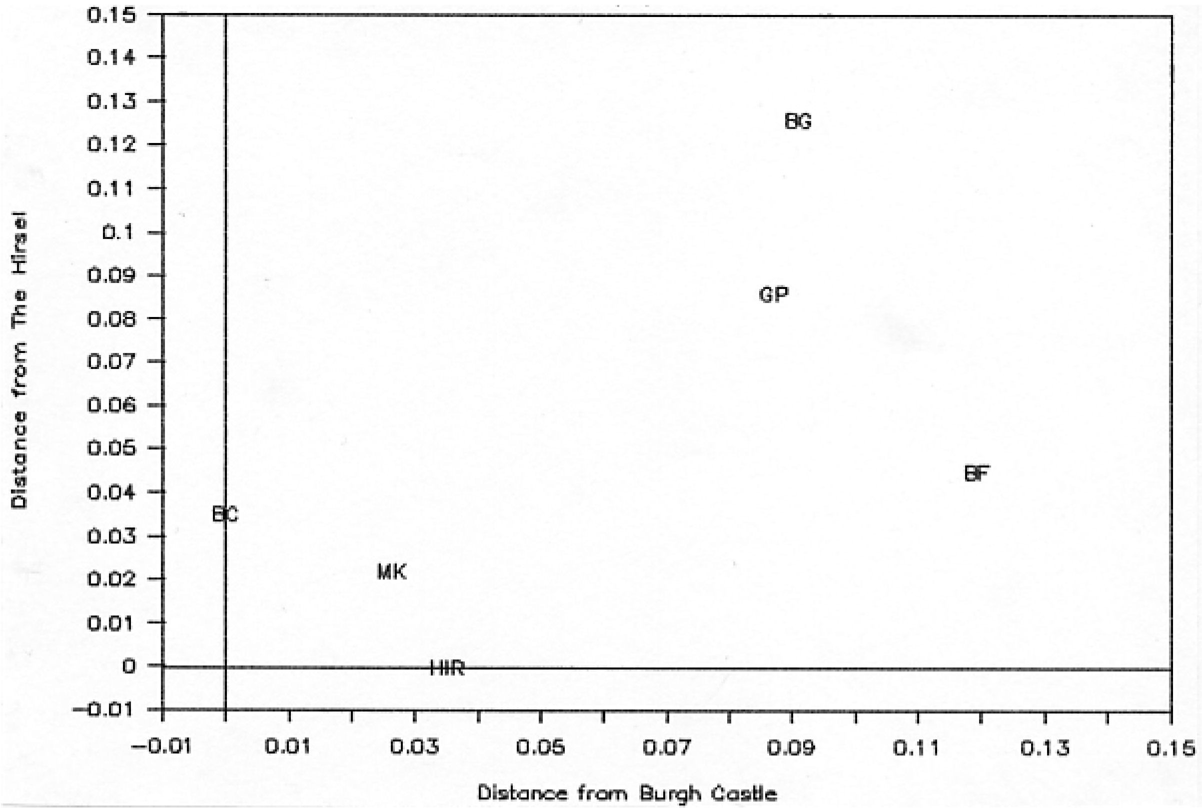


Figure 5.2. Biological distances: 1. greatest geographical distance.

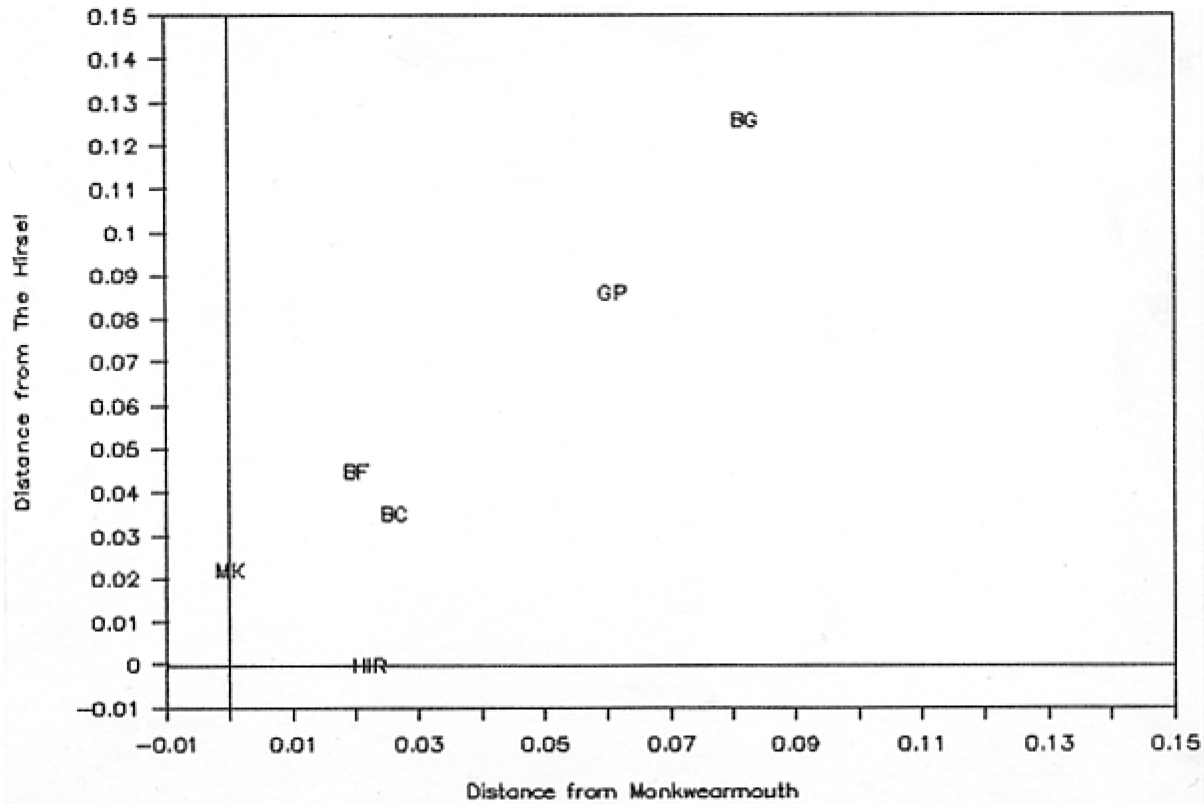


Figure 5.3. Biological distances: 2. greatest metrical distance.

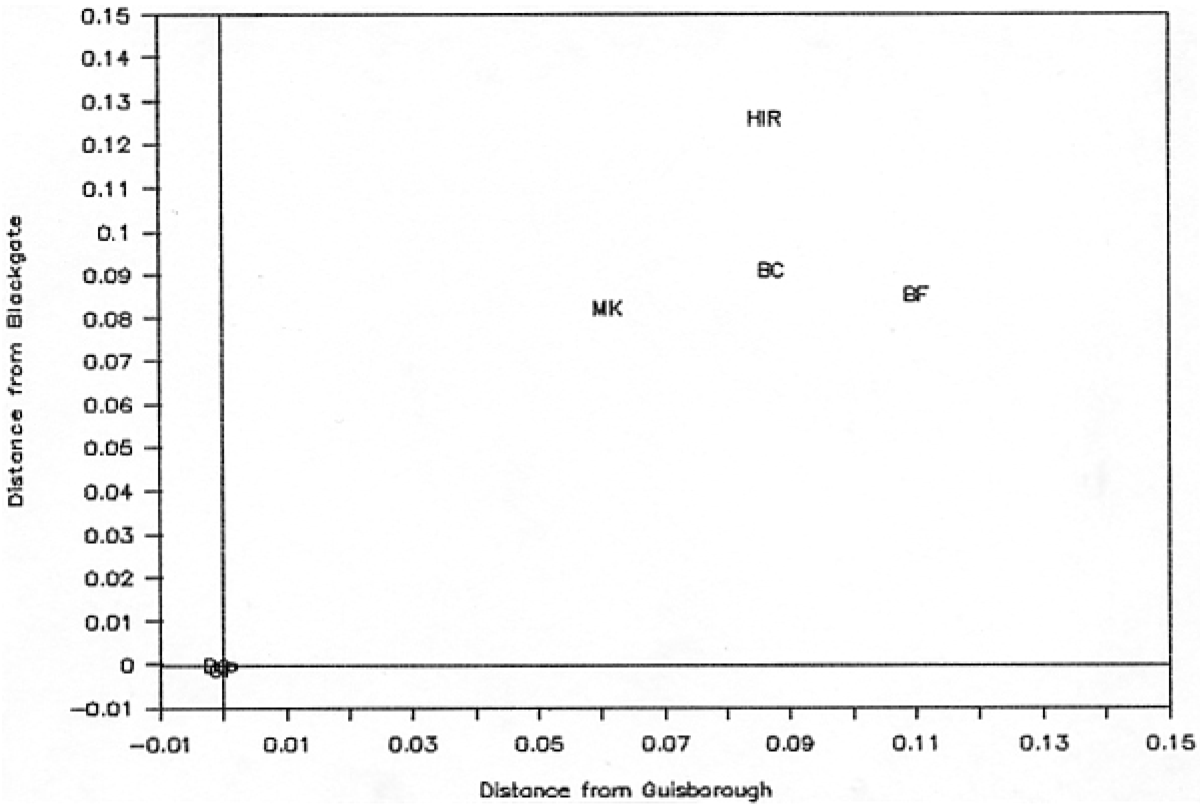


Figure 5.4. Biological distances: 3. least non-metrical distance.

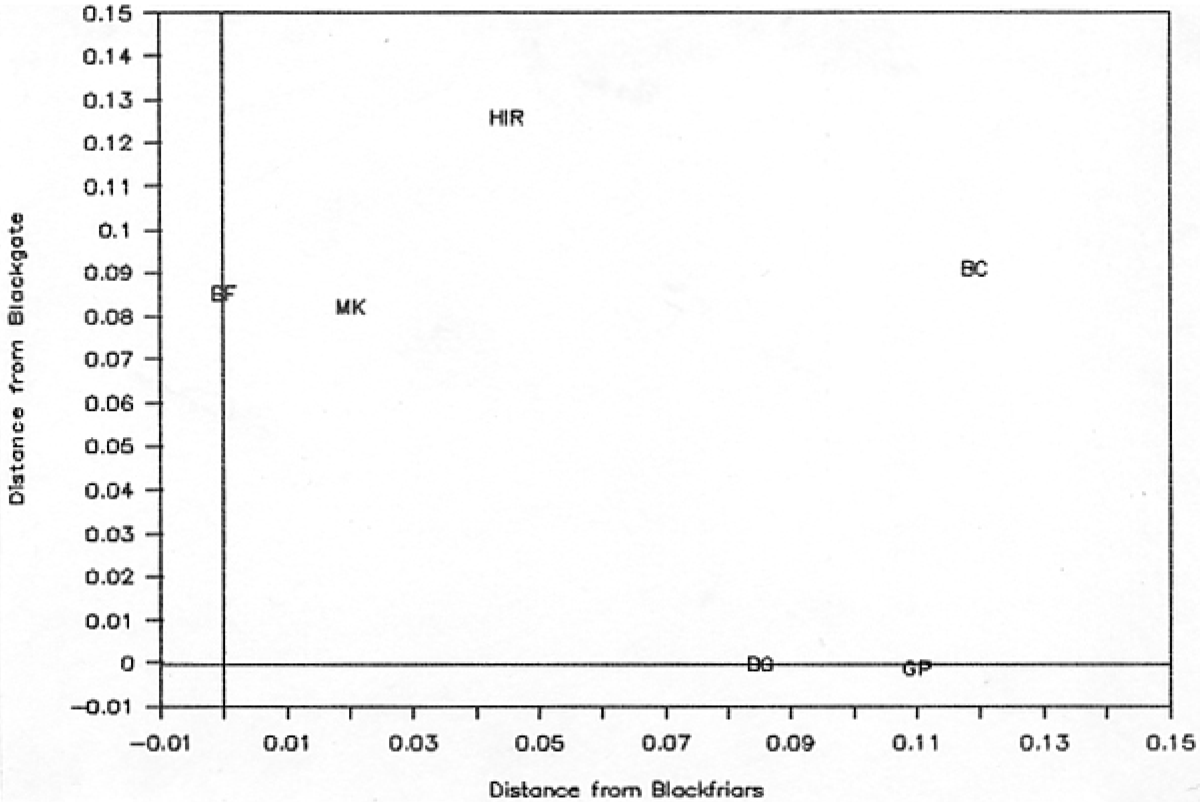


Figure 5.5. Biological distances: 4. least geographical distance.

Table 5.3 shows the non-metric traits which were significantly different between the populations used in the measure of divergence. The pairs of sites are numbered in order from least to greatest divergence as follows:

1. GP-BG
2. MK-BF
3. MK-HIR
4. MK-BC
5. BC-HIR
6. BF-HIR
7. MK-GP
8. MK-BG
9. BF-BG
10. GP-HIR
11. BC-GP
12. BC-BG
13. BF-GP
14. BF-BC
15. BG-HIR

	Site references (see above)															
Trait	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Tot.
PF					*					*					*	3
CW	*						*			*	*		*			5
SW								*	*				*			3
LW							*			*	*		*	*		5
EB				*		*	*			*			*	*		6
PN			*							*	*				*	4
IB															*	1
TM	*				*			*	*			*			*	6
DHC								*				*		*		3
PCC		*				*							*	*		4
SA															*	1
TT											*	*		*		4
ADF		*		*				*				*			*	4
AC					*				*	*			*	*	*	6
Total	2	2	1	2	3	2	3	4	3	6	4	4	6	6	7	55

Table 5.3.

The most divergent populations obviously have the greatest number of significantly different traits, although the trend is not completely linear. The most discriminatory traits, for these populations at least, appear to be the epipteric bone, the mandibular torus, the acetabular crease, the coronal wormian bone and, perhaps surprisingly given its prevalence in most groups, the lambdoid wormian bone. Five traits were not significant in any of the groupings. These were metopism, asterionic ossicle, torus palatinus, maxillary tori and torus auditivus. This is probably not surprising since the percentage frequencies of these traits at the sites concerned are not very different.

5.4.2. Within-group Study

Having considered inter-population variation in the study groups, it is useful to look at one other aspect of the use of non-metric traits, that of intra-population study. This involves the assumption that the traits are heritable, and that they can therefore suggest family relationships between buried individuals. There are three main problems with this approach to population studies. Firstly, in a poorly preserved series the plotting of traits on a site plan does not highlight the missing evidence where skulls or other important parts of the skeleton are missing. Secondly, a large number of children, for whom non-metric traits usually cannot be scored, will have a similar effect on plotting of traits. Thirdly, married women are probably more likely to be buried with their husband's family than with their own, and this may also provide anomalies in the plotted trait pattern. In practice, this last problem can be overcome if a large family group is thought to exist, since the females in a group will presumably pass on some of their features to their offspring. The problem comes when these offspring are buried elsewhere, or when a married couple are buried together but without the rest of their family. In these cases it is obviously impossible to show relationships.

Bearing in mind these caveats, it is possible to consider two of the sites in this study in more detail. The Hirsel has been chosen for this type of analysis because it is a large population in fair condition, and all the traits have been scored by the present author. Guisborough Priory was selected for comparison because although it is a fairly small section of a population, it is an extremely well-preserved group on the whole, it contains few children or unassessable adults, and it covers a small area of a priory church, where family groups might be expected to occur.

The results obtained from both these sites are presented in Figures 5.6 and 5.7. These show plans of the two sites with major trait groups plotted. Only the rarer traits were used in both cases, since characters such as wormian bones in the lambdoid suture occur in large sections of the adult burials at most sites, and cannot therefore be used alone to distinguish familial relationships. In these two cases, however, they have been used in conjunction with other traits.

Some interesting associations were seen at The Hirsel. For example, only two male individuals at this site were metopic (sks. 306 and 308), and these were buried at the middle of the south side of the church adjacent to each other and at similar levels. One female case of metopism was also buried to the south of the church (sk. 164), but at a greater distance than the two males. The burial was disturbed, which makes it even more difficult to suggest any association with the two males. Three other examples of metopism in females were located to the north side of the church, all at a fair distance from each other (sks. 62, 190 and 224).

Three possible family groups were seen at The Hirsel on the basis of various traits. These are as follows:

<u>Group 1</u>:

Sk. 94 - SW, TP, LW.
Sk. 93 - CW, DHC, LW.
Sk. 323 - SW, LW.
Sk. 325 - SW, DHC, PCC.
Sk. 96 - DHC, TP, PCC, LW.
Sk. 327 - LW.
?Sk. 65 - CW, EB, PCC.
?Sk. 44 - CW, EB.

Skeletons which could not be assessed for traits but which may belong to this group are numbers 64, 66, 95 and 324. Most of these burials respect the others and lie on a fairly similar orientation. They are on the north side of the church with few other interments close to them.

<u>Group 2</u>:

Sk. 321 - CW, DHC, LW.
Sk. 225 - LW.
Sk. 314 - LW.
Sk. 240 - EB, DHC, PCC, LW.
Sk. 239 - AB, DHC, PCC, LW.
Sk. 232 - PCC.
?Sk. 336 - LW.
?Sk. 293 - SW, LW.
?Sk. 338 - TP, LW

The most likely individuals to be genetically related from this group are numbers 321, 240, 239 and 232. The others may belong, but it is noticeable that all those with LW only are from the lowest levels of the group. A few children may also belong: 179, 248 and 249. Sk. 104, buried a few metres north of the group, may have some affinity with it, having the following traits: DHC, PCC and TP. The group is located at the west end of the church, and shows little respect for graves. Perhaps this is tentative evidence for a less wealthy family using a smaller patch of land for their burials. Considering the large areas of space available in this churchyard (especially to the west and north of the church), there does not seem to be any other reason than family plots for burying individuals in such a tightly packed group.

<u>Group 3</u>:

Sk. 199 - DHC, PCC, TP (cf. 104)
Sk. 186 - IB, TP, LW.
Sk. 200 - EB, TP, PCC.
Sk. 209 - PCC, TP.
Sk. 174 - PCC, TP, LW, PN.

There does seem to be a high concentration of torus palatinus in this small area of the churchyard, at the most south-easterly limit of the excavation. A few unassessable individuals may also belong: sks. 187, 261 and 201. The graves are all on the same orientation and only 187 cuts into one of the other graves (186), but at exactly the same orientation. Sk. 261 may have been disturbed by either 186 or 200 and may have nothing to do with the group.

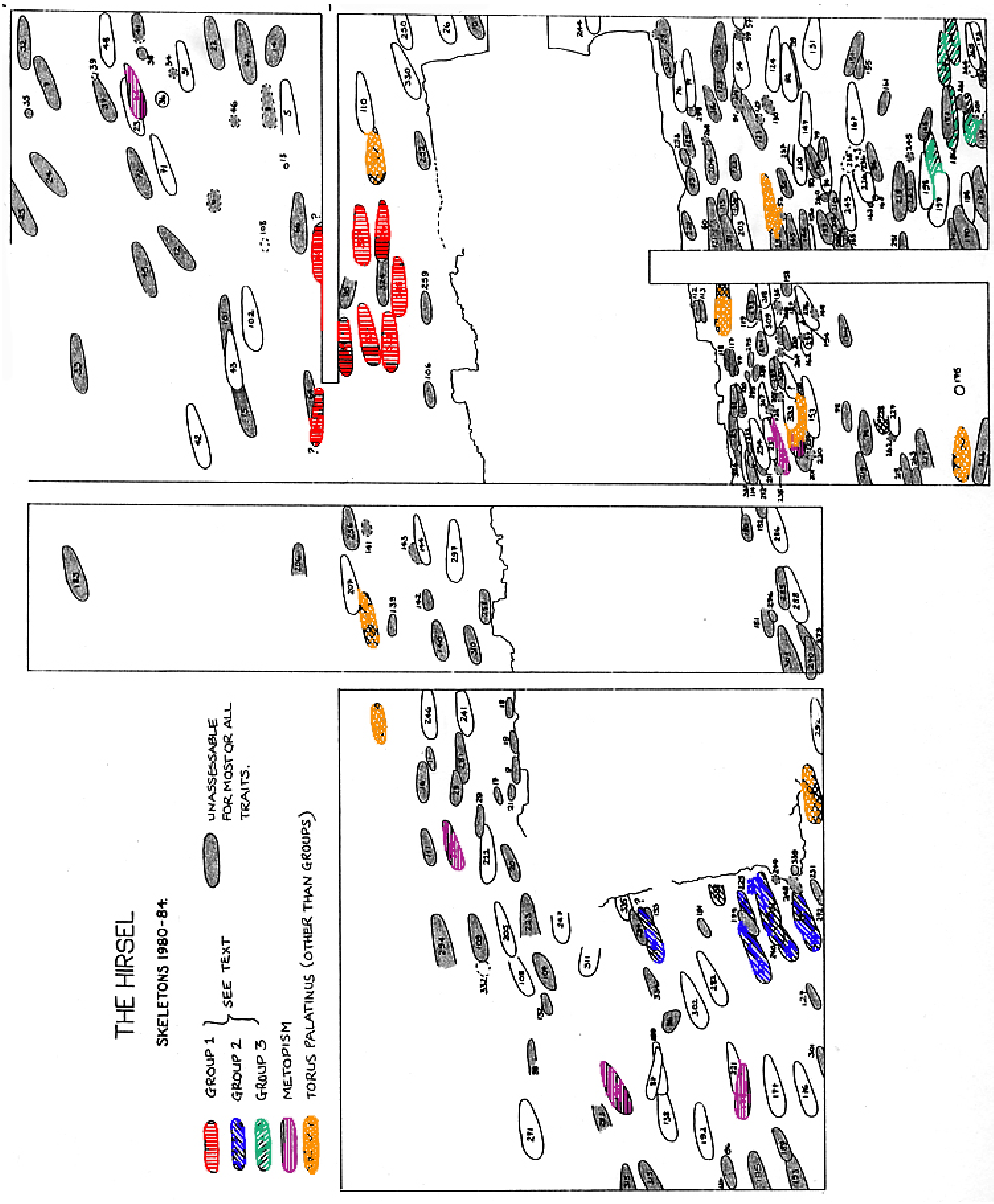


Figure 5.6. Non-metric traits at The Hirsel.

At Guisborough, the plotting of traits seemed to indicate an affinity between virtually all the assessable adults in the burial area, and it is possible that the remains represent a small inbreeding community or perhaps one large extended family. It is noticeable that a high level of extra-sutural bones of all types was found in this population than is usual in a medieval group.

Skeletons 3 and 4 (female and ?female) both had large pre-condylar tubercles with a canal running through the base. This is an unusual form of the trait, and it seems likely that the two women were related in some way, even though they were not buried particularly close together. This may be a case of burial separation due to marriage.

Certain family groups were suggested before the skeletal analysis was carried out. The mixed and greatly disturbed burials of sks. 1/9, 2, 4, 7 and 8 was thought to be such a group. From the non-metric traits, it seems possible that at least 1, 2 and 4 were related. Other groups which may have been closely related, based on the evidence of combined cranial and post-cranial traits, were as follows:

<u>Group 1</u>:	Sk. 14 - CW, LW, PF1, 6S.	
	Sk. 31 - CW, LW, PF1, 6S, AC.	
	Sk. 32 - CW, LW, AB, MT	
<u>Group 2</u>:	Sk. 3 - CW, SW, LW, DHC, PCT.	
	Sk. 5 - CW, SW, LW, M, AB, ADF, PF1.	Sub-Group I
	Sk. 27 - CW, SW, LW, DHC, PF1.	
	Sk. 1 - CW, LW, DHC, TP, AC.	
	Sk. 2 - CW, LW, TP.	Sub-Group II
	Sk. 4 - CW, LW, PCT, TP, MT.	
<u>Group 3</u>:	Sk. 34 - CW, AB, PN EB, TP.	Sub-Group I
	Sk. 35 - CW, EB.	
	Sk. 25 - CW, PN, TP.	Sub-Group II
	Sk. 36 - CW, SW, PN, ADF, TT, AC.	
	Sk. 42 - CW, LW, PN, AC.	
	Sk. 26 - CW, LW, PN, TP, AC, TT.	Sub-Group III
	Sk. 24 - CW, LW, DHC, PN, EB, TP, MT, ADF.	
<u>Group 4</u>:	Sk. 43 - SA.	
	Sk. 50 - LW, EB, SA, TT.	Sub-Group I
	Sk. 49 - CW, LW, DHC, SA, TT.	
	Sk. 28 - CW, LW, EB, TP, TM, 6S	Sub-Group II
	Sk. 30 - LW, EB, TP	

These four groups may have a lesser relationship with each other, and skeletons 37 (CW, LW, DHC, TP, TT) and 39 (CW, LW, DHC, PCC, M, TT) may also belong somewhere in this possible extended family. However, as stated by the present writer in the report on the Guisborough Priory skeletons (Anderson, forthcoming), 'it must be remembered...that any such "relationships" are entirely based on supposition - they cannot and must not be regarded as fact. They are merely shown here to suggest some evidence of possible interbreeding within this small population, which is also suggested by the high levels of certain of the rarer traits.' The estimated time span of burial at Guisborough (340 years) suggests an average burial rate (for this group) of one interment every seven years. This makes the possibility of establishing relationships between skeletons even less likely.

All of the evidence presented in this section should be treated with speculation and caution. Genetic affinity of all these traits is far from being proven, although in the majority it is very likely. At least some of the groupings noted at The Hirsel and Guisborough seem unlikely to have occurred by chance, but, as stated above, they must not regarded as factual relationships between what are after all only the last remains of once living people.

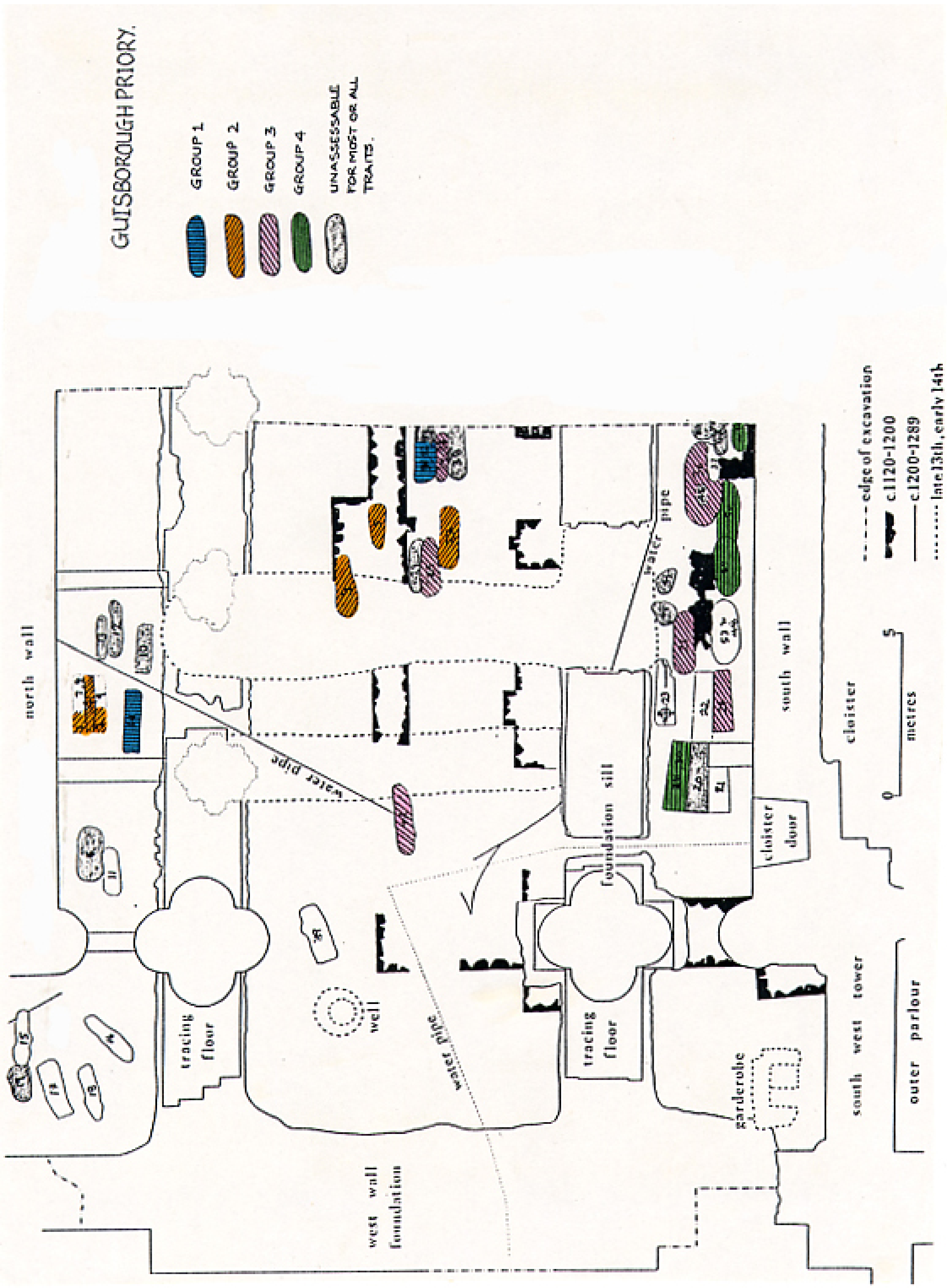


Figure 5.7. Non-metric traits at Guisborough.

SECTION 6.
Odontological Study

The study of the human dentition in archaeology can provide almost as much information about past populations as that of bones. Teeth can be studied under all the headings considered for skeletal material, but because of their equal importance they are generally accorded a separate section in skeletal reports. Information on age, sex, metrical and non-metrical variants, and pathology can all be gathered from dental study.

Since teeth have already been considered in the estimation of age (Section 3.1), and to a limited extent in the determination of sex (Section 3.2), only aspects of metrical and non-metrical characteristics and pathological processes will be considered here.

6.1. Dental Variation

6.1.1. Metrical Analysis

The two most common measurements to be taken on the teeth are the mesio-distal and bucco-lingual diameters (Hillson, 1986), although the odontometric points for these are not always easy to identify, especially on worn teeth. The two measurements, and their indices, can be used as a guide to overall tooth size within a population and, as mentioned previously, can be useful in sex determination.

Studies on mice, and twin studies, have suggested a strong genetic rather than environmental component in the determination of tooth size, although the extent of this is uncertain (Hillson, 1986). Obviously there is some correlation with disease and malnutrition, and it is possible that twin studies for example might be showing a pattern caused by shared prenatal environment rather than inheritance.

Population distancing has been attempted from odontometric studies. Lavelle (1973), for example, studied the difference between maxillary molars and premolars of different ethnic groups. He found that univariate statistics did not show a significant difference between groups, but that multivariate analysis proved useful in distinguishing between the main racial groups. He also noted a significant difference between the 19th century remains from St. Brides and the 16th-18th century group from Moorfields, and twenty Anglo-Saxons from Bidford-on-Avon. The last two, however, were very little removed from each other and from American Indian and West African groups.

Hillson (1986) reviews a number of studies on population distancing from tooth measurements based on various racial groups. He states that ‘by and large, dental measurements do not seem to be very efficient discriminators between populations’ (1986:243).

6.1.2. Non-metrical Analysis

Like cranial non-metric traits, dental variants are usually scored on a present or absent basis. They involve such variations as extra cusps, congenitally absent teeth, and general morphological differences.

A few traits have been considered in detail by various workers. For example, the presence of shovel-shaping of the maxillary incisors has often been studied in the past. Carbonell (1963) states that a high frequency of the trait is found in mongoloid races, and a low frequency occurs in caucasoid groups. She found that if the variant is present in the median incisor it is usually found in the lateral incisor to the same degree. Pronounced shovelling appears to be more frequent in females than males, although the actual prevalence of all degrees of the trait may be more common in males. At Westerhus, Sweden, for example, the trait occurred in 24.1% of females and 38.5% of males. Blanco and Chakraborty (1976) studied the trait in two Chilean groups, and concluded that 68% of the total variability of the trait can be ascribed to the additive effect of genes.

Congenital absence of teeth (hypodontia) was studied by Brothwell, Carbonell and Goose (1963). Complete hypodontia is rare, but absence of one or more teeth is not so uncommon. It may affect both the anterior and posterior teeth, or just one type of tooth in particular. The order of frequency of missing teeth is quoted as third molars, maxillary lateral incisors, second premolars, mandibular central incisors, and maxillary first premolars, with absence of other teeth occurring only very rarely. Heredity is stated to be the most important cause of hypodontia. The authors found the frequency of absence of the maxillary lateral incisors to be in general not greater than 2.5% in modern populations. Third molars vary in the frequency of absence from 0.2% to more than 25%, and this has increased through time.

Alexandersen (1963) studied Danish populations of the Neolithic and the Middle Ages for the presence of double rooted mandibular canines. In the Neolithic, the frequency of occurrence was 5.6%, and in the Medieval period it varied from 5.1% to 8.0%. Other European populations studied showed no significant difference from these figures.

Other traits are recorded by Hillson (1986). These include the number of lingual cusps on the premolars, the shape of the third molar (e.g. peg shape), the number of molar cusps, the presence of a Carabelli's cusp (a supernumerary cusp on the lingual surface of a molar), fissure shape in the lower molar crowns, and supernumerary teeth. These traits have various prevalences, but since many are not studied in a normal osteological analysis it is difficult to make comparisons between archaeological skeletal populations.

Hillson (1986) reviews some of the work done on population studies by dental traits. He concludes that dental morphology seems to be a useful method of examining biological distances in archaeological populations. He lists the advantages as being the generally good preservation of dental material, the direct comparability of morphology with modern populations, and the demonstrated ability of the technique to provide information on biological distances in modern groups. As with cranial non-metrics, however, there are also disadvantages. The genetic component of morphological variation is still little known, there is no universal standard list of traits or method of scoring, and missing, worn or decayed teeth are difficult to deal with.

Berry (1976) studied the prevalences of 31 tooth crown variants in six European populations. All but one of these studies were based on dental casts of modern children being treated for orthodontic problems. The remaining group was an archaeological group from Orkney and Shetland, from which only small and incomplete samples could be obtained. The examination of this last group showed that most minor dental traits are destroyed by attrition. Berry states that 'this means that great care must be taken when scoring teeth from older members of a population or from any population whose diet tends to early tooth wear, as variants present at eruption may have disappeared by the time the tooth is scored' (1976:266). This, together with the effect of decay, and the lack of knowledge on the interaction of genetic and environmental factors controlling these traits are major problems in the study of non-metrical variation in archaeological groups. Berry suggests that 'until these questions are answered dental variants cannot be considered to be of practical value in anthropological studies' (1976:266).

6.1.3. Dental Variation in the Study Populations

Metrical analysis of the teeth has not been carried out on any of the groups in this study. This is partly because dental measurements are not felt to provide a great deal of useful information, and partly because of the amount of time that such an intensive study would involve.

Only two of the non-metric traits mentioned above were considered in the populations studied here, these being congenital absence of teeth and presence of shovel-shaped incisors. General abnormalities of position or shape of the teeth were noted when they occurred, as was the retention of deciduous teeth in the adult dentition. Summaries of the few traits noted in each of the populations will be found in the relevant reports. Prevalences of abnormalities were not recorded owing to the difficulty of classification, and the fact that only a few occurred in each population.

In archaeological populations which are analysed without the aid of radiography it is usual to find that the prevalence of *unerupted* teeth is recorded, rather than that of congenitally *absent* elements. Often many of these teeth are completely absent, but without an X-radiograph of the mandible it is impossible to be certain unless the jaw happens to be broken at the relevant position. Jaws are only scored as having unerupted teeth if it is almost certain that the lack of a tooth is not due to antemortem loss.

The levels of unerupted teeth in the study groups vary considerably. They are presented in Table 6.1.

Site	Male unerupted		Female unerupted	
	N	%	N	%
HIR	26/1480	1.8	71/1994	3.6
MK	11/944	1.2	9/576	1.6
JA Sax	17/474	3.6	16/371	4.3
JA Med	14/594	2.4	22/767	2.9
BG	11/712	1.5	16/494	3.2
BF	19/497	3.8	14/133	10.5
GP	9/568	1.6	0/461	-

Table 6.1.

This table gives the percentages of unerupted teeth in males and females over the whole dentition. Since in every case the vast majority of unerupted teeth are third molars, it might be more realistic to provide percentages of absent third molars from third molar positions. These are therefore given in Table 6.2 below.

Site	Male 3rd Molar N	Male 3rd Molar %	Female 3rd Molar N	Female 3rd Molar %	Total %
HIR	24/180	13.3	58/238	24.4	19.6
MK	9/89	10.1	9/58	15.5	11.6
JA Sax	17/55	30.9	16/41	39.0	34.4
JA Med	14/58	24.1	20/86	23.3	23.6
BG	11/83	13.3	15/53	28.3	19.1
BF	15/75	20.0	14/20	70.0	30.5
GP	9/63	14.3	0/55	-	7.6

Table 6.2.

In every case, except Guisborough, more congenitally absent or unerupted teeth were found in females than males. A chi square test showed this difference to be significant at The Hirsel, Blackgate and, not surprisingly, Blackfriars, although at the other sites it was not. This sex difference is probably due to the fact that female jaws are smaller than those of males. The evolutionary trend is towards smaller jaws and reduction in number of teeth, and this tends to affect the third molar the most, since it is the last tooth to form. Studies on mice have suggested that absence of the third molar is determined by a gene for tooth size rather than actual absence. If the tooth germ fails to develop beyond a certain size, it will be reabsorbed before it is due to erupt. Since women in general have smaller teeth than men, it is not really surprising that they have a greater prevalence of third molar absence.

The percentages of unerupted teeth at these sites do show a slight increase with time, although Guisborough and Saxon Jarrow appear anomalous in this respect. This may be because the figures are based on small populations, or it may be due to their genetic make-up. This latter seems unlikely at Jarrow, however, since there would seem to be a decrease from early to late periods if the figures are representative.

Other teeth were found to be probably congenitally absent at most of the sites. At The Hirsel, for example, one female had only one premolar in each quadrant of her dentition, three individuals lacked one or more canines, two lacked an incisor, and in one female mandible the right second and third molars had apparently never developed. At Blackgate one female had retained her left deciduous maxillary second molar, and the second premolar had not erupted, either as a cause or an effect of this. The percentage frequencies of unerupted teeth by area of the jaw and by sex are shown for each site in Figures 6.1 to 6.7. These bar charts also show the percentages of teeth present, those lost ante- and post-mortem, and percentage of missing or unassessable jaw sections.

Shovelling of the incisors was only looked for systematically at two sites, Norton and Guisborough. At Norton the prevalence of occurrence based on individuals was 36.1% (Marlow, forthcoming), and at Guisborough it was 61.5%. This discrepancy may be due to variations between scoring techniques at the two sites, especially since the analyses were carried out by different observers, or it may be caused by the small sample size at Guisborough. On the other hand, it may be a real difference due to the possible inbreeding at Guisborough which was suggested by the cranial non-metric traits. Since the trait was only studied at two sites it is impossible to be certain of the reason for the divergence.

Other anomalies noted in the jaws included abnormal eruption position or impaction, extra roots of premolars, canines or molars, and traits such as Carabelli's cusp. At Guisborough, for example, three individuals had premolars with one or two extra roots, and one man had an upper left canine which had remained in the alveolar bone and appeared to be erupting towards the incisive foramen.

6.2. Dental Pathology

6.2.1. Introduction

A number of common pathological processes can be seen in the teeth and alveolar bone of ancient populations. The most obvious, and most frequently occurring today, is tooth decay or caries. However, individuals in the past were affected by processes which occur less often in modern societies. These include periodontal abscesses, enamel hypoplasia and dental calculus (tartar). Although gingivitis (gum disease) is a relatively common infection in modern mouths, and was likely to have affected past individuals to an even greater extent, it is unfortunately unlikely to be recognised in the alveolar bone.

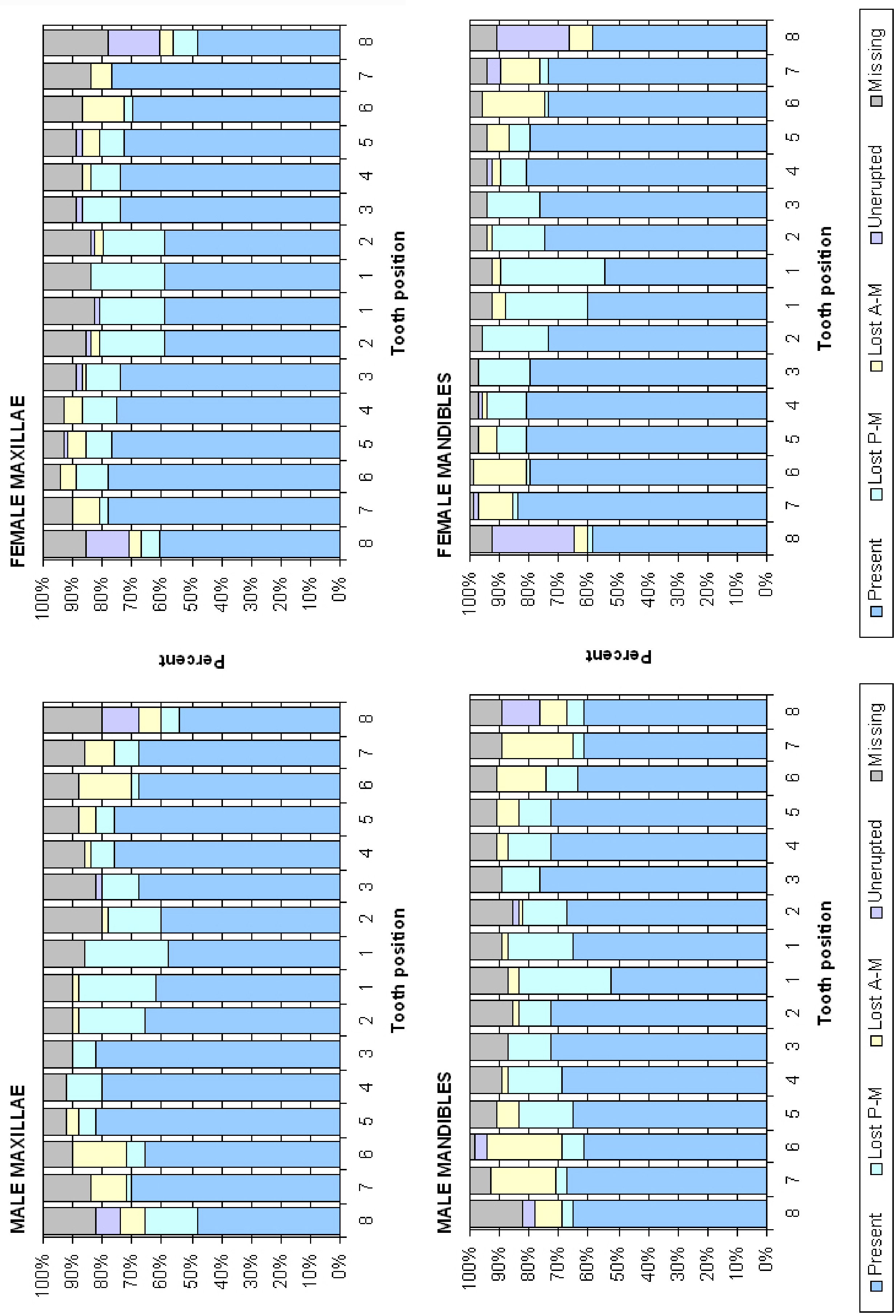


Figure 6.1. Percentage remains by tooth position 1: The Hirsel

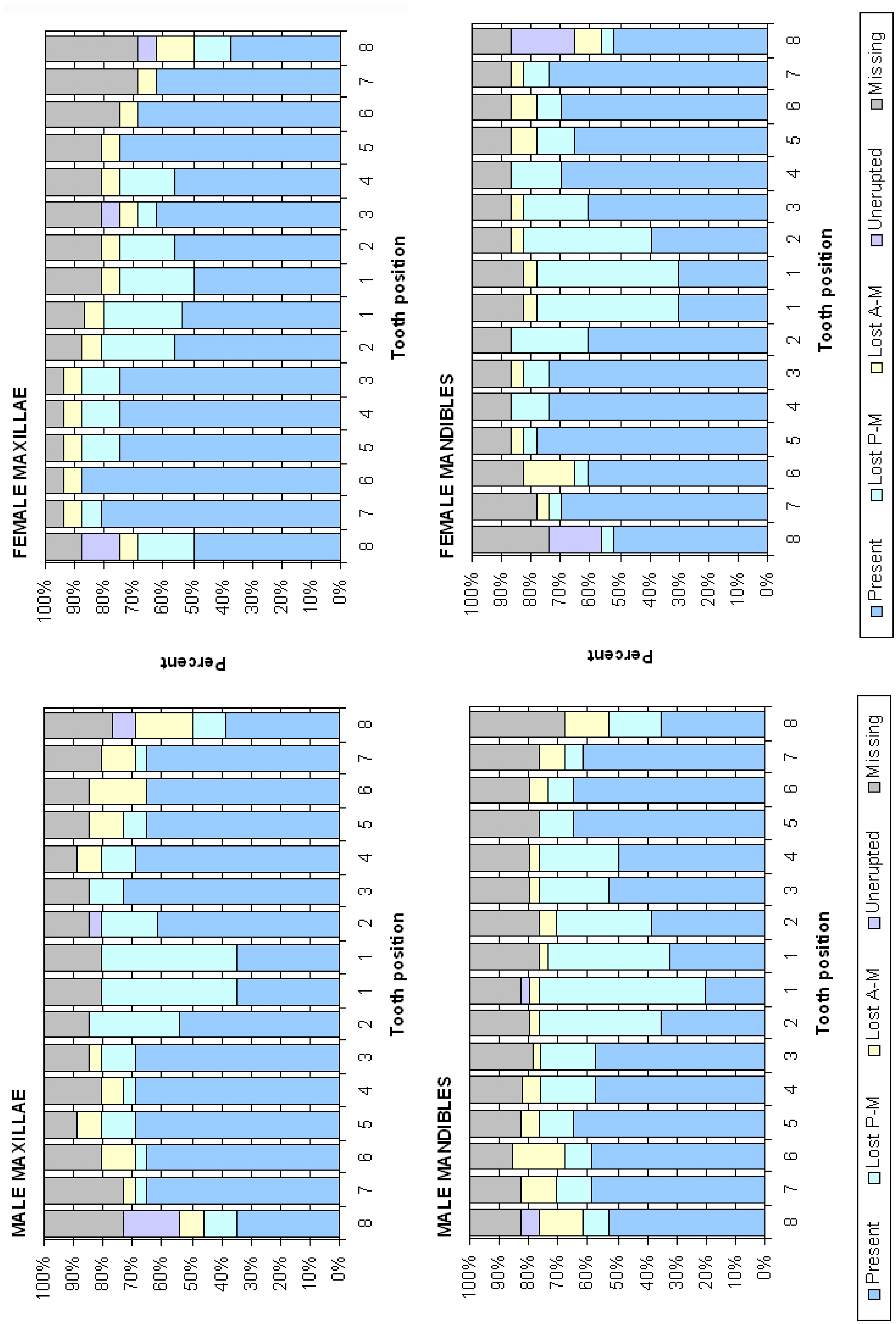


Figure 6.2. Percentage remains by tooth position 2: Monkwearmouth

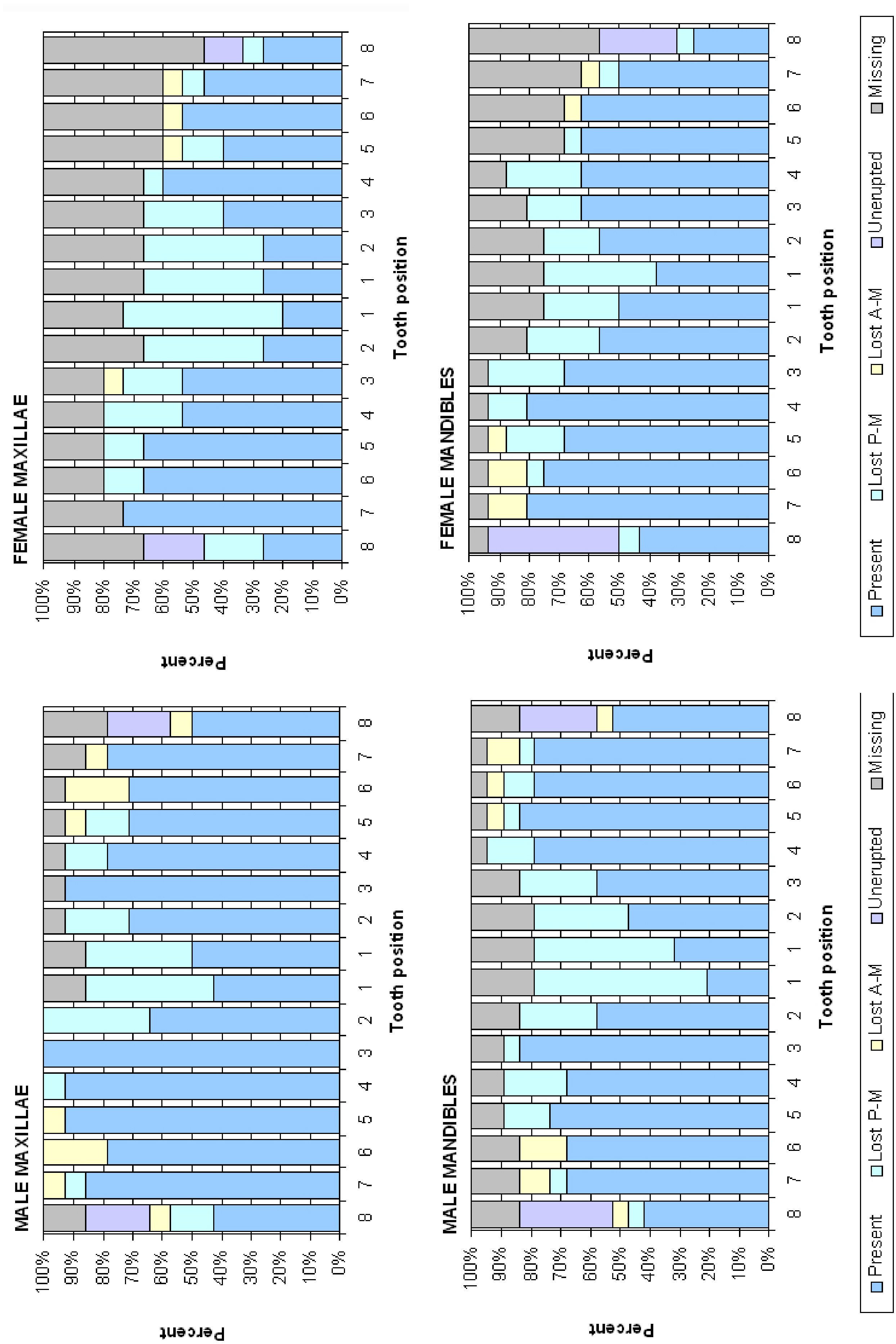


Figure 6.3. Percentage remains by tooth position 3: Saxon Jarrow

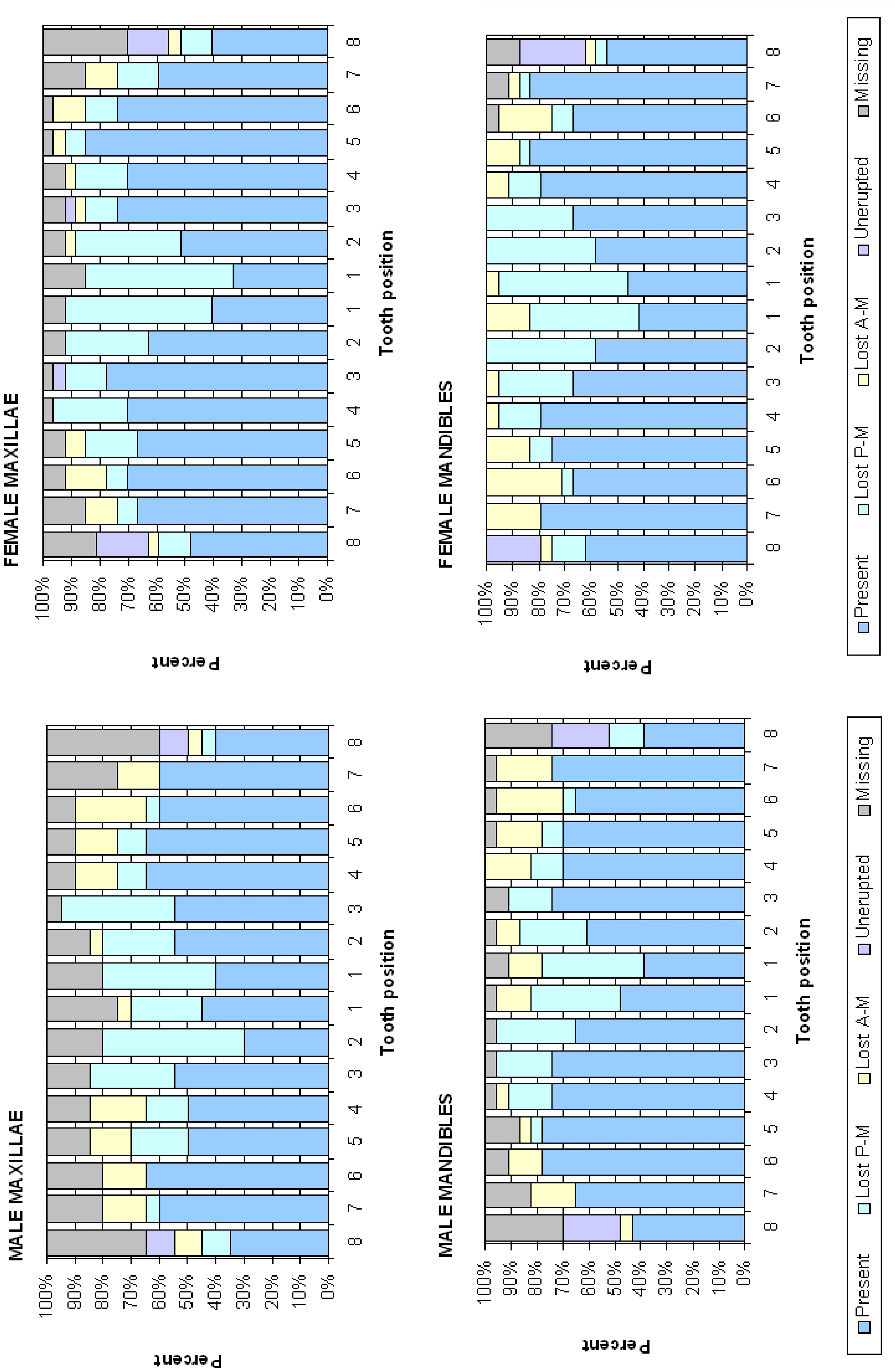


Figure 6.4. Percentage remains by tooth position 4: Medieval Jarrow

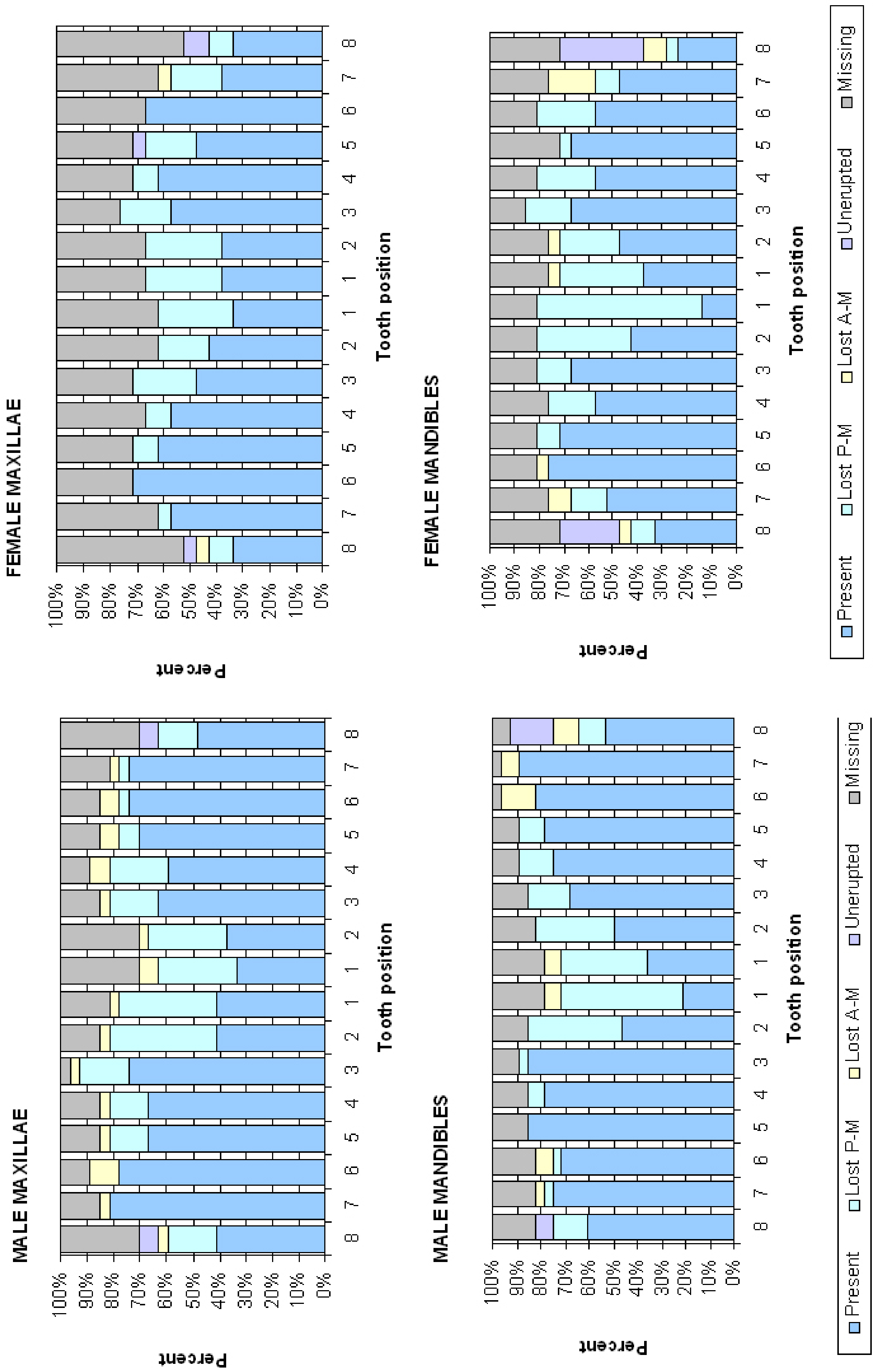


Figure 6.5. Percentage remains by tooth position 5: Blackgate

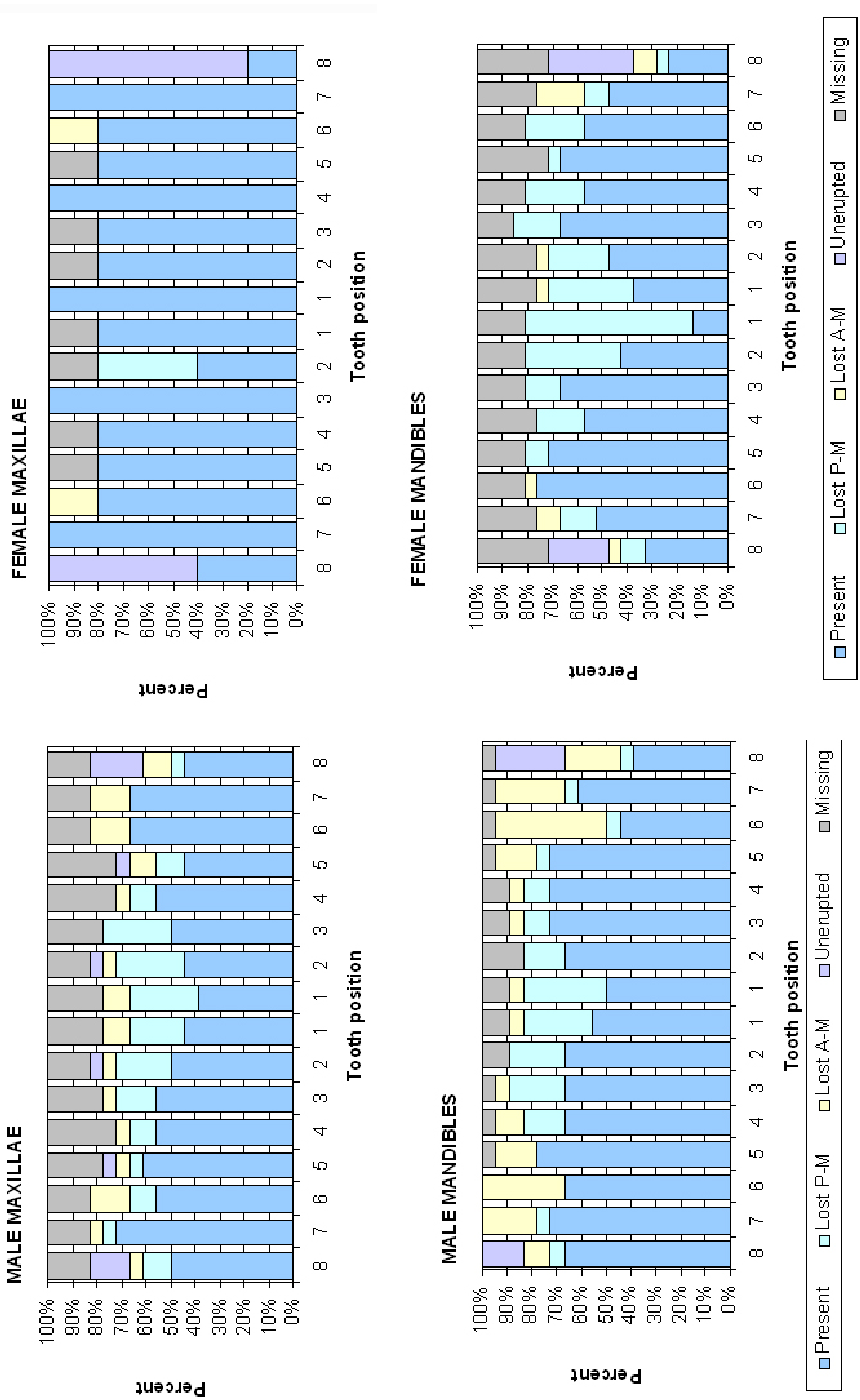


Figure 6.6. Percentage remains by tooth position 6: Blackfriars

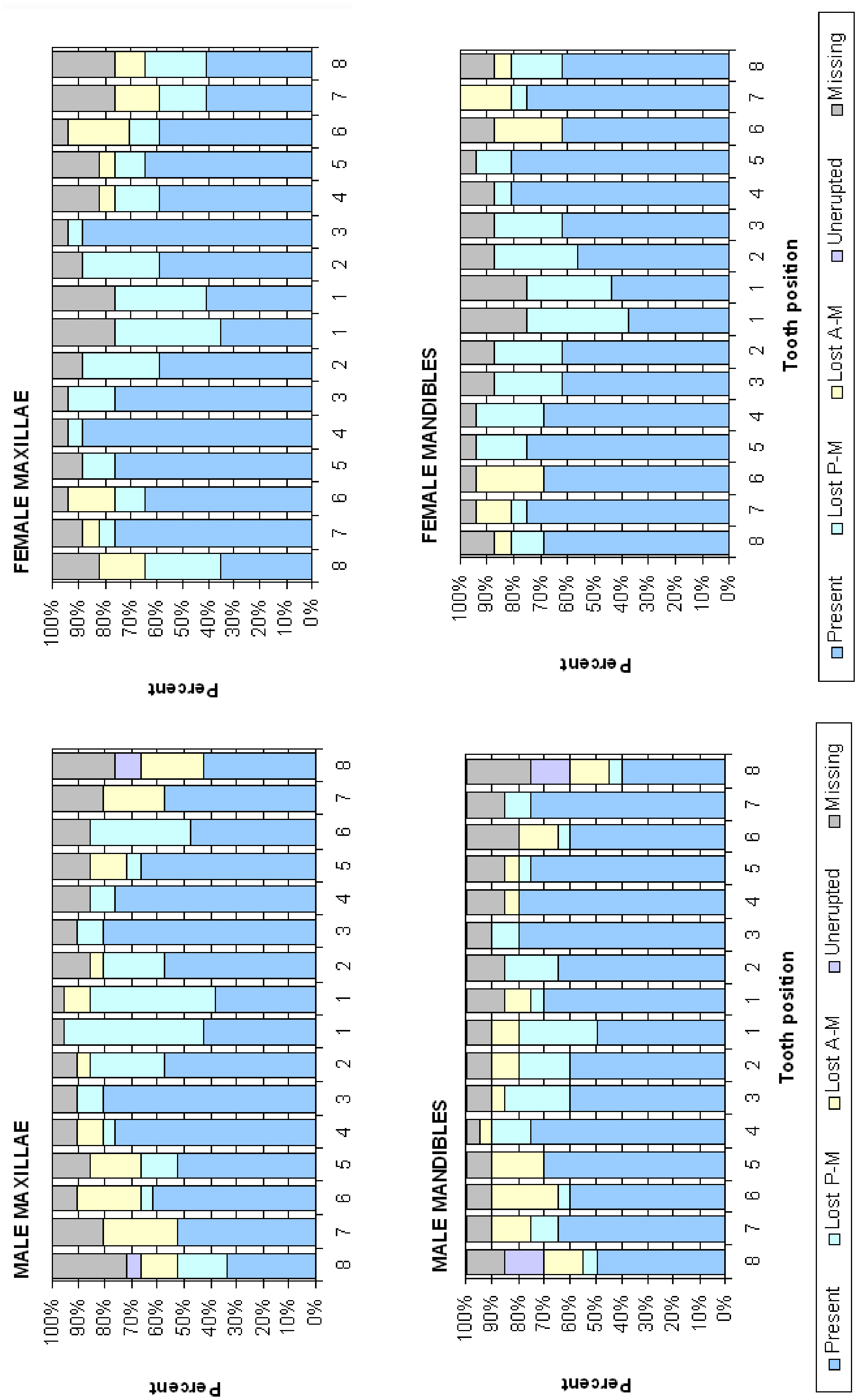


Figure 6.7. Percentage remains by tooth position 7: Guisborough

A brief aetiology of each of the major dental diseases found in archaeological populations, together with some of the archaeological problems involved in their study, is provided below. Microbiological details involved in the disease processes are not given since these are covered in detail in general works such as that by Hillson (1986).

6.2.1.1. Caries

Caries, or tooth decay, is caused by acid attacks on the enamel, cement and dentine of a tooth. Acid is produced by the interaction of various bacteria with food remnants in the mouth, and particularly in the tooth fissures. Decay occurs at pH 4 to 5.5, a level which is particularly easily reached when sucrose or other fermentable carbohydrates form part of the diet. It is possible for small lesions to remineralise or remain stable, but if decay spreads large lesions may reach the pulp cavity, often resulting in tooth loss (see below, Periapical Lesions). Susceptibility to caries may be genetically controlled, but obviously some environmental factors must also be involved, since these may determine the strength of the enamel.

Lesions can occur at a number of sites on a tooth. In modern societies they are most frequently located in the occlusal or chewing surface of the molars, where remnants of food remain stuck in the fissures and are difficult to remove even by brushing. Soft, easily consumed foods are partially to blame for this, since vigorous chewing can often remove such vestiges. The second most common site of tooth decay in modern man, and by far the most common in past populations, is at the contact (interproximal, interstitial or approximal) areas of neighbouring teeth. Surface wear can occur at this point, and this facilitates the acid attack, since it is another position where plaque is easily built up. Another common position for carious lesions is at the gingival margin, in the cervical region of the tooth, particularly if periodontal disease is also present. Early lesions at this position can be very difficult to distinguish from post-mortem decay, which frequently occurs at the junction between the alveolar bone and the neck of the tooth, particularly on the buccal surface. Other sites may be affected by caries, but these are rarely seen in archaeological specimens.

Caries can occur in both the deciduous and the permanent dentitions, but in archaeological populations it is most often seen (or at least more frequently scored) in adult teeth.

6.2.1.2. Calculus

Dental calculus, or tartar, is caused by the mineralisation of plaque which occurs when a low pH does not predominate, and when the teeth are not cleaned on a regular and frequent basis. It is composed mainly of minerals (70-90%), but the remainder consists of plaque bacteria and matrix. In life it is usually covered by a layer of active plaque.

The nature of the material is such that it is usually preserved in archaeological material - if the tooth survives then so will the calculus. However, despite the difficulty of removing this deposit in life, it is very easily removed after a long period of burial and can be lost in the cleaning process. Small pieces tend to stick to the tooth more firmly than larger deposits, so lack of care during bone washing is more likely to remove the latter. This could lead to a bias in the scoring of extent of calculus, suggesting that a slight amount of calculus was more common than was actually the case.

Two kinds of calculus may be formed, supragingival and subgingival. The former is the most common type to find in archaeological populations. It is hard and clay-like, varying in colour from light brown through grey to green. Subgingival calculus is harder and more heavily mineralised, and dark brown to green-black in colour. It could be mistaken for a ground water mineral deposit and either scrubbed off or not scored.

Deposits are usually scored on a three-point scale of light, medium, heavy after Brothwell (1981:155). Calculus can occur at any age, but is usually more frequent and more extensive in adults.

6.2.1.3. Periodontal Disease, Periapical Abscesses and Ante-mortem Tooth Loss.

As stated above, ordinary gum disease cannot be distinguished on bony remains, since it only affects the soft tissues. However, if teeth are not cleaned the accumulation of plaque associated with gingivitis can, over a number of years, intensify into the more serious condition of periodontitis. Until the advanced stage is reached, this disease is difficult to diagnose or detect in the alveolar bone of skeletonised material.

The advanced stage consists of the formation of a sulcus which enlarges into a ‘periodontal pocket’, due to the activities of plaque bacteria. Supragingival plaque along the gum margin contributes to the inflammatory process, and the plaque is able to penetrate behind the gum, bringing its bacteria with it. Alveolar bone may be lost following this process, although this can also occur simply as a phenomenon of ageing, and cannot of itself be used as evidence for periodontal disease. Periodontitis can affect individuals of all ages, but is most common past the age of 30-35 years.

As stated above, carious lesions can spread to the pulp cavity. This, as well as opening of the cavity by severe attrition or occasionally trauma, allows bacteria from the mouth to invade the soft tissues causing infection and inflammation, and an abscess is formed within the pulp chamber. The pulp will eventually be killed, and the infection then proceeds down the root canal to the root tip (apex), where a periapical abscess is formed. Bone is resorbed around the root, and eventually the pus within the abscess may break through one of the alveolar walls, most often the buccal. The sinus or fistula formed in this way may be the only evidence for such a process in an archaeological specimen, unless radiography can be used to look for smaller lesions.

Enlargement of the lesion to the stage where it is able to break through the compact bone may have a number of consequences. If it has happened early on in the process, if the lesion was close to the wall for example, the pus may be lost and the tooth will probably remain in the jaw. If the lesion was large, however, the release of purulent material may leave a hole large enough for the tooth to move about in, and it may consequently be lost (although there may be other reasons for such an eventuality). There may also be an infection of the jaw if the soft tissues become infected, or of the maxillary sinus if the abscess breaks through in that direction.

6.2.1.4. Trauma

Traumatic events, if they occur at all, most commonly affect the front teeth, since these are the most exposed to accidents or violence. The most frequent such event affecting archaeological dental remains is the fracturing and rehealing of the incisors. If teeth are broken without rehealing it is unlikely that this will be noted since other processes, such as caries or attrition, will affect the tooth after the crown, or part of it, is lost.

Occasionally a fractured jaw may occur, and if the event took place in childhood it is possible that some of the developing teeth may be affected. This type of lesion is rarely seen in archaeological remains.

6.2.1.5. Odontomes

Odontomes are usually developmental malformations of teeth. Hillson (1986) considers the enamel pearl to be one of these, but the more normal type involves the retention of a mass of dental material within the alveolar bone. Small examples may not be found unless an X-radiograph is available, but larger specimens may break through the compact bone and be easily seen. Brothwell (1959a) describes a particulary large one from Socotra in the Indian Ocean.

6.2.1.6. Enamel Hypoplasia

Although strictly speaking this condition is not itself pathological, it may be caused by disease processes or poor nutrition in childhood, and it will therefore be considered under the heading of dental pathology.

Goodman and Armelagos (1985) state that ‘dental enamel hypoplasia is a deficiency in enamel thickness resulting from a disruption in the secretory/matrix formation phase of amelogenesis’ (1985:479). The defects can be caused by local trauma, hereditary conditions, or stress. The latter type is the one most commonly seen in archaeological material. The main difference is that stress induced hypoplasia will occur on more than one tooth, and the area of the defect will reflect the stage of calcification of the crown of each tooth. Single events will therefore occur at different heights on different teeth, since each type of tooth is formed at a different age. Hereditary conditions will cause enamel defects from birth, and these therefore affect the whole of the tooth crown, whereas localized trauma will probably only affect one or two adjacent teeth.

Goodman and Armelagos found that time of development of the tooth is not the only determinant of hypoplasia, since sections of teeth developing at the same time do not record hypoplasias to a similar degree. This suggests differences in susceptibility both within and between tooth crowns. Differences in defect frequency between teeth are likely to be caused by the genetic stability of the particular tooth. Stable teeth (i.e. those which have a fixed size to which they will develop) will be more affected by hypoplasia than unstable teeth, since the latter will merely be stunted in growth.

Although stress induced hypoplasia is related to the environment of the individual, and in particular to nonspecific disease, some workers on modern populations have shown that the occurrence of hypoplastic defects is not entirely correlated with malnutrition and disease. Dobney (1988) studied groups of children in Mexico and Bradford. In Mexico one of two groups was provided with vitamin supplements, whilst the other was not. More hypoplasia was found in the non-supplemented children, as would be expected from previous theories. However, the Bradford school children showed a greater amount of hypoplasia than the non-supplemented Mexican children, so the link with malnutrition is far from clear cut. El-Najjar *et al* (1978) could not find any specific aetiology for the condition.

Hypoplastic defects generally consist of grooves or pits in horizontal lines across the surface of the enamel. If there is more than one band the tooth has a wrinkled appearance. Grooving seems to be more common in archaeological populations than pitting. The most affected teeth vary between populations, but the most frequently defective teeth seem to be the lower canines and the upper mesial incisors.

Since enamel hypoplasia is a developmental defect, it only forms during the calcification and eruption stages of tooth growth, and can therefore only reflect periods of stress occurring in childhood or adolescence. The actual hypoplastic defects, however, are retained into adult life and are not resorbed, thus leaving a record of physiological disturbance, even if the exact cause is unknown.

6.2.2. Archaeological Studies in Dental Pathology

A number of studies have been carried out on dental disease in various of the world's populations. Only the ones most related to the present study will be considered here.

In 1959, Brothwell produced a broad review of dental pathology in man from the palaeolithic to the present day. The British remains showed a decrease in caries rates from the Neolithic to the Bronze Age, followed by a rise to Roman times, another decline in the Anglo-Saxon period, and a steep increase to the present day. Tooth loss due to disease was found to be highest in Roman times and lowest in the Bronze Age. Periodontal disease and calculus were common from the Neolithic to Saxon times. He concludes that 'the last straw, as far as British populations are concerned, was the introduction of sugar in the 12th century, and refined white flour in the 19th. Indeed, we are led to the painful conclusion that if we had been content to chip flints and keep away from foreign trade our teeth would have been the healthier for it' (1959b:64).

Hardwick (1960) considered caries through the ages in relation to diet. This was based on Brothwell's studies of past populations, together with a study of the effects of the use of refined sugar. He found a greatly increased caries rate from the second half of the 19th century onwards, and noted a high correlation between this and the consumption of refined sugars and flours of finer texture. He suggested that natural or raw foods actually contain 'protective factors of an inorganic nature, possibly as trace elements' (1960:17) which would help to prevent caries. He concluded that the major influence on caries susceptibility was dietetic in nature.

Emery (1963) also studied dental disease in various archaeological populations (Neolithic to Saxon). He states that caries has always existed but that its widespread distribution seems to be related to the cultivation of cereals and the spread of civilisation. Ante-mortem loss was found to be greatest in highly civilised populations, where teeth could have been extracted and replaced by artificial ones. Pathological lesions occurred most frequently from the Iron Age to Saxon times.

Tattersall (1968b) looked at dental disease in Medieval Britain, which had hitherto remained unstudied. The data, based on a group from Clopton, Cambridgeshire, showed that the prevalence of caries was higher than that of the Anglo-Saxon period, similar to the Roman, and lower than 17th century London, as would be expected. No clear pattern of ante-mortem tooth loss was found, as was the case in Brothwell's study (1959b). The percentage of abscesses (9.19%) recorded was remarkably high compared to all other time periods. Hypoplasia was found in most individuals in varying degrees. Congenital absence of the third molar was found to be significantly more common in females.

Moore and Corbett (1971, 1973) carried out an extensive survey of dental caries in archaeological populations from the Iron Age through to the Medieval period. (They also considered 17th and 19th century populations in later papers, but these are outside the scope of the present study.) Studies on the four earlier groups (Iron Age, Romano-British, Anglo-Saxon and Medieval) showed that there was no great change in the distribution of dental caries by site, age and tooth throughout the periods. The interstitial cervical area of the tooth was most commonly affected, although in younger age groups occlusal fissure cavities were more frequent, probably due to the fact that in older individuals this area would be almost worn away. They suggest that the majority of lesions were secondary to alveolar recession following severe attrition, which allowed stagnation of food deposits around the necks of teeth.

In their 1983 study, Moore and Corbett found a low caries rate in the Saxon period, with more caries in the back teeth, and an increasing number of lesions with increased attrition. Cemento-enamel junction caries seemed to be more correlated with attrition than were contact area lesions. Lavelle and Moore (1969) found a marked increase in alveolar bone resorption from the Saxon period to the 17th century. However, although they claim to have excluded age differences by using only individuals with very little wear, it is clear that the later population suffered less overall attrition, and was therefore likely to contain older individuals than those in the Saxon period with a corresponding amount of attrition. This is not to exclude the possibility that alveolar bone loss does increase through time, but the problem of ageing later populations needs to be dealt with in more detail before making such a conclusion.

6.2.3. Dental Pathology in the Study Populations

In the populations considered here, the dental study is based on macroscopic analysis, since the time and resources for histological and radiographic study were not available.

The numbers of dental remains available for study in the populations considered here are presented in Table 6.3 below.

No. of:	HIR	MK	JAS	JAM	NEM	BG	BF	GP
Males	56	37	20	26	37	28	18	21
Maxilla	50	28	14	20	16	25	18	21
Mandible	55	32	19	23	31	26	18	20
Females	71	21	18	28	25	24	5	17
Maxilla	69	15	15	27	12	22	5	17
Mandible	68	21	16	24	21	22	5	16
Position								
Expected	3872	1536	1024	1504	1280	1520	736	1184
Missing	398	258	179	143	152	317	92	155
Observed	3474	1278	845	1361	1128	1203	644	1029
PM Loss	458	265	169	275	159	248	77	187
AM Loss	239	97	34	126	46	42	73	101
Unerupt.	96	20	33	36	17	27	33	9
Teeth	2681	896	609	924	906	886	461	734

Table 6.3.

The percentage distributions of the lower rows of the table are shown in Figures 6.1 to 6.7 by section of jaw and by sex. The basic trends which can be seen from these bar charts are as follows: (1) missing sections of jaws are fairly evenly spread throughout, although in most cases the percentages are greater in the less well-preserved material and at the ends of the quadrants; (2) unerupted teeth are most commonly third molars; (3) ante-mortem loss is usually greatest in the molar area (6-8); (4) post-mortem loss occurs most frequently in the anterior teeth (1-5), since these are single rooted and most liable to fall out, particularly in the maxilla; (5) the percentage of teeth present reflects both preservation of the material and care in excavation.

6.2.3.1. Caries, Tooth Loss and Periodontal Disease

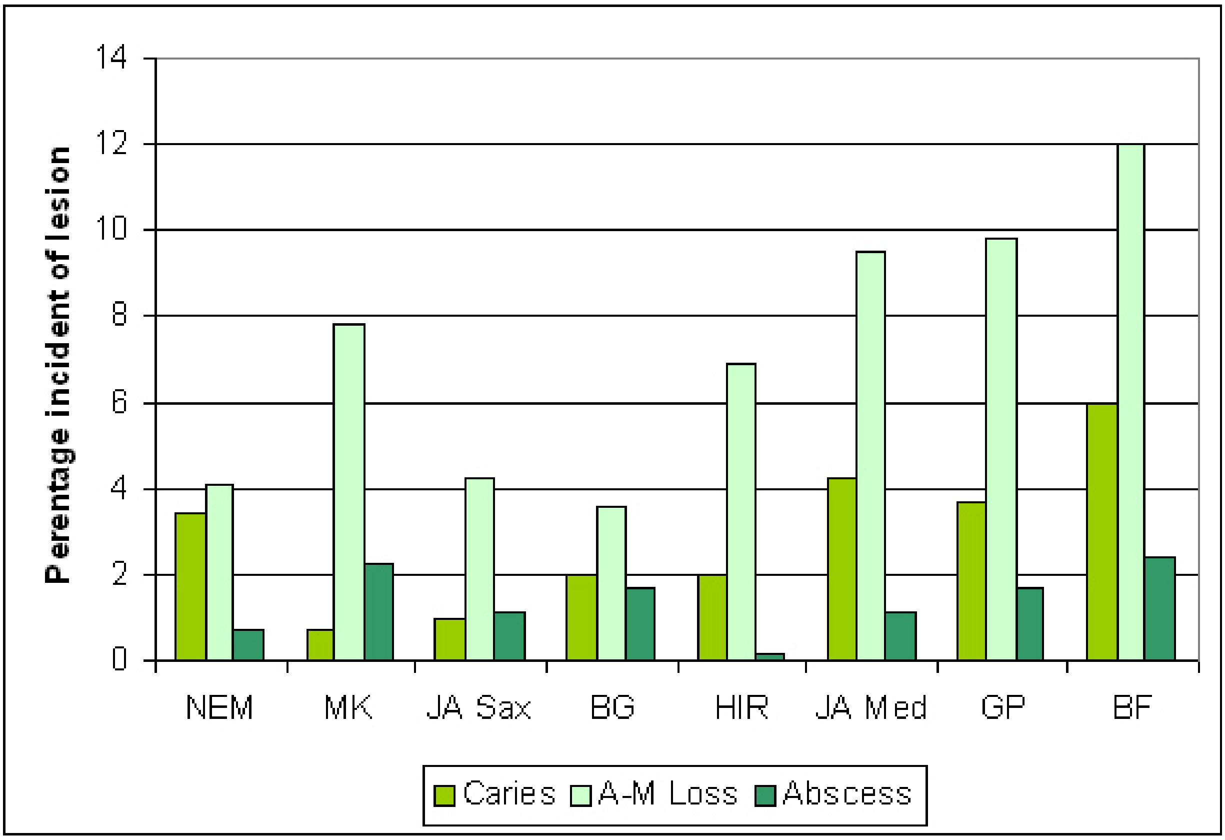
Table 6.4 below gives the percentages of caries, antemortem tooth loss and periodontal abscesses for combined sexes in each of the eight groups.

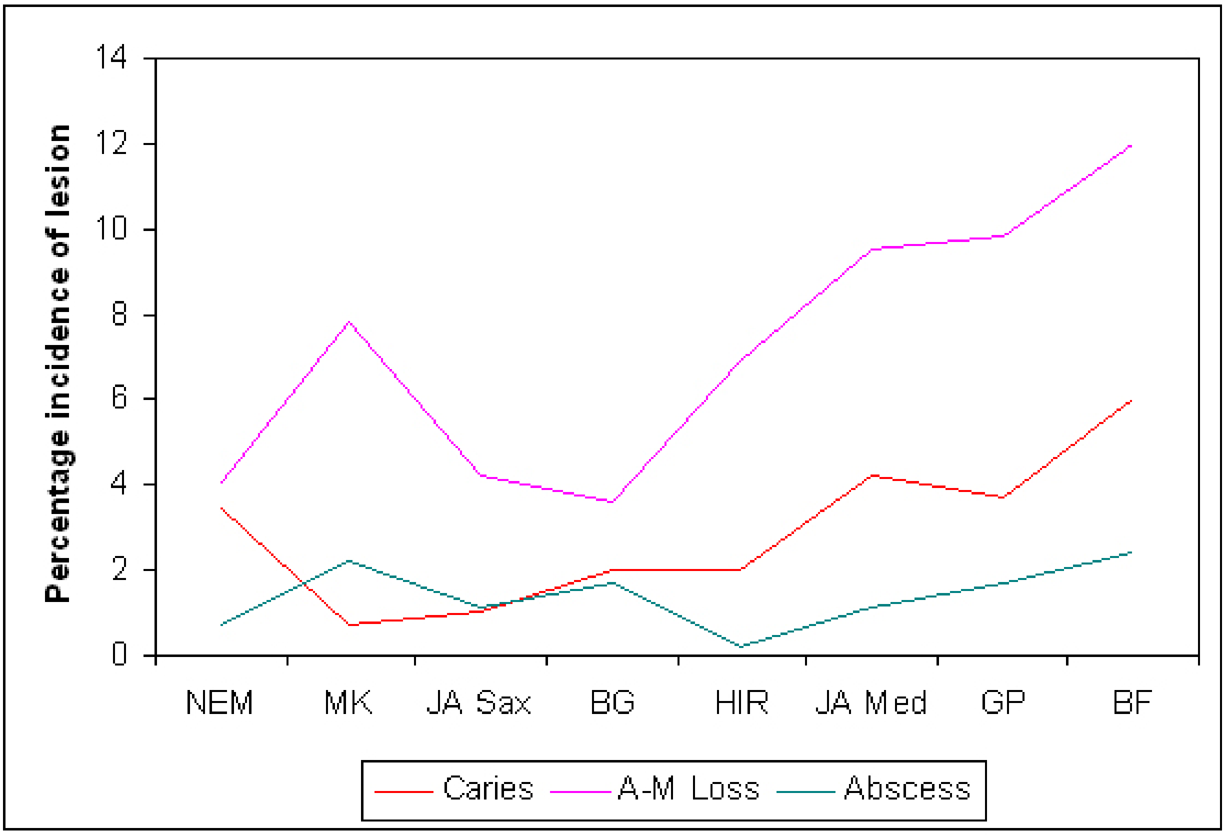
Site	% Caries	% A-M Loss	% Abscesses
HIR	2.0	6.9	0.2
MK	0.7	7.8	2.2
JA Sax	1.0	4.2	1.1
JA Med	4.2	9.5	1.1
NEM	3.4	4.1	0.7
BG	2.0	3.6	1.7
BF	6.0	12.0	2.3
GP	3.7	9.8	1.7

Table 6.4.

The percentages in Table 6.4 show a great difference in prevalence of the three lesions at all the sites. A possible reason for this is the change of disease patterns through time. Figures 6.8 and 6.9 show the percentages of pathological lesions (per tooth in the case of caries, and per alveolar position in the case of ante-mortem loss and abscesses) by broad time period from earliest to latest sites. The bar graph, although being the more correct form of representation in this case, is supplemented by a line graph of the same data, since the trends are easier to pick out in this format. The high percentage of antemortem loss at Monkwearmouth is probably due in the main to the presence of three edentulous individuals. Exclusion of these would reduce the figure to fit better with other Saxon groups. Nevertheless, the pattern of increasing tooth loss and caries through time can be easily seen, although the trend of abscess prevalence is more obscure. The low percentage at The Hirsel is particularly difficult to explain. It is possible that it could be related to the smaller number of old individuals at this site. This shows the problems involved when comparisons are made of prevalences over whole sites regardless of age groups (Perizonius and Pot, 1981; Pot, 1988), since all of these lesions appear to be more associated with old age.

The numbers given in Tables 6.3 and 6.4 are important in the study of dental disease prevalence. However, the percentages of disease at each tooth position may give a better picture of spread of disease, since some regions of the jaw may be less affected than others. Figures 6.10 to 6.17 show the distribution by tooth type of ante-mortem tooth loss at each of the sites for each sex. In every case the molars are affected to a significantly greater extent than the other teeth, which vary in the different groups. The reason for such variation is uncertain, but may be due to differing genetic susceptibility or eating habits in the different groups.





Figures 6.8 and 6.9. Dental Pathology by broad time period

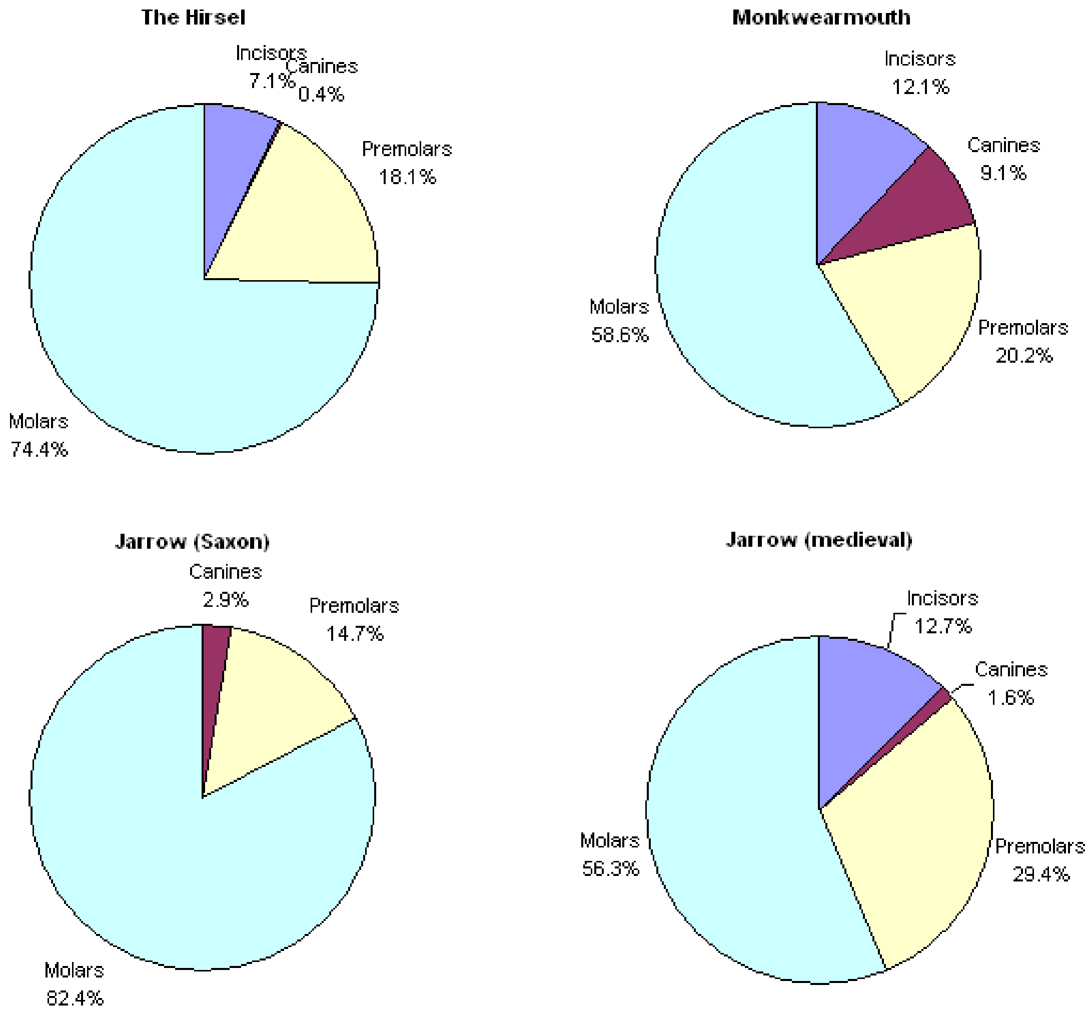
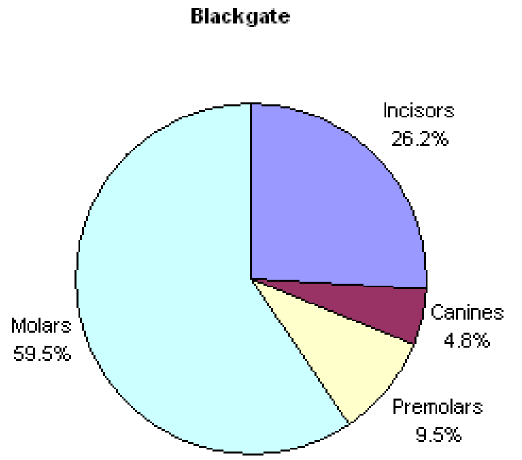
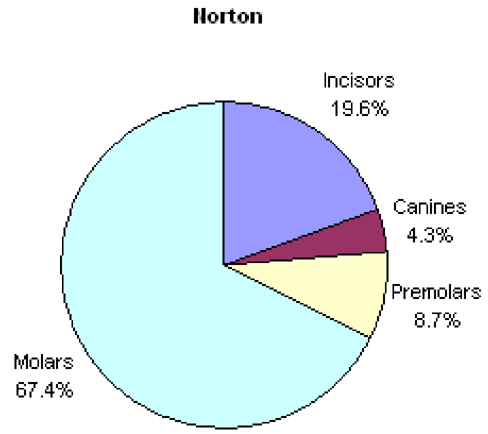
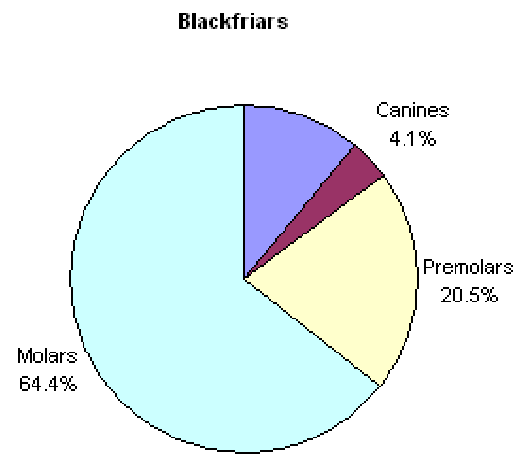


Figure 6.10. Ante-mortem tooth loss by jaw area: The Hirsel
Figure 6.11. Ante-mortem tooth loss by jaw area: Monkwearmouth
Figure 6.12. Ante-mortem tooth loss by jaw area: Saxon Jarrow
Figure 6.13. Ante-mortem tooth loss by jaw area: Medieval Jarrow







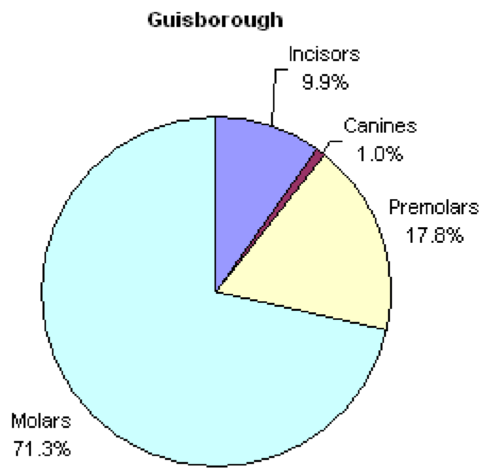


Figure 6.14. Ante-mortem tooth loss by jaw area: Blackgate
Figure 6.15. Ante-mortem tooth loss by jaw area: Norton
Figure 6.16. Ante-mortem tooth loss by jaw area: Blackfriars
Figure 6.17. Ante-mortem tooth loss by jaw area: Guisborough

The percentages of caries were tested for significant difference between sides and type of jaw at The Hirsel using the chi square test. The results are shown in Table 6.5 below.

Jaw Segment	R. Max.	L. Mand.	Mand.	R. Side
R. Mandible	0.50	0.35	-	-
L. Maxilla	0.01	0.05	-	-
Maxilla	-	-	0.39	-
L. Side	-	-	-	0.21

Table 6.5.

None of these differences are significant at the 5% level. All sites were tested for significant differences between the caries rates in the sexes, with the following results.

Site	X^2	Site	X^2
HIR	0.04	BG	0.93
MK	0.16	BF	0.05
JA Sax	0.19	GP	2.24
JA Med	1.82		

Table 6.6.

Again, there was no significant difference at the 5% level. Similar tests were applied to ante-mortem tooth loss and periodontal abscesses. Significant differences were found between the sexes at The Hirsel and Medieval Jarrow for both lesions, and at Blackfriars and Guisborough for ante-mortem tooth loss only. Numbers of abscesses were found to be significantly different between the maxilla and the mandible for Hirsel males. The frequencies of male and female maxillary and mandibular lesions are presented in Figures 6.18 to 6.21, which show distributions of the three diseases by tooth position at The Hirsel. Similar patterns would be seen at all the sites, with most lesions affecting the molar region, particularly the first molar.

The numbers of individuals with dental lesions are recorded in Tables 6.7 and 6.8 below. They show that the majority of individuals had caries of only one or two teeth, but abscesses often affected two or more alveoli. The total column shows the percentages of individuals with the two types of lesions out of the total number of jaws seen for the particular site and sex.

Site		Carious Teeth Per Individual					Total	
		1	2	3	4	5+	N	%
HIR	M	10	2	0	0	0	12	21.4
	F	14	7	0	0	0	21	29.6
MK	M	4	0	0	0	0	4	10.8
	F	2	0	0	0	0	2	9.5
JASax	M	2	1	0	0	0	3	15.0
	F	1	0	0	0	0	1	5.5
JAMed	M	4	1	1	0	0	6	23.1
	F	6	2	3	0	1	12	42.9
NEM	M	6	0	1	3	0	10	27.0
	F	3	0	1	2	1	7	28.0
BG	M	2	4	0	0	0	6	21.43
	F	2	2	1	0	0	5	20.8
BF	M	4	2	3	0	1	10	55.6
	F	1	0	0	0	1	2	40.0
GP	M	5	1	0	1	0	7	33.3
	F	1	1	3	1	0	5	29.4

Table 6.7.

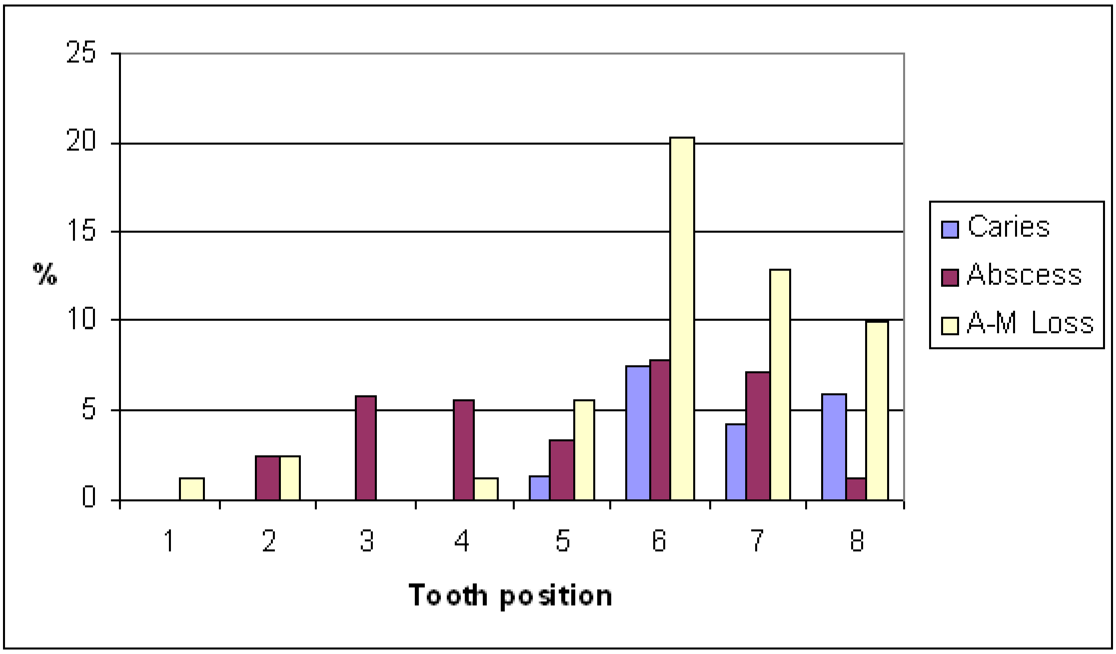


Figure 6.18. Distribution of lesions by tooth at The Hirsel: male maxillae

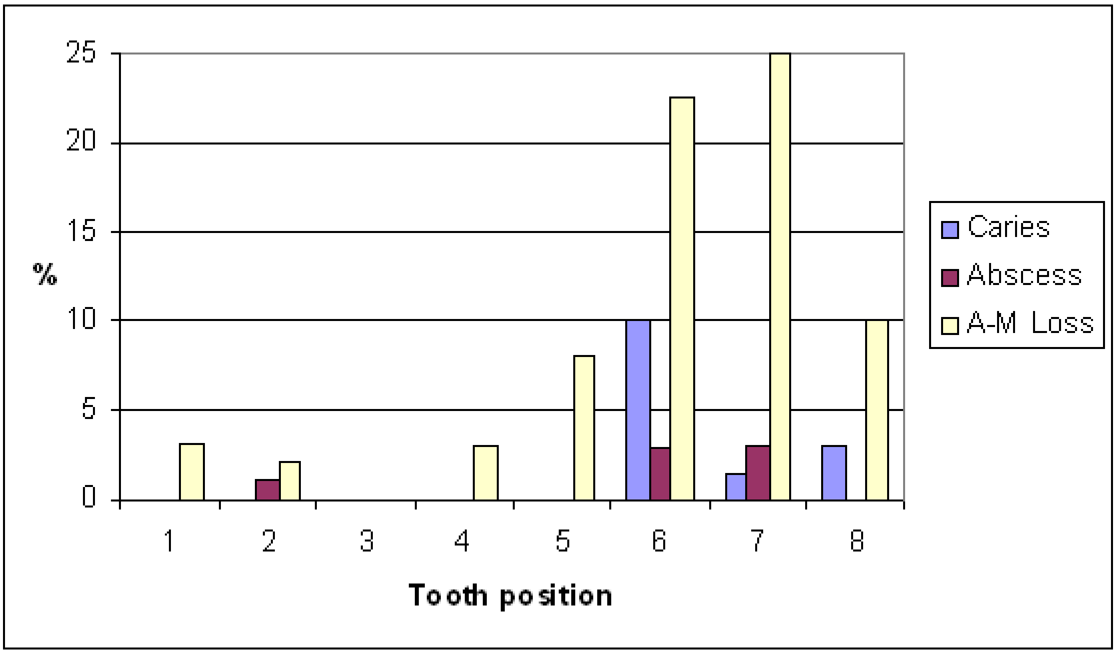


Figure 6.19. Distribution of lesions by tooth at The Hirsel: male mandibles

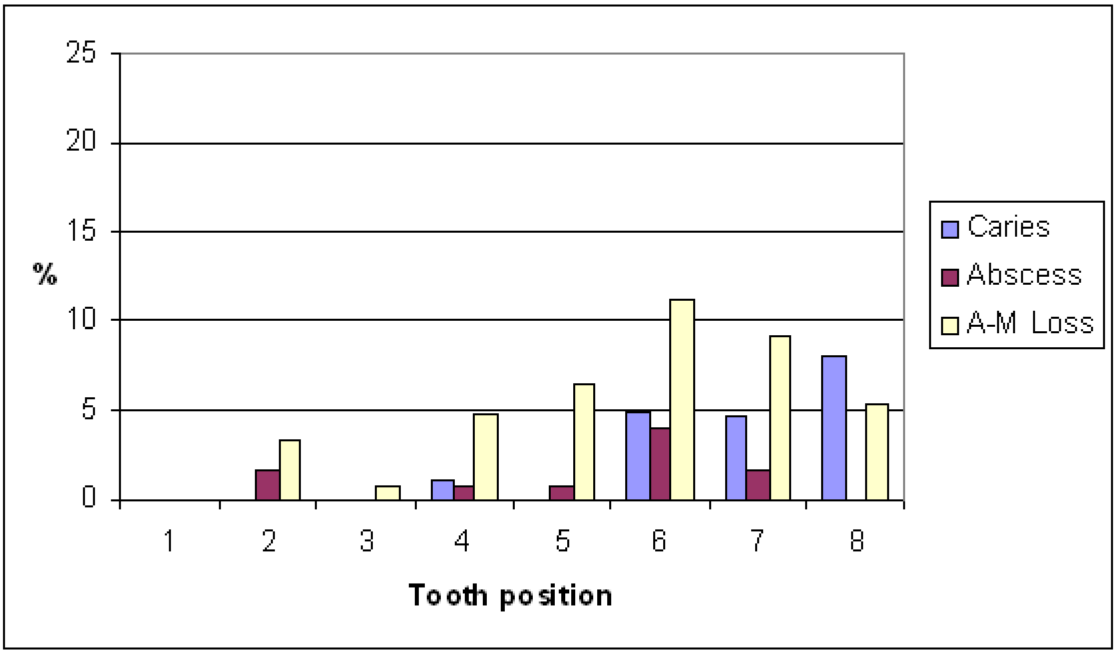


Figure 6.20. Distribution of lesions by tooth at The Hirsel: female maxillae

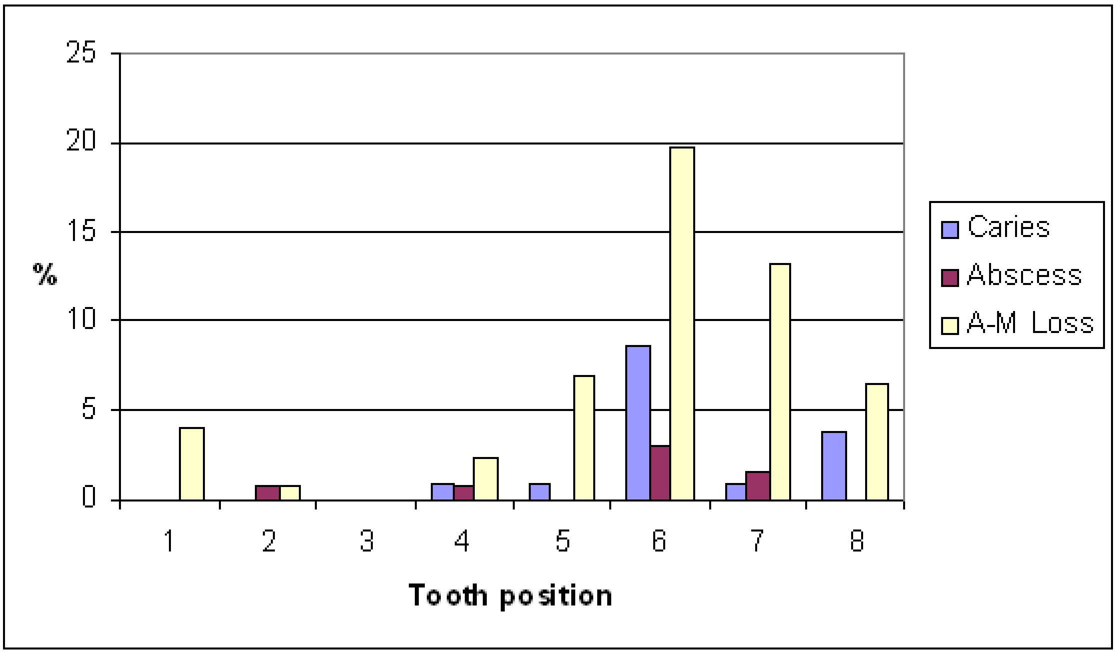


Figure 6.21. Distribution of lesions by tooth at The Hirsel: female mandibles

The medieval sites show a higher proportion of individuals with caries, as would be expected.

Site		Abscesses Per Individual					Total	
		1	2	3	4	5+	N	%
HIR	M	4	3	3	1	1	12	21.4
	F	12	2	0	1	0	15	21.1
MK	M	4	3	1	1	0	9	24.3
	F	2	2	0	1	0	5	23.8
JASax	M	2	0	0	0	0	2	10.0
	F	2	0	0	0	0	2	11.1
JAMed	M	4	0	1	0	1	6	23.1
	F	1	1	0	0	0	2	7.1
NEM	M	2	1	0	0	0	3	8.1
	F	0	2	0	0	0	2	8.0
BG	M	5	3	2	0	0	10	35.7
	F	2	1	0	0	0	3	12.5
BF	M	1	1	1	0	1	4	22.2
	F	0	0	0	1	0	1	20.0
GP	M	2	0	0	1	1	4	19.0
	F	2	2	0	0	0	4	23.5

Table 6.8.

A fairly similar proportion of individuals seem to be affected at each site, except Saxon Jarrow, Norton, the females from Medieval Jarrow, and Blackgate.

Perizonius and Pot (1981) found that the three major dental diseases (caries, periapical lesions and ante-mortem tooth loss) increased markedly with age. Because of this, they concluded that disease prevalences should not be compared between populations of greatly different mean adult age at death. Similar patterns have been found by other workers, for example by Lunt (1974) in Scottish Neolithic to Medieval groups, and by Whittaker *et al* (1981) at Poundbury. Figures 6.22 and 6.23 show the trends by age of the three pathological processes at The Hirsel, which was the only site with a large enough sample to split into age groups. This does show a marked increase in both sexes of all the lesions with increasing age. Antemortem loss is particularly high in the 45+ age group, which is perhaps not surprising since individuals with a large amount of tooth loss are most likely to be classified as old (their most likely, but not necessarily correct, age group).

6.2.3.2. Juvenile Caries

Although alveolar resorption and ante-mortem loss are not likely to be seen in juvenile individuals, carious lesions are, and these were scored in the groups studied here. Table 6.9 records the percentages of children with carious lesions at each site (except Jarrow and Norton, for which figures were not available). The number of children scored includes only those juveniles with more than one erupted tooth. The percentage given in this column is out of the total number of children scored from the site. The problem with any method of scoring caries in juvenile jaws is that the sample is generally too small to divide the group up into age sets, but the scoring is not really correct unless this is done. Very few children had caries at any of the sites. The majority of lesions were in the deciduous teeth, but occasionally the first permanent molar was affected.

Site	Children scored		Children with caries	
	N	%	N	%
HIR	82	53.6	9	11.0
MK	22	19.0	1	4.5
BG	15	41.7	0	-
BF	2	66.7	0	-
GP	4	57.1	2	50.0

Table 6.9.

Williams and Curzon (1985, 1986) studied the dentitions of 34 children from The Hirsel. At least eleven of these children (some of which have not been seen by the present author) had caries, but since the group was specifically selected for the purpose of studying dental pathology in a medieval population it can hardly be seen as a random sample.

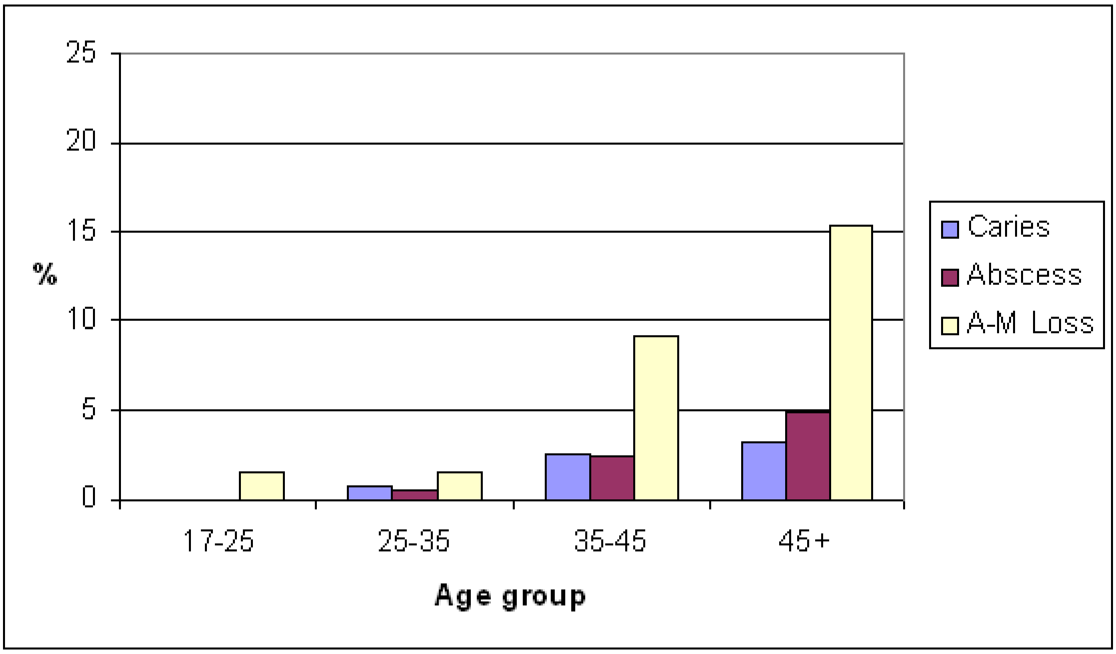


Figure 6.22. Dental pathology by age at The Hirsel: males

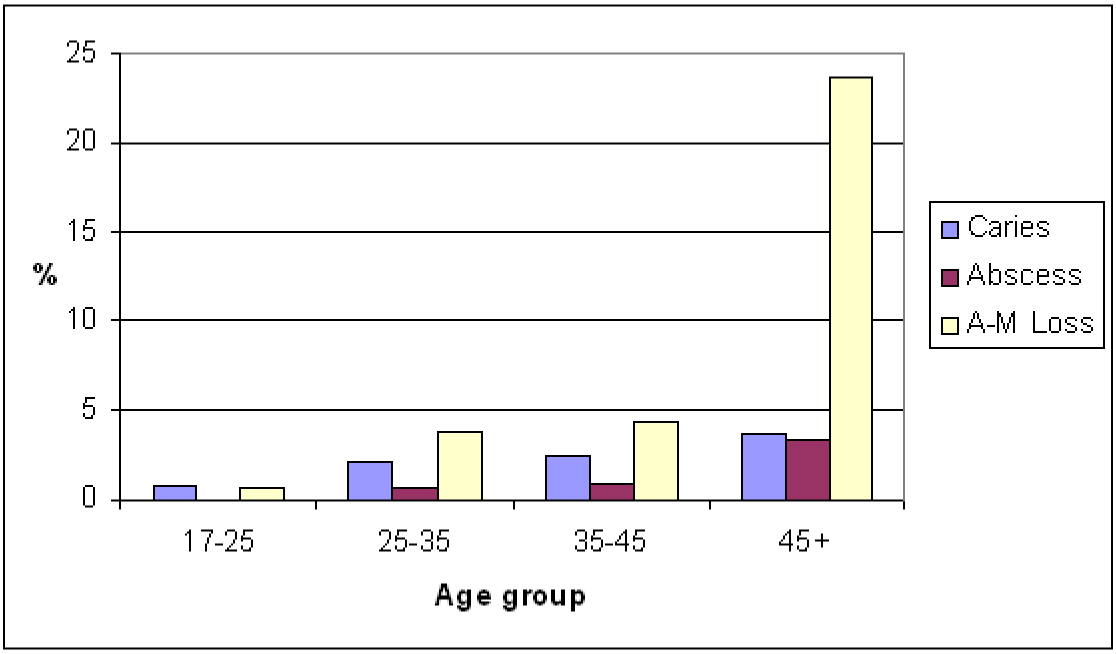


Figure 6.23. Dental pathology by age at The Hirsel: females

6.2.3.3. Alveolar Resorption
Alveolar resorption was scored as slight, medium or heavy at most of the sites. A heavy amount usually correlated with old age or the presence of periodontal abscesses, as would be expected. A typical example, from The Hirsel, is shown in Table 6.10 below.

Sex	Jaws	Slight	Medium	Heavy	Total
	N	N %	N %	N %	N %
M	42	15 35.7	18 42.9	6 14.3	39 92.8
F	55	16 29.1	17 30.9	9 16.4	42 76.4
?	4	0 -	2 50.0	1 25.0	3 75.0
All	101	31 30.7	37 36.6	16 15.8	84 83.2

Table 6.10.

This shows a slight difference between males and females, with males showing a greater frequency of resorption but with females more affected by heavy resorption. This may be due to the fact that the males were living to a greater age and that this was the main cause of the resorption seen in their jaws, whereas the women with heavier resorption were more affected by periodontal disease, perhaps due to different eating habits.

6.2.3.4. Calculus
Deposits of calculus were also scored on a threepoint scale, with the following results at The Hirsel.

Sex	Jaws N	Slight N %	Medium N %	Heavy N %	Total N %
M	45	19 42.2	8 17.8	1 2.2	28 62.2
F	55	18 32.7	11 20.0	4 7.3	33 60.0
?	4	0 -	1 25.0	0 -	1 25.0
All	104	37 35.6	20 19.2	5 4.8	62 59.6
Juv	73	14 19.2	2 2.7	0 -	16 21.9

Table 6.11.

Again, the males have a slightly greater frequency than the females, but the greater degrees of occurrence are present in the females. This seems to concur with the evidence from alveolar resorption, to suggest that females had a slightly different diet to the males. Wells (Jarrow MS) suggested that they were eating a greater proportion of softer foods than the males, and this would seem to fit in with their general levels of dental health. Table 6.12 presents the overall distributions of calculus for males and females at some of the other sites.

Site	% Calculus	
	Males	Females
HIR	62.2	60.0
JA Sax	25.0	47.1
JA Med	42.3	60.7
NEM	82.9	91.3
BG	86.7	82.6
BF	94.4	100.0
GP	95.0	70.6

Table 6.12.

At Jarrow the females were found to have a greater frequency of calculus and the degree was also much greater in the women. These figures are possibly even more suggestive of the greater consumption of soft foods by women. Wells explains this in the Jarrow MS as follows: 'Since tartar tends to be reduced when the teeth are vigorously used for powerful chewing and increased by diets of paps, light snacks and functionally less demanding foods, it is possible that the Jarrow women were affected more than the men because they used to nibble cakes and buns about the house, cull dainty morsels from the cook pot and, by assuaging their appetites on tit-bits, feel less inclined to champ the tougher cuts of meat which their ravenous menfolk gnawed with relish, at the end of a hungry day, to the benefit of their jaws if not their digestive systems.' However, at the other sites the difference between the sexes is small, and at two the males are greater than the females, so the theory is by no means well established.

6.2.3.5. Hypoplasia
Hypoplastic lesions were distributed as follows at The Hirsel.

Sex	Jaws N	Slight N	Slight %	Medium N	Medium %	Gross N	Gross %	Total N	Total %
M	45	26	57.8	5	11.1	0	-	31	68.9
F	54	32	59.3	2	3.7	0	-	34	63.0
?	4	2	50.0	0	-	0	-	2	50.0
All	103	60	58.3	7	6.8	0	-	67	65.0
Juv	76	19	25.0	7	9.2	2	2.6	28	36.8

Table 6.13.

This shows a slightly greater and grosser occurrence in males than in females, although the children exhibit the most gross lesions. It is possible that the worst lesions are consistent with long periods of illness in childhood, which makes it less likely that such individuals will reach maturity. Table 6.14 shows the male, female and juvenile figures for some other sites.

Site	% Hypoplasia Male	Female	Juvenile
HIR	68.9	63.0	36.8
NEM	80.0	69.6	-
BG	43.3	47.8	27.3
BF	94.4	100.0	-
GP	70.0	76.5	66.7

Table 6.14.

The high figures recorded at Blackfriars and Guisborough are probably partly a result of the small numbers of individuals (5 females at the former and 3 juveniles at the latter). The reason why the earlier site of Blackgate should have less hypoplasia than the medieval sites is uncertain.

6.2.3.6. Conclusions

The pattern of dental disease seen at all the sites was broadly similar, although there was an increase in prevalence through time. Where caries occurred, it was most common on the interstitial surfaces of the teeth, and in the cervical area. Occlusal caries was very rarely seen, probably due to the amount of attrition in older individuals, particularly on the molars. Antemortem loss was most frequent in the molar area and in old age, and abscesses affected the premolars and molars more than the anterior teeth. Calculus and hypoplasia were common on all teeth at all sites. Hypoplasia particulary affected the canines and the second molars, whereas calculus was common on the incisors and molars. Other dental pathologies were rare. Odontomes were seen in the maxillary incisive fossa of a child from The Hirsel, and in the same position in a child from Blackgate. Enamel pearls were present on the maxillary second molars of a Medieval female from Jarrow. One child from Blackgate had a fractured lower incisor which had healed at a slight angle. Otherwise, the people of these eight populations were quite normal in their dental health for the periods in which they were living. They probably took little care over dental hygiene, and halitosis was likely to have been the norm, with lost teeth and painful mouths being accepted occurrences.

SECTION 7.
Short note on the Pathological Study

The study of pathological conditions in human skeletal remains is an enormous and specialised field, and I have not attempted to discuss pathological cases in this work. Most cases of interest from all of the sites considered here have either already been published (Wells, 1974a, 1974c, 1976d, 1977a, 1979; Wells & Woodhouse, 1975), or will be in the near future (Anderson and Birkett/ Anderson, forthcoming), and the details of these will not be repeated here.

Unlike previous chapters, there will be no attempt to study general papers on the subject, since the enormous number of papers on the subject of palaeopathology make this all but impossible within the scope of the present work.

It was intended that prevalences of the more common diseases at each site would be given, but this has proved impossible for Jarrow, Monkwearmouth, The Hirsel and Norton, since the present writer was only superficially involved with the pathological study of these. In the case of Jarrow, Monkwearmouth and The Hirsel the pathological reports are in the process of completion by Dr. Birkett. Some information can be obtained from Wells' studies of Jarrow and Monkwearmouth, and Birkett's analysis of the Norton skeletons, but this is not always comparable with the data recorded from the sites whose pathology was studied by the present writer (Blackfriars, Blackgate and Guisborough).

In every case, analysis of the skeletal remains from the seven sites considered here was carried out for the purpose of writing short reports. No time or resources were available for the detailed examination of every bone and joint for signs of diseases such as osteoarthritis. Histological, microscopic and radiographic techniques could be used in very few cases. Only macroscopic analysis was possible for the majority of the remains, and descriptions of probable and possible pathological changes are noted in the catalogues.

In view of this, it was decided that it was best not to attempt a prevalence study of diseases in the three groups studied by the writer, since these are at best small and at worst disordered. It is felt that a patchy survey of a few diseases at a few of the sites could not hope to be as detailed as the anthropological study of these cemeteries, nor would it provide a great deal of information in the scope of a comparative work. It is to be hoped that in the future there may be the resources available for a detailed pathological prevalence study of a large site such as The Hirsel, in a field such as rheumatology.

In the meantime, all that can be said about the pathology of these groups is that there were very few examples of serious bone disease, that degenerative disease was common at all sites in the older age groups (as might be expected), that examples of trauma and/or weapon injury were noted at nearly every site, and that non-specific infections were noted fairly regularly. Greater detail can be found in the relevant reports.

SECTION 8.
Archaeological Implications

This thesis has been concerned with the techniques used in the study of human skeletal biology and their application to particular sites in the North-East of England. The archaeological information which this sort of data provides is implicit in the previous chapters, but it needs to be considered separately to show the implications of this type of work.

The type of information which osteoarchaeology can provide for archaeologists includes that on human variability (physical characteristics of an archaeological group - stature, head/face shape, diet/nutrition, disease), life style, and demographic data. These can be used to suggest patterns of disease in the past, cultural behaviour (burial customs related to ethnic group, sex, age), possible family relationships, and life expectancy.

There are of course problems with osteoarchaeological data, and therefore with the information it provides. Archaeological 'populations' are almost always too small and unrepresentative of the living populations from which they are derived. Long periods of use of a site, particularly one with a relatively small quantity of burials, means that conclusions are even more prone to error, particularly when attempts are made to divide a small group into even smaller sets of rough periods. As discussed at length in previous chapters, ageing and sexing techniques provide inaccurate results. The majority of diseases do not affect bone and are therefore excluded from knowledge about past epidemics, despite the fact that they probably affected a large proportion of the individuals studied, and may have been the cause of death of many. There are problems with determining the cause of many observed variations within and between groups - are they genetic or environmental? In comparative studies, the problem of inter- and intra-observer error is an added complication. On top of this, implicit assumptions are frequently made. For example, it has often been assumed that groups which have similar spatial and temporal characteristics will have other elements in common. This assumption has been made in this study when considering the use of metrical and non-metric traits as tools for distinguishing relationships between populations, and if it is incorrect then non-metric mean measures of divergence may be more useful than suggested in this respect. There is also assumed cultural knowledge, which may be reasonable in Christian Medieval and later societies, but is perhaps less reliable in earlier groups. If, for example, the Saxons were not burying in family groups, use of 'genetic' markers to indicate such groups may give a false impression.

Little can be done to remedy most of these problems given the present state of knowledge, but they cannot be ignored, and any information provided by skeletal work should be viewed, and used, with caution. Only part of the picture is presented, and some parts are blurred or incorrectly painted. The implications of this for archaeology are clear - although study of human bones is necessary to provide more complete information about a population, the actual data collected may be unreliable. However, although the type of information provided by bones is often limited, it is the only source of such information other than written records, and for any group of pre-Medieval bones it is likely to be all we have to go on. Grave goods might provide some information on the sex and possibly age of individuals, but who can be certain if this is any more reliable than physical evidence? Studies of physical variation cannot be based on artefactual evidence, nor can theories about health in the past (except in the rare case of the discovery of medical implements). Assumptions are necessary in many aspects of archaeological study, if only because of lack of evidence, and there are always limitations in the study of past peoples. Although this does not justify the technical problems involved in the use of skeletal data, it does suggest that there should be less demand on the data to obtain information which it cannot be expected to provide.

8.1. Comparisons with other sites

Up to now, very little comparison has been made with sites other than the seven under consideration. It was felt that enough error had already been introduced within these groups by the various people studying them, and that to bring in further sites and observers would only cloud the picture and provide even fewer positive conclusions. However, this section will attempt a comparison with other groups, chiefly those studied by the present author and her colleagues (the late Calvin Wells and David Birkett), but also with other groups to see if any obvious differences might be attributable to techniques used by certain observers, or whether they might in fact be genuine differences between populations.

The archaeological implications of these comparisons, and the type of information which might be recovered for the benefit of archaeological research will be considered. A few key points will be discussed under each heading, but it should be remembered that there are no certain answers to any of the problems mentioned above or subsequently.

The following 15 sites have been chosen for comparative analysis:
1. Trentholme Drive, York (Wenham, 1968). Roman Garrison cemetery, 2nd-4th centuries. MNI 350.
2. Cirencester (Wells, 1982). Roman cemetery. MNI 421.

3. Bidford-on-Avon, Warks. (Brash & Young, 1935). Anglo-Saxon cemetery, early 6th century. MNI 253 (inhumations).
4. Burwell, Cambs. (Layard & Young, 1935). ?Christian Anglo-Saxon cemetery, 7th century. MNI 125.
5. Brandon, Suffolk (Anderson, 1990). ?Christian Middle Saxon cemetery. MNI 153.
6. Nazeingbury, Essex (Putnam, 1978). ?Monastic Middle Saxon cemetery. MNI 153.
7. Caister-on-Sea, Norfolk (Anderson, 1991). Christian Saxon cemetery. MNI 139.
8. Burgh Castle, Norfolk (Anderson & Birkett, 1989). ?Christian Saxon cemetery. MNI 197.
9. North Elmham, Norfolk (Wells, 1980b). Ecclesiastical (Cathedral) cemetery, Saxon. MNI 206.
10. Raunds, Northants. (Powell, forthcoming). Churchyard, 6th-15th centuries. MNI 364.
11. St. Helen-on-the-Walls, York (Dawes & Magilton, 1980). Urban churchyard, 10th-16th centuries. MNI 1041.
12. St. Mark's, Lincoln (Dawes, 1986). Urban churchyard, 10th-18th centuries. MNI 248.
13. St. Nicholas Shambles, London (White, 1988). Urban churchyard, 11th-12th centuries. MNI 234.
14. Blackfriars Street, Carlisle (Henderson, 1986?). Friary churchyard, 13th-16th centuries. MNI 214.
15. Iona (Wells, 1981a). ?Monastic. MNI 110.

These sites have been chosen in preference to others firstly because of their size (MNI greater than 100), secondly because they allow a wide range of temporal and/or spatial comparisons with the study groups, and thirdly (in the case of six of them) the methods used in their analysis are the same as those employed on the study groups. More specifically, Raunds may be seen as a good comparison site for The Hirsel because they are both small medieval churchyards, Blackfriars Street, Carlisle, is a similar type of site to Blackfriars, Newcastle, some of the East Anglian Saxon sites represent monastic and ecclesiastical sites which are contemporary with Jarrow, Monkwearmouth and Blackgate, Bidford-on-Avon is of roughly the same date as Norton, and the Medieval urban churchyards provide a contrast for Gisborough Priory. Unfortunately it was not possible to compare them all with the study populations in all respects, due to lack of conformity in the data.

8.1.1. Palaeodemographic Analysis

One of the major problems with this area of study is the lack of child remains discovered on many sites. The table of percentages of child burials at each of the seven sites in this study can be found on page 51, and it will be seen that the proportion of children varies from 8.3% at Blackfriars to 45.8% at The Hirsel. Similar figures were found at 13 of the 15 sites mentioned above (figures were not available for Burwell and Bidford-on-Avon), although one site (Iona) had only one child (0.9%) represented by a single bone only. The largest percentage of children was found at Raunds (47.1%). The average percentage for the 13 sites was 22.6% (if Iona is excluded this becomes 24.4%), which may be compared with 29.9% from the seven study groups.

A number of reasons can be suggested for differences in the proportions of child burials at different sites. Firstly, if it is assumed that children might be excluded from burial in certain areas of some cemeteries, then those cemeteries which are not completely excavated might produce a biased picture. This may be the case at Brandon, Suffolk, where two cemeteries were uncovered, one of which was completely excavated and had 20.3% children, and the other which was only partially dug and contained 64.5% children. Such exclusion might occur due to a variety of factors, such as religious belief, lack of status or money, or even time of year. This last might affect burial patterns if a certain area of the burial ground was in use when an epidemic hit the younger members of a community. Sometimes children may be excluded because of the type of site - medieval urban churchyards tend to have a slightly higher proportion than medieval monastic sites for example (the mean proportion of children at St. Nicholas Shambles, St. Helen-on-the-Walls, and St. Marks is 33.1%, compared with a mean of 18.8% from the medieval monastic group of Jarrow, Guisborough, Blackfriars and Carlisle). Preservation may also be a factor, but the large proportions of juveniles at Monkwearmouth and Brandon Cemetery 2 for example came from particularly poorly preserved groups. Finally, it might be considered that the percentages found are actually close to the original proportions of children buried, either because of burial customs, or simply due to the fact that there was a much lower child mortality in these periods than has previously been assumed. Complete excavation and analysis of many more cemeteries is needed to solve this dilemma.

As well as different proportions of juvenile burials at these sites, there are also differing proportions of burials within child age groups. In particular, the percentage of infants varies considerably from site to site. In the study groups the proportion varies from 12.1% at Norton to 48.1% at Monkwearmouth. There are similar problems with this study as with the above. Perhaps infants were not buried in churchyards at certain times or for various reasons, or maybe they were healthier in certain periods or areas than others. Once again it is difficult to be certain when the whole of a cemetery population has not been excavated.

The percentages of individuals distributed over the adult age groups were found to vary considerably in the study populations. A possible reason for this is that two sites (Jarrow and Monkwearmouth) where mortality was higher in the older age groups than in the younger, were largely aged by Calvin Wells using different techniques to the present writer. Since the two sites are closely contemporaneous and of a similar type, this may be a true reflection of their similarity. To test this, it is necessary to consider other groups studied by Wells to see if the patterns of adult age distribution are similar at these. At both North Elmham and Cirencester, the largest proportion of adults died in the middle-aged category (in this case 38-47 years), although the proportion of old adults at Cirencester was quite high. This seems to suggest that the age distributions seen at Jarrow and Monkwearmouth are not a reflection of techniques used. Later sites and monastic sites might be expected to have older inhabitants. Monks were likely to have had better living conditions than contemporary peasants, although perhaps not as good as those of the aristocracy (who were probably buried at these sites anyway). Variations in age distributions at various sites may be due to social differences, such as burial of older people in more prestigious cemeteries or areas of a cemetery, or they may be due to biological differences between groups which make ageing difficult. Certain occupations, such as those involving strenuous labour, may give rise to degenerative changes at an earlier age than more sedentary ones. Thus a rural group (or a group of monks) might seem older overall than an urban one.

The implications of large numbers of unaged individuals at some of the study sites are difficult to assess. It might be expected that most skeletons to which an age cannot be assigned are in very poor condition, and that these are either very young or very old, with thin porous bones which are easily damaged in the ground. This does not seem to be the case at Monkwearmouth and Saxon Jarrow, where there were large proportions of children and old people despite poor preservation. As it seems unlikely that younger bone was more susceptible to decay, it can only be assumed that those individuals who could not be aged fall into similar age groups as those who could. If this is the case then unaged individuals can be disregarded since their exclusion will have little effect on the final results.

The skeletal problem with perhaps the most serious implications for archaeology is that of inaccuracy of ageing techniques. Since most methods have been shown to be so imprecise in the assessment of skeletal age, it seems that only age categories which do not involve definite figures should be used. Thus, although “young”, “middle-aged” or “old” may not be entirely acceptable categories from an archaeological point of view, they are the most accurate available if expensive and destructive ageing techniques are not feasible.

The assumption that there should be a 1:1 ratio of men to women in a “normal” society is more or less confirmed by the analysis of many groups. Those which differ from this norm are often known to be monastic sites, but others may have no obvious explanation. In these latter cases the usual hypothesis is that warfare separated the burial places of men and women. At Cirencester and Trentholme Drive, York, the sex ratios are heavily biased in favour of males (69:31 and 82:18 respectively) and this has been explained by the fact that they are cemeteries for legionary garrisons. Iona (27:73) and Nazeingbury (28:72) show the opposite picture, with greater proportions of women than men, perhaps as a result of religious segregation in the form of nunneries. Of the monastic sites, friaries seem to show the most sexual divergence. Blackfriars, Newcastle, and Blackfriars, Carlisle, have similar ratios (63:37 and 64:36 respectively), and other friary sites have also produced more men than women. The most nearly normal site in terms of sex distribution seems to be Caister, where there were 49 men and 50 women, but other Saxon and Medieval sites vary between 49-60% men. Norton, at the top end of the scale, may have some warrior burials which could explain the high proportion of men. The other sites do not appear to show any particular groupings, with Saxon and Medieval Monastic and Ecclesiastical sites having a wide variety of ratios. Unless the divergence is significant, or there are distinct groupings of the sexes in a burial ground, the use of sex ratios to provide information on the type of site is hazardous, particularly if the whole cemetery has not been excavated, or there is a large number of unsexable adults, or the cemetery has not been closely phased.

At many sites greater percentages of women have been found to die in the younger age groups than men. In the past it has been suggested that this was caused by difficulties in childbirth, or by different nutritional standards for men and women (Wells, 1980b). There is very little supporting evidence for either of these claims, unless we are dealing with post-medieval populations. The assumption that poor medical knowledge increases the risk of death in childbirth may be true of the 19th century slums, but it does not necessarily apply to pre-industrial societies. Except in cases where a woman has a markedly android pelvis, or there is some other complication with the birth, there is no reason why the majority of women in a rural society should not survive labour. Differences in eating habits between the sexes as young children might have some effect, particularly if girls were less well fed than their brothers in times of hardship, but there is no skeletal evidence to suggest that women were any more affected by avitaminosis or malnutrition than men. It seems that, except in a few cases where death in childbirth is evident from the presence of a foetal skeleton in the grave, the majority of women probably had healthy pregnancies. Large numbers of pregnancies might drain a woman and cause an early death simply because she was “worn out”, possibly helped by malnutrition and reduced immunity to infection, but since it is not at present possible to judge the number of children carried by a woman from her skeletal remains there is no support for this theory either. One possible cause of differing life expectancy between men and women on pre-industrial sites seems to be the problem of inaccurate ageing techniques. Many ageing techniques rely on bony changes which may be greater on the more robust bones of men. This might have the effect of overageing men and underageing women, which would produce the observed discrepancies. If women were eating softer food than men (although there is no proof that they were) there would also be a difference in the amount of tooth wear seen, which would serve to enhance the problem.

The archaeological implications of unreliable ageing methods would seem to be that it is impossible to construct valid life tables for cemetery populations (although there are of course many other problems with this branch of palaeodemography, as related in Section 3), and it is by no means certain that differences in age at death between men and women are as great as the analysis of many groups has suggested. Suggestions of biological age, in the form of categories (young, middle-aged, old), seem to be the only solution at present. This kind of information should not be treated as inferior to chronological age, however, since it is the biological age and appearance of a person which affects his or her status in society and the contribution he or she is able to make. Since this is the kind of information which is required to make an archaeological reconstruction, perhaps it is unnecessary (as well as unrealistic) to expect more from skeletal remains.

8.1.2. Metrical Analysis

Although it might be expected that mean heights of populations should increase through time, due to such factors as better nutrition and standards of living, there was no real evidence for this in the study groups (p.108). However, other Medieval groups in the North, such as Wharram Percy, St. Helen-on-the-Walls and Rothwell Charnal House (quoted by White, 1988) are much shorter on average than those seen by the present writer. This may be due to a difference in the regression formulae used in two cases, but it is certainly not in the case of St. Helen's. If the mean male statures from six Northern Medieval populations (the three mentioned above plus JA, BF and GP) are averaged, and compared with the average of four Northern Saxon groups (JA, MK, NEM and BG), the Saxon group is found to have a greater mean (172.3cm compared with 169.7cm for the Medieval group). This would imply that men were actually shorter in the later period. The results for the women of these groups (excluding Wharram Percy for which figures were not available) were 160.4cm for the Medieval group and 160.3cm for the Saxon group, which suggests almost no change in the female population through time. It is difficult to know how this should be interpreted, but if it is true that 90% of the determination of stature is genetic this might suggest that the women of these groups were more genetically stable through time than the men. The slight differences in male and female craniometric indices might also be evidence for this.

It has also been suggested (p.118) that Northern populations might be shorter on average than Southern groups. Although there are no obvious groupings when male means are plotted on a map of the British Isles, the averages of groups of means suggest a slight difference between the north and the south in the Saxon and Medieval periods. The mean stature for three sites in the south (St. Nicholas Shambles, Guildford Friary and St. Leonard's Hythe) was 172.7cm for the males and 157.7cm for the females. This suggests that men were taller but women were shorter on average than their northern contemporaries (figures given above) in the Medieval period. In the Saxon period, only one site was available for study in the south (Kings Worthy), so a group of five sites from East Anglia (North Elmham, Burgh Castle, Caister, Brandon and Nazeingbury) will be used instead. These suggest a slightly higher stature in the eastern group for both males and females (173.2 and 162.0cm respectively). Further confirmation of the theoretical greater height of Southerners can be obtained from the two Scottish sites available for study (Iona and The Hirsel) which provide average statures of 165.5 and 158.0cm for men and women respectively. This split might suggest a larger component of indigenous peoples in the north, with a greater proportion of Germanic peoples in the south and east.

This kind of study may prove useful if comparisons are made with some Germanic groups in the homelands and they are found to be taller than the northern British. It has already been shown (p.116) that the Alamanns had longer limb bones than the Hirsel men, but a number of large groups would need to be studied before this could be any more than a theory. Unfortunately, as with all osteological studies, most cemetery sites have only yielded small groups of individuals for whom stature could be calculated, so it is difficult to compare means with any confidence.

Table 8.1 lists the mean lengths (together with numbers of bones involved) of right and left femora, tibiae, humeri, radii and ulnae for males and females from a number of sites in four groups. These consist of mean lengths from a collection of Saxon bones from all over Britain (Munter, 1936), four North-Eastern Saxon sites, three East Anglian Saxon groups, and five North-Eastern Medieval populations. A few points may be considered with regard to this data. Firstly, within the north-eastern Saxon group, Norton tends to have the greatest mean bone lengths. This is particularly true of the females, who in every case have the longest bones in this group, and also, with the exception of the left femur, have the greatest mean lengths overall. The shortest male bones are spread between the other three groups in the Saxon North-East, but the shortest female bones generally belonged to the women from Blackgate. In the eastern group, the Burgh Castle males have the longest bone lengths in every case, whereas the females have the longest leg bones in their group, but the shortest forearms (except the right ulna). Brandon tends to have the shortest bones for both sexes. The patterns are less clear-cut in the Medieval group, with Blackfriars men having the longest legs and Gisborough men the longest arms, whilst the females of both groups have the longest bones but in a less distinctive configuration. The shortest bones in this group are widely spread amongst the male populations, but seem more concentrated on St. Helen-on-the-Walls for the females. The means collected by Munter fall within the ranges of means for every bone, which is perhaps not surprising given the wide dispersal of the sites he studied. He felt that pooling of the measurements was justified because there was no significant difference between maximum lengths of the right femur for Angles, West and South Saxons and Jutes.

Much of this is reflected in the mean statures of these groups, which were discussed above, although this is perhaps more influenced by the leg bone measurements. It is interesting, therefore, to note differences between the arm and leg bones of a population, and the discrepancies between the males and females from a single site when compared with those of others. Patterns like these might suggest a lack of homogeneity between the sexes at some sites, although it is difficult to ascertain whether similar or opposite patterns have the greatest significance in reaching such conclusions. For example, if the women of a group have very long bones but the men have rather short bones, they might have greater homogeneity than a group in which both sexes have consistently long or short bones. The interpretation of this type of data is thus difficult because of the problems of comparing large quantities of numbers without complicated multivariate statistics, and again because of small sample size in many groups. Probably the best use of long bone lengths is to calculate stature, one figure which can be easily compared between populations and which actually has some meaning in archaeological studies. It is unlikely that a relatively shorter arm or leg length would affect the daily life of a group of people, but with large samples of measurements, precise questions and the appropriate statistical tests it may be possible to use such measurements to form at least the basis of a genetic study.

The difficulty of interpretation of the two most commonly calculated post-cranial indices, Platymeria and Platycnemia, has already been discussed (Section 4.2, p.119ff). Similar patterns to those seen in the study populations were observed in other groups for which figures were available, these being that later sites had higher Meric indices (although Burgh Castle had rather high means of 81.1 for the males and 79.2 for the females), the females had relatively thinner femora, and the female Cnemic index was greater than that of the male in most cases but there was no correlation of this index with time. The differences between males and females might suggest some kind of functional factor is the cause of these conditions, perhaps due to the need for carrying a wider pelvis in women. This would have to be tested by searching for a correlation between wide pelves and wide tibiae in individuals, a study which is beyond the scope of the present work. However, if the women from these sites are of a different geographical background to the men, it may be that the difference seen is a racial one, although this does seem a little difficult to believe in the light of so many similar cases. Whatever the cause may be, there does not seem to be any immediate use of these indices for archaeological interpretation, and perhaps it is time for more detailed anatomical study, in the hope of a more reasonable explanation for their cause. Thus, perhaps for the present they should be excluded from archaeological reports.

The major problem with craniometry is that of small sample size. This has made it difficult to use anything other than the simplest statistical studies on the skulls included in this work and the same is true of most other groups. Complicated statistical tests have been applied to combined groups in the past, but it is difficult to prove the validity of such studies when the sample sizes of the individual collections concerned are such that the differences between them cannot be adequately explored.

Although the sample sizes for complete crania are small in all the groups looked at in this study (p.142), the largest group, The Hirsel, may be compared with other sites. Table 8.2 below presents the mean cranial indices and their categories for men and women at those sites for which the appropriate figures are readily available.

Site	Period	Male	Female
Wetwang	Iron Age	73.6 D	74.0 D
Trentholme Drive	Roman	76.5 M	75.8 M
Bidford	Middle Saxon	73.5 D	73.8 D
Burgh Castle	Saxon	73.1 D	75.5 M
Burwell	Middle Saxon	74.8 D	75.8 M
Caister	Saxon	75.0 M	75.1 M
THE HIRSEL	Medieval	79.0 M	77.9 M
St. Helen, York	Medieval	79.4 M	81.2 B

Table 8.2

This suggests an increase in the cranial index from the Iron Age to the Roman period, followed by a reduction in the earlier Saxon groups and a gradual increase as the Medieval period is approached. It also seems to suggest that changes in the shape of the head affect the females of a population first. In most cases (the exceptions being Trentholme Drive and The Hirsel) the mean is slightly higher for the females than the males. The same trends were seen in the study groups (p. 143), and this might suggest a lack of environmental influence in this particular change since the trend seems to apply irrespective of the type of site or its geographic location.

Table 8.3 lists the means of some of the more common cranial and facial measurements from sites in a number of distinct areas, as well as the pooled means of Saxons from various parts of Britain collected by Morant (1926). Like Munter (mentioned above in connection with long bone measurements) he found little difference between the Saxon, Jutish and Anglian groups in his study. This is consistent with the information obtained from study of Table 8.3, in which no real difference was seen between the Saxon East and North-East, although the minimum figures for each measurement are slightly higher in the east, perhaps due to larger sample sizes. A few other points may be noted about the data given here. The least variable means between groups are nasal breadth and height, and minimum frontal breadth. Nasal breadth is remarkably similar at all sites and also between the sexes, presumably because it is the smallest measurement and therefore has the least scope for variability. The greatest difference between Saxon and Medieval male populations is in cranial length, with the Saxon range being 187-196 and the Medieval 182-187 (in females it is 182-186 and 172-183 respectively). There is slightly greater overlap in cranial breadth between the two time periods (male Saxon 136-143 and Medieval 141-147; female Saxon 132-139 and Medieval 134-142). This presumably reflects the change to brachycephaly over time, but the actual reason for the shortening and broadening of the cranial vault is unknown, although it is suggestive of either gradual genetic drift or new genetic input. Cranial height shows less change through time in the males, but in the females there is a slight decrease from 125-134 to 125-127. The main difference between the populations in the East and North-East can be seen in the width of the female face, which is greater in the East (91-95) than in the North-East in either the Saxon (81-90) or the Medieval period (83-92). The length of the facial part of the skull (LB) is greater in the Saxon females from all areas than those of the Medieval period in the North-East. Monkwearmouth has the longest skulls of all for both males and females, whilst the shortest skulls in both sexes are from Blackfriars. Cranial length appears to be the most constantly similar measurement between the sexes at Saxon sites at least, and for example Brandon has the shortest and Burwell the longest skulls in the East Saxon group for both sexes. Other measurements often show opposite patterns when the sexes are compared, so that Brandon males have the shortest skulls (H') in their group but Brandon females have the tallest, and Monkwearmouth males have the narrowest faces but Monkwearmouth females have the widest in their group. These patterns could reflect greater homogeneity in these characteristics between the sexes, although they might be a result of small sample size.

Although grouping together of data (as used by Morant and others) is useful in providing a larger sample for statistical purposes and might provide general racial traits (for example between Saxons and Jutes), it is of little use for comparison of single populations. If the groups in Table 8.3 had been pooled the differences within them would not have been seen, and those between them may have been obscured. So whilst pooling, and the access it allows to complicated statistical tests, is of great value in generalised studies of large groups of people over whole geographical areas, it is of little use in the context of a single site.

Unfortunately this type of study is limited by the small numbers of complete crania excavated from most sites, so it has not been possible to include a number of the sites listed in Section 8.1. Problems may also arise when using material from a single cemetery with a long period of use, since changes through time at a single site are difficult to study unless preservation is exceptional. This might obscure any sharp changes in metrical traits by smoothing the data. However, that there is a definite change through time seems to be indisputable, and it only remains to find a plausible explanation. For this, much larger samples of skulls which are more closely datable and which allow comparisons both within and between sites are necessary. It does seem from the evidence available that cranial shape change is more genetically than environ-mentally determined, since it occurs in so many different areas (see p.138). It may represent a demographic change through time, in which case it may be possible to link it with observed cultural changes, or it may simply be a gradual fluctuation within a fairly homogeneous population.

In general, metrical comparisons are difficult due to inter- and intra-observer error, a problem which is magnified by increasingly complicated statistical studies. Then there is the added complication of genetic versus environmental factors as causes of observed change through time and differences between groups. From an archaeological viewpoint, differences in osteological measurements might be of little use in a social reconstruction of past populations, but where they can be shown to be significant in demographic and biological terms, they might suggest possible lines of research into cultural changes.

8.1.3. Non-Metric Traits

The major problem with this field of study is the difficulty of comparison between sites due to the different lists of traits used by various observers. The archaeological implications of this would seem to be that the specialist will only be able to produce full comparisons with sites he or she has previously studied, which may not necessarily be those which are archaeologically most useful. For example, a comparison of certain types of sites or sites within a particular area may be possible in almost every other particular, but unless the specialist has worked on other sites in the chosen category it may not be possible to produce a meaningful comparison of genetic traits. However, although suggestions of possible genetic links between population groups would be helpful in archaeology, this may be another case of expecting too much of the evidence. The problem of lack of knowledge concerning genetic components of non-metric traits means that possible relationships both within and between sites must remain speculation for the present. If this knowledge were available it would obviously be extremely frustrating if comparisons between sites were impossible because of the different traits chosen by various workers. At present it is not, except possibly in the case of metopism which does appear to be genetic in origin.

A number of solutions might be suggested for the current state of affairs. Firstly, it would be helpful if all specialists used the same list of traits, preferably that described by Berry and Berry (1967), so that comparisons are possible at least on a very basic level. Secondly, studies of these traits in at least two (and preferably many more) documented populations with large groups of related individuals are necessary to make a start on solving the genetic content of some of the traits. Finally, studies on specific traits are necessary, perhaps in living populations, to determine their genetics in more detail. This last is unlikely to be achieved until well into the future, but it is to be hoped that standardisation of trait observation might make present results useful to future workers in this field.

8.1.4. Dental Study

The state of a individual's dentition can provide information about his/her health in childhood, nutritional standards, age at death, and oral hygiene. All these categories of information, when taken from a large group of individuals, shed light on living standards in the past and are therefore of great use to the general archaeologist.

It might be expected that the study of third molar agenesis would produce data to suggest an increase of the condition through time. There was a slight suggestion of this in the study groups (p.197-198), but other groups do not seem to show a time-related change. Where figures were available, the women always had a greater prevalence of the condition than the men, as is usually the case. The overall figures for East Anglian Saxon groups were very similar (Brandon 11.8%; Caister 17.6%; Burgh Castle 17.2%; North Elmham 16.1%), and there seems to be a temporal difference in York (Trentholme Drive 12.2%; St. Helen-on-the-Walls 23.4%, although this may be due to the relatively large number of males at the former). The two Scottish groups show similar prevalences (Iona 18.2%; The Hirsel 19.6%), but so do St. Mark's Lincoln (20%) and St. Nicholas Shambles (19.2%). From this evidence it is possible to tentatively suggest a temporal change within regions (if the two anomalies of Saxon Jarrow and Gisborough are ignored), with the regions showing some autonomy from each other. However more sites in each area need to be studied for confirmation of this idea. Differences between groups are presumably determined by the genetic make-up of a population, and third molar agenesis is probably most useful to archaeology as a genetic marker if used in connection with other non-metric traits.

Changes with time are observed more readily in studies of dental pathology. Carious lesions, for example, are more frequent in Roman and Medieval teeth than Saxon dentitions. Trentholme Drive and Cirencester both showed relatively high prevalences of the disease (4.6% and 5.1% respectively), whereas the prevalences seen in the Saxon study groups (p. 219) and in most of the East Anglian Saxon groups (Brandon 1.0%; Caister 1.8%; Burgh Castle 1.9%; Raunds and Nazeingbury exact figures unknown but caries "rare") are much reduced. North Elmham is an exception, having a caries frequency of 6.4%, presumably related to the fairly high status of its incumbents. In later groups there is again an increase (St. Helen's 6.1%; St. Mark's 4.0%; St. Nicholas' 5.5%), but there are of course exceptions (Blackfriars Carlisle 2.7%; Iona 0.4%). Wells (1981a) suggested that Iona was anomalous because the population was likely to have had a diet rich in sea food and therefore fluorine, and presumably it would also have been lacking in carbohydrates. The Carlisle group may have had a quite humble diet compared with their contemporaries, particularly if most of the burial population consisted of friars, but the higher caries rate found at Blackfriars Newcastle (6.0%) might suggest that this was not the case.

Abscesses generally do not appear to change in prevalence a great deal through time. In the study groups they ranged from 0.2% prevalence at The Hirsel to 2.3% at Blackfriars Newcastle, and other groups are also more or less within this range (Cirencester 1.2%; Brandon 2.5%; Burgh Castle and North Elmham 2.0%; St. Helen's 1.2%; Carlisle 1.8%; St. Mark's 0.7%; Iona 0.4%). As with all things, there was an exception. At Caister-on-Sea the abscess frequency was found to be 5.4%, and many abscesses seemed to have been formed following severe attrition of the tooth concerned, but unfortunately the reason for this wearing (which was often much greater on the affected tooth than on those surrounding it) is unknown. In general, whereas caries is found to increase through time and is related to the increase of carbohydrates in the diet, abscesses have a different aetiology and are found increasingly in older individuals (see p. 232). They might be expected to increase through time as life expectancy increased, and also due to greater exposure of the pulp cavity due to greater frequencies of carious attack, but this does not appear to be the case. The best method of comparison for periodontal abscesses is to compare frequencies for each age category, but unfortunately these figures are not easily accessible in most skeletal reports, and in many cases the sample sizes would be reduced so much that the results would be unreliable.

Ante-mortem tooth loss in the study populations appeared to be fairly steady in the Saxon groups at around 4% (with the exception of Monkwearmouth), and increased through the Medieval groups (p. 220). Other groups do not seem to suggest this pattern. The East Anglian Saxon groups of Brandon (7.1%), Caister (6.5%) and Burgh Castle

(6.3%) show similar frequencies but at North Elmham the prevalence is much greater (11.1%), suggesting that, as with caries, it is more like a Medieval group. However, eastern and southern Medieval groups have similar prevalences to the other Saxon groups (St. Mark's 6.3%; St. Nicholas' 7.6%). The St. Helen's population have the greatest frequency at 17.5%. Ante-mortem loss ought to be greater in populations with higher life expectancy, and should therefore increase in later populations.

As with all aspects of skeletal analysis, there are many factors involved in the production of patterns of dental disease found by the osteologist. The food consumed (hard?, soft?, rich in sugars?, etc.), medical aid/interference (such as tooth extractions), occupational use of the teeth, oral hygiene, genetic susceptibility to disease and the taphonomic process (for example loss of the areas of dentition most affected by disease) will all affect the frequencies of oral pathology recorded by the analyst. It is not always easy to make assumptions which might explain how these factors will affect the results, as for example at Iona where large amounts of calculus might imply poor oral hygiene, but very little dental pathology was seen. In this last case it is perhaps possible to suggest that one of the other factors listed above had a greater effect than the lack of a toothbrush, but in this and other groups it is not possible to assess the contribution made by each component.

Nevertheless, the dentition holds a great deal of information about particular individuals, which when combined with data from other skeletons can provide an insight into lifestyles in the past. Some suggestions can be made about health in childhood from the presence or absence of enamel hypoplasia, and if a comparison is made between Saxon and Medieval groups in Newcastle (Blackgate and Blackfriars) and Cleveland (Norton and Gisborough), it can be seen that overall the condition is more prevalent at the two Medieval sites. This seems to suggest a difference in living conditions, perhaps reflecting a greater chance of contracting contagious diseases in childhood in an urban environment, even though the people buried at Medieval monastic sites are assumed to have higher status than those buried in earlier community cemeteries.

Nutritional standards might also be inferred from odontological study. Susceptibility to tooth decay may be determined by genetics, but it may also be affected by environmental factors, so that additional fluorine and/or calcium in the diet might strengthen the teeth and the possibility of carious attack may be reduced. However, even this would not protect the individual from decay if large amounts of sugar were present in the mouth for long periods which may be the case in Medieval groups who paid little attention to the state of their mouths. This might explain the increase in caries at Jarrow through time, despite the possibility (suggested by Wells in the Jarrow report MS) that seafood would have introduced reasonable amounts of fluorine to the diet of the people of Jarrow and Monkwearmouth.

The importance of dental study for the reconstruction of past lives should not be underestimated, despite the difficulties involved. There is little doubt that tooth eruption and attrition can provide an idea of age at death, which in turn provides the archaeologist with demographic information. Genetic studies can be made based on non-metric traits found in the teeth, although only third molar agenesis has been discussed here, and can add to osteological information in the same field. An idea of standards of nutrition can be obtained from the teeth, especially as they are the only part of the digestive system to survive in most cases, but microscopic study probably provides the most reliable information in this respect. They can also provide a gauge of health in childhood, especially when used in conjunction with other aspects of palaeopathology outside the scope of this work.

8.2. Conclusions

8.2.1. General Implications for the Study Groups

A few general conclusions can be made about the seven study groups with reference to some of the implications listed above.

Firstly, The Hirsel is thought to be a rural "British" population, and as such should show physical differences to "Saxon" groups further south. The findings suggest that the people of The Hirsel were slightly shorter on average than their North-Eastern English contemporaries, they tended to have a lower life expectancy, and they were more brachycephalic. Unlike the other groups it has not been possible to make direct comparisons with a close neighbour, and this has made it difficult to ascertain how typical The Hirsel is of a Border population, or whether there has been any change through time except by comparison with the groups from further south. In connection with this, it would be interesting to know whether The Hirsel population is more brachycephalic because it is a Medieval group or because it is British.

This question is raised again by the findings at the two Cleveland sites, Anglian Norton and Medieval Gisborough. The Norton group ought to show more Germanic characteristics than later groups in the area, such as Gisborough, who were presumably a mixture of the settlers and the indigenous population. The people of Norton were quite tall with long limb bones (comparable to the Saxon population at Burgh Castle), and were generally dolichocephalic. The Gisborough Priory people in contrast were shorter and more brachycephalic, and in these respects resemble the

British group at The Hirsel. This might suggest that the greater numbers of the British population was able to swamp out any genetic input from the Germanic groups, although this assumes that the British characteristics were genetically dominant.

Blackgate and Blackfriars, within a mile of each other in the city of Newcastle, ought to show similar patterns to the Cleveland sites if the theory is to stand. As usual there is a change from long narrow skulls to short broad ones from the Saxon to the Medieval period, but the Blackgate population is shorter than the Blackfriars group. More people died young at Blackfriars than at Blackgate, perhaps because the Friary may have had a role as a hospital, but the Cleveland sites show the opposite picture with Norton containing more young people than Gisborough, perhaps because of the status required for burial in a Priory, or because of the famed longevity of monks. The two Newcastle populations are also very different with respect to their non-metric traits. The problem with the Blackfriars men is that there is no way of telling if they are drawn from the local population, or whether they are friars from other parts of the country.

Blackfriars and Gisborough Priory, being two different types of Medieval religious houses, are also good subjects for a comparison. Blackfriars, in common with other contemporary friaries in Carlisle and Guildford, has more men than women buried in its graveyard, but Gisborough has an equal number of men and women. Presumably this reflects something about the different roles of Friaries and Priories in Medieval society.

Jarrow and Monkwearmouth, also monastic houses, present different palaeodemographic patterns to the later Medieval monastic cemeteries mentioned above. Blackfriars and Gisborough both had very few juvenile skeletons, but at Monkwearmouth and Jarrow the percentages are quite high, and in fact correspond with the numbers seen at The Hirsel. This might suggest that Jarrow and Monkwearmouth were being used like a parish church by the local people and perhaps burial there was not quite as prestigious as at Blackfriars and Gisborough. Jarrow and Monkwearmouth both had large numbers of old individuals in their cemeteries, which may reflect the benevolence of the monasteries to the surrounding people producing an increased life expectancy, or may be a result of large proportions of old monks. Blackgate and Norton also had small numbers of children, presumably for different reasons. At Blackgate only a selective sample was kept for analysis, and bones from Norton were poorly preserved, although it may have been a prestigious burial site and seems to have had a number of warrior burials. If, however, these cemeteries had been completely excavated it would be possible to make more positive suggestions.

At Jarrow, there was the opportunity of comparing two different phases of burial, but little difference was seen between the two in any category, perhaps because the Saxon group was rather small. It was not possible to separate the monks from the laity, although this could prove an interesting study if it were feasible elsewhere. Monkwearmouth, spatially and temporally close to Jarrow, had very similar patterns of age and sex distribution and stature to the latter, unlike Caister and Burgh Castle in Norfolk which were remarkably different despite their geographical proximity.

8.2.2. Problems and Solutions

A number of problems concerning the implications of osteological work for archaeology have been outlined in this discussion. Some of the most fundamental appear to be the lack of conformity of skeletal reports making comparisons difficult in many aspects of the study, the lack of availability of European data for comparison with “immigrant” populations in Britain, the difficulties inherent in studying small “groups” of people buried over long periods of time in a single cemetery, and the inability of osteological data to live up to the expectations of archaeologists.

Some solutions can be offered for these problems. Two obvious responses to the first difficulty, of lack of conformity in reports, are to publish data in full whenever possible so that it can be used as required by other analysts, or else to agree on some degree of consistency in what is published. The main problem with the former is the cost of publishing complete “Level III” reports, but this can be overcome if the data is made available in microfiche form by bodies such as the Ancient Monuments Laboratory (a policy which is already in operation, assuming that the work is commissioned by English Heritage). The difficulties with the latter are much greater since it involves getting all osteologists, without exception, to follow a standard pattern of report writing, which would involve much discussion to ensure that nothing was omitted, and would probably produce reports longer and more expensive to publish than is already the case!

The second problem, which involves a lack of dissemination of data from the Continent to Britain, might be overcome by making mainland European reports available on fiche in the same way that AML reports are produced at present, or failing that by encouraging libraries and other purchasers of journals to become less insular in their buying policies. Both require some organisation, and are probably unlikely to occur within the near future.

Thirdly, there is the problem of analysing cemetery populations by phase or by type of burial. As Carver states (1987:95), 'The experience of one age is not going to be the experience of the next, so a cemetery in which more than twenty generations are buried, such as St. Helen's, can hardly be treated as a single population'. With large cemeteries phasing can be used to attempt to emphasise changes in the population through time, although in general the groups produced by close phasing are so small as to be unusable statistically. It seems likely, on present evidence, that any change occurred gradually, as with increase or decrease in height through time, or the shift towards brachycephaly, but in any case the nature of the dating evidence, particularly in Christian cemeteries, is such that there is unlikely to be any distinct physical change noticeable even if it exists. A study of this sort requires the total cemetery population if it is to produce meaningful results, and unfortunately the opportunities for excavating complete cemeteries are very rare. Similar problems exist in attempting to compare groups of, for example, monks with laity, where there might be expected to be some difference since the former are likely to be a non-local heterogeneous group, and the latter should be drawn from a fairly small, if not selective, local catchment area.

An important factor for consideration in this kind of study is that, even if fully excavated, cemetery populations are not representative of the living population from which they are drawn. Any fluctuations with time in the latter might be blurred by discriminatory burial practices, so that in a poor cemetery, for example, an influx of Norman nobility might not be as noticeable as it could be in a rich cemetery, assuming that cemetery continuity could be demonstrated between Saxon and Medieval times. Until all the cemeteries in an area under study are excavated in full it is difficult to say anything definitive about the people living in that area during the period in question, but the same problem is present in all aspects of archaeology and should not be allowed to detract from the information which can be gleaned from even an incomplete skeletal population.

The fourth problem mentioned above can be summarised as "What does the archaeologist really want to know about the population he/she has excavated?". A general archaeologist cannot be expected to show an interest in the minutiae of osteometric differences between individual skeletons, but on the other hand it is necessary to produce such data for the benefit of other workers in osteology and to allow conclusions about the physique of a group of people to be made. Archaeologists in general, although they are grateful for demographic information, and to a certain extent information about the physical appearance of the people they are studying, are more interested in cultural and social aspects of daily life. At the extreme, this is illustrated by archaeologists who might use osteological demographic data simply to confirm (or not!) their own conclusions from the analysis of grave goods.

Social status may be reflected in grave furniture or method of burial in rich pagan cemeteries, but it is difficult to demonstrate if no grave goods are present. In this case there may be some indications from the skeletal remains, particularly if pathological changes are found. Generally, although the aetiologies of some bone diseases are not fully understood, certain diseases affect certain types of individual. For example, deficiency diseases affect those most vulnerable to fluctuations in food production, which might suggest they were poorer. Dental caries is more likely to affect the rich, at least at the start of the middle ages. Osteoarthritis, although not definitely associated with physical stress, may affect certain parts of the body more often with certain types of occupation, and at the very least might indicate manual labour. Infectious and contagious diseases would have affected rich and poor alike, and unfortunately only the chronic type can be seen in the archaeological record since acute infections would either kill or be cured before the bone was involved. Specific infections, such as leprosy, tuberculosis, poliomyelitis and syphilis, although they do not reflect social status, would presumably affect the social relationships of the individual concerned, and how he or she was treated by others.

Physical aspects of cemetery populations are important in the reconstruction of past societies because the outward appearances and physical compositions of people affect how they react to situations and how others see them. Their status and function would change through life as they matured, so it is important to know the relative proportions of males, females, infants, teenagers, young women, old men, etc. that are present within the cemetery population. As stated previously, the osteologist can only be expected to provide estimates of biological age, since the chronological age of an individual is not necessarily reflected by his or her physical appearance, but in the past it was this appearance, perhaps coupled with productiveness, which would have affected the person's role in society.

It may be that there is a fundamental lack of communication between the excavator of a site and the specialists employed to study the finds. Very often the analyst is commissioned to "write a report" on a particular category of finds without being informed of the questions which the excavator would like to answer about his or her site. The excavator is then presented with a large report containing vast amounts of technical information which mean little to him and which he has to be able to understand to answer his questions. This is perhaps entering the realms of the problem which is concerned with who the specialist should be aiming the report at, and is beyond the scope of this work, but the point has to be made that communication is a two-way thing and the lines are severed in both directions. The osteologist needs information from the archaeologist to help with the interpretation of the former's results, and there really needs to be constant dialogue between the two so that the implications of the site for both are not lost. For example, the osteologist needs information about possible groupings in the cemetery, or skeletons buried in an unusual fashion, so that physical differences can be looked for rather than lost in the general picture. Conditions in towns or villages might be suggested by archaeological study, and this would be of use to the osteologist in picking out patterns which might reflect certain lifestyles within the buried population. Urban squalor might produce signs of deficiency diseases which would not be expected to occur in a rural group (such as rickets), but rural famine might produce smaller (but more robust) individuals with high frequencies of enamel hypoplasia and other indicators of physical stress. The osteologist cannot be expected to be an expert in all aspects of life in the past (particularly as human skeletal biology is a multi-period discipline), and he or she needs the archaeologist to answer questions, for example, concerning the conditions of peasants during the Saxon and Medieval periods, or the possible change in the nobility after the Conquest. Information about social conditions at the period in question would be of great use in helping the osteologist to produce conclusions which will be of help in reconstructing the way of life of ordinary people in the past.

The physical remains of an individual can tell the archaeologist little of that individual's hopes, aspirations, and religious beliefs *per se*, although the way the body was laid out in the grave might suggest the way he or she was regarded by others or the funerary practices of the survivors. However, the bones can provide information about age, sex, physical appearance, and possibly pathological conditions. They might suggest ill-treatment, or poor nutrition, or evidence of violence, all of which are just as necessary to help complete the picture of our ancestors' way of life as are the type of pots they used, or the exchange mechanisms they had, or the way they produced their food. Carver (1987:93) sums this up neatly: 'The greater the number of burials examined, the more clearly human conditions can be observed, and the more evocative become the individual aberrations from the norm', the point being, of course, that if we did not study physical remains we would not spot the deviations from the norm, or indeed know what the "norm" was.

CONCLUSIONS

This study has attempted to present an overview of the physical anthropology of the skeletal remains from seven sites in the North-East of England. In every section recent work on aspects of osteological study have been considered, both in their own right and in relation to the study groups.

As has been discussed in Section 3.1, the techniques of ageing an adult human skeleton are currently undergoing major revision because of their inadequacy. It seems unlikely at present, however, that methods based on any part of the skeleton other than the teeth are likely to give a reasonable estimate of age. Tooth attrition, although it should be used with care on different populations, seems to produce the best picture of advancing age, although it is by no means a constant and steady process. Although it is of little use for more recent populations, it seems likely that with some revision it could be of use for groups of medieval or earlier date.

In the case of children, the assessment of age is less troublesome and more accurate. The results from the seven groups considered here suggest that the largest proportion of child deaths occurred in the 0-2 year age group, and it seems likely that this represents a real trend. The proportions of children present were broadly similar at the three main sites under consideration (Jarrow, Monkwearmouth and The Hirsel), although the Monkwearmouth figure was slightly lower than the others, possibly due to the nature of the site (i.e. poor preservation and disturbed burials).

The other four sites had proportionally fewer juveniles, possibly due to poor preservation at Blackgate and Norton, but most likely due to differential burial practices in the high status medieval monastic groups of Guisborough Priory and Blackfriars.

The age group with the greatest proportion of adult burials varied at each site. At Jarrow and Monkwearmouth the greatest numbers of adult deaths occurred in the oldest age group (“45+”), at Blackgate in the second oldest (“35-45”), at The Hirsel, Blackfriars and Guisborough in the 25-35 year group, and at Norton in the youngest group (“17-25”). It is likely that the teeth of the Norton group would have had a reasonable amount of wear for their age, since it would be expected that the earlier the population the less refined the food, and attrition would thus occur at a faster rate. Individuals from Norton are therefore perhaps less likely to be underaged from dental wear, which suggests that the group recovered from the site were actually dying at a fairly young age. Whether this is a result of differential preservation discriminating against older osteoporotic individuals (and juveniles), or whether it is a social or environmental phenomenon is unknown. Blackfriars and Guisborough, being medieval groups, are perhaps most likely to have been underaged by dental attrition, and the large proportion of young to middle-aged individuals probably reflects this rather than a true mortality pattern. The great majority of Hirsel adults died in middle-age (“25-45”), and this may be an accurate reflection of their mortality rates due to the rural nature of the site. Jarrow and Monkwearmouth, although partially aged by the present writer, were analysed in the greater part by Calvin Wells, and it is likely that his methods of ageing were different. The largest proportion of adults at both sites were in the “Old” age group, suggesting that his techniques may have been more accurate, since this is what we might expect to find. One other alternative is that the people of Jarrow and Monkwearmouth benefitted from the presence of a monastic order and survived to a greater age because of it.

An attempt was made to test the effects of inaccurate ageing on palaeodemographic life tables by using weighted figures. This seemed to suggest that similar patterns would be seen, although actual life expectancy and survivorship figures would change slightly.

The Hirsel showed the lowest life expectancy of the three main sites, perhaps because it was a rural population with little wealth. The survivorship curves show broadly similar patterns at all three sites, although 50% of the deaths at Monkwearmouth had occurred by the age of 10, at Jarrow by 14, and at The Hirsel by 17 years. This is probably a reflection of the difficulties of ageing some of the poorly preserved skeletons at the first two sites. The probability of death curves show the greatest probability of death in infancy and old age, as expected. The least chance of dying occurred between 14-17 years at all three sites, so although there are some differences in the shapes of the curves, the basic trends are actually the same.

Although individuals may have been older than suggested by tooth wear, it does seem that a smaller proportion of adults were reaching old age at The Hirsel than at Jarrow and Monkwearmouth. Tooth wear is probably unlikely to produce a bias in this direction because it seems reasonable to assume that a rural population would be more likely to have worn teeth than an urban group.

It has already been noted that analysis of Jarrow and Monkwearmouth by Wells could have introduced a biasing factor when the two sites are compared with those analysed by the present author. However, the two sites are spatially, temporally and culturally the closest, so there is no real reason why they should not be similar to one another. It is possible that the large proportions of individuals who could not be aged at the two sites have introduced another biasing factor.

Section 3.2 considered the problems of sex determination of skeletal remains. Although easier than ageing, it is still more difficult than might be expected, especially since different dividing lines between the sexes are found in different populations. No reliable objective method is available for use with all groups at present, and it seems unlikely that one which is applicable to every group will be found. Only the pelvis shows primary sexual characteristics due to one of its major functions in life, the bearing of a foetus. Almost every other sexing trait is a function of size and robusticity. This is obviously relative and continuously variable. There have been problems in the sexing of individuals from The Hirsel, where a small set of "females" with masculine skulls were found. Whenever possible the pelvis was used when discrepancies between skull and pelvis were seen.

There were more males than females at every site except The Hirsel, which was actually the closest to the norm (p. 88). It is possible that monastic cemeteries are biased towards male burials, but Norton and Blackgate were not monastic sites, so another explanation for their greater percentages of males must be sought. It is possible that older females with osteoporotic bones would be lost or rendered unsexable, especially on a site with such poor preservation as Norton, or it may be that some "cultural" factor such as warfare or religion caused an increase in the number of men buried in one or both of these cemeteries. The large proportions of unsexed individuals at Saxon Jarrow or Monkwearmouth suggests the possibility of a bias against females. Expectation of life was greater for men than for women at all sites. If more females were dying as children (i.e. before their skeletons are sexable) it is possible that the ratios would be evened out, but this does not seem to be the case at the poorer rural site of The Hirsel, so there is no real reason why it should be true of any other site.

One other factor which concerns palaeodemographers is fertility rates. Unfortunately recent work (see Section 3.3) has shown that the so-called "scars of parturition" seen on the pelvis are not correlated with numbers of pregnancies, or even pregnancy itself. The numbers of children carried to full term by women in the past can therefore only be judged from the study of written records.

Stature was considered in Section 4.1. It proved to be remarkably similar at all the sites in this study, especially if taken to the nearest centimetre. Male means were all within 6cm of each other, and females within 5cm. No particular trend was noted through time, and modes of the sites were all very similar. The Hirsel seems to have had the shortest people, but whether this was due to genetic or environmental factors is uncertain, since the site is likely to be different in both respects from other groups.

Mean height was estimated from all complete long bones at The Hirsel to test differences between means derived using the various formulae. Male heights varied from 167 to 172cm, and females from 158 to 162. The lower arm bones showed the greatest divergence, but all the measurements were within Trotter and Gleser's standard errors, suggesting that it is reasonable to use whichever bones are available when estimating stature for a whole group.

A study of body proportions suggested that all the groups were close enough to the American white population (which was after all derived from earlier European stock) for use of the Trotter and Gleser formulae to be reasonable. There was possibly a slight decrease in arm length relative to leg length from Saxon to Medieval times, but not really enough to affect standard errors in stature estimation.

The slight differences in stature between the groups could be due to a variety of factors, including body proportions, nutrition, and inherited characteristics, but whether it was a combination of these or some other element is impossible to decide with current evidence.

Section 4.2. dealt with the indices which can be taken from long bones. Very few are used, and those which are have unknown aetiologies. For the meric index an increase of the mean was seen through time, with broader femora in later groups. Females were generally found to have relatively thinner femora than men. Similar trends have been noted before (Brothwell 1981). The mean cnemic index also increased through time, although actual distribution patterns of index categories do not seem to be related to time periods. The actual meaning of this is unclear due to uncertainty about the nature of the conditions of platymeria and platycnemia.

Cranial indices were studied in Section 4.3. No complicated statistical analysis was carried out due to lack of time and the small numbers of crania involved. The cephalic index showed an increase towards "round-headedness" (brachycephaly) from Saxon to Medieval times (Fig. 4.17), a phenomenon which has been noted throughout Europe. An index used for European populations showed a similarity between Guisborough, Burgh Castle, and Germanic and Scandinavian groups, and a difference between these and The Hirsel. Some unexpected differences were probably due to small sample size, especially at Monkwearmouth and Jarrow. Plotting of cephalic indices against vault height showed quite a good separation of Saxon and Medieval sites, and produced groupings of populations most likely to be close to Germanic and Scandinavian groups. This seems to suggest that cephalic and other simple indices are quite useful in distinguishing population groupings, since they seem to produce patterns which might be expected given a fairly large sample, but do not require the large numbers of skulls and measurements necessary for multivariate analysis.

Section 5 involved the study of non-metric traits. Various problems were considered, including the fact that the genetic/environmental components of most traits are not fully understood at present, scoring is subjective, there may be relationships between some traits, and sex, age, side, size and shape may all have some influence over their appearance. Raw data from the assessment of scored traits is difficult to use and assimilate, so the Mean Measure of Divergence was used to attempt to show inter-population groupings. Calculated distances were different to those suggested by metrical analysis, and on the whole seemed to be less feasible. Guisborough and Blackgate for example were shown to be the closest groups, which seems unlikely given their geographical and temporal separation.

Intra-population study showed possible groupings when used at The Hirsel and Guisborough. The most likely familial relationship was seen at The Hirsel, where only two males in the whole (assessable) group were metopic, and they were buried next to each other . It seems unlikely that this would occur by chance. Based on trait evidence, Guisborough appeared to be a close inbreeding population, or to have a large extended family presence. Given the size and nature of the area from which the burials were excavated, it seems possible that family groups were present, but it should be remembered that there was a potential 340 year burial period at the site.

Dental research was carried out at all the sites, though more time was allowed for this at some than at others, and the results are collated in Section 6. Little could be said about metric and non-metric analysis. The former was simply not done due to the very small amount of useful information which can be derived from it, and because of the amount of time involved. Anomalies were noted when they occurred, but prevalence studies were only carried out on congenital absence (non-eruption) of third molars. The numbers of unerupted teeth varied considerably between populations. Females always had more unerupted teeth than males, except at Guisborough, probably due to their smaller jaw size. A possible increase through time was noted.

Dental pathology (Section 6.2) yielded more useful data, despite the fact that only a macroscopic analysis was possible. Percentages of caries, ante-mortem tooth loss and abscesses varied in the sites. Some increase through time was seen, particularly of caries and ante-mortem loss. Anomalies in the trend suggest that such a comparison should be based on age groups aswell, but unfortunately this was only possible with The Hirsel, since it was the only group large enough to be divided up. As expected, an increase of dental disease with age was seen. Sex differences of caries were not significant, but some sites showed significant differences in ante-mortem loss and abscesses (particularly the former). Most lesions were found to affect the molar region at The Hirsel, and this picture was likely to be similar at the other sites. Very few children had caries, although the majority of those affected had lesions of the deciduous rather than the permanent dentition.

Alveolar resorption and calculus patterns at The Hirsel suggested a possible difference in eating patterns between males and females. Both occurred to a larger extent in females, but with a greater frequency in males, suggesting that females were eating softer food, but males were living to a greater age (perhaps due to a more nutritional diet of meat, etc.). Calculus frequencies showed great variation between the sites, being greatest at Blackfriars and least at Jarrow. The reasons for this are unknown.

Hypoplastic lesions of the enamel were greatest in males and grossest in children at The Hirsel. This may be because the grossest lesions are representative of the worst childhood diseases and therefore least chance of survival into adulthood. Blackgate showed the fewest hypoplastic lesions and Blackfriars the most, but Norton was also high. There does not appear to be any relationship with period or with wealth from this evidence, and similar findings have been made in modern groups.

The most important information which can be gained from human skeletal material, at least as far as the archaeologist is concerned, is probably that included under the heading of Palaeodemography in Section 3. Age and sex are fundamental pieces of information for the social reconstruction of a site history. Probably the next major source of data is that provided by studies of health and nutrition. Although palaeopathology of these sites could not be considered in this work (as explained in Section 7), some information about nutritional standards can be gleaned from the study of age at death (which involves an assumption of accuracy of age estimation), stature estimation and dental pathology. Information about head shapes and limb proportions is probably of less importance in this respect, although it is a valuable source of information about large population relationships. Non-metric traits appear to be of most use in the study of single groups, and relationships within a cemetery, than for large-scale population studies.

However, the overriding theme which runs through all this work is that none of this information should be presented as if it were factual, despite a tendancy in the past for both archaeologists and anthropologists to do this. In the light of recent studies it now seems that many osteological techniques are even less accurate than has previously been assumed, and it is to be hoped that future research in the field of skeletal ageing in particular will do something to alleviate this problem.

In summary then, from this work it seems that slight differences can be seen in age and sex distributions at the sites, and some attempt has been made to explain these above. Stature at all the populations was within normal limits, although perhaps the people from The Hirsel were rather smaller than their contemporaries. Average head shape may have changed through time, although whether this was due to a genetic or an environmental cause is, as usual, unknown. Non-metric traits have been most useful for showing relationships within groups, and it is after all reasonable to assume that family burial plots did exist in large churchyards and monastic churches (although it is as well to remember that *suggestions* of family relationships are just that). Analysis of the teeth from these groups has produced a picture of generally poor dental health, with increasing prevalences of many lesions through time, as would be expected. It seems that these seven population groups, although they cannot be taken as representative samples of the living populations from which they are derived, are broadly similar in patterns of health and demography, despite their temporal and spatial differences. However, it may be that slight variations could prove to be of significance if it is possible to study them in more detail in the future.

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