Variations in the Health Status of Urban Populations in Roman Britain: A Comparison of Skeletal Samples from Major and Minor Towns

Volume 1 of 2

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Abstract

Romano-British towns are conventionally divided into those that possessed administrative powers (the major or 'public' towns) and those that did not (the minor or 'small towns'). Public towns and small towns differed in terms of size and socio-economic status, with the latter sometimes characterised as semi-rural rather than truly urban. Hitherto, research into the differing nature of the communities at public and small towns has focused primarily on variations in settlement morphology, architecture and material culture. This study provides a new perspective on the issue by examining osteological indicators of lifestyle and health in skeletal samples from these two categories of site. Roman populations from the small town of Ancaster, Lincs (N=271) and the public town of Winchester, Hants (N=330) dating to *c.* AD 200-410 were analysed using standard osteological methods. Data on age-at-death, growth and stature, and skeletal and dental pathology were recorded and compared using a range of statistical tests to identify potential differences. Additionally, published data for contemporaneous populations were collated for comparison. A biocultural approach was used to contextualise the data with reference to archaeological and historical evidence.

Some differences in demography were observed, but were probably the result of sample biases. No marked differences in growth or stature were observed. Pathology prevalence rates were comparable for many conditions. However, higher rates of joint disease at Ancaster, and differences in the pattern of long bone trauma may point to the Ancaster population having experienced a more agrarian lifestyle, engaging in more frequent and/or extended periods of heavy labour. In contrast, there was more evidence for violent trauma at Winchester, and the frequencies of three non-specific indicators of ill health (cribra orbitalia, porotic hyperostosis and dental enamel hypoplasia) and scurvy were higher. This suggests that people at Winchester experienced greater levels of social, dietary and environmental stress, perhaps reflecting a larger, more heterogeneous population. Dental health status was generally poorer at Ancaster, which may be due to differences in diet, oral hygiene and/or other non-dietary factors. Published data for other populations broadly support the study conclusions, although comparisons were limited by incompatibilities in methodology and data presentation. Overall, the findings corroborate existing perspectives on the socio-economic characters of public and small towns, but differences were not pronounced. The significance of the findings is discussed in relation to the nature of settlement and society in Roman Britain.

Declaration

I hereby declare that:

(a) This thesis has been composed by myself

(b) This work is my own

(c) That no part of this thesis has been submitted for any other degree or professional qualification

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1 Introduction

1.1 Rationale

The study of towns and urbanism has occupied a central place in research on Roman Britain. The development of major towns modelled on the cities of the Mediterranean has been viewed as a key indicator of the success of 'Romanisation' (Mattingly 2006: 255). Approximately twenty-five sites, including London, Colchester and York, achieved the status of 'public' towns, becoming centres of administration, trade and commerce (Wacher 1995). The public towns of Roman Britain have often been compared and contrasted with another category of settlement – the minor or 'small towns' (Brown 1995; Burnham and Wacher 1990). Like the public towns, small towns were nucleated settlements of mixed land use, with substantial populations employed in diverse activities; both were centres of exchange, and foci for social activities (Cowgill 2004; Smith 1989). However, archaeological and epigraphic evidence suggest that they differed in size, settlement morphology, political status and economic character. While the public towns are comparable (at least superficially) with the towns and cities of the Mediterranean region (Jones 2004: 162), many small towns could be better described as semi-rural in character (Todd 1970: 117, 124), and some might be considered akin to medieval market towns (Brown 2005b: 2), with a significant proportion of inhabitants primarily engaged in agricultural activities. At the lower end of the spectrum, the smallest minor towns were little more than villages.

Historically, the public towns and small towns have been studied in relative isolation from one another (e.g. Brown 1995; Burnham and Wacher 1990; Clarke 1995; Hurst 1999a; Todd 1970; Wacher 1995). Comparisons of the two categories of settlement have tended to focus on differences in settlement morphology and structural evidence (e.g. Reece 1985). While clear differences exist in terms of town layout, architectural forms and political status, very few studies have sought to address the question regarding if, and to what extent the lifestyles of the inhabitants of public and small towns actually differed. This question is of relevance to understanding the diverse nature of communities in Britain. It is also of interest in relation to the small towns in particular. General discussions of Romano-British urban life often ignore these settlements (e.g. Jones 2004), yet it is estimated that the total population of the small towns combined was at least equal to that of the public towns (*c.* 200,000-350,000), if not greater (Potter and Johns 1993: 68).

This study aims to provide an alternative perspective on the similarities and differences in settlement and society at public towns and small towns through an examination of osteological indicators of health. It is not concerned with the question of whether the impact of urbanism on population health was positive or negative (*cf.* Peck 2009). Rather, the present research seeks to contribute new insights into the diversity of life in Romano-British towns. The health status of a community is intimately linked to the social, cultural and physical environment (Boldsen and Milner 2012: 118-9). Aspects of the built environment such as domestic architecture, housing density and sanitation may influence the transmission of infectious diseases. The economy can determine the sorts of occupational activities in which people engage, and which may expose them to the risk of trauma, musculoskeletal disorders, pollutants and pathogens. Socio-political structures govern access to food and other resources (Prüss-Üstün and Corvalán 2006; Yen and Syme 1999). By comparing the pattern and prevalence of different skeletal and dental pathologies, in addition to aspects of demography and growth and stature, a bioarchaeological study of populations from public towns and small towns should shed light on the extent to which these factors differed between sites, and how this affected the health of the inhabitants.

1.2 Study aim, objectives and materials

1.2.1 *Aim*

The aim of this study is to provide a bioarchaeological perspective on the extent to which life differed at public towns and small towns in Roman Britain through an examination of osteological indicators of health.

1.2.2 *Objectives*

In order to achieve the aforementioned aim, the following objectives were defined:

(1) To generate detailed data on skeletal and dental indicators of health (demography, subadult growth and adult stature, and skeletal and dental

pathology) in skeletal populations derived from a public town (Winchester, Hants) and a small town (Ancaster, Lincs) using a standardised recording protocol.

(2) To compare and contrast indicators of health between the study samples and utilise statistical tests to identify any significant differences.

(3) To collate and compare published data for other public town and small town populations.

(4) To apply a biocultural approach in interpreting the results with reference to contextual archaeological and historical evidence for Romano-British settlement and society.

In relation to the last objective, a ‘biocultural’ approach emphasises the interaction between biological and cultural factors in determining individual and group health status. Since the 1980s, the dominant model of health has been one of adaptive response to ‘stress’ (Zuckerman *et al*. 2012), with stress defined as, ‘disruptive events on individuals and populations’, (Goodman *et al*. 1988: 169). ‘Stressors’ may be biological, environmental, or cultural (Figure 1). Biological stressors include individual immune status and genetics. Environmental stressors encompass aspects of the natural environment, such as climate, in addition to the built environment. Cultural stressors include specific events, such as wars, or broader aspects of the social environment e.g. differential access to resources according to social class, age or gender. Individuals and populations (attempt to) adapt to stressors biologically and/or culturally. Pathology, subadult growth rates and adult stature, and mortality can be interpreted as indicators of the successful or unsuccessful adaptation of individuals and populations, death being the ultimate measure of failure to adapt (Bush 1991: 11; Goodman 1991: 35).

The ‘biocultural perspective’ also describes a holistic approach to studying past populations that aims to situate the interpretation of skeletal and dental indicators of health within a broader cultural and historical framework, drawing on complementary archaeological and historical evidence (Zuckerman and Armelagos 2011). This approach was developed by North American biological anthropologists in the second half of the twentieth century and was closely associated with the emergence of bioarchaeology (or osteoarchaeology) as a distinct subfield of archaeology (Buikstra 1977; Buikstra and Beck 2006; Buzon 2012). The biocultural approach has been increasingly adopted in Britain over the last three decades (e.g. Bush and Zvelebil 1991; Roberts 2000a, 2000b).

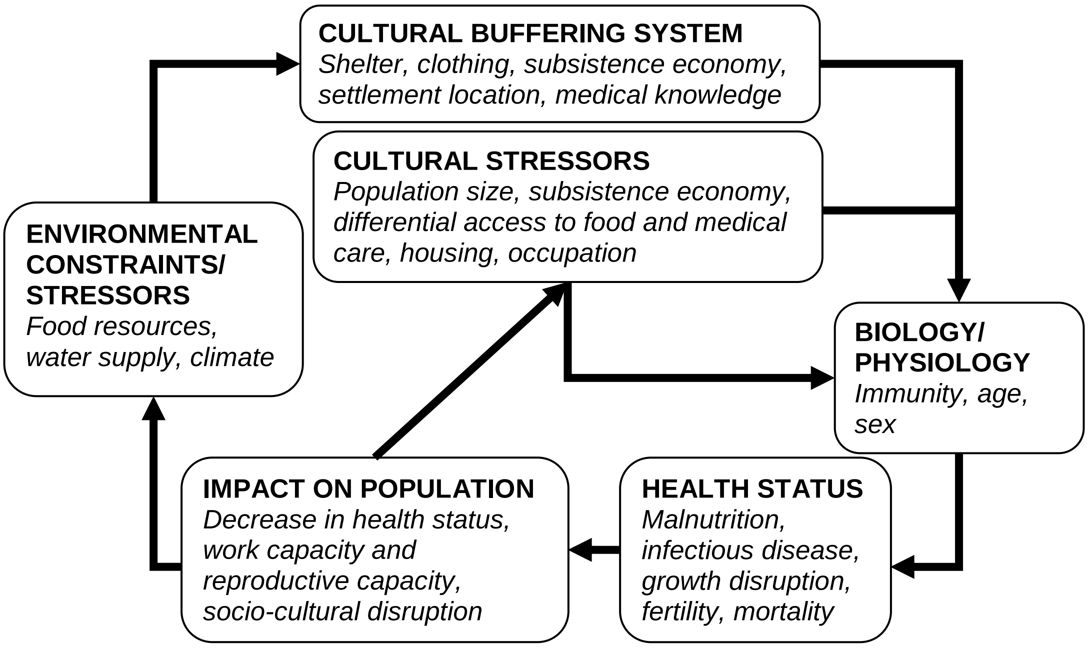

Figure 1. General model of stress (adapted from Goodman 1991).

1.2.3 *Introduction to the study samples*

The skeletal samples analysed for the present study derive from excavations in the Roman cemeteries of Winchester, Hants, conducted in the later twentieth century by Winchester Museums Service (Ottaway *et al.* forthcoming), and Ancaster, Lincs, undertaken in the 1950s-60s by Nottingham University (Whitwell *et al.* 1966; Wilson 1968; Wilson and May 1965). The total number of skeletons examined is 601 (Winchester N=330, Ancaster N=271). The majority of burials in both samples date from the later third-to-early fifth centuries AD (*c.* AD 270-410).

1.3 Significance and structure of the thesis

As already noted, comparisons of public and small towns have focused almost exclusively on size, settlement morphology, structural remains, civic status and, to a lesser extent, economic activities (e.g. Brown 1995; Burnham and Wacher 1990; Grew and Hobley 1985; Rust 2006; Wacher 1995). In contrast, the degree to which the daily lives and experiences of the populations varied has largely been ignored. This thesis presents the first detailed comparative study of populations from public and small towns using data gathered by a single researcher, employing a systematic recording method. Chapter 2 comprises a brief précis of the historical backdrop to Roman Britain and reviews the archaeological setting of public and small towns, including the evidence for late Roman decline. Chapter 3 provides a general overview of existing bioarchaeological research on Roman Britain and the relationship between population health and urbanism. Chapter 4 sets out the materials and methods utilised, and results are presented in Chapter 5. Chapter 6 interprets the osteological data with reference to contextual archaeological and historical information and collates published data for other sites for comparison. Chapter 7 summarises the conclusions, identifies limitations of the present research, and makes recommendations for the future. Raw data generated by the osteological analysis are contained in a Microsoft Access database provided on the accompanying CD. Data for some figures are provided in Excel spreadsheets. References, supporting information, statistical tests and pathology photographs are contained in Volume 2.

1.4 Terminology

'Roman Britain' refers to modern-day England and Wales. 'Late Roman' describes the period from *c.* AD 250 to the withdrawal of Britain from the Empire in *c.* AD 410. This date range reflects the chronological limits of the skeletal material, but also corresponds to broader historical and cultural developments (Cameron 1993). 'Female' and 'male' refer to biological sex and do not imply gender identity, which is socially constructed (Armelagos 1998). 'Adult' and 'subadult' refer to individuals aged ≥18 years and <18 years respectively (Halcrow and Tayles 2008). 'Skeletal sample' and 'skeletal population' refer to an assemblage of human remains recovered from a particular site, and do not equate to modern epidemiological usage of these terms (Waldron 2007: Ch.2). 'Bioarchaeology' and 'osteoarchaeology' are used interchangeably, and refer to the study and interpretation of human remains in their archaeological context (Roberts 2006).

2 Historical and Archaeological Setting

2.1 Historical background

In comparison to other provinces of the Roman Empire, the corpus of surviving textual evidence from Britain is small (Mattingly 2006: 21). The majority of literary sources for Roman Britain are second-hand accounts of political and military events produced by individuals living in distant parts of the Empire. Many treat only those events of particular relevance to the central Imperial authorities in detail (Mattingly 2006: 25; Webster 1993a: 15). Owing to the incomplete nature of the textual sources, numismatic and epigraphic evidence have been crucial in reconstructing the political and military history of Roman Britain (Birley 1980: 13; Ireland 2008: 6-8; Tomlin 1993), although there is a drop-off in the quantity of source material from the third century onwards (MacMullen 1982).

Despite the limitations of the evidence, the basic historical outline of Roman Britain is relatively well established. Following the invasion of AD 43, the conquest of England and Wales was essentially complete by the AD 80s (Dio, *Roman History*; Tac., *Ann.* and *Agricola*; Bird 2002; Collingwood and Myres 1936; Dudley and Webster 1965; Frere 1987; Frere and Fulford 2001; Hanson and Campbell 1986; Hind 1989; Webster 1970, 1981, 1993a). By the beginning of the second century AD, the majority of present day England and Wales constituted a single province (*Britannia*), overseen by a governor and procurator based at London with respective responsibility for day-to-day running of the province and fiscal matters (Betts 1995; Mann 1998a). The second century was a period of comparative stability in Britain and the Empire more widely. Toward the end of the century, there was a short-lived political hiatus when Clodius Albinus, the governor of Britain, unsuccessfully attempted to establish himself as successor to the Emperor Commodus in AD 193 (Dio 73.14.3; Herodian 3.5, 3.7; HA, *Severus* 10.1-2). In the early third century the Emperor Septimius Severus visited Britain, undertaking several military campaigns in Scotland (Dio 76.13, 76.15 and 77.10-15; Herodian 3.14.1-10), dying at York in AD 211. At some point in the Severan period, Britain was divided into a southern (*Superior*) and northern (*Inferior*) province (Dio 55.23.2-6; Herodian 3.8.2), governed from London and York respectively (Mann and Jarrett 1967).

Following the death of Alexander Severus in AD 235, the Empire descended into a period of political upheaval known as the 'Third Century Crisis' (Drinkwater 2005). Britain was largely spared, although in the AD 260s the governor of *Germania Inferior* rebelled against the emperor, taking control of Germany, Britain, Gaul, Spain and Raetia (Drinkwater 2005: 45). These provinces were governed as a secessionist state (the 'Gallic Empire') before being regained in AD 274 (HA, *Probus* 18.5). The crisis of the third century ended with the accession of Diocletian in AD 284, who initiated a series of major political, economic and military reforms aimed at achieving long-term stability (Bowman 2005). The system of provincial administration was reorganised, with the provinces being divided into smaller units (Lo Cascio 2005: 180-1). Britain now comprised four provinces, with capitals at London, York, Lincoln and Cirencester[1] (Mann 1998b; see Figure 2).

While Diocletian's reforms restored order following the events of the third century, there were continued threats from both internal dissenters and tribes beyond the borders. In the course of the later third and fourth centuries several short-lived usurpers emerged in the Northwest (Bowman 2005: 79; Casey 1994; Wardman 1984), most notably Carausius and Allectus in AD 286-96; Magnentius in AD 350-53; and Magnus Maximus in AD 383-88 (Ammianus 14.5; Eutropius 10.10-12; Zosimus 4.35-7). External threats came from Caledonian and Irish tribes to the north and west, and Saxons in the east (Blockley 1980; Tomlin 1974, 1979). In the AD 350s or 360s, barbarian raiding parties reportedly penetrated the south of the province (Ammianus 27.8.1-9, 28.3; Blockley 1980; Frend 1992; Tomlin 1974, 1979). There are references to military campaigns against Caledonian, Irish and Saxon tribes in the later fourth century (Mattingly 2006: 231-2, 235).

The events leading up to the final withdrawal of Britain from the Empire are much debated. Dissent flared up amongst the army in Britain in AD 406-7. Three military commanders in succession crossed to the Continent with the aim of challenging the Western emperor, Honorius (Blockley 1998: 122). The British garrison was depleted as a result, and when the province came under renewed threat from Saxon raiding, the central administration was unable to provide military

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[1] There is some debate regarding whether the capital of *Britannia Prima* was located at Cirencester or Gloucester (Hurst 1999b; Reece 1999).

assistance (Orosius 7.40; Zosimus 6.20 and 6.5.2-3). It is generally accepted that official Imperial involvement in Britain ended in AD 409 or 410 (Kulikowski 2000).

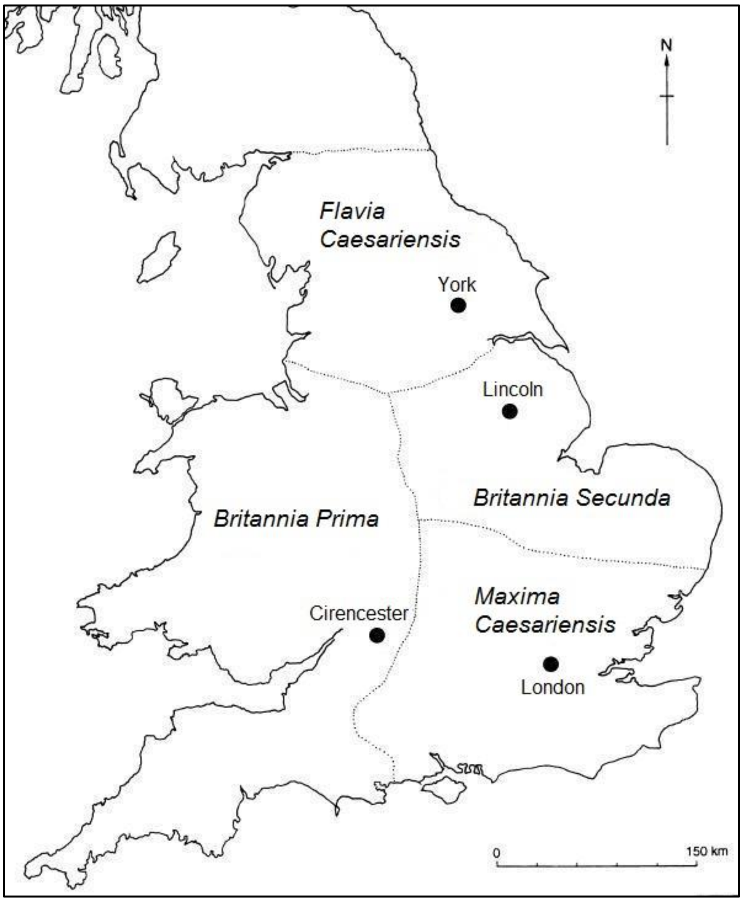

Figure 2. Map showing the provincial divisions of Roman Britain in the fourth century AD (adapted from Mann 1998b).

2.2 Archaeological setting

2.2.1 *Towns in Roman Britain*

The question of what constituted a ‘town’ in Roman Britain has been the subject of much discussion (Todd 1993). Various criteria have been used to determine whether a site should be considered urban, including its politico-legal status, morphology, architectural forms and social and/or economic function. Several ancient sources, such as the Antonine Itinerary, and epigraphic evidence attest to the official civic status of approximately two dozen sites (Blagg 1990; Rivet and Jackson 1970; Rivet and Smith 1979; Rodwell 1975). Provincial towns were defined according to their political status and function (Figure 3). ‘Public’ towns possessed administrative powers and the ability to levy taxes (Wacher 1995: 17). Three categories of public town existed: *coloniae*, *municipia* and *civitas* capitals, the first and second of which were chartered towns (Mattingly 2006: 261; Wacher 1995: 19). As the title implies, *coloniae* were often founded by the settlement of army veterans, although a town of lesser status could be elevated to colonial status. Prior to an Imperial edict of AD 212, only the freeborn inhabitants of *coloniae* possessed full citizenship (Carrié 2005: 271-2). Each *colonia* ruled a surrounding hinterland. In Britain, four *coloniae* existed – Colchester, Gloucester, Lincoln and York (Hurst 1999). Only one *municipium* is known, St. Albans/Verulamium, although there is some doubt as to whether the settlement actually held this status. *Civitas* capitals served as administrative centres for larger territories (*civitates*) that probably corresponded broadly to pre-Roman tribal boundaries (Wacher 1966).

Below the level of *civitas* capital, towns generally lacked official administrative and fiscal powers. The numerous Romano-British settlements considered to represent minor urban centres, but lacking the features and civic status of the public towns, probably held the status of *vicus*, although direct evidence for this, e.g. in the form of inscriptions, is relatively rare (Mattingly 2006: 286; Wacher 1995: 16). The archaeological terminology applied to such sites – small or minor towns – has generated much debate (discussed further below). It has been suggested that a few of these sites, such as Water Newton, Kenchester and Ilchester, might have achieved *civitas* status in the later Roman period (Burnham and Wacher 1990: 39).

Definitions of urbanism based on settlement morphology and function have a long history in archaeology (e.g. Childe 1950), and a focus on the topography and architecture of towns, especially civic buildings and fortifications, has characterised much research on Romano-British settlements (e.g. Greep 1993; Grew and Hobley 1985). This arose from a concern with identifying the influence of Graeco-Roman ideals of town planning and urban living in Britain, with the development of ‘Classical’ towns viewed as a measure of the success of ‘Romanisation’ (Jones 2004; Rogers 2011). There is an element of circular reasoning in this approach, in that the features used to define towns (public buildings, orthogonal street plans, monumental defences, etc.) are characteristic of those Romano-British settlements already known from epigraphic and textual evidence to have held civic status.

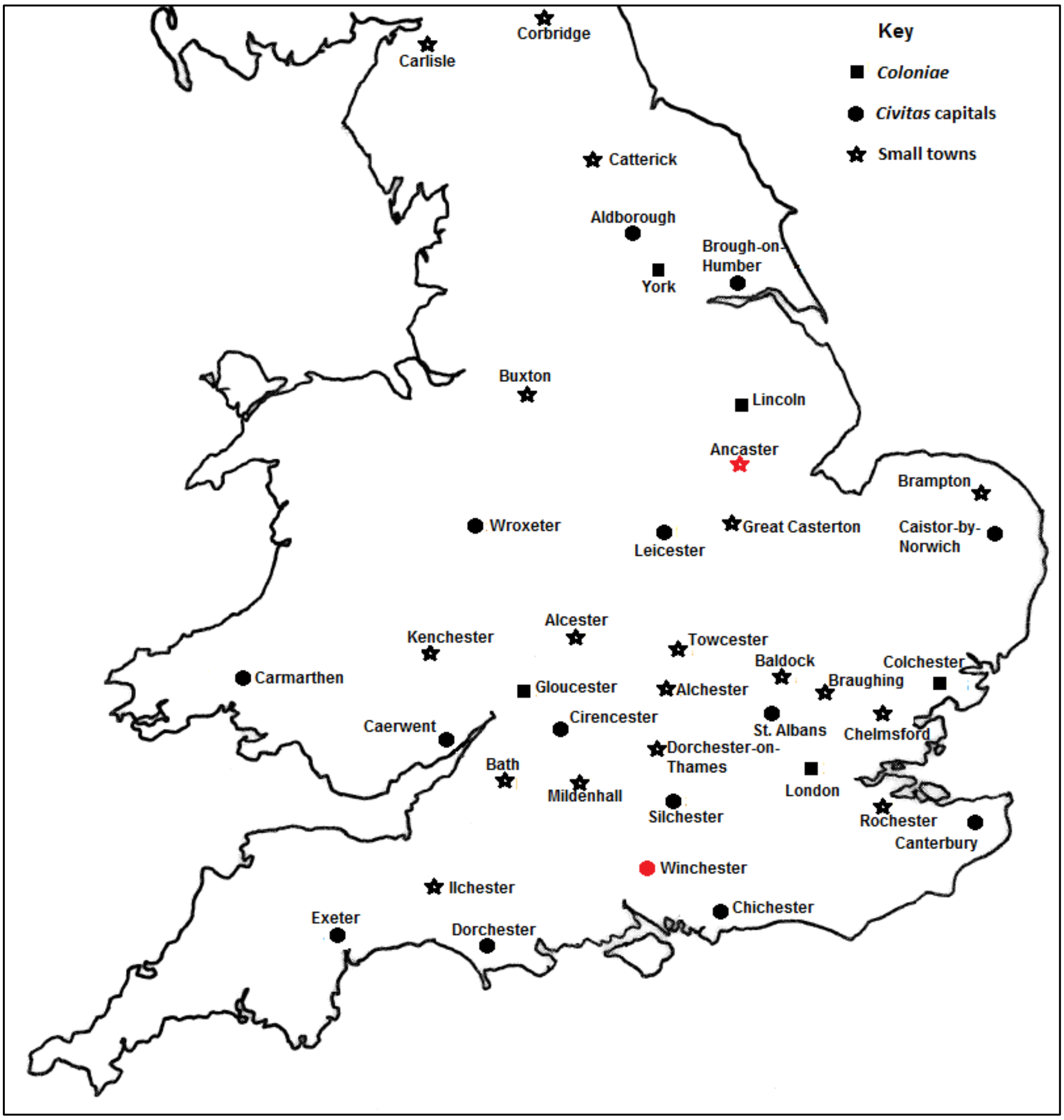

Figure 3. Map showing the public towns and main small towns of Roman Britain.
(The study samples are highlighted in red.)

The preoccupation with classifying sites as urban or non-urban based on settlement morphology and function has led to great difficulties regarding the small towns. Broadly speaking, these sites are larger and exhibit greater morphological complexity than villages, but lack many of the key features usually considered necessary to be classed as urban in the Classical Mediterranean sense (Burnham and Wacher 1990). Further difficulties arise from the wide variation in size and form exhibited by such settlements, and there is considerable disagreement regarding the point at which large villages become ‘small towns’ (Brown 1995: 1; Jones and Wacher 1987: 27). Depending on the criteria employed, the number of identified small towns ranges from 54 (Burnham and Wacher 1990) to more than a hundred (e.g. Smith 1987). Typically, the *ad hoc* settlements that developed outside forts and fortresses (military *vici* or *canabae*; Sommer 1984), have been excluded from the definition of small towns, although some researchers have argued for their inclusion (Clarke 1991).

In an attempt to address the question as to which sites can be considered towns, researchers have tended to focus on sub-dividing small towns into various categories. Burnham and Wacher (1990) identified six sub-categories of small town – potential 'cities' (i.e. *civitas* capitals), minor towns, specialised religious sites, specialised industrial sites, minor defended settlements and undefended settlements – although the reasoning behind this system has been criticised as somewhat obscure (Esmonde Cleary 1992a). In recent years, scholarship has begun to move away from classifying sites as an end in itself, reflecting a growing suspicion of the futility of attempts to develop universally accepted classifications (*cf*. Millett 2001: 65). However, it has also been argued that broad agreement on terminology is necessary to provide a framework for research (Clarke 1991).

2.2.1.1 Origins and development

The development of towns in the post-conquest period reflected the complex interaction of local geographical and socio-political conditions (Jones and Wacher 1987: 27, 29). Many public towns had Iron Age precursors in the form of *oppida*. In most cases, the Roman town developed near an existing Iron Age settlement rather than being directly superimposed (Reece 1985: 37). Colchester (*Camulodunum*) had been a major Iron Age tribal centre. An early Roman fortress constructed near the Iron Age *oppidum* was remodelled to make way for the settlement of veterans in *c*. AD 49/50 (Crummy 1993). The establishment of the *colonia* at Colchester was followed by Lincoln in *c*. AD 90 and Gloucester in AD 96-98 (Crummy 1977, 1982; Jones 1985). At York, the civilian settlement that developed outside the legionary fortress was elevated to the status of *colonia* in the early third century AD (Wacher 1995: 17-18). There is increasing evidence that a fort was established at London in the invasion period (Perring 2011a: 251-2), and an early trading centre had developed by the middle of the first century AD. London relatively quickly became the seat of the provincial governor (Mann 1998a; Perring 1985: 94-5). Unusually, there is no historical or epigraphic evidence for the official status of London, but it is assumed that the town was a *colonia* (Hassall 1996; Wilkes 1996). The *civitas* capitals had varied origins. Some developed at or near early forts, including Cirencester, Exeter and Wroxeter (Barker 1985; Crummy 1982; Webster 1993b), while others were essentially new foundations, e.g. Caistor-by-Norwich (Jones 2004: 174). A number of towns developed at Iron Age *oppida*, including Silchester (Fulford and Timby 2000).

Less is known of the origins and development of small towns. In the past, it was often assumed that most originated as military *vici*. While some sites did develop near early forts, e.g. Alchester (Sauer *et al*. 1999), recent research has emphasised the diverse origins of small towns, with many producing evidence for pre-Roman settlement activity (Burnham 1986; Millett 1990: 145). Some sites developed at Iron Age or early Roman ritual centres, most notably Bath, Springhead and Buxton (Burnham 1986: 196; Cunliffe 2005: 192). In other cases, there is no evidence for either Iron Age activity or an early Roman military presence (Rust 2006), indicating that they were new foundations. Some small towns possibly originated as staging posts for the Imperial messenger service (*cursus publicus*; Burnham 1986: 195).

2.2.1.2 Settlement environment

2.2.1.2.1 Public spaces

The major towns were built according to a street grid system, with buildings organised into blocks (*insulae*) and key public buildings located on the major thoroughfares (Jones and Wacher 1987: 29; Mackreth 1987: 134). In contrast, the vast majority of small towns lacked a planned street system (Todd 1970: 118). Many were characterised by ribbon development along major roads (Burnham and Wacher 1990: 4). A very small number did acquire an element of planning in their layout, including Mildenhall, Godmanchester and Water Newton (Corney 1997: 344; Burnham 1995: 9)

Monumental architecture and public amenities were features of the larger urban centres. All public towns required a forum/basilica complex (Wacher 1995). Public bathhouses have been identified at the majority of sites (e.g. Bidwell 1979;

Down 1988; Ellis 2000; Marsden 1976; Niblett 2006). Theatres and/or amphitheatres were less common, and only one circus has been identified at Colchester (Bateman 1997; Bateman *et al.* 2008; Crummy 1982, 2008; Dunnett 1971; Frere 1970; Fulford 1989). In contrast, very few small towns have produced evidence for structures that might be considered public buildings, temples being the main exception (Burnham and Wacher 1990: 17; Millett 1990: 145). In addition to major religious complexes at Bath (Cunliffe and Davenport 1985), Frilford (Hingley 1982, 1985) and Nettleton (Wedlake 1982), among others, many other sites possessed smaller temples (Burnham and Wacher 1990: 22). Possible examples of public buildings with a non-religious function, including market buildings, have been identified at Braughing, Godmanchester, Kenchester and Water Newton (Brown 1995: 2; Burnham and Wacher 1990: 75, 83, 126).

Some public towns were provided with defences as early as the late first century AD, although most were not fortified until the second century (Fulford and Startin 1984; Wacher 1995: 71). At many sites, early earthwork circuits were rebuilt or refaced in stone in the later second or third century AD, with further modifications (including the addition of bastions) made in the fourth century AD (Frere 1984; Hobley 1983: 79, 81). Many small towns were not fortified; of those that were, most received defences in the second century AD or later. These were often constructed around the central core of the settlement only (Jones 1987: 81).

Most excavations have concentrated on the interiors of towns and their fortifications; less is known of the extra-mural areas. In the case of the public towns, suburbs typically consisted of ‘ribbon development’ along the main roads leading out of town. By contrast, the extra-mural areas of the small towns could be extensive, although this was often the result of the imposition of fortifications around the core of the settlement. Cemeteries were also a key feature of the extra-mural landscape, due to the traditional Roman prohibition on burial within the settlement area (Esmonde Cleary 1985: 75; Toynbee 1996: 48).

2.2.1.2.2 Housing

Much of the evidence for urban housing in the earlier Roman period is ephemeral, as timber construction predominated (Perring 2002: 92-5, 106). Iron Age-type roundhouses have been excavated at a number of sites (e.g. Clarke *et al*. 2007; Perring 1991: 101), but most early dwellings fell into one of three categories: strip houses, 'L'-shaped houses and row-type houses (Mattingly 2006: 286-7; Perring 2002: 55-60, 64-72). Strip houses were ubiquitous throughout the Northwest provinces (Stirling 2010: 87). Such buildings comprised a long, narrow structure set with the short end facing onto the street, often divided internally into two or three rooms (Figure 4). Many strip houses have produced evidence for craft activities in the form of ovens, hearths and other debris; hence, they are generally interpreted as the dwellings of artisans and traders (Mac Mahon 2005; Perring 2002: 59). Studies have shown the density of strip buildings to be greatest near public spaces and along major roads, confirming the view that the majority represent commercial premises and workshops (Mac Mahon 2006).

Row-type houses resembled strip buildings, but were generally larger and possessed more complex internal arrangements, often including a portico or corridor running the length of the property (Perring 2002: 64-5). 'L'–shaped houses are thought to represent a development of the row-type house, comprising a main long, narrow building with an additional block of rooms attached at one end. This type of building was particularly common in the larger towns and people may have rented individual rooms (Jones 2004: 179). Towards the end of the second century, a fourth category of dwelling – the courtyard house – became increasingly common at the large urban centres. Courtyard houses comprised a central peristyle court surrounded by rooms on three or four sides (Figure 4). Many possessed *opus signinum*, tile and mosaic floors, decorated plaster walls, private baths and, occasionally, piped water. This style of house became increasingly popular over time, and many of the most opulent date to the later third and early fourth centuries (Perring 2002: 68-72). Although generally assumed to have been the residences of elites, such properties could also have housed commercial activities (Jones 2004: 181).

At the small towns, domestic architecture included a mixture of 'urban' and 'rural' building forms (Figure 5; Mattingly 2006: 287-8). At a small number of sites, native-style timber roundhouses continued to be occupied into the fourth century (Burnham and Wacher 1990: 17; Mattingly 2006: 285). The majority of excavated structures comprise rectilinear timber-framed buildings of one or two rooms.

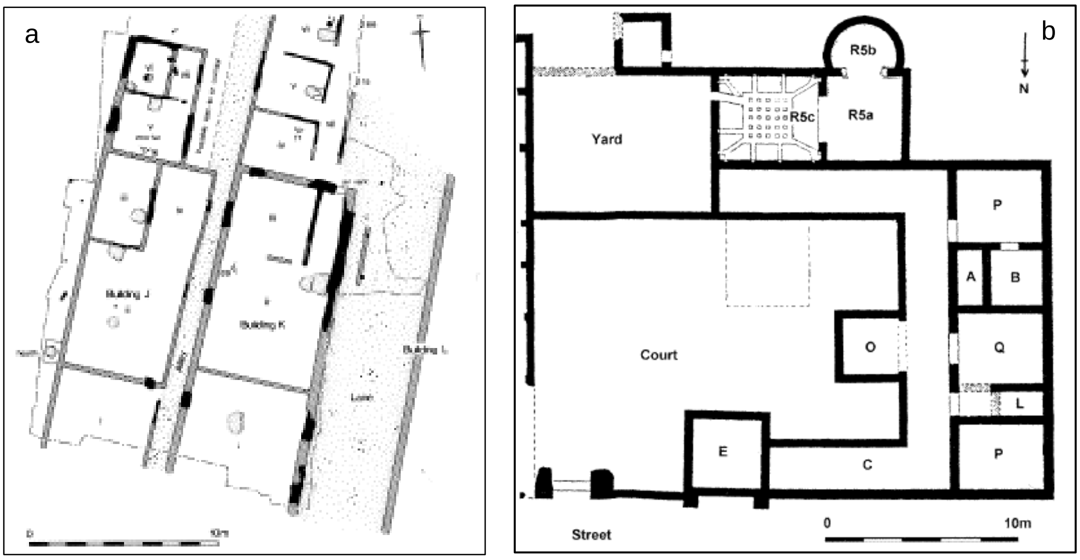

Figure 4. Examples of domestic architecture at public towns: (a) second century strip houses at Newgate Street, London (Perring 2002: 58, Fig. 12); (b) courtyard house at Silchester (Perring 2002: 49, Fig. 9).

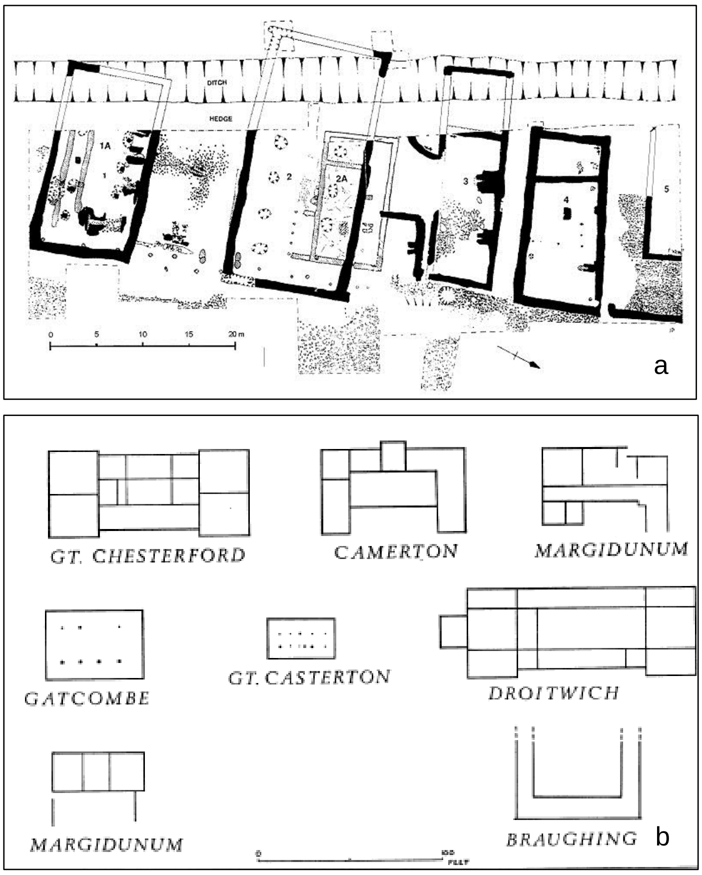

Figure 5. Examples of domestic architecture at small towns: (a) strip houses at Sapperton, Lincs (Simmons 1995: 160, Fig. 14.3); (b) various domestic structures (Todd 1970: Fig. 1).

Strip buildings of the type known at the larger towns were also common (Burnham and Wacher 1990: 17-18). Larger aisled buildings of a type found on villa estates occur at some small towns (as well as a number of public towns, e.g. Cirencester; Perring 2002: 194), and may represent barns and/or combined spaces for domestic and agricultural activities (Hadman 1978). Buildings resembling simple villas of ‘winged-corridor’ type occur at many sites, and could represent higher status residences (Salway 1993: 428; Todd 1970). Substantial courtyard-type houses occur at some sites, and are generally interpreted as *mansiones* – official residences akin to lodging houses used by Imperial messengers – rather than private town houses (Black 1984; Burnham and Wacher 1990: 37). Probable *mansiones* have been identified at Chelmsford (Drury 1988), Godmanchester (Brown 1995: 2), Mildenhall (Corney 1997: 345) and Wanborough (Phillips and Walters 1977), among other sites.

2.2.1.2.3 Water supply and waste disposal

The relatively small size of Romano-British towns negated the need for major aqueduct schemes, and the costs of constructing such systems would have been prohibitive for many communities (Stephens 1985: 198). The majority of people at both the large and small towns thus probably obtained most of their water directly from rivers, streams and wells (Burgers 2001: 4, 11). The collection of water in tanks and cisterns was presumably also well suited to the climate of Britain (*cf*. Beaumont 2008).

Nevertheless, the majority of public towns were supplied by aqueducts, which took the form of covered or open surface channels constructed in brick, stone, lead or wood (Burgers 2001; Stephens 1985). Among civilian settlements, Lincoln possessed one of the most complex water supply systems (Jones 2003). Other public towns supplied by aqueducts included Dorchester (Putnam and Hewitt 1996), Exeter (Frere *et al*. 1983: 322-3), Leicester (Wacher 1995: 350), Winchester (Burgers 2001: 4) and Wroxeter (White and Barker 1998). London is unusual in having produced no evidence of an aqueduct, although timber-lined wells and water-lifting devices have been excavated (Blair *et al*. 2006), and numerous smaller wells have been identified throughout the Roman city (Williams 2003: 244-5). The water supplied by aqueducts was primarily used to provision public baths, as at Wroxeter (Barker

1975). Surplus water was sometimes used to supply public fountains (e.g. Wacher 1995: 175), although relatively few have been identified (Stephens 1985: 200). Very few private residences were directly connected to the water supply network (e.g. Wacher 1995: 369). Some small towns possessed water supply channels, e.g. Catterick (Burnham and Wacher 1990: 114), Chelmsford (Drury 1988), Godmanchester (Green 1975), and Worcester (Burnham and Wacher 1990: 234). In almost all cases, these aqueducts were constructed to supply *mansiones* and associated private bath suites (Burnham and Wacher 1990; Stephens 1985), and evidence for the distribution of aqueduct water for public use is limited.

Elaborate systems for the removal of effluence are characteristic of many military sites (Burgers 2001: 12), but were relatively rare at civilian settlements (Stephens 1985: 206), the complex sewer networks at Lincoln and London being notable exceptions (Jones 2003; Williams 2003). These served to remove human waste, excess rainwater and waste water from bathhouses and industrial processes (Scobie 1986: 412). Very few private properties had flushed latrines (Perring 2002: 196), but many possessed simple internal latrines, sometimes connected to a drainage ditch (Perring 1991: 104).

2.2.1.3 Society

2.2.1.3.1 Population size and density

Estimates of the population size of the Roman Empire often draw on ancient census data and other textual sources that refer to the size of army units and the number of people receiving food hand-outs (Brunt 1987; Lo Cascio 1994; Scheidel 2007). For Roman Britain, no census data of the sort available for other provinces (e.g. Egypt; Bagnall and Frier 1994) exist and textual references to population size (other than military units) are limited (e.g. Tac., *Annals* 14.33). Therefore, most estimates of Romano-British population size are based on settlement size and building density. Estimates for the total population of Roman Britain (England and Wales) generally range in the low millions. Frere (1987: 301) suggested a total rural population of at least two million, with the urban, villa and military communities constituting a further *c.* 300,000. Millett (1990: 185) proposed a similar estimate of *c.* 3 million, while Mattingly (2006) favours a slightly lower estimate of 2.0-2.5 million, including

100,000 at the public towns and 50,000 for the small towns. Potter and Johns (1993: 68) suggest a similar overall figure of *c.* 2.5 million inhabitants and *c.* 120,000 for the public towns, but estimate the combined population of the small towns at as much as 200,000. The latter figure will vary considerably, depending on how many sites are included in the definition of small town.

The populations of individual towns are difficult to estimate, owing to uncertainty regarding variables such as average number of storeys, average family size, problems in dating occupation layers, and the invisibility of more ephemeral timber buildings. Millett (1990: 182) utilised figures for population density per hectare developed for Middle Eastern cities (Hassan 1981), which assume a minimum and maximum of 137 and 216 people per hectare. Applying these figures, Millet derived an estimate for the total urban population (based on the combined walled area) of between 183,971 and 290,057 people. Mattingly (2006: 269-9, Table 9) provides figures for the walled areas of Romano-British towns. Applying Millett's density estimates to individual sites gives a population of *c.* 17,500-27, 6000 for London (rounded to the nearest hundred), based on a walled area of 128 hectares. At the lower end of the scale, the population of one of the smallest *civitas* capitals, Brough-on-Humber, at *c.* 6 ha, would have been *c.* 800-1,300. The population estimates for Winchester (55 ha) and Ancaster (*c.* 3.7 ha; Todd 1981) are *c.* 7,000-11,900 and 400-800 respectively. These figures, however, cannot take into account extramural suburban occupation, nor the fact that intra-mural areas were not necessarily fully occupied (e.g. Milne 1993: 12). While buildings along main road frontages tended to be densely packed, areas away from the public spaces of towns were often less densely built up (Mattingly 2006), and environmental evidence points to the presence of open grassed areas within towns (Dobney *et al*. 1999: 18).

The size of urban populations will have varied over time. It is generally believed that the population of Roman Britain probably peaked in the second century (Potter and Johns 1993: 68). The rate of late Roman population decline at the towns is discussed further below (section 2.2.1.5.2). A relatively rapid increase throughout the later first and early second centuries is inferred from the expansion of settlement areas and an increase in the number and density of buildings (e.g. Perring and Roskams 1991). The issue of urban population expansion raises questions as to levels of migration from country-to-town. Based on comparisons with later periods (e.g. Woods 2003), it has been argued that the populations of Romano-British towns would not have been self-sustaining due to excess mortality, and a continual level of immigration would have been necessary (Esmonde Cleary 1989: 81). This phenomenon, in which deaths in towns and cities outstrip births, has been termed the ‘urban graveyard effect’, although whether it reflects increased mortality rates among urban residents, lower fertility rates, or both, is debated by demographic historians (Scheidel 2004: 15-6; Woods 2003). The growth of many of the small towns in the later second and third centuries could have been at the expense of the public towns, but might also represent increased migration from the surrounding countryside.

2.2.1.3.2 Identity

2.2.1.3.2.1 Status

In the Roman class system, social status was defined by an individual’s parentage and legal status, which in turn placed certain constraints on occupational opportunities, property ownership, and political rights, though this need not determine or equate to one’s standard of living (Garnsey and Saller 1987: 109-25; Parkin and Pomeroy 2007: 3-5, 205, 357-8). In the case of Britain, the extent to which the class system imposed was mediated by indigenous social customs is difficult to assess, owing to the limited range of epigraphic sources and other textual evidence for the majority of the populace.

The principal social distinction was between free individuals (citizens and freedmen) and slaves. Prior to AD 212, the free population included those with full citizenship, native provincials with partial rights, and individuals who originated outside the Empire and did not hold citizenship, but these distinctions ceased to have any importance by the Late Empire (Garnsey and Saller 1987: 115). Members of the governing class held the highest status. Epigraphically, some of the most visible members of Romano-British communities are individuals and groups associated with the Imperial administration. Most of this evidence derives from London and the *coloniae* (Holder 2007), although the presence of government officials is also attested at some *civitas* capitals (e.g. Birley 1980: 42). The upper social stratum of the local populace of a town was the curial class, from which members of the town council (the *ordo*) were drawn (Wacher 1995: 36). The size of town councils, and thus the probable size of the curial class overall, are difficult to determine. At the largest towns, the *ordo* might comprise as many as a hundred councillors. Mattingly (2006: 293) postulates an average membership of around thirty men. Thus, as a proportion of the total population, the curial class was relatively small. In the earlier Roman period, the curial class presumably included local elites drawn to the developing urban centres by the social and financial benefits of political office (Mattingly 2006). The role of elites in later Roman urban society is a topic of debate. Some scholars have argued that participation in public office became increasingly less attractive to the upper classes following the reforms of Diocletian and his successors, as ever-greater financial burdens were imposed on individuals, thus prompting a retreat from urban life (Garnsey 1998: 3). On the other hand, based on the archaeological evidence for an increase in the ratio of town houses to lower status dwellings and commercial properties in the late Roman period, one could argue that the elite comprised a relatively greater proportion of the urban populace in the later third and fourth centuries (see below, section 2.2.1.5).

The relative status of the majority of the free citizens of Romano-British towns is difficult to assess (Mattingly 2006: 295). Merchants, artisans and other professionals could be considered to form a ‘middle class’ of sorts. Whether or not an urban ‘underclass’ existed is unclear. There is no evidence from Britain of the tenements that housed the urban poor elsewhere in the Empire (Todd 1993: 8; Ward-Perkins 1994: 192). Burial evidence is problematic when it comes to assessing the social makeup of urban populations. Few towns have produced substantial cemetery samples dating to the later first or second centuries, when grave furnishings were more common (e.g. Kjølbye-Biddle 1992: 214), and the extensive extra-mural cemeteries that developed in the third and fourth centuries are generally characterised by relatively uniform, unfurnished graves (Philpott 1991: 225-6). Small numbers of ‘wealthy’ graves occur at many sites, including burials in stone and/or lead sarcophagi, and mausolea (e.g. Barber *et al*. 1990: 9; Morris 1986). These are reasonably interpreted as elite burials, although such funerary displays could also be expressions of cultural and/or religious identity, rather than socio-economic status *per se*. Struck (2000) analysed high status burials of first-to-third century date and concluded that the elite probably comprised only a very small percentage of the total population, but whether the bulk of the remainder enjoyed broadly similar status remains unclear as far as the mortuary evidence is concerned. No definite 'paupers' graves have yet been excavated in Britain. A mass grave uncovered at Gloucester (London Road) has been linked to the Antonine Plague of the AD 160s-180s (Simmonds *et al*. 2008), although Hurst (2010) has suggested that it could represent a mass burial pit for the poor. Ancient sources refer to such mass graves (*puticuli*) on the outskirts of Rome (Hope 2007: 132), a number of which were excavated in the latter half of the nineteenth century (Lanciani 1898). However, very few similar burials are known from elsewhere in the Empire (Bodel 2000: 131). At most settlements with a far smaller population than that of Rome, the number of unclaimed bodies was perhaps small enough that they could be accommodated in pre-dug graves. Alternatively, they may simply have been disposed of in ways undetectable archaeologically. Elsewhere in the Empire, the less wealthy members of society were sometimes interred in communal tombs (*columbaria*), which could be sited above or below ground (Toynbee 1996: 50), but no examples are known from Roman Britain.

The literary and epigraphic evidence for slaves in Britain (as opposed to British slaves elsewhere in the Empire) is limited to a relatively small number of funerary inscriptions and writing tablets (e.g. *RIB* 21; Burnham *et al*. 2005: 474; Tomlin 2003). Most attempts to estimate the relative proportions of citizens, freedmen and slaves in the Empire have focused on Rome itself, or Italy more generally. Some estimations suggest that around one third of the population of Roman Italy were slaves (Bradley 1994: 24), but the figure is likely to have been lower in the provinces (Mattingly 2006: 294; Scheidel 2007b).

Evidence for the socio-demographic composition of the populations of the small towns is even more limited than that for the public towns (Burnham and Wacher 1990). With the exception of the shrine at Bath, few sites have produced significant numbers of funerary epitaphs and other inscriptions (Millett 1990: 110). Organised inhumation cemeteries of relatively uniform grave orientation and burial rite occur at several sites in addition to Ancaster (Wilson 1968), such as Ashton, Northants (Dix and Hadman 1984), and resemble the 'managed' cemeteries of the public towns. Higher status burials in stone and/or lead sarcophagi, and mausolea, are known at several small towns (e.g. Harman *et al*. 1979; Matthews *et al*. 1981; Dix and Hadman 1984; Wilson 1968). Such burials could indicate the presence of local elites resident in the small towns themselves, but might also belong to nearby villa owners.

2.2.1.3.2.2 Population diversity and migration

Urban communities must have attracted migrants from within Britain and other regions of the Empire. Non-local migrants would include soldiers and their families, members of the Imperial administration, traders, artisans and slaves (Eckardt 2010: 102). The relative proportions of local and non-local individuals among the urban populace is difficult to assess, and levels of migration probably varied between settlements and over time. It is reasonable to assume that a significant proportion of the early inhabitants of the *coloniae* comprised retired veterans and their families (Birley 1980: 116). Foreign traders and artisans are assumed to have formed a substantial component of the early population of London (Mattingly 2006: 273-4). The role of native elites in the establishment and early expansion of towns has often been emphasised for the *civitas* capitals (Burnham *et al*. 2001: 71).

Epigraphic and textual evidence has been used to explore population diversity in the Roman Empire. A study of inscriptions from Rome concluded that approximately 5% of the total populace during the High Empire were of non-Italian origin (Noy 2000: 286). A similar proportion of inscriptions from Britain indicate a non-local origin for the dedicatee or person commemorated therein (Eckardt 2010: 121). However, using epigraphic evidence to assess levels of mobility in Britain is potentially problematic, as non-locals were more likely to engage in the ‘epigraphic habit’, and will therefore be over-represented (Eckardt 2010: 100; Noy 2010: 18). Several studies have attempted to identify immigrants on the basis of burial rites and grave goods (e.g. Baldwin 1985; Clarke 1979; Cool 2004, 2010; Hawkes and Dunning 1961; Hills and Hurst 1989), although it is impossible to know, based on burial evidence alone, whether individuals interred with ‘foreign’ objects originated from outside Britain, were descendants of migrants, or simply adopted non-British material culture (Pearce 2010). In recent years, analysis of stable isotopes (e.g.

strontium and oxygen) has been used to explore migration in the Roman Empire (Dupras and Schwarcz 2001; Killgrove 2010a, 2010b; Prowse *et al*. 2007; Schweissing and Grupe 2003). A multidisciplinary project examining diaspora communities in Britain included stable isotope analysis of 155 individuals from Roman cemeteries in the public towns of Gloucester, Winchester (Lankhills) and York, and the small town/military *vicus* at Catterick (Eckardt 2010: 109-10). In all cases, the proportion of individuals with isotopic signatures local to the area was *c*. 40-60%. The percentages of individuals identified as non-local, i.e. originating outside Britain, ranged from *c*. 2% at Catterick to as much as 34% at Lankhills (Eckardt 2010: 122). A minority of individuals at each site had isotopic signatures indicating they originated elsewhere in Britain (Chenery *et al*. 2009, 2011; Eckardt *et al*. 2009; Leach *et al*. 2009).

The diversity of the populations of the minor centres is difficult to assess, owing to the scarcity of inscriptions (Millett 1990: 110). The evidence for a low percentage of non-local residents at Catterick (Chenery *et al*. 2011) – originally founded as a garrison settlement, and sometimes included among the small towns (Burnham and Wacher 1990: 111-17) – suggests less mobility. Given the lack of administrative functions and the probability that the majority of small towns were, at most, local market centres, it seems unlikely that significant numbers of foreign migrants would have been attracted to live there.

2.2.1.3.2.3 Death and burial

During the first and early second centuries, cremation was the predominant burial rite in most areas, but was gradually superseded by inhumation from the mid-second century onwards (Philpott 1991: 53; Russell 2010). The reasons for this change are not fully understood, but it mirrors a broader trend towards inhumation across the Empire at this time (Toynbee 1996: 41). Romano-British inhumations were typically extended, supine burials that were often unfurnished, although a significant minority of excavated burials have produced evidence for wooden coffins. Coffins of more durable materials (stone and lead) and flint/stone-lined cist graves are less common (Russell 2010). Prone burials occur in small numbers; they are more common at rural sites, tend to be of later date and are less likely to be accompanied by grave furnishings (Boylston *et al*. 2000: 247; Philpott 1991: 74). The significance of this body position is unclear. Harman *et al*. (1981: 168) suggested that it could represent an attempt to contain the spirit of the deceased, but other explanations have been proposed (Philpott 1991: 74-6)

A number of studies have explored the extent to which burial rites and associated funerary remains expressed social status and/or cultural identity. Since funerary inscriptions are almost never found *in situ*, such studies are dependent on the evidence of mortuary rituals and associated finds. Identity has often been conceptualised in terms of binary opposites, such as Roman/native, military/civilian and, particularly in the context of later Roman Britain, pagan/Christian (Alcock 1980; Baldwin 1985; Black 1986; Clarke 1979; Green 1977, 1993; Hawkes and Dunning 1961). However, such divisions do not necessarily reflect the complexities of individual and communal identity. More recently, researchers, including bioarchaeologists, have considered other aspects of identity, such as gender (Hill 2001; Keegan 2002; Petts 1998) and age (Gowland 2001, 2004; Moore 2010). Subadult burial rites were generally the same as those for adults, although perinates and young infants, unlike older individuals, were frequently buried within settlements (Philpott 1991: 97). This includes burials near or beneath domestic buildings, often in foundation trenches or ditches, particularly at rural sites (Pearce 2001; Scott 1990, 1991). The traditional explanation for such burials is that the Roman prohibition on burials within settlements did not apply to infants, since society considered them non-persons, though this view has been questioned on the grounds that such attitudes largely reflected the sensibilities of aristocratic elites (Carroll 2011). Other researchers have interpreted such infant burials in terms of a symbolic association between newborns and the domestic sphere (Moore 2009; Scott 1990, 1991), or the liminal position of newborns on the boundary between life and death (Pearce 2001).

Roman women held lower status than males in legal, political and economic terms (Allason-Jones 2005: 5-6), but there is little clear evidence that this was expressed in funerary rites. Watts (2005) has argued that traditional Roman gender roles led to a decline in the relative status of women in the post-conquest period. Watts compared burial rites and the provision of grave goods, etc., between females and males in the Iron Age and Romano-British periods. She concluded that Iron Age women were equally likely to be accompanied by indicators of ‘status’, but that in the Roman period, fewer women than men had high status burials. However, Watts did not employ any statistical analysis in her study; hence, her conclusions may be impressionistic only. Additionally, other researchers have found no evidence for significant differences in the proportions of females and males interred with grave goods and furnishings (Hamlin 2007, cited in Redfern and DeWitte 2011b: 199), although the types of objects with which individuals were buried do vary by sex (Philpott 1991: 233). Bioarchaeological studies of mortality and morbidity have also failed to support the notion that female status declined in the Roman period, at least in so far as it affected health (Redfern 2006; Redfern and DeWitte 2011b).

2.2.1.4 Economy

2.2.1.4.1 Production and consumption

Discussions of urban economies in the Roman period have been dominated by the ‘consumer’ *vs.* ‘producer’ city debate (Parkins 1997). The consumer city model envisages towns as administrative and social centres draining their surrounding hinterlands of resources, where manufactured goods were primarily intended for consumption by the urban population. This contrasts with the producer city model, in which towns are viewed as self-sustaining, enjoying a reciprocal relationship of exchange with their agricultural hinterland and further afield (Wilson 2002: 231-4). In recent decades, research on Roman urbanism has begun to move beyond such dichotomies (e.g. Mattingly and Salmon 2001; Parkins 1997).

A wide variety of commercial, craft and industrial activities are attested at towns (Wacher 1995: 68). Substantial quantities of foreign foods and other goods were imported to Britain (du Plat Taylor and Cleere 1978; Richardson and Tyres 1984; Williams and Carreras 1995). London possessed monumental port facilities (Brigham and Hillam 1990; Milne 1985), and other large towns have also produced evidence for harbours (Cleere 1978: 38; Mattingly 2006: 284). Inscriptions indicate the presence of individual merchants and guilds of traders involved in import/export activities (Birley 1980: 125-8; Hassall 1978). Market buildings have been excavated at Cirencester (Holbrook 1998), Leicester (Cooper and Buckley 2004), Verulamium

(Niblett 2001) and Wroxeter (Ellis 2000). Craft and industrial activities included pottery production, glass making, carpentry, smithing, precious-metalworking, mosaic production (Allen 2012; Cool 1986; Evans 2005; Price 2005), and the processing of animal products such as leather, wool, antler and bone (e.g. Crummy 1981; Rhodes 1987; Wild 2002). Large quantities of animal bones recovered from refuse deposits point to the presence of specialist butchers (Maltby 2007; Seetah 2005). The building trade must have been economically important during the period of urban expansion in the later first and second centuries, and from the later second century onwards, the construction and outfitting of private town houses would have provided employment for artisans (Johnson 1993; Ling 1985). Brick and tile production primarily took place outside towns, although kilns were often located near the major population centres, suggesting a relatively steady demand for materials (Darvill and McWhirr 1984; Frere 1987).

In addition to those trades and industries for which archaeological evidence survives, many other less visible occupations and professions must have been present at towns. The Edict on Maximum Prices, issued under Diocletian and the Tetrarchs in AD 301, lists a wide range of skilled and un-skilled occupations, including painter, tailor, seamstress, and day labourer (Corcoran 2000: 205-33). While the Edict primarily reflects the economic environment of the Eastern provinces (Corcoran 2000: 221), some of these services must also have been required by the inhabitants of Romano-British towns. Activities such as money changing/lending and tax collection would also have been important elements in the urban economy (Esmonde Cleary 1989: 74).

Discussions of the urban economy sometimes give the impression that the entire populace was gainfully employed in some specialist craft or other trade, but there must have been some level of under-employment or seasonal employment, e.g. in unskilled labour (Garnsey 1998: 135). Additionally, it is almost certain that some people living in or near towns were occupied in farming the surrounding land (Birley 1980: 137; Salway 1993: 421-2), which may have included seasonal labour (Erdkamp 1999: 558). Faunal deposits from a number of small towns suggest livestock were raised in the immediate vicinity of settlements (Johnson and Albarella

2002). The term ‘agro-city’ has been used to refer to urban centres of this type (Hourani 1981: 26).

In relation to the small towns, the central debate concerns the relative significance of commercial and craft activities *vs.* agricultural activities (Burnham 1993: 102). A small number of sites were important centres of ceramic production or mineral extraction, such as Water Newton (Mackreth 1995) and Droitwich (Woodiwiss 1992), and many others have produced evidence for metalworking and other crafts. Small towns generally produce less evidence for ‘higher order’ activities, such as trade in luxury goods (Esmonde Cleary 1989: 75). While there is evidence for artisans at many sites, the generally ‘rural’ character of most buildings in small towns suggests a greater dependence on agricultural activities (Burnham and Wacher 1990: 5). The presence of large aisled buildings, usually interpreted as barns, workspaces and/or combined living spaces for people and their animals, points to livestock rearing and other agricultural activities (Burnham and Wacher 1990: 20). A number of researchers have noted an apparent relationship between small towns (including Ancaster) and major villa estates, which may indicate that the development of some settlements was driven by their role as places for the exchange and distribution of agricultural produce (Brown 1995: 2; Mattingly 2006: 289). It is likely that some inhabitants of small towns worked as agricultural labourers on surrounding villa estates (Birley 1980: 137), and Brown (1995: 2) notes that agricultural implements are common finds in excavations at the minor centres. Many small towns in the south and east of England have produced iron wool combs, suggesting that sheep farming and wool processing was an important element of the small town economy in these regions (Wild 2002: Fig. 3). This may also be supported by the evidence for higher percentages of sheep/goat remains in faunal assemblages from the minor urban centres (King 1999: 180).

At some small towns, there is evidence for a reversal in the ratio of agricultural-to-craft/trade activities in the later second and third centuries, the latter becoming more prominent (Brown 1995: 2). Evolution in the economic character of some sites may be reflected in architectural developments, with timber buildings being progressively replaced by masonry structures (Rust 2006). This may point to the increasing prosperity of some sites, although the trend towards masonry construction is observed more widely in Romano-British architecture (Perring 2002: 39). In the later third and fourth centuries, military and political reforms increased the tax burden on the provincial populace, and small towns probably became increasingly important as centres for the collection of revenue, both in the form of coin and taxation in kind. The fortification of many of the minor centres in the third and early fourth century, and the fact that defences often only enclosed the central core of a settlement (as at Ancaster; Todd 1981), may reflect a concern for the protection of money and goods collected by the state (Esmonde Cleary 1989: 64).

2.2.1.4.2 Diet

Evidence for diet in Roman Britain includes botanical and faunal remains, residue analysis, cooking utensils and wares, and other archaeological evidence for food production, processing and storage (Cool 2006: 8-20). Plant foods would have comprised the bulk of the diet. Cereals, in particular barley and wheat, dominate the archaeobotanical record (Jones 2000; Van der Veen *et al*. 2007). Some researchers have suggested that most people had only limited access to meat (Garnsey 1998: 243), but it is now thought that meat comprised a greater proportion of an average individual's diet than once believed (Cummings 2009; King 1999). In the Northwest provinces, faunal deposits tend to be dominated by cattle (King 1999: 180), followed by pig, with smaller proportions of sheep/goat, fowl, wild game and fish and shellfish (e.g. Fulford *et al*. 1995: 131-9; Luff 1993; Maltby 2010). The large numbers of cattle bones recovered from many sites may also point to the importance of dairy and other secondary products (Dobney 2001: 36-7). There is some evidence for an increase in fish consumption during the Roman period (Locker 2007), including the popular fish sauce *garum* (Corcoran 1963).

The relative importance of different plant and animal species in the diet varies slightly between settlement categories. Pig remains are somewhat more prevalent at villa and military sites, possibly suggesting that pork was consumed in greater quantities among higher status groups (Grant 2004: 380). Remains of fowl are more common at towns compared to rural settlements (Maltby 1997). In terms of differences between the public and small towns, both are similar in that faunal deposits are dominated by cattle (e.g. Johnson and Albarella 2002; Maltby 2010), although, as noted above, sheep/goat remains occur in greater proportions at small towns (King 1999). Analysis of plant remains from various sites has shown that a wide range of plant species, including new species introduced during the Roman period, were being consumed at both the public and small towns (Van der Veen *et al*. 2008). Towns and military sites have produced the majority of large fish bone assemblages (Locker 2007: 155).

In recent years, stable isotope analysis has confirmed the picture of a largely terrestrial-based diet (e.g. Chenery *et al*. 2010; Cummings 2009; Redfern *et al*. 2010). However, analyses of human remains from Poundbury, Dorset and Gloucester suggest that some segments of the population consumed greater quantities of marine foods and that, overall, fish and shellfish comprised a more significant component of the diet in urban areas (Chenery *et al*. 2010; Cheung *et al*. 2012; Richards *et al*. 1998).

2.2.1.5 Late Roman towns

The question of what happened to Romano-British towns in the fourth and early fifth centuries AD has been the focus of much research in recent years. While there is broad agreement that town life, as least as it is usually understood, had ceased at many sites by the middle of the fifth century (Arnold 1984; Brooks 1986; Russo 1998), scholars are divided regarding the speed of decline and its underlying cause(s). Some characterisations of late Roman urbanism take the view that the public towns had become little more than ‘administrative villages’ as early as the beginning of the fourth century AD (Reece 1980: 88). Explanations have been sought in the events of the later third and early fourth century, especially Diocletian’s reforms, which were continued under Constantine (Faulkner 2000). Others propose a slower decline, becoming more pronounced from *c*. AD 380 onwards (Esmonde Cleary 1989). Some have questioned whether the concept of ‘decline’ is appropriate, arguing that many of the developments of the fourth century could be viewed as representing a change in the nature of urbanism and the function of towns (*cf*. Rogers 2011). Much of the debate centres on the physical fabric of the public towns, especially the fate of civic buildings, in addition to economic decline and population contraction (e.g. Faulkner 1994; Marsden and West 1992; Perring 2011b).

2.2.1.5.1 Physical decline or transformation?

The later layers of Romano-British towns have been compared unfavourably to the evidence for urban settlement in the second and early third centuries (Rogers 2011). There is little evidence for new building in the later third and fourth centuries, with the exception of fortifications (Esmonde Cleary 1989: 72). In addition to a lack of building activity, civic buildings at some sites fell into a state of disrepair or were completely demolished. Parts of the forum/basilica at London were demolished in the later third or early fourth century and street surfaces in the vicinity were no longer being maintained (Brigham 1990). Similar evidence for early decline has been claimed for Wroxeter, where the basilica was not restored following a fire at the turn of the fourth century (White and Barker 1998). However, the picture differs at other sites such as Silchester and Verulamium, where there is no evidence for abandonment of the forum/basilica until the late fourth century at the earliest (e.g. Fulford and Timby 2000; Hebditch and Mellor 1973; Niblett *et al*. 2006).

The fate of other civic buildings and public amenities, such as bathhouses and associated aqueducts, theatres, amphitheatres and temples, also varied. Again, London provides evidence for early decline, the main public bathhouse being demolished in the late second/early third century (Marsden 1985: 102). By the turn of the fourth century, the amphitheatre had been abandoned (Bateman 1997: 68), and maintenance of the ports had ceased (Brigham 1990: 159; Milne 1993: 12). Colchester’s circus was no longer in use by the end of the third century (Crummy 2008: 29). At other towns, though, there is evidence for continued use of such structures into the mid-to-late fourth century (Esmonde Cleary 1989).

Decline in the urban fabric has also been inferred from the apparent neglect of road surfaces and gates, and the accumulation of refuse deposits within towns. At Winchester, excavations revealed late Roman rubbish pits and piles of building rubble dating to *c.* AD 350-70 inside the West Gate (Frere *et al*. 1985: 311). However, it has been suggested that the presence of such deposits could be explained by the fact that they were not subject to the same degree of re-working as earlier material (Mattingly 2006: 342). At Lincoln, substantial quantities of animal bone (mainly waste from the processing of cattle carcases) were used as infill to stabilise the ground along the water front, and it has been suggested that this could only have been achieved if the civic authorities were still organising the collection and disposal of waste on a large scale (Dobney *et al*. 1999: 20).

The evidence from the major towns thus points to the abandonment of some public buildings as early as the third century, especially at London (Milne 1993; Perring 2011b), although at other sites this did not occur before the last quarter of the fourth century (Esmonde Clearly 1989; Rogers 2011). The dilapidated state of some public buildings at the turn of the fourth century, especially those associated with civic activities, has led some to assume that they were no longer required, and that the administrative importance of towns must have been reduced. Others have noted, however, that administrative activities do not necessarily require grandiose accommodation (Esmonde Cleary 1989: 71-2; Mattingly 2006: 337). Additionally, the continued investment in urban defences (Hobley 1983) also argues against early political decline (Millett 1990: 141; Webster 1983). In the case of bathhouses, theatres/amphitheatres and temples, the lack of investment in their upkeep might reflect changes in cultural attitudes with the rise of Christianity (Rogers 2011: 89-103). An apparent unwillingness to channel resources into public buildings has also been set against the evidence for increased investment in private display in town houses and villas (see section 2.2.1.2.2). It has been argued that the system of public munificence by which members of the curial classes funded the construction and maintenance of civic amenities was never adopted as enthusiastically in Britain as elsewhere in the Empire (Hope 1997: 245-50; Mann 1985), with communities choosing to construct their identities in different ways (Mattingly 2008).

2.2.1.5.2 Population decline

Several lines of evidence point to urban population decline in the later Roman period. Once again, some of the earliest signs of decline are seen in London. Marsden and West (1992) identified a marked reduction in the quantity of refuse deposits and wells following a major fire in the Hadrianic period, and other studies have also noted a decline in the quantities of finds from the later third century onwards (Perring 1991: 76; 2011b). Faulkner (1994, 2000) has argued, based on an assessment of the evidence for building use at late Roman Colchester and Verulamiun, that both towns experienced significant contraction as early as the mid-third century, with many elite town houses no longer occupied by the mid-fourth century. At many sites, the extent of suburban occupation also seems to have contracted in the later fourth century (Esmonde Cleary 1989). Millett (1990: 134) suggests that the public towns increasingly resembled 'garden cities' by the fourth century.

While the picture of lower settlement density and abandonment may hold true for some towns, this was not necessarily the case elsewhere. Early Victorian and Edwardian excavation plans of Silchester indicated large areas of open space between houses, but modern excavations have shown that timber structures raised on stone pads were interspersed between masonry buildings, suggesting higher building density than hitherto appreciated (Clarke and Fulford 2002a: 163; 2002b). Similar evidence could have been overlooked at other sites excavated before the development of modern techniques. Additionally, Silchester is atypical in that it has not been continuously occupied in later periods, meaning later Roman levels are likely to be better preserved (Mattingly 2006: 339; Millett 1990: 221). The potential impact of post-Roman agricultural activity on the survival of late Roman occupation layers has been highlighted at Verulamium by Niblett *et al*. (2006: 101-3), and at Leicester, where near-complete truncation of Roman habitation layers by later medieval activity has been observed (Cooper and Buckley 2003: 41).

A much commented upon feature of the latest Roman layers at many of the public towns (and some small towns) is 'dark earth' (Esmonde Cleary 1989: 127; Mattingly 2006: 340). The term refers to deep, apparently unstratified deposits that commonly seal the final layers of Roman occupation at many towns. Such deposits typically contain very few structural features and large quantities of refuse (Macphail *et al*. 2003). Dark earth is particularly common at London (Roskams 1991). The traditional interpretation of dark earth is that it represents a combination of decayed timber buildings and the development of open areas in towns, suggesting partial abandonment towards the end of the Roman period. Some deposits appear to represent the intentional dumping of soil for horticultural or agricultural purposes, as 'tip lines' have been noted at several sites in London (Perring 1991: 78; Roskams 1991). However, detailed analysis of dark earth deposits suggests that the view that they represent abandonment may be incorrect in some cases. A review of London's dark earth found that the layers immediately beneath the dark earth had often been subject to biological re-working that could have destroyed the latest Roman layers (Yule 1990). Furthermore, evidence for later Roman activity may have been lost at many sites, since it was standard practice to remove dark earth with little examination until relatively recently (Rogers 2011: 10). Perring (2011b: 272) considers it unlikely that such disturbance accounts for the relative dearth of late Roman finds at London, arguing that, by the third century, a majority of the intra-mural area was open space. At most sites, however, dark earths are of very late Roman or post-Roman date (Esmonde Cleary 1989: 127-8).

The evidence for marked decline in population at the small towns in the later third and early-to-mid fourth centuries is less clear. For those sites that were important centres of production, evidence for intensification of such activities in the third century implies population growth, with artisans previously based in the major urban centres possibly relocating to the smaller towns. At some sites, the construction of fortifications enclosing the core of the settlement resulted in the abandonment of the newly created extra-mural areas. This could have been the case at Ancaster, as the later cemetery overlies earlier second and third century settlement activity (Todd 1981). Similarly, the positioning of the late Roman cemeteries at Baldock and Godmanchester suggest contraction (Burnham and Wacher 1990: 129, 286). At other sites, habitation in the newly formed suburban areas was unaffected (Esmonde Cleary 1985: 76).

The size of late Roman urban cemeteries contradicts other evidence for population decline (*cf*. Cooper and Buckley 2003: 41). The extensive burial grounds that developed at towns – the full extent of which has yet to be mapped in many cases – could be interpreted as evidence for substantial late Roman populations (Esmonde Cleary 1989: 80). Unfortunately, precise dating of late Roman burials is often problematic, due to the general absence of grave goods (e.g. Barber and Bowsher 2000: 8-11), thus it is difficult to assess what proportion are late third, early fourth or late fourth century in date. The majority of burials at Butt Road, Colchester, were dated to the early fourth century or later, and at least 50% of late Roman burials at Winchester date to AD 340 or later (see Chapter 4). The burial evidence thus suggests that the towns were by no means abandoned by the later fourth century. The 'managed' appearance of many burial grounds in terms of the neat ordering of graves and standardisation of orientation, depth and form, may indicate the continued role of the civic authorities in regulating burial (Hatton 1999).

2.2.1.5.3 Economic contraction

Discussions of the economic role of towns in the later Roman period have concentrated on the question of the extent to which they remained important centres of production and consumption. It has been suggested that the increasing role of tax in kind, rather than coin, diminished the importance of the public towns as centres of commerce and trade (Millett 1990: 129). This may be reflected in a reversal in the ratio of commercial spaces (i.e. strip buildings) to town houses. At some sites, strip housing were demolished and replaced by fewer, larger, buildings, or their plots left vacant (e.g. Niblett *et al*. 2006: 100-1). However, whether this points to economic decline, as opposed to a re-orientation of the economy of the public towns, is disputed (Rogers 2011). One industry that is widely attested at late Roman towns is metalworking, with many sites producing evidence for such activities within public buildings and spaces. The forum/basilica complexes at Cirencester, Colchester, Leicester, London, Silchester and Wroxeter among others were evidently used for iron and bronze working in the fourth century (Rogers 2011). In the past this was sometimes described as 'squatter occupation', but it has been suggested that such activity could represent the establishment of state-run workshops or *fabricae*, producing goods and equipment for the army (Rogers 2011: 143). Winchester may have been the location of an Imperial weaving facility (*gynacaeum*), based on a reference in the *Notitia Dignitatum*, although there is no known building that is obviously associated with such a facility (Rees *et al*. 2008)[2].

The army may have become increasingly important to the economy of late Roman towns, due to the military's role in overseeing the collection of taxes and the fact that it was a major consumer of grain (Faulkner 2000: 128). Furthermore, changes to the organisation of the army potentially resulted in small units being billeted at towns (Mattingly 2006: 251). It is not known when, for how long, and at which towns these troops might have been stationed, as no definite late military

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[2] Alternative readings of the *Notitia Dignitatum* identify 'Venta' as Caerwent or Caistor-by-Norwich (Wild 2002: 29).

structures have been identified, and the material culture of late Roman military and civilian settlements differ little (Gardner 1999). A masonry building of fourth century date excavated at Wolvesey Palace in Winchester may have been linked to the army (Biddle 1975). A military presence at a number of other sites is also postulated on the basis of certain styles of belt buckles, brooches and knives found in some burials (Hawkes 1974; Hawkes and Dunning 1961), although there is disagreement concerning their interpretation. Units of soldiers might have been stationed at some small towns to oversee the collection of taxes and monitor movement along roads (Todd 1970: 120).

2.3 A note on landscape and climate

Although it has been argued that there was large-scale deforestation in the Roman period, as attested in the pollen record (e.g. Dumayne and Barber 1994), there is evidence that considerable loss of tree coverage had already occurred by the later pre-Roman Iron Age (Dark and Dark 1997: 30). The forested area of Southern England in the Roman period may not have been much greater than today (Dark 1999).

A climate optimum, occurred across much of Europe in the early first millennium AD, and is referred to as the ‘Roman Warm Period’ (Piva *et al*. 2008: 165; Seppä *et al*. 2009: 531). Temperatures in Britain were at least 1°C higher, on average, than the present day. From the mid-third century, temperatures declined and the climate became wetter, worsening from the turn of the fifth century (Dark and Dark 1997: 18-19; Jones 1996: 204). The impact of climatic change on agricultural output has been raised as a possible contributory factor to late Roman decline, although it is questionable whether the magnitude of change was great enough to exert a significant effect (Jones 1996: 215).

3 Bioarchaeology of Roman Britain

3.1 Background to bioarchaeological research in Roman Britain

Historically, the study of human remains has played a relatively minor role in Romano-British archaeology. This can be related to the status of burial archaeology within the discipline more generally. In the early 1980s, Reece (1982: 347) observed that burial archaeology had long been, 'judged peripheral to the mainstream of Roman studies in the north-west Empire'. Others have also noted the untapped potential of burial archaeology (e.g. Pearce *et al*. 2000). Pearce (1999: 6) and Philpott (1991: 2) both suggest that this is partly due to the abundance of settlement evidence, which has been prioritised over other categories of data. This is in contrast, for example, to the Anglo-Saxon period, which is characterised by a dearth of settlement evidence and wealth of funerary remains (Dickinson 2011). Additionally, the tendency for Victorian and Edwardian scholars to draw parallels between the Roman and British Empires, which encouraged a focus on military sites and the 'civilising' influence of Classical urban culture, further contributed to the primacy of the settlement record (Hingley 2000). The marginalisation of burial archaeology in Romano-British studies is also arguably a consequence of the traditional relegation of material evidence in Classical studies more widely (Dyson 1989; Moreland 2001; Sauer 2004b). Finally, the study of death and burial in the Roman Empire has often focused on textual and artistic evidence (e.g. Toynbee 1996), both of which are relatively less abundant in the case of Britain, further discouraging research on Romano-British burial practices (Philpott 1991: 2).

Another reason for past disinterest in skeletal data among Romano-British scholars may relate to the burial record itself. In the 1960s and 70s, the development of mortuary analysis in archaeology was partly driven by a growing awareness of the potential for linking biological and demographic data with funerary evidence as a means of reconstructing social systems and identity (e.g. Binford 1971). The funerary record of the earlier Roman period is dominated by cremation in most regions. Believing cremated bone to be of little analytical value, earlier excavators often discarded the skeletal remains and retained only the cinerary urns and/or associated grave goods, thus restricting the potential for integrating archaeological and osteological data (McKinley 1997; Philpott 1991: 3). In the case of the larger inhumation cemeteries of the third and fourth centuries, the fact that the majority of burials are unfurnished and often relatively uniform in terms of coffin type, body position and grave orientation, to some extent restricts the scope of mortuary analysis (*cf.* Gowland 2007: 165), with Rahtz (1977: 56) noting a lack of enthusiasm for excavating large numbers of unfurnished burials. Consequently, the few sites with unusually high proportions of furnished graves have received a disproportionate share of attention, particularly the Lankhills area of the Northern Cemetery of Winchester (e.g. Clarke 1975; Baldwin 1985; Gowland 2001, 2002, 2007).

Although burial evidence has played a lesser role in Romano-British studies compared to other regions and periods, there is nevertheless a relatively substantial body of research on aspects of funerary ritual and material culture. Pearce (1999: 5-6; *cf.* Morris 1992: 15) has noted that the study of death and burial in Roman society has often involved, either implicitly or explicitly, drawing a distinction between expressions of religious and/or ethnic, and social identity. In Romano-British archaeology, most studies of burials have tended to focus on the former (e.g. Alcock 1980; Black 1986). In particular, the somewhat ambiguous nature of much of the material and architectural evidence for Christianity in late Roman Britain (compared to other regions of the Empire) has led many to focus on burial practices (e.g. Green 1977, 1993; Watts 1991: Ch.3). The study of religious beliefs and practices relies primarily on material evidence, and human remains have often been ignored as a result (although see Jenny 2011). It is only more recently that studies of gender, age, social status and ethnic identity – research questions to which bioarchaeological data can contribute to a greater extent – have been addressed (e.g. Petts 1998).

While particular aspects of the historical development of Romano-British studies have contributed to the marginalisation of funerary studies and bioarchaeology in Romano-British scholarship, this situation also reflects broader trends in British archaeology. Many of the key figures in the development of bioarchaeology were primarily trained in the clinical sciences, thus the analysis of ancient skeletal material was often approached from a medical-historical perspective (Roberts 2006). Consequently, much of the earlier literature on skeletal remains from archaeological contexts comprises case study reports, often published in specialist medical or anthropological journals (Mays 2010a, 2012a). Population-based palaeopathological analyses were often aimed at defining the range of skeletal manifestations of particular diseases and/or epidemiological trends from the perspective of the natural history of disease, with little attempt to situate the skeletal evidence in its cultural context (e.g. Thould and Thould 1983). This situation has, however, changed considerably in recent decades, with the widespread adoption of population-based biocultural approaches (Armelagos 2003; Bush and Zvelebil 1991; Roberts 2006).

3.2 Publication categories

Bioarchaeological literature can broadly be divided into three categories, namely: (1) case study reports; (2) population studies/syntheses; and (3) skeletal reports contained within, or as appendices to, excavation reports (*cf.* MacKinnon 2007). To this can also be added methodological studies that develop, refine or test techniques (Mays 2010a). Table 1 lists recent and past studies of Romano-British cemeteries and skeletal populations according to type and subject of publication[3]. It includes all relevant publications in key journals (International Journal of Osteoarchaeology, American Journal of Physical Anthropology, Journal of Archaeological Science, International Journal of Paleopathology and Journal of Paleopathology), and other articles identified through a search of electronic journal repositories (e.g. JStor).

The bulk of the literature comprises cemetery excavation reports. Those cited in Table 1 are almost all published reports pertaining to larger cemeteries associated with public towns and larger small towns. Numerous other reports on the excavation of individual skeletons and smaller groups of burials exist in local county archaeological journals. A number of cemetery excavation monographs have been published recently, including several long-awaited reports (e.g. Barber and Bowsher 2000; Fitzpatrick-Matthews and Burleigh 2007; Ottaway *et al.* forthcoming; Stuckert forthcoming). The delay in publication highlights the problem of backlogs resulting from the growth of developer-funded archaeology (Roberts 2009: 310).

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[3] This is not an exhaustive list, as it cannot include the many unpublished masters' and doctoral theses, and unpublished skeletal reports forming the so-called 'grey literature'. Additionally, it does not generally include those studies in which skeletal material of Romano-British date was used, but where the date of the material was not relevant to the research, e.g. the focus of the study was the development/application of a new osteological technique, etc.

Table 1. Bibliographic references to Romano-British bioarchaeological literature.
(A list of references classified according to type is provided on the accompanying CD.)

Type/Topic	**References**
Palaeopathology -Case reports	Anderson 1998, 2001a, 2001b; Boylston *et al*. 2000; Brothwell 1958, 1961, 1974; Dalby *et al*. 1993; Knüsel *et al*. 1996; Mays and Steele 1996; McKinley 1992, 1993; Molleson and Cox 1988; A. Roberts *et al*. 2006; Roberts 1987, 1988a, 1988b; Stirland and Waldron 1990; Stuckert and Kricun 2011; Turner 1911; Waldron 1993a, 2000; Wells 1964, 1973, 1974; Wells and Dallas 1976
-Population studies	Anon. 1962; Brickley 2002; Brothwell 1959; Cave 1956; Dubar and Perrot 1989; Gowland and Redfern 2010; Griffin *et al*. 2011; Hodges 1991; Jenny 2011; Klingle 2012; Levers and Darling 1983; Lewis 2010, 2011, 2012; Lewis and Gowland 2009; Manchester 1992; Mays 1985, 2006a, 2006b; Mays *et al.* 2012a; Melikian and Waldron 2003; Moore and Corbett 1973; O'Sullivan *et al*. 1993; Pitts and Griffin 2012; Reader 1974; Redfern 2003, 2006, 2007, 2008b, 2010; Redfern and Gowland 2011; Redfern *et al*. 2012; C. Roberts *et al*. 2004; Roberts and Wakely 1992; Robledo *et al*. 1995; Rogers *et al*. 1981; Rothschild and Rothschild 1995; Stuart-Macadam 1985, 1987a, 1987b, 1989, 1991; Thornton 1991; Vignon and Perrot 1989; T. Waldron 1991a, 1993b, 1995; Whittaker *et al*. 1981, 1982, 1985a, 1985b, 1987, 1998
Palaeo-demography	Brothwell 1972; Davison 2001; Gowland 2007; Gowland and Chamberlain 2002; Matthews 1999; Mays 1993, 2003; Mays and Eyers 2011; Molleson 1989, 1992; Redfern and Chamberlain 2011; Redfern and DeWitte 2011a, 2011b; Watts 2001
Metric/non-metric variation	Blackburn 2011; Brothwell and Krzanowski 1974; Buckland-Wright 1970; Buxton 1935; Lavelle 1972; Lloyd-Jones 1997; Russell 2005, 2006; Morant 1926
Bone chemistry (e.g. stable isotopes, ancient DNA, etc.)	Budd *et al.* 2004; Chenery *et al.* 2010, 2011; Cheung *et al*. 2012; Cummings 2009; Eckardt 2010; Eckardt *et al.* 2009; Evans *et al.* 2006; Fuller *et al.* 2006; Leach *et al.* 2009, 2010; Lightfoot *et al.* 2009; Mackie *et al.* 1975; Mays and Faerman 2001; Molleson *et al.* 1986; Montgomery 2002; Montgomery *et al.* 2010, 2011; Müldner and Richards 2007a; Müldner *et al*. 2011; Pollard *et al.* 2011; Redfern *et al*. 2010; Richards *et al.* 1998; H.A. Waldron 1981, 1982, 1983; Waldron and Wells 1979; Waldron *et al*. 1976, 1979; Whittaker and Stack 1984
Excavation and/or bone reports (published)	Akerman 1867; Algar 1963; Atkin 1987; Atkinson 1953; Barber and Bowsher 2000; Barber *et al.* 1990; Bentley and Pritchard 1982; Birley *et al*. 1933; Booth 1992; Booth *et al.* 1991, 2010; Burleigh *et al*. 2006; Chambers 1976, 1987; Charlton and Mitcheson 1984; Clarke 1979; Collis 1977; Cooper 1996; Croom and Caffell 2005; Crummy *et al.* 1993; Darling and Keith 1987; Davey 1935; Davies *et al.* 1985, 2002; Dawson 1994, 2004; Down and Rule 1971; Durham and Rowley 1973; Ellis 1999; Evans *et al*. 1997; Farwell and Molleson 1993; Fitzpatrick-Matthews and Burleigh 2007; Going *et al*. 1997; Hadman 1984; Harman *et al.* 1979; Hogg and Smith 1974; Hunter-Mann 2007; Hunter-Mann *et al.* 2000; Jackson and Ambrose 1978; Jones 1975; Leach 1982, 1994; Leech 1981; Mackinder 2000; Matthews and Hutchings 1972; Matthews *et al*. 1981, 1992; McGavin 1980; McWhirr *et al.* 1982; Matthews 1981; Niblett *et al*. 2006; Ottaway *et al.* forthcoming; Parrington 1978; Partridge 1977, 1981; Price 2000; Qualmann 1981; Rahtz *et al.* 2000; Ramm 1957; Rodwell 1987; Rook *et al.* 1984; Simmonds *et al.* 2008; Snape 1994; Stead and Rigby 1986, 1989; Swift 2003; Taylor 1993; Wainright and Davies 1995; Watson 2003; Wenham 1968; Wheeler 1921, 1985; Whytehead *et al*. 1986
Burial practices, mortuary ritual, etc.	Anderson and Parfitt 2002; Baldwin 1985; Clarke 1975; Collis 1977; Cooke 1998; Eckardt 1999; Fitzpatick-Matthews 2007; Gowland 2001, 2002; Green 1977, 1982, 1993; Hall 1996; Harman *et al*. 1981; Hatton 1999; Isserlin 1997; Kjolbye-Biddle 1992; McKinley 1994, 2000; Pearce 1998, 1999a, 1999b, 2001; Petts 1998; Philpott 1991; Rahtz 1977; Rosten 2007; Weekes 2005, 2008; White 2007; Williams 1999; Wilson 1968
Other	Booth 2001; Boylston and Roberts 1995; Mays 1995; Molleson and Cohen 1990; Reece 1982; Rogers and Dieppe 1984; Scott 2001; Turner-Wilson 2007; Watts 2005

The majority of the remaining references in Table 1 comprise research articles published in journals, conference proceedings, edited volumes, etc. As noted above, population-level analyses have become more numerous in recent years, although a number of reviews have shown that case study reports continue to dominate British literature (Mays 2010a, 2012a; Park *et al*. 2010). However, despite the historical dominance of case study reports, the increasing tendency for bioarchaeologists to be trained in archaeology means that more researchers are seeking to address specific research questions of historical and archaeological interest. This accounts for the growth in population studies on Romano-British material in recent years, most notably thanks to the work of Rebecca Gowland, Rebecca Redfern, Mary Lewis and others (e.g. Gowland 2001, 2002, 2004; Lewis 2010, 2011, 2012; Redfern 2003, 2006, 2008a, 2008b and 2010; Redfern and Chamberlain 2011; Redfern and DeWitte 2011a, 2011b). From Table 1, it can be seen that population studies are slightly more numerous than case studies for Romano-British material, though this owes much to the recent work of R. Redfern on material from Dorset. It should also be noted that some studies included are analyses of secular trends in disease rates that included material of differing date (e.g. Brothwell 1959; T. Waldron 1991a, 1993b, 1995).

3.3 Overview of major research themes

The following sections provide an overview of the existing bioarchaeological literature on Roman Britain. The discussion is divided into four broad themes (after Mays 2010a), namely: (1) palaeodemography; (2) palaeopathology; (3) bone chemistry; and (4) metric and non-metric variation.

3.3.1 *Palaeodemography*

There are few studies of Romano-British demography beyond general discussions of the age and sex composition of samples contained in cemetery reports (e.g. Pinter-Bellows 1993: 63; Molleson 1993: 207-14; Roberts 2007: 235-7; Wells 1982: 135-6). In most reports, the biological profile of skeletal samples is briefly compared with one or more contemporaneous populations, and often interpreted with reference to a ‘typical’ mortality profile for a pre-industrial population (e.g. Wells 1982: 135-6). Molleson (1989, 1992, 1993: 207-14) attempted a more detailed analysis of the demography of the Poundbury sample. Comparisons between sites are hindered by differences in the ageing methods and age categories employed by researchers (Falys and Lewis 2011). Biases introduced by preservation also limit comparisons between populations (e.g. Roberts 2007: 235). A number of researchers have recently applied statistical modelling to explore aspects of mortality in detail (Redfern and Chamberlain 2011; Redfern and DeWitte 2011a, 2011b).

One subject that has received some attention in the literature is infanticide, following a study by Mays (1993), who argued that a pronounced peak in perinatal mortality at full-term in Romano-British populations could be interpreted as a signature of infanticide. Mays has reiterated this argument in subsequent studies (Mays 1995; 2003; Mays and Eyers 2011). Other researchers have questioned the evidence for infanticide, citing problems in the methods used to age perinates (Gowland and Chamberlain 2002; Ingvarsson-Sundström 2004). Additionally, Mays' (1993) argument relies on the assumption that natural perinatal mortality in the past followed a similar pattern to that observed in modern populations, but this may not have been the case, owing to differences in neonatal care and feeding practices and/or factors influencing the prevalence of late-term stillbirths (*cf.* Halcrow *et al*. 2008: 389). At present, there is no agreement on the significance of perinatal mortality curves in relation to infanticide (Lewis 2007: 94; see Bonsall 2013 for discussion).

Another feature of the skeletal record widely commented upon is the tendency for females to be under-represented in Romano-British cemeteries. At some sites, equal numbers of females and males occur, or the difference in the numbers is only slightly biased towards males, but at others, the imbalance between the sexes is statistically significant. The natural sex ratio at birth varies between populations and sub-groups within populations, but is approximately 1.05 on average (Sieff 1990: 25). In certain archaeological contexts, e.g. battlefield sites or monastic cemeteries, an imbalanced sex ratio is expected. In other contexts, an unexpected surfeit of one or other sex may point to cultural practices, such as differential burial, different patterns of male/female migration, or sex-selective infanticide (e.g. Drusini *et al*. 2001; Lowell 2007; Macchiarelli and Salvadei 1994; Wicker 1998). Watts (2001) collated data on the sex ratios of Romano-British populations from urban and rural sites, and found a tendency for the imbalance to be most marked at the large towns. Watts argued that the under-representation of females is explained by preferential female infanticide, which she views as a largely Mediterranean phenomenon not widely practiced prior to the Roman conquest, and limited by the influence of Christianity in the later Roman period (Watts 2001). Others have criticised this interpretation, stressing alternative explanations such as the military presence, possible differential burial treatment of the sexes, and errors in sexing (Crowe 2001; Davison 2001).

3.3.2 *Palaeopathology*

The historical development of bioarchaeology in Britain has resulted in a strong tradition of palaeopathological research (Roberts 2006), though not all categories of pathology have received equal attention. A recent review of journal articles found that studies of metabolic disease and trauma dominate the literature (Park *et al*. 2010: 501). To some extent, this reflects the fact that certain pathologies, e.g. specific infections such as brucellosis, are relatively rare and/or difficult to diagnose in skeletal material (Ortner 2003: 180-1), and thus do not lend themselves as readily to a population-based approach as do common diseases such as osteoarthritis. Other conditions, including many congenital anomalies, are often benign or asymptomatic, and may be of less interest to palaeopathologists as a result.

Figure 6 illustrates the breakdown of journal articles on palaeopathology according to disease category (see accompanying CD for list of articles included). Articles were classified using the same descriptive categories as Mays (2010a). As reported by Park *et al*. (2010), one of the most studied topics is trauma. Park *et al*. included two general stress indicators (cribra orbitalia and porotic hyperostosis) in the metabolic disease category, but here they are classified as non-specific stress indicators (along with non-specific periostitis and dental enamel hypoplasia) after Mays (2010a). When non-specific stress and metabolic disease are combined, they form the second largest group of studies. A relatively large number of studies of dental disease have been published, but this includes several studies of differing aspects of dental pathology carried out by Whittaker and colleagues using the same material from Poundbury (Whittaker *et al*. 1981, 1982, 1984, 1985a, 1985b, 1987, 1998).

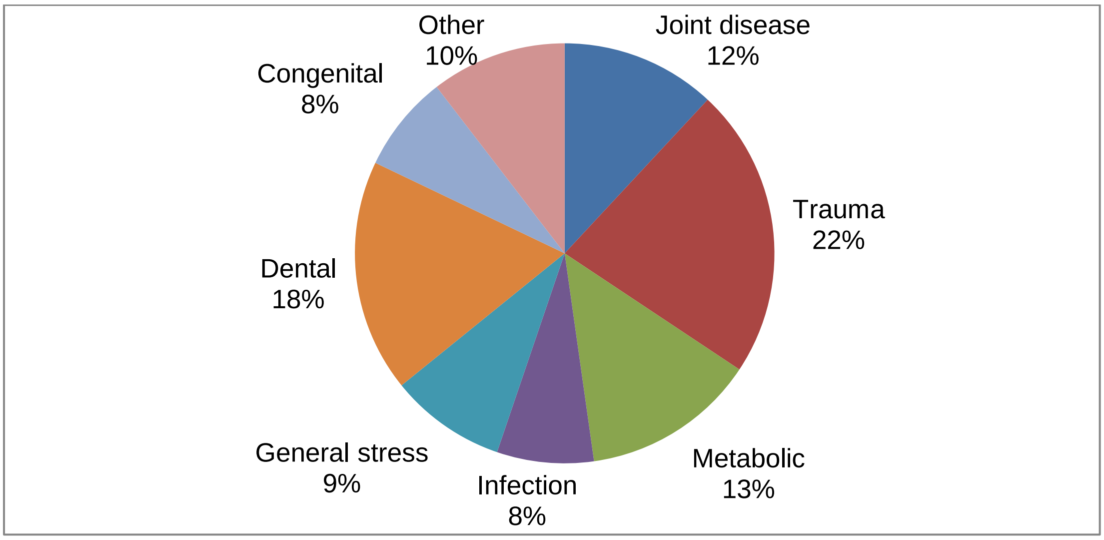

Figure 6. Palaeopathological research on Romano-British skeletal material.

The study of joint disease in Romano-British populations is a neglected area of research. Only a small number of studies have attempted to examine the pattern and prevalence of joint disease in Roman period skeletal samples, and very few of these attempt to situate the material within its archaeological context. This includes a study of joint disease among a sub-sample of adults from Poundbury (Thould and Thould 1983; see also Rogers and Dieppe 1984), and several papers on secular changes in osteoarthritis in British skeletal populations by Waldron (1993b, 1995) that included samples of Roman date. These studies were primarily concerned with establishing the pattern of arthropathies in terms of the natural history of joint disease, rather than interpreting the data from a biocultural perspective. The majority of excavation reports contain data on joint pathology, although interpretations are often limited to observations that joint disease reflects a ‘strenuous’ or ‘hard’ life (e.g. Wakely and Carter 1996: 50). For reasons that are not explained, Redfern (2006, 2008b) did not include joint disease in her otherwise comprehensive analysis of health in Roman Dorset. Many older reports do not distinguish between different spinal pathologies (e.g. spinal osteoarthritis, disc disease and Schmorl’s nodes), do not provide detailed prevalence data, and do not give breakdowns of prevalence rates by age and sex (e.g. Harman 1987).

It is evident from Figure 6 that trauma has received more attention than other categories of pathology. Most published papers deal with fracture trauma (Anderson 2001; Boylston *et al*. 2000; Mays 2006b; Redfern 2006, 2008b, 2010; T. Waldron 1991a; Wells 1974). Redfern's research has primarily focused on the evidence for inter-personal violence and fracture treatment. Other studies of skeletal trauma have addressed aspects of medical knowledge, evidence for surgical practices (including the identification of at least two embryotomies), and decapitation burials (Brothwell 1974; Knüsel *et al*. 1996; Mays *et al*. 2012a; Mays and Steele 1996; McKinley 1992, 1993; Molleson and Cox 1988; Stuckert and Kricun 2011). Like prone burials (see section 2.2.1.3.2.3), decapitation burials appear to become more common in the later Roman period in particular, the significance of which is unclear (Philpott 1991: 78-9). They occur in small numbers at many late Roman sites (Anderson 2001a; Boylston *et al*. 2000; Harman *et al*. 1981; McKinley 1993; Philpott 1991). Individuals of both sexes and all ages are represented (Philpott 1991: 79). Analysis of cut marks suggests that, in the majority of cases, individuals were probably decapitated post-mortem, but execution or battle trauma is more likely in other cases (Boylston *et al*. 2000; Harman *et al*. 1981). It is possible that some decapitated individuals were social outcasts or criminals (Philpott 1991: 84-7). At York a group of *c.* 80 burials (almost all males) excavated at Driffield Terrace, spanning the period from the late first to late third or fourth centuries, included many decapitations (Hunter-Mann 2007; Müldner *et al*. 2011).

Studies of metabolic diseases (scurvy, rickets/osteomalacia and osteoporosis) are relatively few in number for the Romano-British period (Brickley 2002; Lewis 2010, 2012; Mays 1985; Melikian and Waldron 2003; Roberts 1987, 1988a; Roberts and Wakely 1992). Studies of osteoporosis in Romano-British populations are particularly limited (Mays 2006b). For most populations, reported prevalence rates for metabolic disease are very low (Roberts and Cox 2003: 143). It is likely that these conditions are under-diagnosed, as many of the more subtle manifestations of metabolic disease have only been widely recognised in recent years (e.g. Brickley and Ives 2006; Mays *et al*. 2006; Ortner and Ericksen 1997; Ortner and Mays 1998; Ortner *et al*. 2001). Lewis (2010) identified additional individuals with evidence of metabolic disease in her re-examination of the subadults from Poundbury, including probable cases of thalassaemia, a genetic anaemia (Lewis 2012).

The most commonly observed specific infection in skeletal material of Roman date is tuberculosis, and a number of studies have focused on this disease (Anderson 2001; Stirland and Waldron 1990). Nevertheless, fewer than two dozen definite cases have been reported in the published literature[4] (Roberts and Buikstra 2003: 132; Roberts and Cox 2003: 118-20). The only other specific infectious diseases reported in Romano-British skeletal material are leprosy and poliomyelitis (Manchester and Roberts 1989: 266; McKinley 2007: 297; Reader 1974; Roberts and Cox 2003: 127; Wells 1982: 181). A number of putative cases of treponemal disease have been reported in skeletal material from Classical antiquity (e.g. Pàlfi *et al*. 1992; Rissech *et al*. 2011), but none are from Britain[5].

Non-specific stress indicators in Romano-British populations have been examined by several researchers, most notably Stuart-Macadam, who conducted several studies of cribra orbitalia and porotic hyperostosis in the Poundbury population (Stuart-Macadam 1985, 1987a, 1987b, 1989, 1991). Robledo *et al*. (1995) examined cribra orbitalia in the late/sub-Roman population from Cannington. Gowland and Redfern (2010) compared general stress indicators in Romano-British populations with samples from the City of Rome. They found that the prevalence rates for Britain were generally lower, with the exception of London, which they interpreted as evidence that living conditions were generally better in Britain relative to more urbanised parts of the Empire.

The study of dental disease in the Romano-British period has been somewhat limited (Dubar and Perrot 1989; Levers and Darling 1983; Thornton 1991), with the exception of the studies of Whittaker *et al*., already noted. Dental disease, particularly the prevalence of caries, is one of the few categories of pathology for which prevalence data are provided in older publications. A number of studies have reported higher caries prevalence in Romano-British skeletal material compared to

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[4] Additional cases in isolated skeletons not yet published exist (e.g.: http://www.york.ac.uk/news-and-events/news/2008/roman-skeleton/). A putative case of tuberculosis in a skeleton that supposedly dates to the late Iron Age or Roman period has recently been reported (Eickelmann 2011), but its provenance is dubious.

[5] Severe enamel defects observed in a subadult from Gloucester were noted as resembling defects caused by congenital syphilis, but no other indicators of treponemal disease were present (Márquez-Grant and Loe 2008: 45-6).

both earlier and later populations, indicating a change in dietary habits and/or oral hygiene practices in the Roman period (Moore and Corbett 1993; O'Sullivan *et al.* 1993).

3.3.3 *Bone chemistry*

There has been a proliferation of research applying scientific techniques to skeletal remains in recent years. Many studies have employed the analysis of stable isotopes of carbon and nitrogen in the study of diet, examining temporal changes (Redfern *et al.* 2010), dietary differences between status groups (Richards *et al.* 1998), and variations between settlement categories (Cheung *et al.* 2012). In contrast to some other regions of the Empire, there has been relatively little research on weaning in Roman Britain (Fuller *et al.* 2006). Studies of population mobility using stable isotopes of strontium and oxygen have already been referred to in Chapter 2 (Budd *et al.* 2004; Chenery *et al.* 2010, 2011; Eckardt *et al.* 2009; Evans *et al.* 2006; Leach *et al.* 2010; Müldner *et al.* 2011; Pollard *et al.* 2011). This research has been of great importance in establishing levels of mobility and diversity. To date, the evidence suggests that a significant minority of urban residents may have been non-local, including relatively equal proportions of men and women, in addition to children.

The other main type of bone chemistry analysis applied to Romano-British skeletal material has involved the study of lead concentrations (Eldridge 2002; Mackie *et al.* 1975; Molleson *et al.* 1986; Waldron 1981, 1982, 1983; Waldron and Wells 1979; Waldron *et al.* 1976, 1979; Whittaker and Stack 1984). Romano-British individuals have been found to have higher lead levels compared to pre-Roman and Anglo-Saxon individuals (Montgomery *et al.* 2010).

Few studies have applied DNA analysis to Romano-British skeletal material. As part of a larger project examining tuberculosis in British skeletal populations, Romano-British individuals exhibiting osseous changes associated with TB were sampled for pathogenic DNA amplification (R. Müller, personal communication). Mays and Faerman (2011) tested the hypothesis that preferential female infanticide was practiced in Roman Britain by sexing perinatal burials using DNA analysis, but actually identified a preponderance of male infants among the individuals tested. Waldron *et al.* (1999) obtained similar results for perinate burials from villa sites.

3.3.4 *Metric and non-metric variation*

Biometric analysis aimed at characterising the origins and genetic diversity of ancient populations was popular among British anthropologists in the nineteenth and early twentieth centuries. Several researchers examined metric variation (particularly craniometrics) in Romano-British populations (Buxton 1935; Morant 1926), generally concluding that that the people of Roman Britain were largely homogeneous[6]. However, Buxton (1935) considered skulls from York to exhibit greater heterogeneity and, in his analysis of the human remains from Trentholme Drive, Warwick (1968) also reported that males displayed more variation. Recently, modern forensic techniques have been used to investigate the ancestry of individuals from York (Leach *et al*. 2009, 2010). Buxton (1935), Morant (1926) and others believed that the craniometric data pointed to a general continuity in the population from pre-Roman to medieval times, but few later studies have explored this topic.

In recent decades, this type of metric analysis has fallen out of favour (Mays 2010b: 106-7), and very few modern studies of metric and non-metric variation in Romano-British skeletal populations have been conducted (Blackburn 2011; Brothwell and Krzanowski 1974; Buckland-Wright 1980; Lavelle 1982). Two studies have examined the Romano-British/Anglo-Saxon transition: Lloyd-Jones (1997) using dental metrics, and Russell (2005, 2006) using craniometrics. Russell (2006) found that Romano-British populations were distinct from both earlier Iron Age and later Anglo-Saxon populations craniometrically, although all the Romano-British samples utilised by Russell derived from public towns (Cirencester, Dorchester and York), therefore her findings may reflect the wider ethnic diversity of these populations.

3.4 Urbanism and population health

The impact of urbanism on health has been a key theme in many recent bioarchaeological studies of Romano-British populations. Historically, Classical scholars have been divided in their views on the relationship between health and

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[6] "[The Romano-British] physical type is fairly consistent. The head is moderately long, with a flattish top, given an upright, square, and somewhat low forehead, generally marked by a transverse groove above the eyebrows; the back of the head projects strongly; the cranial capacity is about the same as that of an average Englishman, the stature somewhat less; the figure is as a rule sturdy and muscular." (Collingwood and Myres 1936: 17).

urbanism in Roman cities, with some emphasising the benefits of town planning, water supply systems and sewerage infrastructure, and a culture of recreational bathing. Others, however, have highlighted ancient descriptions of the squalid environment of towns and cities and preference for country living among elites (Jackson 1988: 40; Morley 2005). Archaeologists and historians have also debated the impact of urbanism on the health of Romano-British populations, and whether the effects were broadly positive or negative, for over a century. In the nineteenth and early twentieth centuries, concerns over the impact of industrialisation and the consequent unchecked expansion of towns and cities in Britain, meant that the smaller, planned towns of Roman Britain were often viewed as a better model of urbanism (Butler 2011). In 1913, Frances Haverfield published an extended essay on towns in antiquity, in which he set out the benefits of Classical urban planning. However, while Haverfield admired certain aspects of Romano-British towns, such as the orthogonal street grids (Haverfield 1913: 14), he did not consider most to be fully urban, owing to the low density of structures and his view that the large town houses of the elite resembled villas. Collingwood (1936: 66-7) also appears to have viewed Romano-British towns such as Silchester (one of the most extensively excavated towns at the time) as akin to the planned 'garden cities' of his own era, whose residents enjoyed the benefits of country-living in an urban context.

In the years since Haverfield and Collingwood, the perception of Romano-British towns as healthful places has evolved. Environmental analyses (including soil samples from burials) have provided evidence for the presence of vermin and parasites in urban environments (Addyman 1989; Hall and Kenward 1995; Jones 1993). Additionally, the development of post-colonial perspectives has resulted in a shift from a view that the adoption of urban life was a mark of the civilising influence of Rome, to one that has increasingly emphasised the negative, as well as positive, impact of Imperial culture-contact on indigenous populations (e.g. Mattingly 2011).

Several bioarchaeological studies have considered the relationship between urbanism and health in Roman Britain. Redfern and Roberts (2005) collated published data for seven urban populations (the public towns of Chichester, Cirencester, Colchester, Dorchester, London and York, and the small town of

Ilchester) to examine the impact of urban living on population health. They identified ‘statistically significant’ prevalences of various non-specific stress indicators (cribra orbitalia, dental enamel hypoplasia and periostitis) and concluded that urban centres were, ‘unsanitary and often squalid’ (Redfern and Roberts 2005: 126). However, Redfern and Roberts did not include any chi-square or *p*-values, and they did not provide any explanation as to what their results were compared against; hence, it is not possible to conclude from their study that the health of populations in towns was any poorer than that of other communities.

Lewis (2010) re-examined the subadult remains from the cemetery at Poundbury Camp, Dorchester (*Durnovaria*), Dorset. She reported prevalence rates for metabolic diseases (vitamin C and D deficiency) similar to those observed in some later medieval and post-medieval populations, which were interpreted as possible evidence for high population densities, unsanitary living conditions and dietary stress (Lewis 2010). Additionally, re-analysis of the Poundbury material led to the identification of several probable cases of childhood tuberculosis, which Lewis (2011: 20) suggested could point to overcrowding. Lewis (2010: 410) noted the possibility that Poundbury could be anomalous among Romano-British populations, owing to the fact that *Durnovaria* may have been home to a large early Christian community. She suggested that the high rates of metabolic stress among subadults could point to the adoption of certain dietary practices, governed by religious attitudes (Lewis 2010: 414). However, as previously noted (section 3.3.2), it is possible that other researchers have under-diagnosed the prevalence of metabolic conditions in Romano-British skeletal samples.

A small number of studies have explored variations in population health between Romano-British urban populations. Gowland and Redfern (2010) compared non-specific indicators of stress (cribra orbitalia and dental enamel hypoplasia) in individuals from the Roman cemeteries of London with skeletal samples from several necropoleis in Rome to investigate if, and to what extent, health varied between the core and periphery of the Empire. They found that the prevalence rates for both conditions were similar in the samples from Rome and London, but that prevalence rates for London were high when compared with other Romano-British populations, an exception being the prevalence of cribra orbitalia at Poundbury (*cf.*

Lewis 2010). Gowland and Redfern (2010: 31) also suggested that the high prevalences for Poundbury may be atypical, but did not consider the possible under-diagnosis of prevalence rates in other skeletal samples. This is despite the fact that the prevalence rates they provide for London are notably higher than those previously reported (Conheeney 2000: 285).

Jenny (2011) compared indicators of stress in a sub-sample of the population from Butt Road, Colchester, with the sample from London's West Cemetery in an attempt to explore how culture and identity influenced health status, based on the possibility that the late third/fourth century burials from Colchester represent a predominantly early Christian community (*cf*. Millett 1995). Her results suggest that indicators of stress and metabolic disease were less common at Colchester relative to London, which she ascribed in part to the influence of Christian beliefs and practices on diet and lifestyle, in direct contrast to Lewis' (2010) interpretation of stress indicators in the Poundbury population.

In the studies of Lewis (2010, 2011), Redfern (2003) and Redfern and Roberts (2005), the absence of comparable data for rural or military sites, or a comparison between towns of differing size and status, means it is difficult to assess the relative health of urban populations. To date, the only study that has explicitly sought to compare health status between different settlement categories is a recent paper by Pitts and Griffin (2012). Employing the Gini coefficient (a measure of dispersion or inequality), they utilised summary statistics for various indicators of morbidity to assess the relative health status of populations from major towns, small towns (which are referred to as 'nucleated settlements'), and rural sites. Pitts and Griffin found that the three categories of settlement tended to form distinct groupings. In contrast to most other studies, their results suggest that health was poorest among rural populations, while the inhabitants of the major towns enjoyed better health status. However, Pitts and Griffins' study is potentially limited by variations in recording methodology and sample biases. Additionally, the assumption that lower disease prevalence rates equate to healthier populations is not necessarily correct (see Chapter 4, section 4.2.7.2 on the 'osteological paradox'). Their study was limited to those conditions that tend to occur in relatively high frequencies (e.g. dental disease, joint disease and trauma), and they did not include less common conditions such as scurvy, rickets and osteoporosis (which provide insights into diet and lifestyle), or specific infections such as tuberculosis. One of the largest samples included in their study, that from the Eastern Cemetery of London, has very low reported prevalences for many conditions, but this is probably due to inadequacies in recording (Conheeney 2000: 355-6), and is not reflected in more recent data for London (*cf.* Gowland and Redfern 2010; Jenny 2011). Additionally, the large skeletal series from Trentholme Drive, York (Wenham 1968), was not included among the major towns; like London, York has also produced relatively high prevalence rates for some conditions suggestive of poor health (Peck 2009). Finally, summary prevalence data may conceal variations in the patterning of disease. For example, Pitts and Griffin (2012) compared the prevalence of trauma between Romano-British populations in terms of the average number of fractured bones per person. While this may provide a general indicator of relative trauma levels, it offers no insights into mechanisms of injury, an understanding of which is important for biocultural interpretations.

The broader impact of urbanisation on the population at large, in terms of increased disease transmission resulting from long distance communications, demands placed on rural communities to increase agricultural surpluses, and the effects of changing power structures and social dislocation, has been explored by comparing Romano-British populations with samples from the Iron Age. Roberts and Cox (2003: 163) noted an increase in the prevalence of specific infections, non-specific stress indicators and metabolic disease between the Iron Age and Roman periods. Peck (2009) compared Iron Age and Roman populations from Yorkshire. He found that the Roman population of York (Trentholme Drive) exhibited higher rates of trauma, dental disease, metabolic disease and non-specific stress indicators, concluding that the ‘sociocultural implications’ of urbanism were generally negative (Peck 2009: 189). Redfern (2006, 2008a, 2008b) observed some similar changes in populations from Dorset, although her findings differed from Peck’s (2009) in that Romano-British populations exhibited less trauma relative to the Iron Age. Redfern and DeWitte (2011a) compared mortality in Iron Age and Roman skeletal samples from Dorset, and found mortality risk increased in the post-conquest period. This was interpreted as evidence for the negative impact of colonisation and urbanisation on life expectancy in the post-conquest period, although it is conceivable that Iron Age and Romano-British populations may not be comparable in terms of the range of social groups represented. Given the relative paucity of Iron Age burials and the likelihood that many individuals were disposed of in ways that are not visible archaeologically (Wait 1985), Iron Age samples could include relatively fewer 'low status' individuals compared to the Roman period, skewing the evidence in favour of Iron Age elites who may have enjoyed better health than lower status groups.

3.5 Limitations of the existing literature

Research on Romano-British skeletal populations suffers from several limitations that are generic to bioarchaeological scholarship. A number of issues arise from the fact that the bulk of the literature comprises bone reports contained within excavation monographs. The inclusion of osteological data represents a welcome development from the previous situation in which human remains were described summarily, if at all (e.g. Clarke 1979), but bone reports are nevertheless constrained by several factors (Roberts and Cox 2003: 27). Firstly, detailed interpretations of osteological data are rarely possible, owing to limits on time and costs, although in this respect it is interesting to note that many publications devote considerable space to the description of artefactual evidence, such as grave goods. For example, in the report on London's Eastern Cemetery (Barber and Bowsher 2000), the osteological report comprises less than ten per cent of the total page count while, in contrast, over one third of the volume is dedicated to a catalogue of grave goods and furnishings. Furthermore, while there are many high-quality colour images of small finds, there are almost no illustrations of pathology. It is arguable that page counts are a crude measure of the relative importance attached to different categories of evidence; nevertheless, considering that the bulk of evidence from a large cemetery excavation usually comprises the human remains, it is notable that the discussion of artefacts continues to dominate (*cf*. Reece 1982: 355). Reports that are more recent have devoted greater space to discussions of human remains (e.g. Booth *et al*. 2010; Simmonds *et al*. 2008).

Older excavation reports are often of limited use to modern researchers, as the type of information collected and methods of data presentation reflect contemporaneous research priorities that may be less relevant today. For example, older reports frequently include large quantities of metric and non-metric data (e.g. Warwick 1968), which is less likely to be included in modern reports. Similarly, methodological variations between contemporary researchers are a major obstacle (Roberts and Cox 2003: 29). The methods used to collect and analyse data reflect the nature of the material (e.g. inhumed or cremated), as well as being tailored to particular research question(s). Although basic guidelines have been established to encourage greater standardisation (Brickley and McKinley 2004), constraints on time and resources mean that researchers must also be selective in what and how they choose to record. A related problem concerns the use of differing age ranges in constructing demographic profiles, which complicates comparisons of mortality curves between samples (Falys and Lewis 2011). Diagnostic criteria for many pathological conditions have developed rapidly in recent decades, and even reports produced as recently as the 1990s may require some revision in light of new research. For all these reasons, data collected by different researchers is rarely comparable.

An additional limitation of the literature concerns data presentation. In many reports, pathology prevalence data are provided in the form of ‘crude’ prevalence rates (CPRs), which express the prevalence of a condition in terms of the number of individuals affected as a percentage of the total number of individuals in the sample. ‘True’ prevalence rates (TPRs), i.e. prevalence rates calculated as the number of elements affected as a proportion of the number of elements present, are less frequently provided, especially in older reports. CPRs are necessary for statistical comparisons within and between populations (Mays *et al*. 2004: 7). However, they are potentially problematic, as CPRs can be significantly influenced by skeletal preservation. In poorly preserved skeletal samples, the prevalence of diseases may be under-represented if pathological elements are incomplete or absent (Brickley 2004a: 6). Conversely, it is also possible for crude prevalences to be over-estimated in incomplete material, as the ratio between the total quantity of bone recovered and pathological bone is lower. For this reason, TPRs should also be provided for comparison. Other factors also influence prevalence data, such as whether subadults are included or excluded from the denominator, as many conditions are age-related. Ideally, prevalences should be broken down by age and sex (Mays *et al*. 2004: 9).

In addition to these generic issues, studies of the health status of urban populations in Roman Britain suffer from a number of more specific limitations reflecting both the constraints of the burial record and the way in which osteological data have been contextualised. Despite the fact that the majority of research has been conducted on populations from the major urban centres, Lewis has recently summarised the state of knowledge on urban population health as follows:

> "The health of the inhabitants of Roman Britain is little understood, and population studies that integrate skeletal evidence with archaeological and environmental data are few. Many questions remain about what impact the introduction of urban centres and the gradual economic decline at the end of the Roman Empire had on the local population...[W]e still have little concept about what life in Romano-British urban centres was like, and how it affected the health of the general population."
>
> Lewis (2010: 405)

One of the barriers to understanding the impact of urbanism on Romano-British population health is the lack of large skeletal samples from distinctly rural contexts. The total number of rural 'cemeteries' far outnumbers urban cemeteries, but the numbers of individuals recovered are invariably small (Pearce 1999a: 25). The typically small sample size of most rural cemeteries raises issues in terms of sample bias. Some rural samples have extremely skewed demographic profiles, e.g. the ratio of males-to-females at Owslebury, Hants, was 6.5 (Collis 1977), which could indicate that the cemetery was primarily used for the burial of male agricultural labourers. While subadult burials occur in large numbers at some rural sites, such as Barton Court Farm, Oxon (Miles 1986), Bradley Hill, Somer (Everton and Leech 1981) and Hambleden, Bucks (Mays and Eyers 2011), at others they are considerably under-represented, e.g. Icklingham, Suffolk (Watts 2005) and Lynch Farm, Cambs (Wells and Wilson 1975). Another problematic issue in relation to rural cemeteries concerns the identity of the buried population: were individuals interred at villas the owners of the villa itself, the slaves of the villa owners, or non-slave labourers? The socio-demographic composition of urban cemeteries is similarly uncertain, but larger sample sizes make the issue less problematic.

Studies of urban population health are also limited by the near-exclusive focus on the public towns. In contrast, the study of populations from the small towns has been far more limited, and no study (with the exception of the paper by Pitts and Griffin 2012) has yet attempted to compare and contrast skeletal samples from public and small towns in detail – a gap in research that the present study seeks to address. Cemetery samples from the minor centres tend to be relatively small, the population from Ancaster (examined for the present study) being one of the largest yet excavated. Other large samples exist but await full analysis and publication. Excavators recovered at least 120 burials of mid-to-late fourth century date at Ashton, Northants, but a detailed bone report has yet to be produced (S. Parry, personal communication). A population of 112 individuals excavated at Dunstable, Beds, has been published (Matthews *et al*. 1981), but the osteological data included in the report are extremely limited with respect to pathology. At Kelvedon, Essex, 95 burials were excavated, but preservation was so poor that no osteological analysis could be conducted (Rodwell 1988: 91). Figure 7 illustrates the extent to which research has relied heavily on a small number of samples by showing the number of studies (journal articles and conference proceedings, etc.) of material from different sites. The studies included are those listed in Table 1 (palaeopathology, palaeodemography, bone chemistry and metric/non-metric variation only). A number of studies utilised material from multiple sites, including several isotope studies and metric analyses. Occasionally, the source location of the material used was not provided (e.g. T. Waldron 1991a, 1993a, 1993b, 1995). In terms of individual sites, by far the most studied collection is that from Poundbury, Dorchester. If case study reports are excluded, the range of sites represented drops markedly. There is also some replication in the literature, e.g. Stuart-Macadam’s studies of cribra orbitalia and porotic hyperostosis at Poundbury, and several stable isotope studies of different aspects of mobility in skeletal samples from York (Leach *et al*. 2009, 2010), including two studies of the decapitations from Driffield Terrace (Müldner *et al*. 2011; Montgomery *et al*. 2011). Roberts and Mays (2010) have recently discussed the over-reliance by British researchers on a small number of collections, noting that this may have resulted in a biased view of past populations. To some extent, the issue is unavoidable, as certain collections are simply larger and better preserved (e.g. Poundbury), although accessibility and bench fees imposed by some institutions can dissuade researchers from examining other collections.

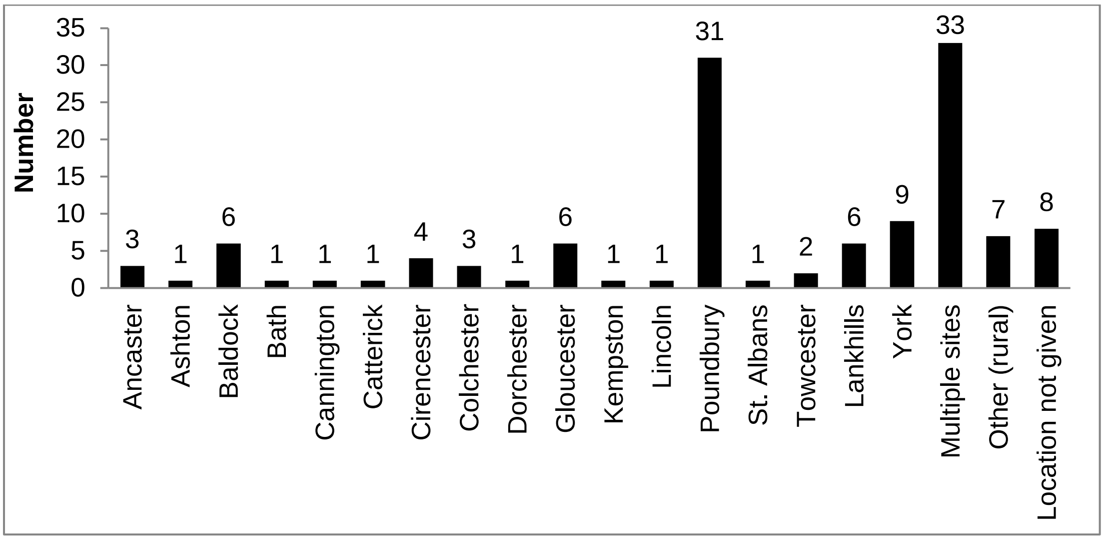

Figure 7. Graph illustrating the number of bioarchaeological studies conducted on Romano-British skeletal material according to site, excluding bone/excavation reports.
(See Table 1 and CD for references.)

Another criticism of Romano-British bioarchaeological research, noted by Lewis (2010), is that some existing studies fail to integrate osteological and archaeological evidence. It has already been suggested that, in the case of excavation reports, the reasons for this are often practical, although there is sometimes a lack of even relatively brief references to the particular archaeological setting of samples. For example, when discussing joint disease as it relates to activity and lifestyle, Pinter-Bellows (1993: 85), and Wakely and Carter (1996: 50) interpret the evidence as indicating that the populations of Colchester and Leicester undertook heavy labour, but do not elaborate on the sorts of activities in which these communities are envisaged to have engaged. Wells' (1982) analysis of the Roman population of Cirencester is more detailed than many reports and attempts to situate the findings with reference to lifestyle and settlement environment, but this is sometimes couched in rather generic terms[7]. Where skeletal data have been contextualised with reference to archaeological and historical evidence, there is often a tendency to conflate archaeological evidence from different periods. This is potentially

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[7] It should be noted that the Cirencester monograph (McWhirr *et al*. 1982) was not published until after Wells' death in 1978, and his bone report may not have been complete.

problematic, in light of the evidence for a change in the character of towns in the later Roman period. For example, Redfern and Roberts (2005: 120-1) refer to the dense zone of strip housing excavated at the site of One Poultry in London as an example of urban living conditions. They suggest that the density of settlement indicated at this site, 'may be reflected in the prevalence of tuberculosis at Poundbury Camp,' (Redfern and Roberts 2005: 122). Yet, the strip buildings to which Redfern and Roberts refer predominantly date to the first-to-third centuries (Perring 2002), while the majority of cases of tuberculosis identified at Poundbury (Dorchester, Dorset) were of late Roman date (Molleson 1993: 190), and settlement environment and housing in late Roman Dorchester may not have been comparable to early Roman London.

The interpretive limitations of existing Romano-British bioarchaeological studies reflect broader issues within the discipline. A criticism that can be levelled at much bioarchaeological research in general is that archaeological and historical data are sometimes accepted uncritically in reconstructing the cultural settings of skeletal samples, resulting in a recent characterisations of bioarchaeology as a 'handmaiden' to history (Perry 2007). In part, the problem arises from difficulties inherent in combining skeletal, archaeological and textual evidence. Classical archaeologists, and historical archaeologists more generally, have long debated the problem of integrating evidence from different (albeit closely-related) sub-fields, each accompanied by their own discplinary conventions and epistemological issues (Dyson 1989; Moreland 2001; Sauer 2004b). In purely practical terms, it is rare for one individual to possess an equally detailed grasp of both written and material sources (Sauer 2004a), yet all forms of evidence have inherent biases and limitations, and these must be addressed to avoid erroneous conclusions based on incorrect readings of one or other. In the context of bioarchaeology, such issues are magnified by the complexity of integrating information from three fields (osteology, archaeology and history), and the 'disciplinary disconnect' between osteology as a 'hard science', and archaeology and history as 'social sciences' (Sofaer 2006: 3-4).

4 Materials and Methods

4.1 Materials

4.1.1 *Ancaster*

4.1.1.1 Archaeological setting

4.1.1.1.1 Geography and geology

Modern-day Ancaster is a small village in Lincolnshire, located *c.* 28 km south of the City of Lincoln. Ancaster is situated at a gap in the limestone escarpment that runs north-south throughout much of Lincolnshire, referred to as the 'Lincoln Edge'. The River Slea rises approximately 3.2 km to the south-west, flowing north and east through present-day Ancaster. The Slea joins the River Witham, which empties into the Wash just to the south of Boston. The local geology of the area is primarily clays/gravels with underlying oolitic limestone[8].

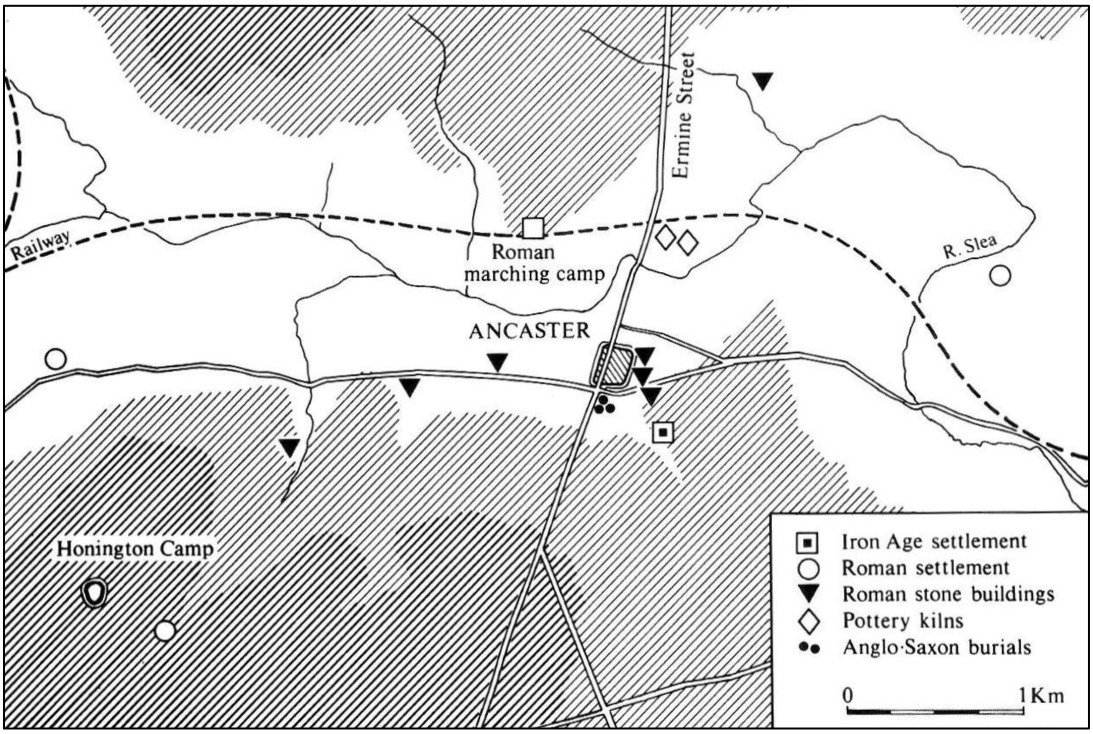

Figure 8. Map showing the location of the settlement at Ancaster (from Todd 1981: 3, Fig. 1).

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[8] "Local soils are predominantly of the Blackwood Association, deep, permeable, sandy and coarse loamy soils in a glaciofluvial drift, with a finger of Ruskington Association, gleyic brown calcareous earths against a background of Elmton 1 Association, which are characterised as shallow brown rendzinas(...)These overly a solid geology of Great Oolitic Limestone and Upper Lincolnshire Limestone", (Hambly 2000: 1-2).

4.1.1.1.2 The Roman town

Roman Ancaster was a small, defended settlement straddling the main road to the north of the province, Ermine Street (Figure 8). The town was established in the first century AD, probably owing to the presence of an early temporary military camp and subsequent fort, although there is also evidence for Iron Age settlement activity (Burnham 1986). Excavations carried out in the 1950s-70s concentrated on the town walls and exploration of the interior of the settlement was limited (Barley 1964; Barley *et al*. 1974; Todd 1975, 1981; Whitwell *et al*. 1966; Wilson and May 1965; see also entries in *JRS* and *Britannia*, 'Sites Explored', 1957, 1961-71 and 1976).

Ancaster probably served as a small market town. There is some evidence for small scale production, including metalworking and pottery. The settlement may also have been a centre for stone masonry due to its proximity to high-quality limestone deposits (Burnham and Wacher 1990: 239), and several scupltures and inscriptions have been excavated in the area (Ambrose 1979; Burnham *et al*. 2002: 355-6; Frere 1961; Henig and Bagnall Smith 2001; Wright 1962: 192). Due to its location on Ermine Street, Ancaster may have been a staging post for the *cursus publicus* (Burnham and Wacher 1990: 4). In the past, Ancaster was identified as *Causennae* in the Antonine Itinerary, but this is now thought to be Sapperton (Rivet and Jackson 1970: 47).

The walled area of the town (*c.* 3.7 ha) is at the lower end of the spectrum of defended small towns (Todd 1970: 116), but extra-mural settlement extended over a larger area of *c.* 25 ha (Burnham and Wacher 1990: 237). Very little is known of domestic architecture at Ancaster. Several small, rectilinear timber buildings were excavated in the extra-mural area, some of which might represent houses and workshops (Burnham and Wacher 1990: 239). The town's masonry circuit has been dated to the later third century and its construction necessitated the demolition of existing buildings (Burnham and Wacher 1990: 239; Todd 1981). Whether this coincided with a general contraction in the settlement area is uncertain (Figure 9).

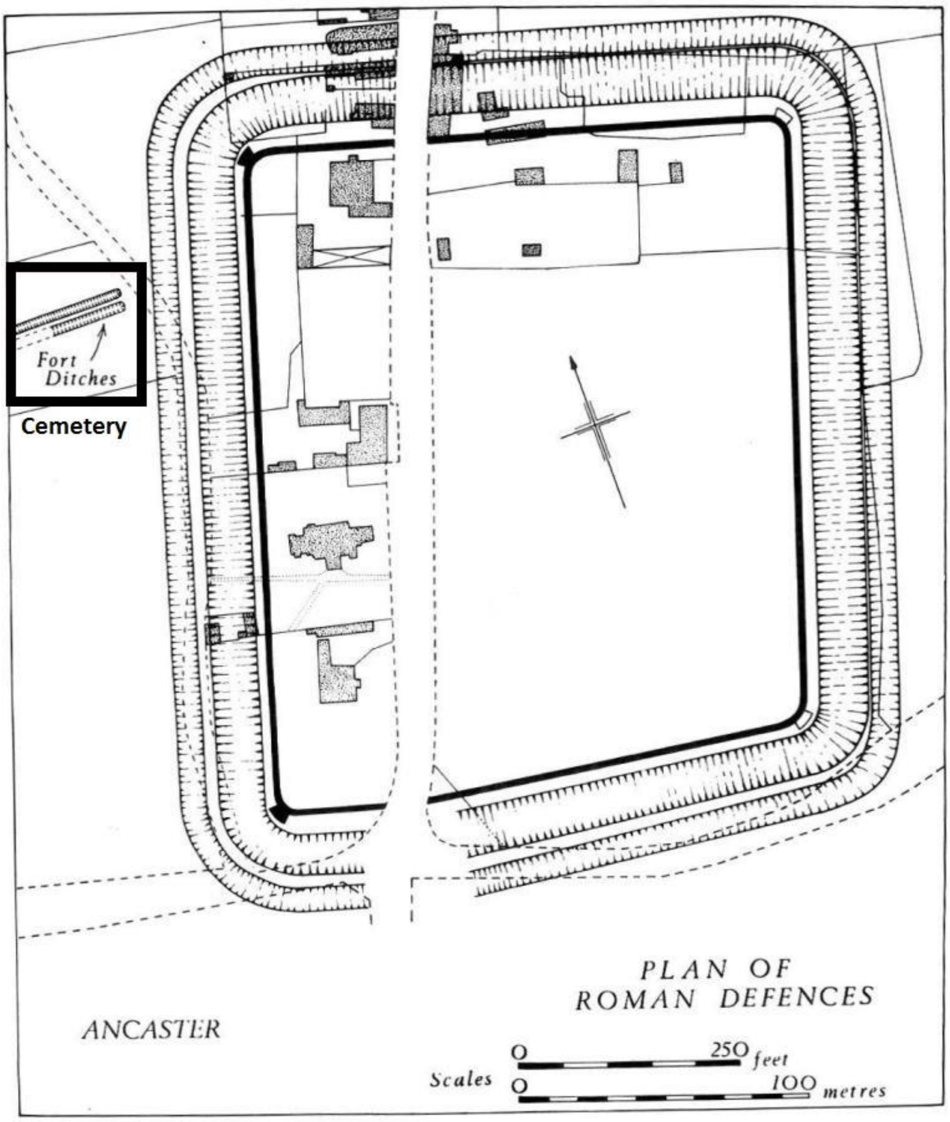

Figure 9. Plan of Ancaster showing the town and location of the cemetery (adapted from Todd 1981: 6, Fig. 2).

4.1.1.1.3 The cemetery

Ancaster possessed one cemetery to the west of the town, located beneath the modern village cemetery (see Figure 9). Excavations were carried out in 1964-1973 by a team from Nottingham University led by David Wilson after modern gravediggers encountered Roman graves. The excavations are not fully published, although a brief overview and several interim reports exist (Barley *et al*. 1974; Whitwell *et al*. 1966; Wilson 1968; Wilson and May 1965). The author obtained a copy of Wilson's unpublished notes on the excavations (D. Watts, personal communication). These notes form the basis of the following summary.

4.1.1.1.3.1 Location

The eastern limit of the Roman cemetery was identified *c.* 13 metres from the outer ditch of the Roman town wall. Roman burials were inserted into and around double ditches associated with an earlier fort. Graves were dug into the natural gravel deposits except in areas where these had been removed during Roman times.

4.1.1.1.3.2 Cemetery layout and organisation

There are no published plans of the cemetery in its entirety, although a copy of an unpublished plan from the site archive was obtained (see Appendix 1). Almost all burials were aligned with the head to the west, typically 270-275°.

4.1.1.1.3.3 Burial practices, grave containers and furnishings

The majority of burials were supine inhumations, although several individuals were buried prone (Wilson 1968). Many graves had head and/or footstones, slab linings and packing stones. At least 39 graves produced evidence for wooden coffins and 16 stone sarcophagi were excavated[9]. Of the 271 individuals included in the study sample, 51 (18.1%) were buried in coffins. Very few graves produced burial goods, with the exception of items of jewellery in two graves, and several coins, including examples minted in AD 360 or later (Burnham and Wacher 1990: 239).

4.1.1.1.3.4 Grave depth

Wilson's unpublished notes provide depths for 88 burials (Table 2). Depth was measured from the modern ground surface to the base of the grave, thus the figures do not represent the depth of grave cuts. On average, subadult graves were slightly shallower than adult burials, and female burials were shallower than male burials (Figure 10). However, the difference in mean grave depths is not statistically significant in either case (subadults *vs.* adults: t=0.590, d.f.=86, p=0.557; females *vs.* males: t=0.887, d.f.=71, p=0.378).

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[9] Recent small-scale excavations uncovered another stone coffin burial (Roberts *et al*. 2006), but the remains contained in the sarcophagus were not included in the present study.

Table 2. Average grave depth (in metres) by age and sex: Ancaster.

	All			**Females**			**Males**		
	N	**Depth**	**1 SD**	**N**	**Depth**	**1 SD**	**N**	**Depth**	**1 SD**
Perinates	0	-	-	-	-	-	-	-	-
<1	2	0.94	0.04	-	-	-	-	-	-
1-5	4	1.19	0.24	-	-	-	-	-	-
6-11	4	1.15	0.14	-	-	-	-	-	-
12-17	0	-	-	-	-	-	-	-	-
US	1	1.40	-	-	-	-	-	-	-
Total subs	11	1.15	0.20	-	-	-	-	-	-
18-24	7	1.27	0.31	5	1.21	0.36	2	2.84	0.07
25-34	24	1.26	0.20	10	1.20	0.16	14	1.31	0.22
35-49	18	1.13	0.24	8	1.15	0.23	11	1.11	0.25
≥50	12	1.19	0.36	3	1.28	0.26	8	1.20	0.30
UA	16	1.16	0.29	9	1.16	0.24	5	1.31	0.25
Total adults	77	1.20	0.27	35	1.19	0.23	38	1.24	0.25

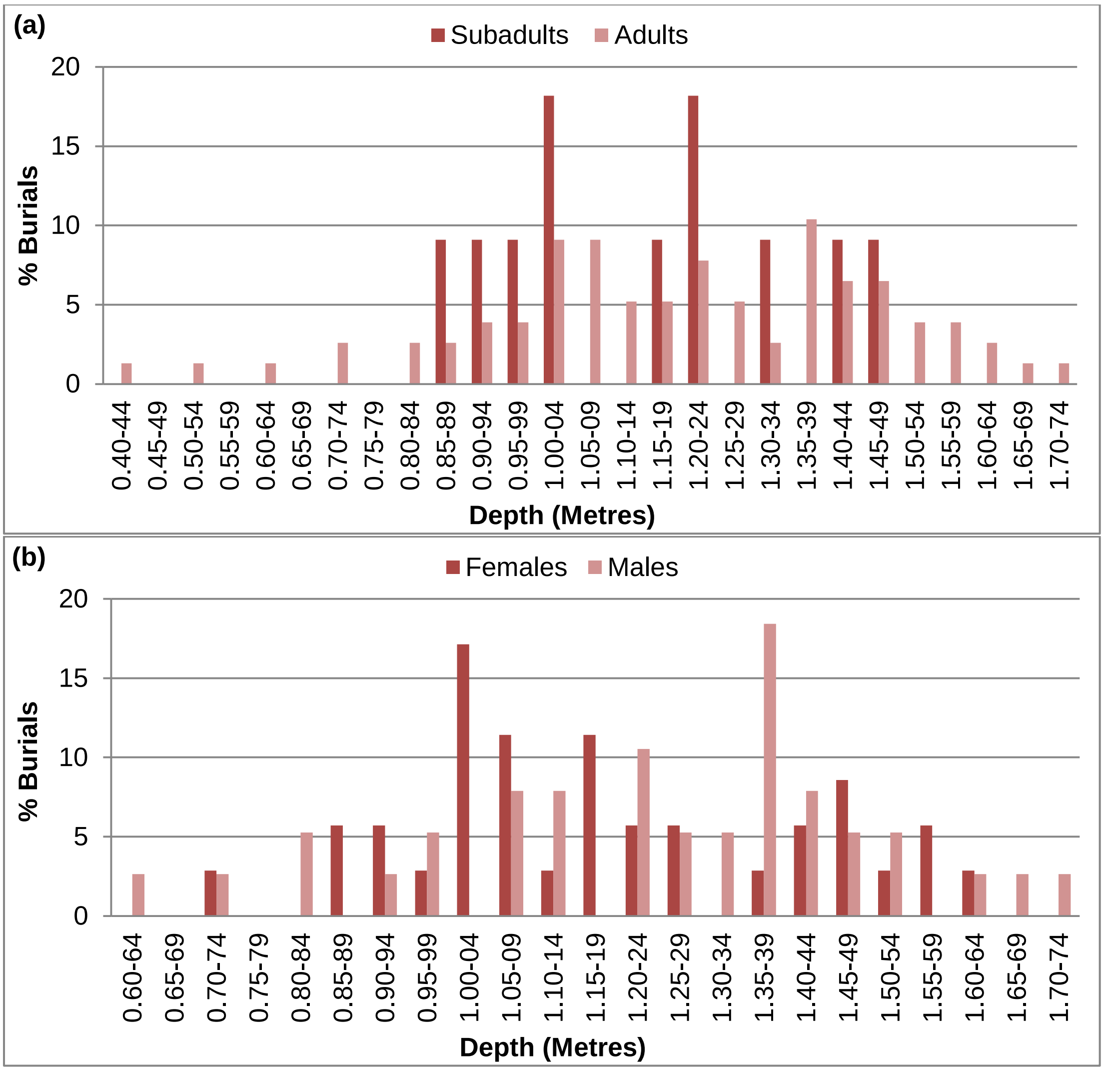

Figure 10. Graphs comparing (a) subadult and adult and (b) female and male grave depth at Ancaster.

4.1.1.1.3.5 Chronology

Evidence for settlement activity in the cemetery area pre-dating the burials suggests the cemetery was established following construction of the walls and abandonment of extra-mural settlement to the west of the town in the later third century (Burnham and Wacher 1990; Todd 1981). Large quantities of residual pottery were recovered during Wilson's excavations, and this material has been dated to the fourth century (A. Doherty, personal communication). A late Roman date is also inferred from the general characteristics of the cemetery, particularly the W-E alignment of graves and general absence of burial goods. Wilson (1968) considered the cemetery to be an early Christian burial ground based on the W-E grave alignment, as do Thomas (1981: 237) and Watts (1991). The layout of the cemetery and nature of the burials is similar to the cemetery at Ashton, Northants, which dates to the mid-to-late fourth century and has been identified as a likely candidate for an early Christian burial ground (Burnham and Wacher 1990: 281). Others have contended that there is no definitive evidence that the cemetery at Ancaster was used by a Christian community (Rahtz 1977), although a lead object bearing a Chi-Rho inscription was found near Ancaster in 1991[10] (Watts 1995: 322).

4.1.1.2 The study sample

The human remains from Ancaster are currently housed at English Heritage's Centre for Archaeology in Portsmouth. The assemblage comprises *c.* 330 separate contexts. The material was previously analysed by Margaret Cox (1989), but the bone report is unpublished. Based upon archive material and personal communications with the excavator, Cox separated the sample into a main assemblage comprising the burials excavated by Wilson (*c.* 295 contexts), and an additional sample of *c.* 32 contexts comprising individual burials and isolated skulls accidentally disturbed by modern gravediggers. Cox considered it likely that many of the skulls in this latter group belonged to individuals from the main assemblage. Since treating this unprovenanced material as discrete contexts could lead to the same individual being included twice, it was decided to exclude the undocumented material from the current analysis. Due to time constraints, only 271 individuals were examined.

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[10] The object is currently in the British Museum.

Some contexts were intentionally excluded on the basis that they were extremely incomplete or comprised the co-mingled remains of multiple individuals that could not be separated. There were several instances of two or more individuals having been assigned the same grave number (differentiated by A, B, C, etc.). Wilson's notes do not identify any multiple burials, but the remains had not been fully analysed at the time these notes were compiled, therefore the presence of multiple burials may not have been recognised until later. For the purposes of this study, the context numbers are prefixed with the abbreviation 'ANC', thus burial 1 is identified as 'ANC 1'.

4.1.2 *Winchester*

4.1.2.1 Archaeological setting

4.1.2.1.1 Geography and geology

Winchester is located in south-central Hampshire approximately 20 km north of the Solent. It lies at the western edge of the South Downs. The River Itchen, which rises near Cheriton *c.* 12 km to the east, passes through Winchester before turning south. The underlying geology of the Winchester region is primarily chalk. In the eastern part of the Roman town and cemeteries, the soils also comprise alluvial clays and silts deposited by the Itchen (Booth *et al*. 2010: Fig. 1.2).

4.1.2.1.2 The Roman town

Winchester was not a major population centre in the Iron Age, although the site may have been an important ritual centre (Qualmann 1993: 74). Several trade routes converged in the Winchester area, linking the east of England with the port at Hengistbury Head in Dorset (Mattingly 2006: 56). The recent discovery of a significant hoard of late Iron Age jewellery near Winchester suggests an elite presence in the area (Hill *et al*. 2004). A large ditched enclosure of *c.* 20 hectares, known as Oram's Arbour, was constructed in the middle Iron Age (Qualmann *et al*. 2004). Its precise purpose is unclear, although a ritual function has been suggested (Cunliffe 2005: 402-3; Millett 1990: 24).

The region was placed under the rule of a local client ruler (Cogidubnus) in the immediate post-conquest period (Fulford 2000: 566-7; Salway 1993: 71). The area was lightly garrisoned and there is no definitive evidence for an early Roman fort at Winchester, although excavations at Lower Brook Street revealed possible military ditches (Biddle 1975). The Roman town was established during the mid-to-late first century, and Winchester was probably made the capital of the *civitas Belgarum* (an administrative region encompassing much of modern-day Hampshire) during the Flavian period (*c.* AD 70s/80; Wacher 1995: 293). An area of flat land on the west bank of the River Itchen was drained in the later first century and the earliest phases of the street grid were laid out with the forum/basilica complex at the centre (Figure 11). Winchester subsequently acquired a bathhouse and temples, although no theatre or amphitheatre has yet been discovered (Hassall *et al*. 1972: 349; Wacher 1995). An earthen defensive circuit was constructed in the later first century (Grew *et al*. 1980: 395; Wacher 1995: 291). This was replaced by a masonry circuit in the later second century AD (Wacher 1995: 296). In terms of enclosed area (*c.* 55 hectares), Winchester was the fifth largest town in the province (Millett 1990: Table 6.4). Extensive extra-mural suburbs developed along the major roads leading to Cirencester, Silchester, Chichester, Old Sarum and Neatham (Ottaway *et al*. forthcoming).

Winchester has produced similar evidence of late Roman decline to that seen at other public towns. Internal streets were still being maintained in the late fourth century, although one of the town gates collapsed and the rubble was never cleared, the main road running north to Cirencester fell into disrepair, and the Silchester road gate was closed or blocked up (Rees *et al*. 2008). The bathhouse had fallen out of use and the Lower Brook Street temple was demolished by the early fourth century (Hassall *et al*. 1972: 349; Rogers 2011: 87, 101). Some new buildings were constructed in the early fourth century. At The Brooks site, earlier structures were demolished in the first quarter of the fourth century to be replaced by a larger, courtyard-type house with substantial masonry foundations, mosaic floors and hypocaust, but this appears to have been no longer occupied by the middle of the century (Zant 1993). Dark earth deposits dating to the later fourth or early fifth century AD have been identified in some parts of the town (Rees *et al*. 2008).

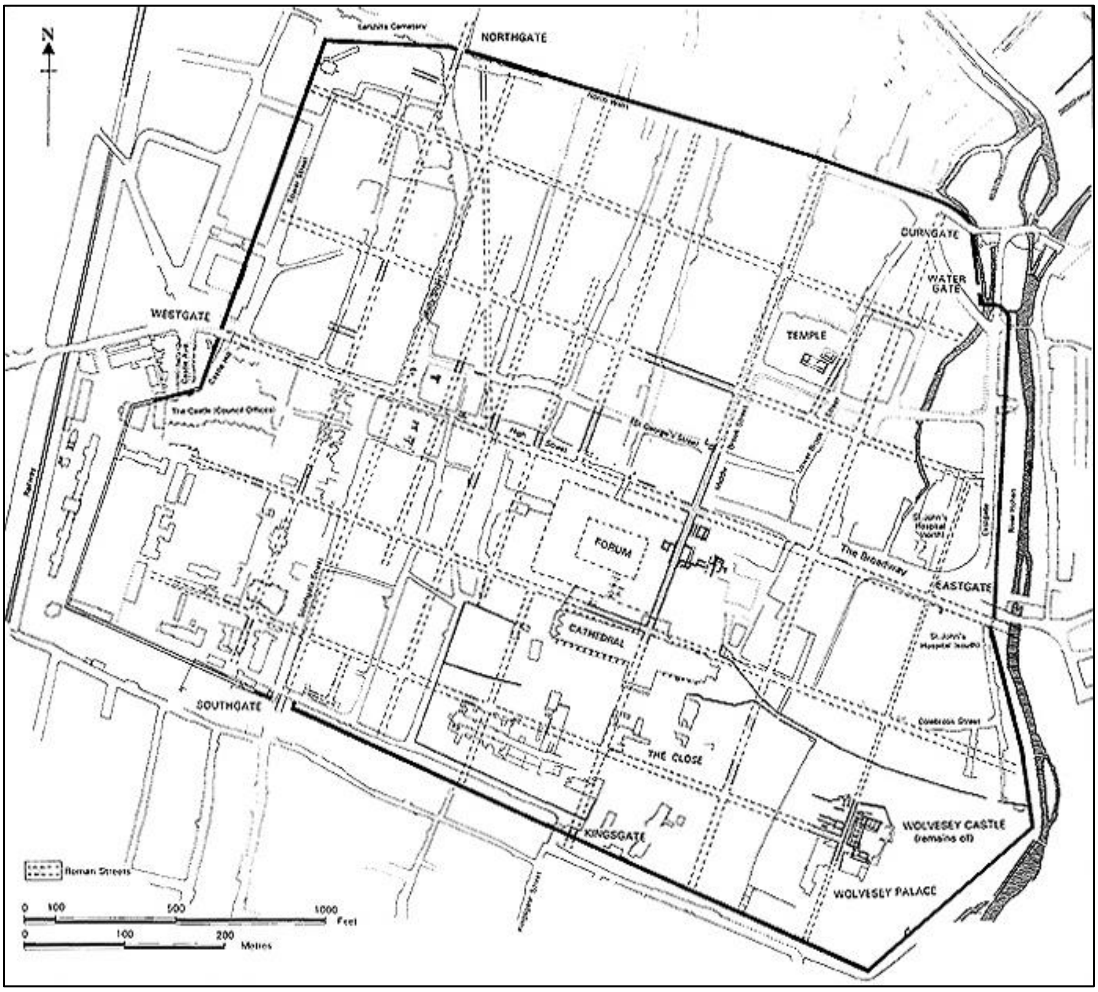

Figure 11. Plan of Roman Winchester (from Wacher 1995: 294, Fig. 132).

4.1.2.1.3 The cemeteries

To date, in excess of 1,200 burials have been recovered in controlled excavations in the cemeteries to the north, east, south and west of the town, although none of the burial grounds has been excavated in its entirety. Many more burials have been observed in watching briefs and numerous chance discoveries have been made during construction activities. The results of these excavations are soon to be published in a monograph on Winchester's Roman cemeteries and suburbs (Ottaway *et al*. forthcoming[11]). Figure 12 shows the location of the cemeteries (indicated by the stippled grey areas) in relation to the Roman town.

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[11] A draft version of the manuscript was provided to the author by H. Rees, Winchester Museums Service. The monograph has since been published (2012), but it was not possible to obtain a copy in time to include page references in the present study.

4.1.2.1.3.1 Location

The Northern Cemetery developed in the area between the roads leading to Cirencester and Silchester. Parts of the cemetery have been excavated at Lankhills, Victoria Road, Andover Road, Hyde Street and Hyde Close. The Lankhills site has produced the largest number of burials (800+, almost all late Roman), recovered during two major series of excavations in the late 1960s-1970s and early 2000s (Booth *et al*. 2010; Clarke 1979). At Victoria Road, excavations in the 1970s uncovered over three hundred burials, including 195 early Roman cremations in the eastern part of the site and 116 late Roman burials at the western end (Goodburn *et al*. 1976: 371; Wilson *et al*. 1975: 279). Excavations at Andover Road (Eagle Hotel), Hyde Close and Hyde Street carried out between the 1970s and 1990s uncovered a further *c.* 80 burials in total (Burnham *et al*. 2002: 348; Teague 1999). The Eastern Cemetery was situated outside the town on the opposite bank of the River Itchen. Approximately *c.* 140 late Roman Burials have been excavated at Chester Road, St. Martin’s Close and St. John’s Street since the 1970s (Frere *et al*. 1977: 419; Frere *et al*. 1986: 421). To the west of the Roman town lies the Oram’s Arbour enclosure. It appears that the Iron Age ditch was maintained throughout the first and second centuries AD, before being in-filled and used for burial from the late third century onwards (Qualmann *et al*. 2004). Excavations at sites within the ditch (Carfax, New Road, Romsey Road and Clifton Road) uncovered *c.* 90 burials, including a large number of perinates at Carfax and New Road (Frere *et al*. 1986: 421; Goodburn *et al*. 1976: 371-2; Qualmann 1981; Rankov *et al*. 1982: 391). The extent and layout of the cemetery outside the South Gate is poorly understood at present (H. Rees, personal communication), and few burials have been excavated (Burnham *et al*. 2002: 349). Maps of individual sites are provided in Appendix 1.

4.1.2.1.3.2 Cemetery layout and organisation

The Northern Cemetery generally conforms to a type known from other major urban centres, referred to as ‘formal’ or ‘organised’ cemeteries (Philpott 1991). Burials at Lankhills, Victoria Road, Andover Road and Hyde Street were arranged in rows and/or columns with little intercutting, implying an element of planning (Booth *et al*. 2010: 463; Ottaway *et al*. forthcoming). Later burials at Victoria Road were somewhat less organised, but continued to be well spaced out. Burials interred within the Oram's Arbour ditch at Carfax and New Road were aligned with the ditch itself. The only site where graves intercut one another was Chester Road, although burials were nevertheless generally arranged in rows. At St. Martin's Close, two burials were excavated within a masonry structure presumed to be a mausoleum (Morris 1986). At all sites, most graves were broadly aligned east-west, with the head to the west, although some earlier burials had a N-S alignment. There is little evidence for grouping of graves according to age and/or sex, with the exception of the concentrations of perinate burials at Carfax and New Road (Ottaway *et al*. forthcoming).

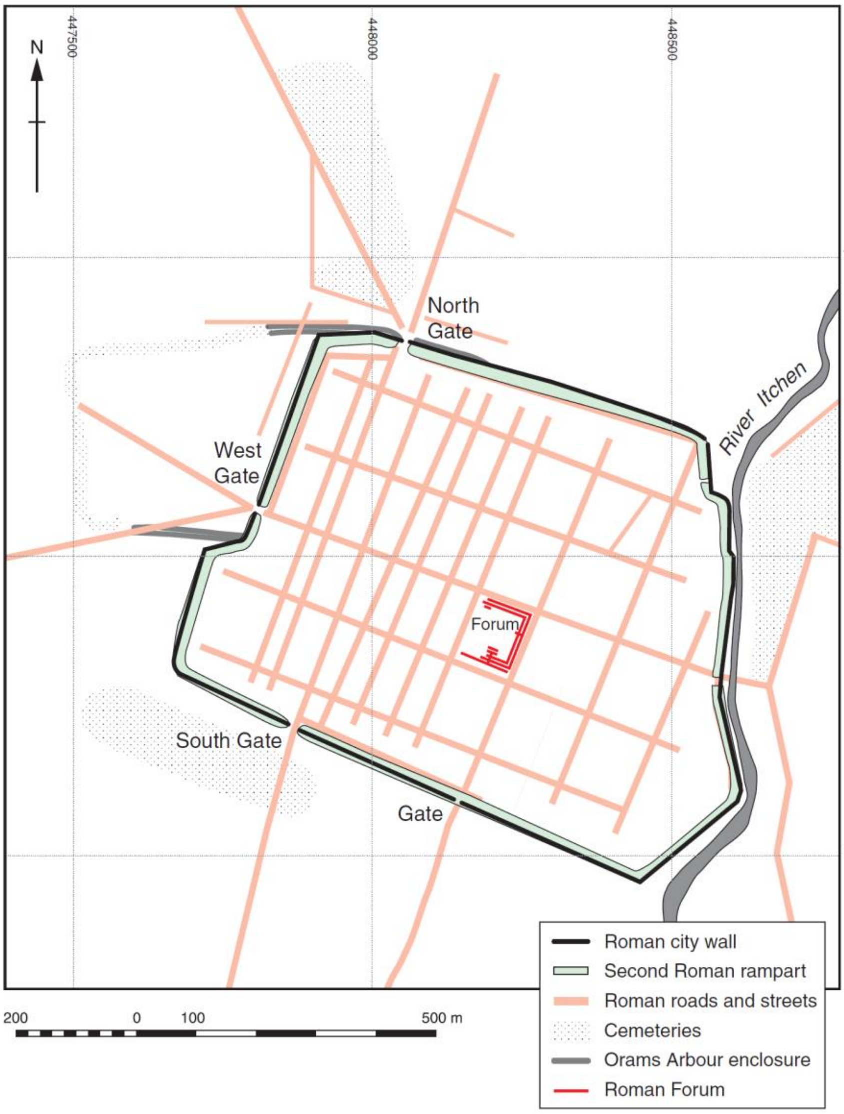

Figure 12. Plan of Winchester showing the location and extent of the Roman cemeteries, indicated by grey stippling (provided by H. Rees, Winchester Museums Service).

4.1.2.1.3.3 Burial practices, grave containers and furnishings

The majority of late Roman burials were supine inhumations, although cremation continued into the third and fourth centuries. At least 17 individuals were interred prone. Most were single burials, although there were at least two double infant inhumations at New Road and three subadults were interred together in a wooden coffin. At Carfax, an adult female with foetal remains in the abdominal region was found, and an adult male was interred with an infant positioned at his feet. A small number of probable decapitations were identified, and several of these individuals were buried prone (Ottaway *et al*. forthcoming).

The proportion of coffined graves varied between sites from zero, to 45% of graves at Victoria Road (Ottaway *et al*. forthcoming). At Andover Road, one individual was buried in a lead-lined wooden coffin and a young female from the masonry structure at St. Martin’s Close was interred in a wooden coffin with a lead lining and lid (Morris 1986). Few infants were buried in coffins, a notable exception being a triple inhumation in a wooden chest at New Road (Ottaway *et al*. forthcoming). Of the 330 burials included in the study sample (see below, section 4.1.2.1.3.3), 38.2% were coffined (44.5% of adults and 28.5% of subadults). Some graves contained flint or tile packing and the young female from the mausoleum at St. Martin’s Close had gypsum packing, often interpreted as a Christian practice (Green 1977), although this is not certain.

Most burials contained few or no grave goods. The most common objects included were coins (sometimes placed in the hands), ceramic vessels and hobnails from footwear. Several graves contained items of personal adornment and toiletry equipment, although some were probably accidental inclusions. Perinates and infants were rarely provided with grave goods (Ottaway *et al*. forthcoming). An exception to the general absence of grave goods is the Lankhills site, where a significant proportion of burials were furnished. A number produced artefacts originating in Central Europe, possibly identifying their occupants as migrants (Baldwin 1985; Clarke 1979; see also section 4.1.2.1.3.3). Recently, stable isotope analysis has indicated that most of the individuals interred with ‘foreign’ artefacts originated within Britain, although some were non-local (Eckardt *et al*. 2009; Evans *et al*. 2006). There is no definitive iconographic or architectural evidence for an early Christian community at Winchester (Rees *et al*. 2008).

4.1.2.1.3.4 Grave depth

Grave depth was measured from the top of the grave cut to the base of the grave. Depths are available for 119 of the burials included in the study sample (Table 3 and Figure 13). On average, subadult graves were considerably shallower than adult burials, largely owing to the number of shallow perinate burials, and the difference in mean grave depth between subadults and adults is statistically significant (t=7.950, d.f.=117, p=<0.000). Female graves were shallower than male graves, but the difference in mean depth between the sexes is not statistically significant (t=1.239, d.f.=64, p=0.220).

4.1.2.1.3.5 Chronology

Burials were assigned absolute dates based on associated graved goods where present. A minority of graves produced coins, providing a *terminus post quem* for some burial groups, although the coins could have been in circulation for some time when deposited. Owing to a lack of datable artefacts, most burials were dated according to their stratigraphic relationships with other features. The large proportion of furnished graves at Lankhills allowed the development of a relative tight chronology for this part of the Northern Cemetery, which was used to help date burials elsewhere (Ottaway *et al*. forthcoming).

Broadly speaking, the majority of cremation burials (e.g. at Victoria Road East) date to the first and second centuries, while inhumations are of mid-third-to-early-fifth century date, a pattern observed at many other Romano-British sites (Philpott 1991). The burials at Victoria Road (West) were separated into three phases dating from *c.* AD 270-340, 340-390 and 390-410, after which the area was abandoned. In the case of Hyde Street, most burials date from AD 350-410. Burials at Andover Road were divided into five groups dating from *c.* AD 350 to the early fifth century.

Table 3. Average grave depth (in metres) by age and sex: Winchester.

	All			**Females**			**Males**		
	N	**Depth**	**1 SD**	**N**	**Depth**	**1 SD**	**N**	**Depth**	**1 SD**
Perinates	22	0.22		-	-	-	-	-	-
<1	9	0.30	0.30	-	-	-	-	-	-
1-5	8	0.47	0.34	-	-	-	-	-	-
6-11	7	0.40	0.28	-	-	-	-	-	-
12-17	1	0.06	-	-	-	-	-	-	-
US	-	-	-	-	-	-	-	-	-
Total subs	47	0.30	0.20	-	-	-	-	-	-
18-24	11	0.69	0.34	5	0.61	0.28	6	0.76	0.39
25-34	15	0.83	0.46	9	0.84	0.43	5	0.91	0.54
35-49	14	0.88	0.54	3	0.48	0.23	11	0.98	0.56
≥50	18	0.77	0.30	7	0.76	0.29	10	0.79	0.33
UA	14	0.76	0.29	6	0.76	0.32	4	0.66	0.10
Total adults	72	0.79	0.39	30	0.73	0.34	36	0.85	0.43

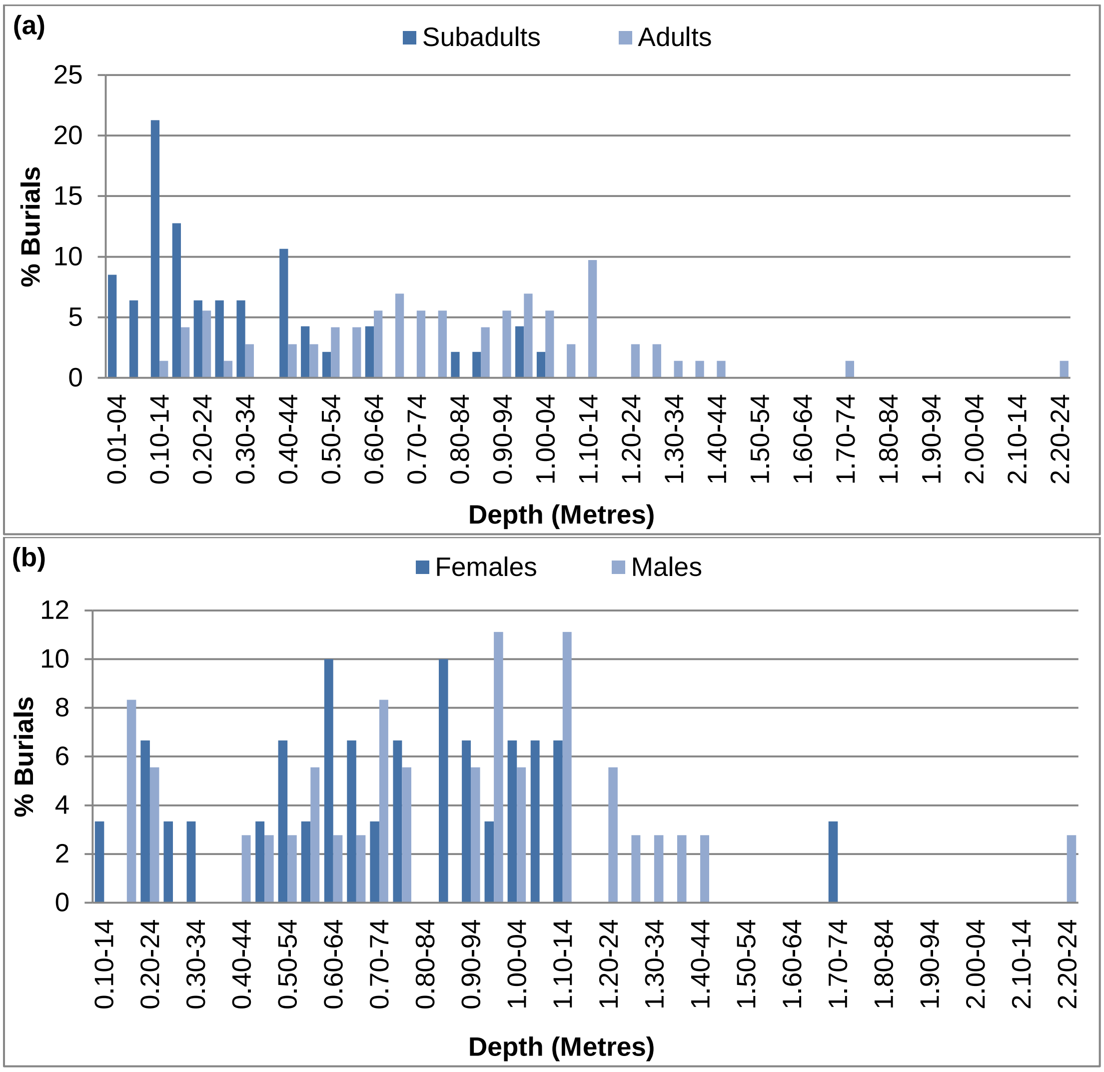

Figure 13. Graphs comparing (a) subadult and adult and (b) female and male grave depth at Winchester.

At Chester Road, seven main phases of burial were defined, spanning the period *c*. AD 250-410. The burials at St. Martin’s Hill also date to the late fourth-to-early fifth century. One burial produced a bone comb of late fourth century date (Frere *et al*. 1986: 421). At Carfax and New Road, the burials interred within the Oram’s Arbour ditch were made in several phases beginning in the mid-third century, separated by periods in which natural deposits were allowed to accumulate in the ditch. The latest burials at Carfax overlay deposits containing a coin of AD 388-402. The burials at Romsey Road have been dated to the late third-to-early fifth centuries on the basis of ceramic and numismatic evidence. Although the upper end of the date range for the Roman cemeteries is usually set at AD 410, it is possible that a small number of graves are sub-Roman, but no graves produced finds of definite post-Roman date and there is no evidence for continuity of burial into the Anglo-Saxon period[12] (Ottaway *et al*. forthcoming).

4.1.2.2 The study sample

Winchester Museums currently curate the skeletal remains of over four hundred individuals recovered during excavations since the 1970s. This does not include the burials from Lankhills excavated by Clarke in 1979 (Stuckert forthcoming), and the more recent sample excavated by Oxford Archaeology (Booth *et al*. 2010), and neither collection is included in the present study. The majority of the material held by Winchester Museums was previously analysed by several different researchers. S. Browne (forthcoming) examined some of the material and produced a report on the late Roman inhumations utilising archive reports for the remaining samples.

Due to time constraints, it was initially felt that a conservative approach should be taken regarding the number of individuals that it would be possible to examine fully. The decision was made to analyse the largest sub-sample from each cemetery area, rather than all burials from one cemetery, because certain areas could have been reserved for particular socio-economic or cultural groups, as suggested for Lankhills. The initial sample thus comprised the burials from Victoria Road, Carfax

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[12] A planned programme of radiocarbon dating was abandoned due to lack of funding (H. Rees, personal communication). Radiocarbon dating of burials from Lankhills produced problematic results in that burials considered to date from the very late fourth century produced C14 dates spanning the third and fourth centuries; it was suggested that this may be due to a ‘carbon reservoir’ effect caused by consumption of marine foods (Booth *et al*. 2010: 455-6).

and Chester Road. Subsequently, it was possible to include the burials from Hyde Street, Hyde Close, Andover Road, Romsey Road and New Road. In total, 330 individuals were examined (Table 4). Context numbers assigned during excavation were retained. Individuals from multiple burials were designated A, B, C, etc. For the purposes of the present study, burial numbers are prefixed by the site code, thus burial 1 from Victoria Road is identified as 'VR 1'. The chronology of the study sample is summarised in Figure 14. Approximately 12% of burials date to the late third/early fourth century (*c.* AD 270-340) and more than half (54.2%) are mid fourth/early fifth century in date (*c.* AD 340-410). A small number of burials from Chester Road (7.9% of the total sample) date to *c.* AD 320-370. Four burials from Chester Road (1.2% of the total) date from *c.* AD 100-300, but are probably of second century date. Approximately one quarter of burials date to *c.* AD 200-410.

Table 4. Composition of the Winchester sample.

Cemetery	Site	Site Code	Number
Northern	Andover Road	AR98	33
	Hyde Close	HC99	16
	Hyde Street	HYS79	30
	Victoria Road	VR72-80	104
Eastern	Chester Road	CHR76-80	82
Western	Carfax	CF85-86	35
	New Road	NR74-77	23
	Romsey Road	45RR	7
Total			330

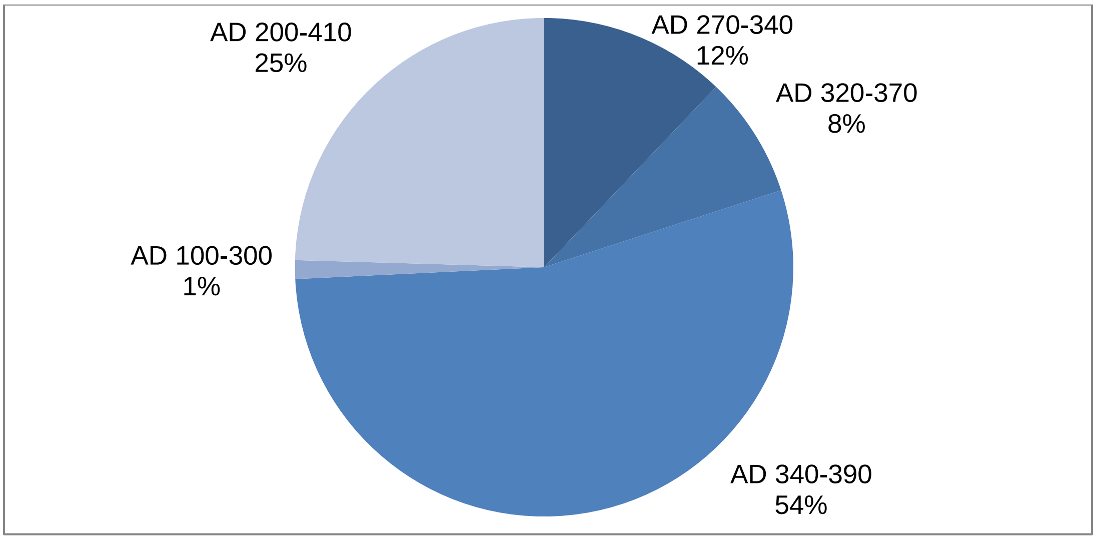

Figure 14. Pie chart showing the percentage distribution of dated burials in the Winchester study sample.

4.1.3 *Condition of the material*

The samples included in the present study have been analysed to varying degrees by other researchers over several decades. Damage, mixing and loss of material has occurred as a result. The material was stored in cardboard boxes (typically two or three boxes – one for the skull, and one/two for the post-cranium). Prior to commencing the analysis, inventories of both collections were made to determine what material was present and aid subsequent relocation of material. During this process, it became apparent that, in both samples, one or more boxes from a particular context was missing, and a small number of contexts listed in the accompanying documentation were absent entirely. In the case of the Winchester collection, some material had been removed by other researchers and was unavailable for analysis at the time of recording. Attempts were made to locate missing material, although in most case this was unsuccessful. Both collections were stored in large warehouses and it is possible that some of the missing remains had been incorrectly labelled and shelved elsewhere.

Occasionally the remains of multiple individuals were stored in the same box. In the case of the Winchester sample, some remains had been marked with the site and context number; hence, co-mingled remains could be separated. The Ancaster material was unmarked. Usually, remains of different individuals had been placed in separate paper or plastic bags, though occasionally this was not the case. In the case of a triple infant burial from New Road, the remains of all three individuals had become co-mingled. There were several instances where the grave numbers written on the boxes did not match the grave numbers on the bones or bags, although the correct grave context could usually be determined from the documentation available.

In both collections, some pathological bones had been removed from their skeletons and placed in separate boxes of pathology specimens. These were wrapped individually and it was possible to match them with the correct skeleton. After analysis of the Winchester collection was completed, it became apparent that some pathological bones had been removed from several skeletons for scientific analysis, but details and photographs of these bones were subsequently obtained. It is possible, however, that other bones with interesting or unusual pathologies had also been removed from skeletons at some point in the past.

In both collections, bones were generally stored in cardboard boxes with no specialised packaging. This meant that the material was not properly supported, and some boxes were over-filled. It was evident that some fragmentation of the material had occurred owing to repeated removal, examination and replacement of the bones over the years (Caffell *et al*. 2001).

The majority of the remains had been washed or brushed to remove excess soil. This should be borne in mind when considering the prevalence of calculus deposits in the dentition. In a small number of burials from Winchester, significant soil deposits remained and were removed by gentle brushing, but facilities to clean the material properly were unavailable. The local soils of the Winchester area are primarily clay/chalk and some bones were encased in such deposits. In a number of cases where this affected the dentition, differentiating between these deposits and calculus was problematic.

4.2 Methods

Skeletal and dental remains were analysed macroscopically with the use of a hand-held magnifying glass when necessary. No radiography or histology was carried out, although radiographs of selected pathologies in the Ancaster sample had been taken previously (Cox 1989). Roberts (1988) included some of the material from Winchester in her analysis of fracture trauma and treatment in British archaeological populations and radiographed several specimens.

4.2.1 *Skeletal and dental inventories*

4.2.1.1 Skeleton

Detailed skeletal and dental inventories are necessary for the calculation of pathology prevalence rates (Brickley 2004a; Connell 2004). The use of pro formas, such as those provided in Brickley and McKinley (2004) or Buikstra and Ubelaker (1994), has the advantage of allowing rapid recording of a large number of individuals. Initially this technique was adopted, using modified versions of the subadult and adult inventories in Brickley and McKinley (2004: Appendices 4 and 5). It became apparent relatively quickly that this method would not provide the necessary level of detail for calculating pathology prevalence rates (Stodder 2012: 345), e.g. it does not allow for the detailed recording of individual spinal joint surfaces. Therefore, this approached was abandoned in favour of recording each skeleton separately in a Microsoft Excel spreadsheet using a pre-designed recording form listing the various elements and sub-elements, with columns for recording details of the completeness and condition of each bone, pathology, and any other features of interest, e.g. staining from metal objects and post-mortem damage. This information was then uploaded to a master inventory in an Access database[13].

Some elements were recorded as single units, others were recorded according to their constituent sub-elements. This approach facilitated the calculation of disease prevalence rates for those conditions that only affect certain elements/sub-elements (e.g. cribra orbitalia). Long bones were recorded using the segments method of Judd (2002b). For the purpose of calculating the numbers of elements and disease prevalence rates, (sub-)elements were counted as ‘present’ if at least 50% complete. Further details of the skeletal inventory system used are provided in Appendix 2, Table 83.

4.2.1.2 Dentition

The dentition was recorded using the Universal Numbering System (Schaefer *et al*. 2009: 68), in which the permanent dentition is numbered 1-32 (starting at the maxillary right third molar and moving clockwise to the mandibular right third molar), and the deciduous dentition is similarly coded from A to T (see Appendix 2, Table 84). This system was chosen as it was considered easier than the Zsigmondy and FDI systems to employ in a database (Connell 2004: 8). The dentition was recorded by individual tooth position. Crown development, root formation and stage of eruption were noted for deciduous teeth. Post-mortem and ante-mortem tooth loss were distinguished by the presence/absence of remodelling. Distinction was also made between non-eruption, congenital absence and ante-mortem tooth loss where possible (see Appendix 2, Table 85 for details of the notation system used). The

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[13] The Access database contains separate skeletal inventories for adults (Table D1) and subadults (Table D2), and an inventory of adult joints (Table D3).

dentition was recorded for each individual using a form contained in the Microsoft Access database[14].

4.2.2 *Preservation*

The condition of skeletal material can influence demographic reconstruction and also influences the extent to which pathological changes can be identified and recorded. In the present study, three measures of skeletal preservation were employed – skeletal completeness, bone surface preservation and element survival rates.

4.2.2.1 Skeletal completeness

For each individual, skeletal completeness was determined by considering the skeleton as comprising four regions, estimated to represent the following proportion of the skeleton:

- Skull = 20%
- Torso (including the clavicles, scapulae and pelves) = 40%
- Upper limbs = 20%
- Lower limbs = 20%

The completeness of each region was estimated visually and the values summed to arrive at an overall estimate, e.g. skull 10%, torso 15%, upper limb 5%, lower limb 10% = 40% total. Four grades of skeletal completeness were defined:

(1) ≥75%, near complete
(2) 50-74.9%, relatively complete
(3) 25-49.9%, relatively incomplete
(4) <25%, very incomplete

The Master Catalogue in the Access database (Form A) contains estimates of completeness for each skeleton.

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[14] The Access database contains two dental inventories – one lists the presence/absence of each tooth/socket vertically, and indicates the presence of any dental pathology by tooth/socket position (Table D4); the other lists the presence/absence of teeth horizontally, organised by skeleton ID (Form D/Table D5).

4.2.2.2 Bone surface preservation

The condition of each (sub-)element was assessed using a simplified version of the grading system recommended by McKinley (2004), as follows:

(1) Good = Bone surface in good-to-excellent condition with little or no post-mortem damage. Surface pathology (if present) would be clearly visible.

(2) Moderate = Bone surface in moderate condition. There is some post-mortem damage but surface pathology (if present) would still be visible.

(3) Poor = Bone surface in poor/very poor condition (weathering, root action, etc.). There is widespread post-mortem damage to the cortex, including joint surfaces. Surface pathology (if present) unlikely to be visible, but gross morphological changes (e.g. fractures) probably would be.

Bone surface preservation was recorded in the individual Excel skeleton inventories, and is contained in the skeletal inventories in the Access database (Tables D1 and D2). The overall surface preservation of each skeleton was also assessed using the categories described above. Bone surface condition sometimes varied across a skeleton, in which case the average condition of the bones was used. This information is provided in the Master Catalogue of burials in the Access database (Form A).

4.2.2.3 Skeletal element survival rates

The relative preservation of individual (sub-)elements can be expressed in terms of the survival rate, i.e. the number present as a percentage of the total number of that expected, given the total number of individuals in the sample. For example, in a sample of 100 burials, one would expect to recover 100 frontal bones; if only 75 are recovered, the survival rate would be 75%. In the present study, survival rates were calculated for the major (sub-)elements. In the case of the spine, and hands and feet, survival rates were also calculated in terms of the numbers of individuals with one or more element present. Detailed data on the survival of skeletal elements are provided on the accompanying CD.

4.2.3 *Demography*

4.2.3.1 Sex

Skeletal sexual dimorphism arises from differences in genetically-controlled hormonal regimes between the sexes (Frayer and Wolpoff 1985: 429). The sex ratio at birth varies between human populations (Sieff 1990: 25-6), but on average, approximately 105 males are born for every 100 females (Gillis 1995: 384). If infants of both sexes receive equal care and nutrition, the slightly high sex ratio typically evens out over time, as males experience greater infant mortality (Kishor 1993: 247; Ulizzi and Zonta 2002; I. Waldron 1983).

4.2.3.1.1 Limitations to the determination of sex

Sex can be determined from morphological characteristics, skeletal and dental metrics, and DNA analysis (Mays and Cox 2000: 117). The estimation of adult sex from assessment of pelvic and cranial morphology is considered highly accurate (Lovell 1989; Maat *et al*. 1997; Meindl *et al*. 1985a; Walker 2005; Williams and Rogers 2006). Methods for determining sex from post-cranial metrics perform less well (Cowal and Pastor 2008; MacLaughlin-Black and Bruce 1985; Safont *et al*. 2000). Dental metrics can aid sex determination in incomplete or co-mingled remains (e.g. Vodanović *et al*. 2007). While the determination of adult sex is relatively unproblematic given good preservation, a number of limitations exist. There is some evidence for systematic bias in sexing, with males being more likely to be accurately sexed (Weiss 1971). As the expression of sex in the skeletal is primarily a function of hormone levels, especially testosterone, younger adult males can exhibit somewhat feminine traits, while older females can exhibit rather masculine features (Walker 1995, 2005).

With the exception of DNA analysis, there are no widely accepted methods for sexing subadults, as sexual dimorphism does not become sufficiently marked until later adolescence (Mays and Cox 2000: 121). Several morphometric methods exist (Boucher 1957: 598-99; Molleson *et al*. 1998; Schutkowski 1993: 204-5), and dental metrics have been utilised (De Vito and Saunders 1990), but most perform poorly in tests (Holcomb and Konigsberg 1995:121-23; Mays and Cox 2000: 121; Vlak *et al*. 2008: 314; Weaver 1980: 194-95). The inability to sex subadults will mask any differences between females and males in childhood mortality and morbidity. Additionally, rates of skeletal and dental maturation differ between girls and boys, introducing error into assessment of age-at-death (Lewis 2007: 48; Scheuer and Black 2000a: 4).

4.2.3.1.2 Methods

4.2.3.1.2.1 Morphological assessment

Sexing from the pelvis and skull involves the assessment of multiple features. The most widely used criteria for sexing from the pelvis are those described by Phenice (1969). Blind tests have shown sexing from the pelvis alone to be at least *c.* 90% accurate, and frequently higher (Lovell 1989; Meindl *et al*. 1985a; Walker 2005). Cranial and mandibular morphology produce results of ≥80-90% accuracy or higher (Maat *et al*. 1997; Meindl *et al*. 1985a; Williams and Rogers 2006). Table 5 lists the morphological traits used to assess sex. Most traits were scored on a scale of 1-5, from most feminine to most masculine (Brickley 2004c: 25).

Table 5. Morphological traits used in the determination of sex.

Element	**Trait**	**Scoring System**	**References**
Cranium	Forehead slope Supraorbital ridge Supraorbital margin Mastoid process Nuchal crest	Each scored 1-5	Acsádi and Nemeskéri 1970; Buikstra and Ubelaker 1994
Mandible	Shape	Pointed (=feminine) or angular (=masculine)	Brickley 2004d; Brothwell 1981
	Gonial flare	Minimal (=feminine) or marked (=masculine)	
Pelvis	Greater sciatic notch Subpubic angle Subpubic concavity Ventral arc Ischiopubic ramus ridge	Each scored 1-5	Brickley 2004d; Buikstra and Ubelaker 1994; Phenice 1969

4.2.3.1.2.2 Metric assessment

Post-mortem damage and truncation of burials (particularly in the Winchester sample) meant that a significant minority of adults could not be sexed from visual assessment of pelvic and/or cranial morphology. Determination of sex from the pelvis was achieved for 264/396 (67.7%) of adults and the skull was complete enough for sexing in 258/396 (65.2%) of cases (both samples combined). The number of adults for whom both the pelvis and skull were available for sex assessment was only 186 (47.0%). Older females tended to exhibit masculine cranial morphology (Weiss 1972), and younger males occasionally exhibited somewhat feminine pelvic morphology (Walker 1995, 2005).

Therefore, post-cranial metrics were used to aid the determination of sex. Bass (1995) provides sectioning points for post-cranial metrics collated from various studies, but these are not necessarily applicable to other populations. In an attempt to address the lack of population-specific discriminant functions for most archaeological material, Albanese *et al*. (2005) developed a simple method for deriving sample-specific sectioning points from individuals with unambiguous pelvic morphology. For a particular measurement, average values for males and females are determined, and the mean of these two figures provides the sectioning point. Using this method, Albanese *et al*. (2005) achieved 83% accuracy in sexing a documented skeletal collection, and Garcia (2012) successfully assessed sex in 78-90% of individuals using the tibial circumference. The only prerequisites for using the method of Albanese *et al*. (2005) are that the number of measurements available exceeds 40 for each sex, and the sex ratio of the population is less than 1.5, both of which are met in the study samples. Therefore, using the method outlined, sectioning points were derived for the major joint surfaces and long bone circumferences. There is a range of overlap between the sexes, therefore only measurements below/above which definite females/males fell were used to identify definite and probable females/males. The sectioning points used are provided in Appendix 2, Table 86.

4.2.3.1.2.3 Final assessment of sex

For each individual, separate sex assessments were derived for the pelvis, cranium and mandible, and post-cranial metrics. Each characteristic/element was categorised as definitely female (F), probably female (F?), definitely male (M), probably male (M?) or intermediate (I). In arriving at an overall estimate of sex, pelvic morphology received greatest weight, followed by cranial and mandibular morphology, and post-cranial metrics. Individuals who were too incomplete to allow sexing were categorised as undetermined (U). No attempt was made to sex subadults (see section

4.2.3.1.1). The Access database contains detailed information on sex assessment for all adults (Form C).

4.2.3.2 Age-at-death

4.2.3.2.1 Mortality as an indicator of health status

The age structure of a population provides insights into the changing levels of mortality risk throughout the life course, and is used to reconstruct other demographic parameters (Chamberlain 2006: 6-7). A population's age profile is also relevant for interpreting disease prevalence rates, as many conditions are age-related (Boldsen and Milner 2012: 124). Subadult mortality is a particularly sensitive indicator of population health (Halcrow and Tayles 2011: 339), as infants and children are highly susceptible to both environmental and cultural stressors such as infection and malnutrition (e.g. Liu *et al.* 2012; Pelletier *et al.* 1995). Infant mortality rates in the past may have ranged between *c.* 20-50% in many societies (Coale *et al*. 1983; Lewis 2007: 83). Peaks in mortality in infancy and young childhood can reflect the timing of stressful events such as weaning, when children are introduced to new foods and new pathogens (Domett and Oxenham 2010; Katzenberg *et al*. 1996; Saunders and Melbye 1990).

Many archaeological populations exhibit a peak in adult mortality in the third and fourth decades (Chamberlain 2006: 62). An earlier peak in female mortality relative to males is often observed in skeletal samples (Angel 1969: 430; Eshed *et al*. 2004; Šlaus 2000) and is usually interpreted in terms of mortality during pregnancy and childbirth (Angel 1966; Owsley and Bass 1979; Šlaus 2000). Females also often exhibit greater longevity than males (Candore *et al*. 2006; DeWitte 2010; Nunn *et al*. 2009). Differences in the pattern of age-at-death between the sexes or between populations can reflect other mortality risk factors, such as warfare.

4.2.3.2.2 Limitations to the determination of age-at-death

The age of subadults is determined from assessment of skeletal and dental maturation (Brickley 2004b). Nutrition and disease can influence the rate and timing of subadult growth and maturation, but variations between individuals and populations are generally small; hence, subadult age-at-death can be estimated with a relatively high degree of accuracy and precision. In contrast, determination of age-at-death in adults is both less accurate and less precise (Cox 2000: 64). Most available macroscopic methods involve the assessment of degenerative changes (e.g. Brooks and Suchey 1990; Brothwell 1981; Lovejoy *et al.* 1985a), and are predicated on the assumption that there is a direct, measurable relationship between chronological age and biological age (Cox 2000: 64). Unfortunately, rates of skeletal and dental ageing can vary significantly between individuals and populations due to genetic, physiological and environmental factors (Kemkes-Grottenthaler 2002: 50). For this reason, it is necessary to employ broad, imprecise age ranges when ageing adults.

Other limitations of ageing methods arise from the use of modern skeletal collections of known age-at-death to develop techniques. Rates of ageing may have differed in the past owing to lifestyle factors, thus modern reference samples are not necessarily suitable for developing ageing standards (Usher 2002: 41). Additionally, the demographic composition of many reference collections is skewed, with individuals of certain age groups over- or under-represented (Usher 2002: 29, 40). In particular, older adults are often under-represented, and osteological ageing methods tend to suffer from a lack of resolution in the upper age ranges as a result. A related issue of potential significance is ‘age structure mimicry’ (Cox 2000: 63). Researchers recognised some time ago that certain ageing techniques produce demographic profiles in archaeological (‘target’) populations that resemble those of the reference population(s) upon which the techniques were developed (Bocquet-Appel and Masset 1982; Konigsberg and Frankenberg 1992; Meindl and Russell 1998: 383). This is because ageing from the skeleton/dentition inverts the relationship between biological age and chronological age, treating the former as fixed with a range of potential associated chronological ages when obviously the opposite is true (*cf.* Gowland and Chamberlain 2002: 678). The less accurate the technique, the more significant the problem of age structure mimicry will be (Aykroyd *et al*. 1999: 61).

Inter-observer variation in the selection and application of ageing methods affects the accuracy of both subadult and adult ageing. Macroscopic techniques are dependent to some extent on the experience of the researcher and subjective interpretation of descriptions (Falys and Lewis 2011: 706). A recent comparison of various ageing methods demonstrated the extent to which choice of methodology can influence the results of palaeodemographic analysis (Wittwer-Backofen *et al*. 2008).

4.2.3.2.3 Methods

4.2.3.2.3.1 Subadults

Perinates were assigned an age in gestational weeks using the long bone regression equations of Scheuer *et al*. (1980). These equations were preferred to those of Sherwood *et al*. (2000), as the former are more widely employed (the equations are reproduced in Appendix 2, Table 87). Gestational ages were calculated both for individual long bones and for combinations of bones (e.g. Halcrow and Livingstone 2009), although femoral length has the strongest correlation with gestational age (Mays 2003: 1698). For individuals with no intact long bones, the metric standards of Fazekas and Kosa (1978), reproduced in Schaefer *et al*. (2009), were utilised, although it is noted that the individuals included in Fazekas and Kosa's study were not of known age, rather, their age was estimated from crown-heel length (Scheuer and Black 2000a: 13). Age estimates for the basiocciput were also used as this element often survives well (Tocheri and Molto 2002; Schaefer *et al*. 2009).

Older subadults were aged by combined assessment of dental development and eruption, epiphyseal fusion and long bone length (Brickley 2004c). Dental development provides the most accurate method of ageing subadults, as it is 'buffered' to some extent against stresses such as malnutrition and infection (Cardoso 2007), although the timing of mineralisation and eruption can vary between populations due to genetic factors (Halcrow *et al*. 2007: 1159). Dental development is also delayed in very malnourished children (Gaur and Kumar 2012; Meindl and Russell 1998: 382). Many different ageing standards exist (e.g. Demirjian *et al*. 1973; Gustafson and Koch 1974; Moorrees *et al*. 1963; Schour and Massler 1941; Ubelaker 1989). Most involve subjective assessment of the state of crown mineralisation, root formation and eruption, although metric methods have also been developed (e.g. Liversidge and Molleson 1999). In the present study, the standards of Gustafson and Koch (1974), reproduced in White and Folkens (2005) were used. These were developed on populations of European ancestry, and should be broadly applicable to British skeletal material. Additionally, they have performed relatively well on documented collections (e.g. Liversidge 1994). Age estimates were derived for each tooth present, and used to determine an age range. In some cases, the extent of crown mineralisation or root formation could not be assessed where teeth remained firmly fixed in the alveolar bone (Brickley 2004b: 21), therefore dental age estimates are minimum estimates only. Schaefer *et al*. (2009) provides the basis for age estimates from epiphyseal fusion. Epiphyseal fusion occurs earlier in females, therefore the lower end of the age estimate is for females and the upper end of the estimate is for males. Long bone diaphyseal length age estimates are based on the standards of Maresh (1955). The reference standards for dental and epiphyseal age estimates are provided in Appendix 2, Table 88 and Table 89. Greatest weight was given to estimates obtained from the dentition (Brickley 2004c). Table 6 summarises the methods used to age subadults.

Table 6. Summary of subadult ageing methods.

Age Group	**Method**	**Reference**
Perinates	Cranial and post-cranial dimensions	Fazekas and Kosa 1978, reproduced in Schafer *et al*. 2009
	Long bone diaphyseal lengths	Scheuer *et al*. 1980
Infants, children and adolescents	Dental development and eruption	Gustafson and Koch 1974, reproduced in White and Folkens 2005
	Epiphyseal fusion	Schaefer *et al*. 2009
	Long bone diaphyseal lengths	Maresh 1955

4.2.3.2.3.2 Adults

The most widely used macroscopic methods for ageing adults are dental attrition (Brothwell 1981; Miles 2001), pubic symphysis morphology (Brooks and Suchey 1990; Gilbert and McKern 1973; Katz and Suchey 1986; Meindl *et al*. 1985b), auricular surface morphology (Buckberry and Chamberlain 2002; Lovejoy *et al*. 1985b), sternal rib-end morphology (DiGangi *et al*. 2009; Ïsçan and Loth 1986; Ïsçan *et al*. 1984a, 1984b, 1985; Kunos *et al*. 1999; Kurki 2005), cranial suture closure (Mann *et al*. 1987; Meindl and Lovejoy 1985), and assessment of late-fusing epiphyses (Black and Scheuer 1996; Cardoso 2008a, 2008b; Coqueugniot and Weaver 2007; McKern and Stewart 1957; Owings Webb and Suchey 1985; Schaefer 2008; Schaefer *et al*. 2009; Stewart 1954). Microscopic methods were not used in the present study.

Assessment of dental attrition is considered a relatively reliable ageing technique (Brothwell 1981; Miles 2001; Scott 1979). Brothwell’s method is widely used and has been shown to produce more accurate results than other techniques (D. Whittaker 2000: 87-9). One of the main benefits of attrition as an ageing method is that the dentition tends to survive well under archaeological conditions. Potential limitations include the variable influence of diet on attrition. For example, studies indicate that hunter-gatherers exhibit more rapid attrition than agriculturalists (Deter 2009; Hinton 1981; Littleton and Frohlich 1993; Lev-Tov Chattah and Smith 2006; Smith 1984; Watson 2008). Non-dietary factors can also influence attrition, particularly bruxism and use of the teeth as tools (e.g. Molnar 2008). Other limitations relate to the fact that different stages of attrition do not represent equal time frames (Molleson and Cohen 1990), and incomplete occlusion or lack of occlusion (e.g. owing to tooth loss or congenital absence) can influence patterns of attrition (Mays *et al*. 1995: 668). Asymmetric wear patterns and ante-mortem tooth loss can affect the applicability of the method, and dental attrition does not help in refining age assessment in elderly individuals (O'Connell 2004: 20), although it has been suggested that individuals with at least fifty percent of teeth lost ante-mortem were probably at least 50-60 years old (Mays *et al*. 1995: 668).

Pubic symphysis ageing techniques have been subject to numerous tests. Most methods have been found to under-age older adults and over-age younger adults (Aiello and Molleson 1993; Schmitt 2004). Pubic symphysis ageing is limited by its low precision, as continued revisions have resulted in increasingly broad, overlapping age categories (Berg 2008), and precision decreases with increasing age. Additional limitations of pubic symphysis ageing techniques include bilateral asymmetry (Overbury *et al*. 2009), and inter-population variation in the rate and pattern of change (Hoppa 2000).

Auricular surface ageing techniques suffer from the same problems as pubic symphysis ageing in terms of low precision, broad age ranges, bilateral asymmetry and inter-population variation. Tests of auricular surface *vs.* pubic symphysis ageing have produced mixed findings. Bedford *et al*. (1993: 290) found the auricular surface aged older adults more accurately than the pubic symphysis, but the situation was reversed for young adults. The method of Lovejoy *et al*. (1985b) has been criticised for the subjectivity of its descriptive terminology. Buckberry and Chamberlain (2002) proposed a revised method in which individual features are scored. A comparison of the two (Nagaoka and Hirata 2008) found that the revised Buckberry and Chamberlain method resulted in more individuals falling into the older age brackets, which is probably more realistic for most archaeological populations, although Lovejoy *et al*.'s method is more widely employed.

Cranial suture closure and sternal rib-end morphology are generally considered the least accurate techniques available (O'Connell 2004: 20). Tests of cranial suture closure have found the method performs poorly on material of known age-at-death (Key *et al*. 1994), and it has been widely discarded. Sternal rib-end morphology is limited in its application, as the main scheme applies specifically to the fourth rib, which cannot always be identified (İşcan and Loth 1986; İşcan *et al*. 1984a, 1984b, 1985). The technique also performs poorly in tests of accuracy (Russell *et al*. 1993). Methods of age estimation using the first rib exist, and are easier to apply since the first rib can usually be identified (DiGangi *et al*. 2009; Kunos *et al*. 1999), but also produce low accuracy (Kurki 2005).

Late-fusing epiphyses of the skeleton include the medial clavicle, iliac crest and ischial tuberosity. In addition, the first and second segments of the sacrum usually do not complete fusion until the third decade. Various studies have produced standards for the age and rate of fusion (Black and Scheuer 1996; Cardoso 2008a 2008b; Coqueugniot and Weaver 2007; McKern and Stewart 1957; Owings Webb and Suchey 1985; Schaefer 2008; Schaefer *et al*. 2009; Stewart 1954). It is preferable to use standards developed on modern populations of similar ancestry to the archaeological sample in question, but this is not always feasible.

In the present study, adults were aged from assessment of molar attrition (Brothwell 1981), pubic symphysis morphology (Brooks and Suchey 1990), auricular surface morphology (Lovejoy *et al*. 1985b), epiphyseal fusion (medial clavicle, iliac crest and ischial tuberosity), and fusion of the first and second sacral bodies (Table 7). Additionally, complete or near complete eruption of the third molars was considered to indicate an age ≥17 years (White and Folkens 2005).

Table 7. Summary of adult ageing methods.

Area	Method	References
Dentition	Dental (molar) attrition	Brothwell 1981
Pelvis	Pubic symphysis morphology	Brooks and Suchey 1990
	Auricular surface morphology	Lovejoy *et al*. 1985b
	Fusion of the iliac crest (≥20 yrs)	Schaefer *et al*. 2009
	Fusion of the ischial tuberosity (≥20 yrs)	Schaefer *et al*. 2009
Clavicle	Fusion of the medial epiphysis (≥25 yrs)	Black and Scheuer 1996; Cardoso 2008a, 2008b; Coqueugniot and Weaver 2007; Owings Webb and Suchey 1985; Schaefer 2008
Sacrum	Fusion of the S1-S2 (≥30 yrs)	Schaefer *et al*. 2009

Adults were assigned to one of four age categories (18-24, 25-34, 35-49 and ≥50 years), in addition to a general category of ‘adult’ for individuals who were insufficiently complete for ageing. During the analysis, it became evident that dental attrition was under-estimating age in comparison to other age indicators. Many individuals for whom dental attrition suggested an age of 17-25 also exhibited complete fusion of the medial clavicle epiphyses and/or sacrum, and the auricular surface often indicated an age several phases older than the dentition. A discrepancy in dental and skeletal age estimates has been observed in other Romano-British populations (Clough and Boyle 2010: 351; Molleson 1993: 207-9). Where dental attrition placed an individual in a younger age category than skeletal indicators, greater weight was given to the latter. For example, for an individual with a dental attrition age of 17-25 years, an auricular surface age of 24-29, and a fused medial clavicle, the final age assessment would be 25-34. Where only the dentition was available for assessment of age-at-death, this was used, as to exclude dental attrition completely would have considerably reduced the number of individuals for whom age estimates could be obtained. Additionally, most researchers employ dental attrition as the primary ageing technique. This is, however, likely to bias the age distribution of the study samples towards the younger age ranges.

4.2.3.2.3.3 Final assessment of age-at-death

Using the methods outlined above, individuals were assigned to one of eleven age categories listed in Table 8. All ages are in years unless otherwise indicated. The Access database contains detailed information on the assessment of age-at-death for each individual (Form B; Tables B1, B2i, B2ii and B2iii).

Table 8. Age categories.

Descriptive Category	**Age Range**
Perinate	Foetal to *c.* 1 month
Infant	*c.* 1-11.9 months
Young child	1-5
Older child	6-11
Adolescent	12-17
Young adult (YA)	18-24
Prime adult (PA)	25-34
Mature adult (MA)	35-49
Elderly adult (EA)	≥50
Unaged subadult (US)	<18
Unaged adult (UA)	≥18

4.2.4 *Growth and stature*

4.2.4.1 Growth and stature as indicators of health

All individuals have a genetic potential to attain a particular stature, but various endogenous and exogenous factors influence whether that potential is achieved (Eveleth and Tanner 1990: 176). There is a well-recognised relationship between poverty, malnutrition, disease, growth retardation and low adult stature (e.g. Dettwyler and Fishman 1992; Frongillo *et al*. 1997; Guerrant *et al*. 1992; Moffat 2003; Steckler 1995; Stetler *et al*. 1981).

Childhood growth is widely considered a particularly sensitive indicator of population health (Eveleth and Tanner 1990: 1). Long bone growth involves an increase in shaft circumference (appositional growth) and length (longitudinal growth), the latter occurring at the growth plates (Lewis 2007: 62; Scheuer and Black 2000a: 4). Linear growth retardation can occur as early as the foetal period in malnourished populations (Chang *et al*. 2003; Kinare *et al*. 2010). In skeletal samples, subadult growth is examined by plotting long bone lengths against dental age to construct growth curves (Humphrey 2000). Bioarchaeological studies have examined the relationship between subadult growth and living conditions, socio-economic status, nutrition and disease (Humphrey 2000: Table 1). Many have observed growth retardation in ‘stressed’ subadults (Bennike *et al*. 2005; Jantz and Owsley 1984; Lewis 1999; Pinhasi *et al*. 2006), although others have not (Ribot and Roberts 1996; Schillaci *et al*. 2011), indicating that the relationship between growth, nutrition and disease is complex. Limitations of such studies include inaccurate ageing, inter-population variation in growth and development due to genetic factors, and delayed dental development in extremely malnourished subadults (e.g. Gaur and

Kumar 2012). Additionally, as archaeological data are necessarily cross-sectional, growth studies can be affected by ‘mortality bias’, whereby the subadults present in a sample were particularly small-for-age relative to peers who survived to adulthood (Lewis 2007: 68-74; Saunders *et al*. 1990).

Adult stature has also been used as an indicator of health owing to the well-established link between malnutrition, disease, low socio-economic status, and reduced adult stature (Komlos 1994; Floud *et al*. 1990; Steckel 1995). Numerous studies have identified a long-term secular increase in stature, although, in general, the greatest increase has occurred during the twentieth century, thanks to dramatic improvements in diet, health and general living standards (Cardoso and Gomes 2009; Giannecchini and Moggi-Cecchi 2008; Maat 2005; Shin *et al*. 2012). Secular changes prior to the modern era were relatively minor and included periods of declining stature (Arcini *et al*. 2012; Gustafsson *et al*. 2007; Komlos 1998; Mummert *et al*. 2011; Steckel and Floud 1997; Temple 2008). Some bioarchaeological studies have noted a relationship between greater adult stature and increased longevity in past populations (DeWitte and Hughes-Morey 2012; Gunnell *et al*. 2001; Kemkes-Grottenthaler 2005; Watts 2011). This may support modern data for a link between stature, longevity and a reduced risk of a number of serious health problems such as cardiovascular disease (e.g. Davey Smith *et al*. 2000; although see Samaras *et al*. 2003 for conflicting data).

A potential limiting factor in using growth and stature as measures of health status is ‘catch-up’ growth – accelerated compensatory growth that occurs in subadults when the conditions causing growth retardation are overcome (Kays and Hindmarsh 2006; Wit and Boersma 2002). Individuals who experience stress in childhood can thus achieve the same stature as their unstressed peers. Studies of adult stature also suffer from a number of methodological limitations. The most common methods for estimating adult stature use regression analysis to compute stature from complete long bone lengths or long bone fragments (e.g. Steele and McKern 1969; Trotter and Gleser 1952), and are usually based on modern populations. However, limb proportions vary between and within ethnic groups (e.g. Ruff *et al*. 2012), and stature equations developed on modern populations are not necessarily appropriate for ancient populations (Formicola 1993). Differences in the choice of formulae used and inter-observer error often limit inter-population comparisons (e.g. Maat 2005).

4.2.4.2 Recording of metric data

The range of measurements that can be recorded on subadult skeletal remains is dependent on skeletal maturation and completeness. In the study samples, many subadult elements were too incomplete for the full range of measurements to be recorded. In light of this, and restrictions on time, a range of 19 measurements (seven cranial and twelve post-cranial) were selected for recording after Schaefer *et al*. (2009), based on the condition of the material and their applicability to age determination (see Appendix 2, Table 90). All measurements were recorded using digital sliding callipers (to the nearest 0.1 mm).

In adults, 31 cranial and 50 post-cranial measurements were recorded (after Brothwell and Zakrzewski 2004: 29-30; Buikstra and Ubelaker 1994: 74-84). These are listed in Appendix 2 (Table 91 and Table 92). Dental metrics were not recorded. Measurements were taken using spreading callipers (to the nearest 0.1 cm) and digital sliding callipers (to the nearest 0.1 mm). Long bone lengths were determined using an osteometric board or a fabric tape measure (to the nearest 0.1 cm).

All measurements were recorded on the left bone unless absent or pathological, in which case the right was used. Metric data are contained in the Access database (Forms E1 and E2).

4.2.4.3 Methods

4.2.4.3.1 Subadult growth curves

Diaphyseal lengths were recorded for all intact long bones, but only the femur was used to construct growth curves as growth rates vary between elements (Humphrey 1998). Femoral length was plotted against an individual's mid-point age estimate derived from the dentition (Mays 2010b: 134).

4.2.4.3.2 Adult stature

Stature can be estimated from *in situ* measurements of the skeleton in the grave (e.g. Petersen 2005), but this information was not recorded/available for either study sample. The combined heights of all skeletal elements can be used to estimate stature (Fully 1956; Raxter *et al*. 2007), but this method is difficult to apply to incomplete skeletal material. Therefore, complete long bone lengths were used to estimate stature using the formulae for Caucasians developed by Trotter and Gleser (1952, 1958, 1977), as recommended by Brothwell and Zakrzewski (2004). It has been noted that the Trotter and Gleser formulae, while developed on individuals of European ancestry, may not be the most accurate stature formulae for all ancient European populations (Brothwell and Zakrzewski 2004: 32). Nevertheless, they are widely applied, and were used to ensure comparability with other studies that use the same formulae. For each individual, stature was estimated from whichever bone(s) was available (see Appendix 2, Table 93). However, average statures were calculated using the mean femoral length for females/males in each sample. This is preferable to averaging stature estimates, as it reduces error due to ‘noise’ in the data (Brothwell and Zakrzewski 2004: 32). All stature data are contained in the Access database (Form E3).

4.2.5 *Non-metric data and muscle markers*

No attempt was made to systematically record non-metrics owing to constraints on time, but common traits (e.g. metopism) were recorded where present (Brothwell and Zakrzewski 2004: 31, Table 3). British skeletal populations have a tendency to form bone at attachment sites (Roberts and Connell 2004: 38), therefore entheseal changes were only recorded if unusually pronounced or indicative of pathology (e.g. DISH).

4.2.6 *Pathology*

The range of skeletal and dental pathology that can be observed in human remains is considerable (Ortner 2003), but some conditions are more amenable to biocultural interpretation than others. For example, congenital anomalies can be of value in identifying possible family groupings in cemeteries (e.g. Mays 2009), but are generally less relevant to reconstructing aspects of lifestyle and living environment. Similarly, environmental factors can contribute to the development of bone cancers, but most have a strong hereditary component (Underwood 2000: 238).

Therefore, the present study focuses on those pathologies that are most likely to be influenced by aspects of lifestyle, diet and environment, namely:

- **Joint disease**. Osteoarthritis, disc disease, Schmorl's nodes and rotator cuff disease.
- **Trauma**. Fractures and osteochondritis dissecans.
- **Metabolic disease**. Scurvy, rickets/osteomalacia and osteoporosis.
- **Specific infections**. Tuberculosis.
- **General (non-specific) indicators of health**. Periostitis, cribra orbitalia, porotic hyperostosis and dental enamel hypoplasia.
- **Dental disease**. Caries, calculus, periodontal disease, peri-apical lesions and ante-mortem tooth loss.

Although they will not be discussed in detail, congenital anomalies, neoplasms, diffuse idiopathic skeletal hyperostosis (DISH) and rarer pathologies thought to be primarily genetic in aetiology (e.g. ankylosing spondylitis) were recorded where present and basic prevalence data are provided in Chapter 5 and the Access database. Pathology of uncertain aetiology is described where relevant (Forms F2-F8).

Palaeopathological analysis requires the use of standardised definitions and diagnostic criteria to ensure comparability of results between researchers. In the present study, Waldron's (2009) 'operational definitions' have been employed for the majority of conditions. These provide minimum diagnostic criteria, which aid in preventing over-diagnosis and should allow other researchers to compare their findings with those of the present study. Pathological changes were recorded using the recommendations of Roberts and Connell (2004). The following sections summarise the aetiology and biocultural significance of the conditions included, and the diagnostic criteria and recording protocols employed in the study.

4.2.6.1 Joint disease

Many diseases of the joints (arthropathies) occur in humans and other vertebrates (Rogers and Waldron 1995). The most commonly observed joint diseases are osteoarthritis, disc disease, Schmorl's nodes and rotator cuff disease (Ortner 2003: 545; Waldron 2009: 26, 40-5). Other arthropathies, such as ankylosing spondylitis, psoriatic arthritis and Reiter's syndrome, are relatively rare (Waldron 2012: 521). Many of this latter group are not linked to lifestyle, but have an immunological basis (FitzGerald and McInnes 2006); therefore, only osteoarthritis (OA), disc disease, Schmorl's nodes and rotator cuff disease will be considered in detail.

4.2.6.1.1 Osteoarthritis

4.2.6.1.1.1 Aetiology

Osteoarthritis is one of the most commonly observed pathologies in ancient skeletal remains (Waldron 2009: 26; Weiss and Jurmain 2007: 437), and is prevalent in modern Western populations (Breedveld 2004; Sharma and Kapoor 2007: 3). Historically, osteoarthritis has been characterised as a condition of simple 'wear and tear', thought to be most prevalent in the elderly and individuals undertaking strenuous occupations. For this reason, it is often termed 'degenerative joint disease' (Aufderheide and Rodríguez-Martín 1998: 93; Jurmain and Kilgore 1995), but this view has been increasingly challenged.

At the gross anatomical level, osteoarthritis involves degeneration ('fibrillation' or splitting) and, ultimately, destruction of the cartilage covering the articular surfaces of bones at synovial joints (Hughes 2000: 717; Poole *et al*. 2007: 32). Consequent osseous responses including the formation of bony spurs (osteophytes) at joint margins, and sclerosis (trabecular thickening), porosity (pitting) and eburnation (polishing) at the joint surface itself (Ortner 2003: 546). At the cellular level, osteoarthritis is incompletely understood (Brandt *et al*. 2003: 69). Fundamentally, cartilage destruction results from a disturbance in the functioning of chondrocytes (cartilage-forming/maintaining cells) in the cartilage matrix, whereby there is an imbalance in breakdown *vs.* repair (Poole *et al*. 2007: 27). In normal, unaffected joints, the rate of cartilage remodelling is slow and is controlled by a combination of genetic and biochemical factors. In osteoarthritic cartilage, destruction outstrips repair because of an increase in the production of substances that degrade the cartilage extra-cellular matrix (Loeser 2010: 371). Inflammation of the synovium may develop, resulting in the production of additional chemicals that cause further cartilage destruction (Bonnet and Walsh 2005; Poole *et al*. 2007: 39). Accompanying changes in the bone stimulate the production of further cartilagedestroying products, thus perpetuating the process of joint degeneration (Hough 2007: 53; Poole *et al*. 2007: 34-36). The initial cause of cartilage destruction is believed to be mechanical stress (Goldring 2000; Poole *et al*. 2007: 27). A degree of mechanical loading is necessary to maintain normal cartilage remodelling (Poole *et al*. 2007: 31), but excessive forces cause cartilage micro-fractures and trigger cell destruction (Berenbaum and Sellam 2008; Hough 2007: 52). This can occur in pathological joints placed under normal stress ('secondary OA'; Poole *et al*. 2007: 30). However, in many individuals, osteoarthritis is a primary (idiopathic) condition (Brandt *et al*. 2003: 69; Loeser 2010; Pritzker 2003: 49; Sharma and Kapoor 2007: 10).

Numerous clinical studies have examined the prevalence of OA in people with labour-intensive professions, and athletes (e.g. Cooper *et al*. 1994, 1996; Croft 2005; Croft *et al*. 1992; Kivimaki *et al*. 1992; Maetzel *et al*. 1997; Roach *et al*. 1994). While many studies suggest a link between activity and osteoarthritis, and mechanical factors are known to play an important role in the proximate aetiology of the disease, other research provides little or no evidence for a link (Weiss and Jurmain 2007: 442-3). Many other factors are known (or suspected) to contribute to the development of osteoarthritis, including *inter alia* age-related changes in joint tissues (Grogan and D'Lima 2010; Martin and Buckwalter 2002), sex (Srikanth *et al*. 2005), genetics (Holderblaum *et al*. 1999; Hough 2007: 62), body mass and body fat (Berenbaum and Sellam 2008; Davis *et al*. 1988, 1990; Gabay *et al*. 2008), joint morphology (Sharma *et al*. 2000), and trauma (Buckwalter 2003). These factors can be inter-related. For example, obesity is associated with an increased risk of osteoarthritis of the knee (Coggon *et al*. 2001), but it is unclear whether it is high body mass *per se* – and the resultant increased weight bearing on the knees – or the tendency for obese individuals to develop *varus* deformities of the joints, or both, that contributes to knee OA (Sharma *et al*. 2000). Similarly, disentangling the interactions between genetic and non-genetic factors is extremely difficult (Croft 2005: 29).

Historically, bioarchaeologists have utilised osteoarthritis to reconstruct activity. Its complex aetiology means OA cannot be used to reconstruct individual life histories (Waldron 2009: 29), although it is still common to find references to osteoarthritis as evidence for a ‘hard life’ (e.g. Lalonde 2007: 14; Maynor Bikai and Perry 2001: 63; Tomczyk *et al*. 2011: 441). At the population level, many studies focus on the relationship between joint disease and subsistence-related activity (Bridges 1991, 1992, 1994; Cohen and Armelagos 1984; Eshed *et al*. 2010; Jurmain 1977; Larsen 1995, 1997; Merbs 1983). Differences in prevalence between the sexes have been used to infer gender-based divisions of labour (Bridges 1992; Derevenski 2000; Lovell 1994). However, in recent years, it has become increasingly apparent that many skeletal populations exhibit a similar pattern of joint involvement, regardless of cultural setting, leading to some scepticism regarding the inferential potential of the patterning of OA and inter-population comparisons. In particular, several studies have noted a marked similarity in the patterning of spinal OA, suggesting that its distribution is primarily the result of upright posture and bipedalism (Bridges 1994; Knüsel *et al*. 1997); hence, inferences regarding activity levels based on the pattern and prevalence of osteoarthritis must be treated with caution (Weiss and Jurmain 2007: 444).

Osteoarthritis studies are complicated by several methodological limitations. The disease is strongly age-related, and the imprecision of adult ageing techniques is therefore problematic when comparing populations (Jurmain and Kilgore 1995: 445). Variables such as genetics, body mass and trauma are difficult to adjust for (Weiss 2006). Differences in recording methods and data presentation can make comparisons between studies extremely difficult (Bridges 1993: 289; Jurmain and Kilgore 1995: 449; Waldron 2012: 516). Researchers also differ regarding diagnostic criteria (e.g. Rothschild 1997: 531; Waldron 2009: 34).

4.2.6.1.1.2 Diagnosis

Spinal OA refers specifically to osteoarthritis of the posterior facet (zygoapophyseal) joints of the spine. Extraspinal OA refers to osteoarthritis of the synovial joints of the appendicular skeleton. Osteoarthritis was diagnosed from the presence of eburnation (polishing). If eburnation was not present, then at least two of the following features had to be present: marginal osteophytes, pitting/porosity, new bone formation at the joint surface, and/or change in joint contour (Figure 75; Waldron 2009: 34). Spinal OA was recorded at the individual joint level, including the atlanto-occipital joints, the median atlanto-axial (atlanto-odontoid) joint and the L5/S1 joints. Right and left side facet pairs were recorded separately. Extra-spinal OA was also recorded at the individual joint level. A joint was considered 'present' if one or more surfaces was ≥50% complete, and osteoarthritis was diagnosed if one or more surface was affected. OA was scored for the temporomandibular joint (TMJ), sternoclavicular joint (SCJ), acromioclavicular joint (ACJ), shoulder/ glenohumeral joint (GHJ), elbow (humeroradial, humeroulnar and proximal radioulnar articulations), wrist (distal radioulnar, radioscaphoid and radiolunate articulations), hip/acetabulofemoral joint, knee (medial and lateral femorotibial and patellofemoral articulations), and ankle (distal tibiofibular and talocrural articulations). The number of joints and differing nature of articulations (planar and saddle joints) present in the hands and feet makes calculation of true prevalence rates very difficult in terms of joint units. Therefore, the hands and feet were considered as individual joints, and were considered 'present' if one or more element was present. Prevalences for these joints will thus be minimum estimates, owing to incomplete preservation of the hands and feet (*cf*. Jakob 2004: 95-6).

4.2.6.1.2 Disc disease

4.2.6.1.2.1 Aetiology

The vertebrae are separated by cartilaginous discs that comprise an inner core with a gelatinous consistency (nucleus pulposus), surrounded by an outer ring of more fibrous cartilage (annulus fibrosus). These serve to absorb shock and aid the flexibility of the spine (Steele and Bramblett 1988: 111). Layers of hyaline cartilage cover the superior and inferior surfaces (endplates) of the vertebral bodies and prevent bulging and herniation of the nucleus pulposus (Moore 2000). In adulthood, the nucleus pulposus undergoes dehydration, becoming less gelatinous, and the ratio of collagenous-to-non-collagenous protein decreases throughout the disc, making it more rigid and less capable of absorbing shock. The hyaline cartilage at the endplates gradually undergoes ossification (Moore 2006). Degeneration of the discs leads to porosity of the intervertebral surfaces of the vertebrae (Aufderheide and Rodríguez-Martín 1998: 96-97; Ortner 2003: 549). Additionally, the annulus fibrosus bulges outwards under the weight of the vertebral column (Buckwalter

1995). Where the annulus fibrosus attaches to the margins of the vertebral body via Sharpey's fibres (Kraemer 2009: 19), bulging places traction on the periosteum, triggering the formation of marginal osteophytes. These are initially horizontal but can eventually develop vertically in an attempt to 'buttress' the protruding disc, and osteophytes on adjacent vertebrae can ultimately fuse (Mann and Hunt 2005: 101; Ortner 2003: 549).

Both biochemical and mechanical factors influence disc degeneration, but it is unclear which of these plays the primary role (Hadjipavlou *et al*. 2008). There may also be a genetic component to disc disease (Solovieva *et al*. 2002; Zhang *et al*. 2008). Mechanical loading of the spine is usually considered most important in the development of disc disease, and some clinical studies have linked disc degeneration with activity (Jäger 1997; Luoma *et al*. 2000; Williams and Sambrook 2011). Mann and Hunt (2005: 101) describe disc disease as 'occupation related', and bioarchaeologists have used the prevalence of the condition at the population-level as an indicator of lifestyle (Jurmain 1990). However, some studies have found no difference between populations that archaeological and historical evidence would suggest had very different lifestyles (Knüsel *et al*. 1997). As with osteoarthritis, joint involvement is relatively consistent between populations. The thoracic and lumbar regions are usually more affected than the cervical spine, suggesting upright posture and bipedalism exert a strong influence on joint involvement (Bridges 1992, 1994; Hussien *et al*. 2009; Jurmain and Kilgore 1995; Kahl and Ostendorf-Smith 2000; Novak and Šlaus 2011; Rojas-Sepúlveda *et al*. 2008; Sofaer Derevenski 2000; Üstündağ 2009; Van der Merwe *et al*. 2006).

Differences in diagnostic criteria and descriptive terminology are problematic when comparing studies. Some researchers consider the formation of osteophytes and pitting of the intervertebral surfaces of vertebrae to constitute separate conditions (Jurmain and Kilgore 1995: 445). Others consider the formation of marginal osteophytes and endplate porosity to be indicative of the same general process of degeneration (e.g. Ortner 2003: 549). In palaeopathological studies, disc disease is often subsumed under spinal osteoarthritis, but this is inaccurate, as the intervertebral joints are not true synovial joints.

4.2.6.1.2.2 Diagnosis

Disc disease was diagnosed from the presence of pitting at the vertebral endplate and/or the presence of marginal osteophytes (Ortner 2003: 555; Waldron 2009: 43). Care was taken to differentiate between true osteophytes (horizontally oriented growths arising from the vertebral margin, often with a ‘pleated’ appearance; Figure 76), ossifications of the anterior longitudinal ligament (vertically oriented growths arising from the anterior vertebral wall) and syndesmophytes (vertically oriented growths representing ossification of the annulus fibrosus). The presence of disc disease was recorded at the individual joint interface level. Data are presented for all joints between the second cervical and first sacral vertebrae. Joints were considered ‘present’ if one or both joint surfaces was ≥50% intact, and disc disease was recorded as present if one or both surfaces exhibited diagnostic changes.

4.2.6.1.3 Schmorl’s nodes

4.2.6.1.3.1 Aetiology

Schmorl’s nodes are lesions in the intervertebral surfaces of vertebrae that represent herniation of the nucleus pulposus through the vertebral endplate. The pressure of the herniated material causes resorption of the bone, resulting in the formation of a lesion (Faccia and Williams 2008: 29-30; Mann and Hunt 2005: 95; Ortner 2003: 549). Evidence of remodelling distinguishes these lesions from post-mortem damage. Schmorl’s nodes can be associated with back pain (Faccia and Williams 2008), but are often asymptomatic (Takahashi *et al*. 1995).

While the basic process by which the lesions form is understood, clinicians continue to debate the ultimate cause of Schmorl’s nodes (Kyere *et al*. 2012). Proposed aetiologies include acute trauma (Burke 2012; Fahey *et al*. 1998; Möller *et al*. 2007), gradual compressive loading (Dar *et al*. 2010), congenital defects and genetic predisposition (Hilton *et al*. 1976; Williams *et al*. 2007). A factor that has proved problematic in determining the aetiology of Schmorl’s nodes is the absence of any clear patterning regarding age. Schmorl’s nodes are often said to be common in elderly individuals (Mann and Hunt 2005: 95; Ortner 2003: 549), as would be expected for a degenerative condition, but other studies have found no relationship with age (Hilton *et al*. 1976; Jakob 2004; Jiménez-Brobeil *et al*. 2010; Novak and Šlaus 2011; Pfirrman and Resnick 2001; Üstündağ 2009).

Despite the uncertain aetiology of the condition, Schmorl's nodes have been used to reconstruct the lifestyle and occupation of individuals (Wentz and De Grummond 2009). Relatively few population-based studies have focused on Schmorl's nodes in isolation, but they are often studied in conjunction with spinal osteoarthritis and disc disease as an indicator of lifestyle and activity. The recording of lesions on a presence/absence basis makes comparison of findings between studies relatively straightforward. The general prevalence of Schmorl's nodes is considered an indicator of activity levels (e.g. Klaus *et al*. 2009; Stirland and Waldron 1997). Most studies have found Schmorl's nodes to be more common in males than females, which is sometimes interpreted as evidence for gender-based divisions in labour (Jiménez-Brobeil *et al*. 2010, 2012; Üstündağ 2009), although differences in body size and spinal anatomy could account for the difference. Many studies indicate that Schmorl's nodes follow a remarkably similar distribution in most populations. They rarely, if ever, occur in the cervical spine. The prevalence tends to increase from the T1 to T11/12, then declines between the L1 and L5 (Burke 2012; Dar *et al*. 2010; Jakob 2004; Malmivaara *et al*. 1987; Pfirrmann and Resnick 2001; Stirland and Waldron 1997; Üstündağ 2009). This suggests spinal anatomy and biomechanics exert a significant influence on the distribution of Schmorl's nodes.

4.2.6.1.3.2 Diagnosis

Schmorl's nodes were diagnosed from the presence of smooth-walled depressions in the vertebral endplate (Figure 77; Waldron 2009: 45). Lesions were recorded on a presence/absence basis at the joint surface (i.e. superior or inferior) level. Data are presented at the joint interface level. Joints were considered 'present' if one or both joint surfaces was ≥50% intact, and Schmorl's nodes were recorded as present if one or both surfaces exhibited lesions.

4.2.6.1.4 Rotator cuff disease

4.2.6.1.4.1 Aetiology

The rotator cuff complex is formed by the supraspinatus, infraspinatus, teres minor and subscapularis muscles and tendons. With increasing age, the tissues of the rotator cuff degenerate owing to intrinsic changes in joint tissues, mechanical wear and tear, and trauma (Cohen and Williams 1998; Milgrom *et al*. 1995; Tytherleigh-

Strong *et al*. 2001). Tears to the subscapularis tendon can cause the humeral head to be displaced supero-posteriorly, such that it impinges on the inferior acromial process (Waldron 2009: 41). Skeletal changes include porosity at muscle insertion site, enthesophyte development at joint margins, and eburnation at the humerus and acromion. Rotator cuff disease is a common disorder of the shoulder (Roberts *et al*. 2007), although few bioarchaeological studies have examined the prevalence or patterning of the condition (Miles 1996, 1999 and 2000). Rotator cuff injuries are particularly common in athletes and individuals who frequently engage in activities involving repeated overhead throwing, lifting and/or pulling (Cohen and Williams 1998).

4.2.6.1.4.2 Diagnosis

Rotator cuff disease was diagnosed from the presence of porosity/pitting at the insertions of the rotator cuff muscles and enthesophytic development at joint margins *or* change in contour at insertion sites. Humeral impingement syndrome was recognised from the presence of eburnation at the superior pole of the humerus and/or inferior aspect of the acromial process (Waldron 2009: 42; Figure 87 to 89).

4.2.6.2 Trauma

The most commonly observed skeletal indicators of trauma are bone fractures and osteochondritis dissecans (Ortner 2003; Waldron 2009). Complete or partial dislocation of joints (luxation or subluxation) will only be evident skeletally when dislocations were congenital or long-standing (Roberts 2000: 342). Trauma to muscles, tendons and ligaments can result in soft tissue ossification (Waldron 2009: 79), but may be confused with other conditions. In the present study, only fractures and osteochondritis are considered in detail.

4.2.6.2.1 Fractures

A fracture is defined as a partial or complete discontinuity in bone (Lovell 1997). Fractures arise when the tensile or compressive strength of bone is exceeded (Aufderheide and Rodríguez-Martín 1998: 20). Fractures are classified based on the timing of injury/stage of healing, mechanism of injury (e.g. blunt, sharp or projectile trauma; direct or indirect force) and morphological characteristics (Galloway 1999;

Lovell 1997). The risk of fracture is not evenly distributed throughout the skeleton, but is influenced by factors such as a bone's position, side and structural properties. For example, the prominence and fragility of the nasal bones means they are among the most frequently fractured elements of the facial region (Lovell 1997: 156). Fracture risk also varies between individuals according to age and sex, due to both intrinsic differences in the structural properties of bone and cultural factors. Certain fractures predominantly occur in children, e.g. green-stick fractures. Conversely, the elderly (especially women) are at greater risk of sustaining fragility fractures of the vertebrae, radius and femoral neck due to osteoporosis (Johnston and Slemenda 1994). Sex is another key variable in overall rates and patterning of fracture trauma. Females are more likely to sustain injuries in the home (e.g. Grisso *et al*. 1991), while males tend to suffer higher frequencies of acute fracture trauma linked to occupation, leisure and male-on-male interpersonal violence (Mitchell *et al*. 2012; Saw *et al*. 2010; Søreide *et al*. 2009; Walker 2001), reflecting a greater proclivity for boys and men to engage in 'risky' behaviour (Eckel and Grossman 2008).

The study of fracture trauma has played a key role in research on violence and warfare in the past (e.g. Berger and Trinkaus 1995; Smith and Wood Jones 1910). Nevertheless, identifying evidence of intentional violence is extremely difficult (Judd and Redfern 2012: 365). While the proximate cause of a fracture can often be determined vis-à-vis mechanism of injury (i.e. a blade wound), it is impossible to know whether it was sustained during an assault or accidentally (Wakely 1996). At the population level, a wealth of clinical data indicate that the head and face are preferentially targeted in violent encounters (Arosarena *et al*. 2009; Brink *et al*. 1998; Brink 2009; Crandall *et al*. 2004; Erdmann *et al*. 2008; Fothergill and Hashemi 1990; Goldberg *et al*. 2000; Greene *et al.* 1999; Hussain *et al*. 1994; Lee 2009; Ólafsson 1984; Shepherd *et al.* 1990; Wright and Kariya 1997). The prevalence and patterning of cranio-facial trauma has been widely used to assess levels of interpersonal violence and ancient warfare in archaeological contexts (e.g. Alvrus 1999; Cohen *et al*. 2012; Jurmain and Bellifemine 1997; Kilgore *et al*. 1997; Kjellström 2005; Paine *et al*. 2007; Torres-Rouff and Costa Junqueira 2006; Walker 1989). In addition to cranio-facial trauma, assault victims often sustain fractures to the upper limb, particularly isolated transverse fractures of the distal ulna shaft termed ‘parry’ fractures, which can occur when an individual raises their arms in a defensive posture to fend off a blow (Judd 2008; Smith 1996). Bioarchaeologists have also inferred inter-personal violence from high rates of fractures of the hands and ribs (e.g. Brickley and Smith 2006; Hershkovitz *et al*. 1996), multiple injuries, and the presence of injuries at different stages of healing representing injury recidivism (Judd 2002a; Redfern 2006). However, some researchers have stressed the importance of recognising that patterns of violence are culturally mediated, and not all societies exhibit the same pattern of injury location (Judd 2004: 46-7; Walker 2001).

The majority of fractures observed in skeletal samples will represent accidental injury and many palaeopathological studies interpret the prevalence and pattern of fractures in terms of activity and environmental risk factors. Unusually high prevalence rates of spondylolysis – a partial or complete separation of the *pars interarticularis* of vertebrae, thought to represent a stress fracture (Merbs 1996b, 2002a, 2002b; Standaert and Herring 2000) – have been linked with strenuous lifestyles (Arriaza 1997; Lessa 2011b; Merbs 1983, 1996a, 2002b). Patterns of long bone fractures are the focus of many studies of accidental trauma as it relates to lifestyle (e.g. Alvrus 1999; Domett and Tayles 2006). Certain types of fracture commonly result from accidental trips and falls, particularly fractures of the distal radius (Colles’ fractures), and clavicle fractures (Nowak *et al*. 2000; O’Neill *et al*. 1994). Several studies have identified differences in patterns of fracture trauma between rural and urban communities in the past (e.g. Grauer and Roberts 1996; Judd and Roberts 1999).

4.2.6.2.2 Osteochondritis dissecans

Osteochondritis dissecans refers to avascular necrosis of the joint surface of a bone, resulting in detachment of a segment of cartilage and subchondral bone (Lovell 1997: 142). It most commonly affects convex joint surfaces of the ankle, knee and elbow (Waldron 2009: 153–4). The precise aetiology of osteochondritis dissecans is unknown, but is thought to be traumatic (Cahill 1995; Edge and Porter 2011; Schenck and Goodnight 1996). Very few population-level bioarchaeological studies of osteochondritis dissecans exist since the condition is relatively rare.

4.2.6.2.3 Diagnosis

Fractures were identified as discontinuities in bone (Lovell 1997). Ante-mortem fractures were recognised from evidence for healing (disorganised or remodelled callus). Peri-mortem fractures were distinguished from post-mortem breaks by the presence of smooth-edged fracture lines of similar colour to the surrounding bone (Buikstra and Ubelaker 1994: 103). Fractures were classified according to mechanism of injury, i.e. blunt force, sharp force or projectile (Lovell 1997: 141-2), and by type (see Appendix 2, Table 94). Long bone fracture location was recorded by segment (Judd 2002b), and the following features were also recorded (Roberts and Connell 2004: 37):

- **Angular deformity**. The direction and magnitude (in degrees) of angulation of the distal/lateral fracture segment of long bones was estimated relative to the proximal/medial fracture segment.
- **Apposition**. The degree of contact between fractured segments was estimated as 75-100%, 50-74.9%, 25-49.9% or <25% complete.
- **Rotation**. The direction of rotation of the distal/lateral fracture segment relative to the proximal/medial fracture segment was noted where present.
- **Shortening**. This was assessed for long bones where the opposing bone was available and complete enough to be measured (in mm).
- **Secondary pathology**. The presence of any secondary pathology (e.g. osteoarthritis, infection, pseudo-arthrosis, soft tissue involvement and non-union) was recorded where present.

Osteochondritis dissecans was recognised as a roughly circular depression at the joint surface (Waldron 2009: 153-4). It is relatively common to observe small circular or oval lesions bilaterally in the proximal joint surfaces of the first metatarsals or first proximal foot phalanges; these are often recorded as osteochondritis dissecans, but are more likely to be developmental anomalies (Rogers and Waldron 1995: 29-30).

4.2.6.3 Metabolic disease

Metabolic diseases involve a disturbance in bone (re-)modelling, usually arising from nutritional and/or hormonal factors (Ortner 2003: 383). The most common metabolic bone diseases are scurvy, rickets/osteomalacia, and osteoporosis (Brickley and Ives 2008: xiii). Cribra orbitalia and porotic hyperostosis can be included under the category of metabolic disease (Roberts and Connell 2004: 38), although they are of complex aetiology (Brickley and Ives 2008: 2-3) and are included here under the category of general stress indicators.

4.2.6.3.1 Scurvy

4.2.6.3.1.1 Aetiology

Vitamin C (ascorbic acid) is vital for the synthesis of Type 1 collagen (Ortner 2003: 384). Humans cannot synthesise vitamin C and are wholly reliant on dietary intake (Brickley and Ives 2008: 41). Lack of vitamin C leads to haemorrhaging of the connective tissues, especially the periodontal and gingival tissues, owing to its effects on collagen. This results in bleeding beneath the periosteum (Brickley and Ives 2008: 49), which can trigger the formation of sub-periosteal new bone. A deficiency of ascorbic acid may be the result of low dietary intake and/or mal-absorption in the gut (Brickley and Ives 2008: 55). Scurvy was relatively common in recent historical periods (Thomas 1997), but reported prevalences for archaeological populations are generally low (Roberts and Cox 2003: 105). This may be due, in part, to difficulties in diagnosis, although many individuals with the condition probably died before skeletal lesions developed (Brickley and Ives 2008: 55)

4.2.6.3.1.2 Diagnosis

Features indicative of scurvy include the presence of deposits of new bone/porosity on the skull and/or enlarged, porous epiphyses (Waldron 2009: 132). Characteristic locations for deposits of new bone are the orbital roof, medial aspect of the coronoid process of the mandible, greater wings of the sphenoid, infraorbital foramina of the maxillae, maxillary alveolar processes and scapular body (Brickley and Ives 2008: 61; Melikian and Waldron 2003; Ortner and Ericksen 1997; Ortner *et al*. 2001).

4.2.6.3.2 Rickets and osteomalacia

4.2.6.3.2.1 Aetiology

The hormone vitamin D is necessary for the successful absorption of calcium and its mobilisation in the formation of bone (Lewis 2007: 119). Diet provides only a small proportion of an individual's requirements, the majority being synthesised within the body following exposure to ultraviolet light (Chen *et al*. 2007). In subadults, insufficiency of vitamin D means chondrocytes present in the growth plates of long bones are unable to convert unmineralised osteoid to bone, resulting in characteristic bowing of weight-bearing elements and other changes (Brickley and Ives 2008). In adults, vitamin D deficiency affects the functioning of osteoblasts and is termed osteomalacia (Lewis 2007: 119).

Low vitamin D is usually caused by lack of exposure to sunlight due to lifestyle, cultural factors or confinement because of ill health, rather than dietary factors (e.g. Dawodu *et al*. 1998). A number of genetic conditions can also lead to rickets and osteomalacia (Miller and Portale 1999). Mal-absorption of vitamin D due to persistent diarrhoeal disease is another potential cause, and insufficient calcium intake can contribute to the development of rickets (e.g. Aggarwal *et al*. 2012). In British skeletal populations, rickets increases in prevalence in the late and post-medieval periods, which has been explained with reference to increases in air pollution, poor working environments and the development of high-rise tenement buildings (Brickley and Ives 2008; Roberts and Cox 2003: 308-9).

4.2.6.3.2.2 Diagnosis

Rickets is diagnosed from the bowing of the long bones and/or the presence of enlarged, cupped and frayed/porous epiphyses, swelling of the costochondral junctions ('rachitic rosary') or areas of thinning of the skull or craniotabes (Waldron 2009: 129). Bowing of long bones will only occur in children of crawling/walking age. Additional manifestations of the disease in subadults include orbital roof porosity, deformation of the mandibular ramus, porosity of the sternal rib-ends, deformation of the ribs, deformation of the ilium, general thickening of the long bones, and *coxa vara* deformities of the femora (Brickley and Ives 2008: 90-1, 101; Brickley *et al*. 2005; Ortner 2003: 93, 394; Mays *et al*. 2006; Ortner and Mays 1998). Skeletal manifestations of adult osteomalacia include cranial vault porosity, vertebral fractures, pseudo-fractures (especially of the lateral and inferior margin of the acromial process), rib fractures, and deformation of the sternum, sacrum and pelvis, (Brickley and Ives 2008: 85, 127-29; Brickley *et al*. 2007).

4.2.6.3.3 Osteoporosis

4.2.6.3.3.1 Aetiology

Osteopenia refers to a state of reduced bone mineral density. When this leads to the development of fragility fractures, it is termed osteoporosis. In clinical settings, osteoporosis is diagnosed according to a reference mean bone mineral density or BMD (Waldron 2009: 118-9). Individuals of any age can develop osteoporosis as a sequela to an existing pathology that results in muscle disuse atrophy, including conditions causing confinement and paralysis. Post-menopausal women are at risk of developing osteoporosis because of the effects of declining oestrogen levels on bone metabolism, but both sexes experience a general age-related decline in bone mineral density due to increased endosteal bone resorption relative to periosteal apposition (Brickley and Ives 2008: 152-6, 193-7; Hughes 2000: 704; Kozlowksi and Witas 2012: 408; Waldron 2009: 118; Weaver 1998). Women achieve lower peak bone mass than males, due to a shorter growth period; hence, females also exhibit more rapid loss of bone in older age when decreased oestrogen levels lead to greater endosteal bone resorption (Duan *et al*. 2001; Riggs *et al*. 2004; Ruff and Hayes 1988). Other factors that increase the risk of osteoporosis include diet (especially vitamin D and calcium deficiency), inactivity, parity and lactation (in women), and genetic predisposition (Spencer and Kramer 1986; Stini 1990).

A number of bioarchaeological studies have examined differences in the prevalence of osteoporosis between the sexes, different age groups, and populations from different social and/or settlement contexts (e.g. Agarwal 2012; Beauchesne and Agarwal 2011; Mays 1996, 2006a; Mays *et al*. 1998; Zaki *et al*. 2009). Mays (1996) and Mays *et al*. (2008) observed a marked decline in cortical bone thickness and bone mineral density with age in females from medieval Wharram Percy comparable to that observed in women today, which led them to suggest that age-related bone loss in the past was primarily governed by genetic and hormonal factors. Agarwal (2012) examined bone microstructure in individuals from Wharram Percy and contemporaneous urban populations. She found similar patterns of age-related change in both sexes at Wharram Percy, while urban females exhibited a more marked decline with age relative to males. Agarwal (2012) explained this differences in terms of lifestyle and dietary factors that, she argues, may have exerted a significant influence on age-related bone loss in the past.

4.2.6.3.3.2 Diagnosis

The diagnosis of osteoporosis in skeletal remains is problematic. Clinically, osteoporosis is diagnosed when bone mineral density falls more than 2.5 SD below a reference mean (Waldron 2009: 119), but measurements in dry bone are not comparable with data for living patients due to post-mortem changes in bone weight and density (Weaver 1998: 29). The presence of vertebral fractures (wedge, compression or concave), Colles' fractures of the radius, and femoral neck fractures in elderly individuals is often used to diagnose osteoporosis (Brickley and Ives 2008: 159-70). Although fractures of these elements may occur at any age, the wrist, hip and spine are particularly susceptible to osteoporotic fractures owing to local bone architecture and an increased risk of falls among the elderly (Johnston and Slemenda 1994). Exceptionally 'light' bones can be suggestive of osteoporosis, but are not necessarily diagnostic, as diagenetic factors may also affect bone density (Weaver 1998: 29). In the present study, the existence Colles' fractures, vertebral compression and femoral neck fractures in elderly individuals was considered indicative of probable osteoporosis (Waldron 2009: 121).

4.2.6.4 Specific infections

Infections caused by a known pathogen (bacteria, virus, or fungus) are termed specific (Roberts and Connell 2004: 37). Specific infectious diseases that can be identified in skeletal remains include tuberculosis, brucellosis, leprosy and the treponematoses (Waldron 2009: 84). Only tuberculosis will be discussed in detail here, as other specific infections are extremely rare in Roman-period skeletal populations (Roberts and Cox: 119).

4.2.6.4.1 Tuberculosis

4.2.6.4.1.1 Aetiology

Tuberculosis is caused by one of a number of species of bacteria referred to as the *Mycobacterium* complex. The cause of most cases of tuberculosis in humans is *M. tuberculosis*, which is transmitted via droplet infection (Roberts and Buikstra 2003: 5). *M. bovis*, which affects cattle and other animals, is usually spread to humans via contact with infected animals, handling of infected meat, and consumption of infected meat and dairy products (LoBue *et al*. 2010; Ortner 2003: 227; Waldron 2009: 90-2). It also spreads by droplet inhalation (de Kantor *et al*. 2010; de la Rua-Domenech 2006). Once the bacillus enters the body, the infection spreads haematogenously from the lungs to other organs and potentially bone, although only a very small percentage (*c.* 3-5%) of infected individuals develop skeletal involvement (Roberts and Buikstra 2003: 89). Infection of the bone usually involves destruction with minimal new bone formation, but the relative extent of bone formation *vs.* destruction varies according to an individual's age and the area of the skeleton affected (Roberts and Buikstra 2003: 88). Elements with a high proportion of cancellous bone are most commonly affected, including the spine (especially the lower thoracic and lumbar vertebrae), proximal femur and other major joint surfaces (Roberts and Buikstra 2003: 89-97).

In Europe, the earliest reported cases in humans derive from Neolithic Italy (Canci *et al*. 1996; Formicola *et al*. 1987), although the origins of the disease are much older (Donoghue 2009). Tuberculosis has been confirmed in an early Neolithic female from Israel (Hershkovitz *et al*. 2008), and TB has been proposed as the cause of endocranial lesions observed in fossil *H. erectus* remains from Turkey (Kappelman *et al*. 2008), although the diagnosis has been challenged (Roberts *et al*. 2009). In the palaeopathological record, tuberculosis becomes increasingly common from the medieval period onwards (Stone *et al*. 2009: 70).

4.2.6.4.1.2 Diagnosis

Features considered pathognomic of tuberculosis are focal destruction of the vertebral bodies (Roberts and Buikstra 2003: 89), potentially leading to vertebral collapse and resultant kyphosis ('Pott's spine'). The posterior facet joints are usually spared. Extra-spinal TB is diagnosed from the presence of lytic lesions affecting one or more of the major joints, with no or little new bone formation (Waldron 2009: 95).

Other lesions may be suggestive of tuberculosis (Roberts and Buikstra 2003: 100-107). This includes periostitis at the visceral aspects of the ribs (Kelley and Micozzi 1984; Nicklisch *et al*. 2012; Stone *et al*. 2009: 69), but such lesions can also result from other pulmonary conditions, including lung cancer (Lambert 2002; Matos and Santos 2006; Pfeiffer 1991; Roberts *et al*. 1994; Santos and Roberts 2006; Wakely *et al*. 1991). A study by Mays *et al*. (2002) failed to isolate pathogenic DNA in individuals with rib lesions from Wharram Percy. Hypertrophic pulmonary osteoarthropathy (HPO) refers to widespread, symmetric periosteal new bone formation in the long bones. Like rib periostitis, it can occur in TB sufferers (Carcassi 1992) and has been proposed as a possible indicator of pulmonary TB in skeletal samples (Assis *et al*. 2011; Bathurst and Bart 2004; Mays and Taylor 2002), but it may also be linked to other pulmonary conditions. Lytic lesions and the presence of new woven or lamellar bone on the endocranial surface of the skull have been considered indicative of tuberculous meningitis (e.g. Kappelman *et al*. 2008), but are of heterogeneous aetiology (Lewis 2004; Roberts *et al*. 2009).

4.2.6.5 Non-specific indicators of health

In recent years, palaeopathological research has increasingly focused on a range of skeletal and dental features considered to represent general health stress arising from the interaction of malnutrition, disease and other factors. This includes non-specific periosteal changes, porosity at the orbital roofs and cranial vault (cribra orbitalia and cribra cranii/porotic hyperostosis), and defects in the formation of dental enamel (hypoplasia) considered to reflect physiological stress (Lewis and Roberts 1997).

4.2.6.5.1 Periostitis

4.2.6.5.1.1 Aetiology

Periostitis refers to the formation of new bone beneath the periosteum (the membrane covering the exterior surface of bones). Inflammation of the periosteum triggers the deposition of disorganised (‘woven’) sub-periosteal bone at the cortical surface[15]. If the inflammation resolves or becomes quiescent, lamellar bone will replace disorganised bone (Waldron 2009: 85). Strictly speaking, periostitis is a descriptive, rather than diagnostic, term since it describes the nature of lesions rather than their cause, and periostitis can occur as part of the disease process of specific infectious diseases (e.g. Aufderheide and Rodríguez-Martín 1998: 154, 158). In the absence of evidence for a specific cause, periostitis is usually considered to represent a response to infection (Hughes 2000: 708; Waldron 2009: 84; Weston 2012: 503). Bacterial agents that may cause periostitis include the staphylococcus and streptococcus genera (Waldron 2009:). These are widely present on the skin in both humans and animals, but lacerations or other skin conditions may allow the bacteria to enter into the blood stream. Individuals with already compromised immunity are particularly susceptible to such infections (Chiller *et al*. 2001).

Many other conditions that affect the periosteum (including trauma, ulcers and venous conditions) can trigger the formation of new bone (Aufderheide and Rodríguez-Martín 1998: 179; Nicholls 2005; Ortner 2003: 206-8; Pinheiro *et al*. 2004; Waldron 2009: 115-6; Weston 2008). Periostitis is commonly observed at the visceral aspects of the ribs and the shafts of the lower leg bones, especially the tibia (Roberts 2000a: 147). Rib periostitis may represent pulmonary infection (e.g. pneumonia, brucellosis or tuberculosis), lung cancer or irritation of the lower respiratory tract by atmospheric pollution (see above, section 4.2.6.4.1.2). The predilection for periostitis to affect the tibiae is thought to result from the relatively poor circulation of the lower legs, leading to the accumulation of bacteria (Roberts 2000a: 147). Bilateral tibia periostitis is considered a better indicator of non-specific haematogenous infection or general systemic stress than unilateral periostitis, which is more likely to represent localised infection secondary to and/or trauma, or other soft tissue conditions, such as leg ulcers or venous disorders (Aufderheide and Rodríguez-Martín 1998: 179; Roberts 2000a: 148).

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[15] Osteitis refers to involvement of the cortical bone surface, and osteomyelitis is the term applied to infection of the medullary cavity (Larsen 1999: 82-3). In the present study, no definite cases of osteitis or osteomyelitis were observed, therefore only periostitis is discussed in detail.

4.2.6.5.1.2 Diagnosis

Periostitis was recognised as new bone overlying the normal cortical bone surface. Active periostitis refers to porous or ‘woven’ bone, typically grey or brown in colour. Healed periostitis was identified from the presence of remodelled lamellar bone (Waldron 2009: 85-6). The location of the lesion and aspect of the element affected was noted (e.g. proximal tibia shaft, medial aspect).

4.2.6.5.2 Cribra orbitalia and porotic hyperostosis

4.2.6.5.2.1 Aetiology

Cribra orbitalia (CO) and porotic hyperostosis (PH) refer to porosity (‘pitting’) of the orbital roofs and ectocranial surfaces of the vault bones respectively. These conditions are widely suspected to be indicative of some form of childhood anaemia (Angel 1966, 1981; Cybulski 1977; El-Najjar *et al*. 1976; Stuart-Macadam 1985, 1987a, 1987b, 1989, 1992). Anaemia – an insufficiency of red blood cells (RBCs, erythrocytes) – arises from a decline in red blood cell production or premature red blood cell production (ineffective erythropoiesis), increased RBC destruction (haemolysis), and/or excessive blood loss. Red blood cell deficiency triggers expansion (hypertrophy/hyperplasia) of bone marrow in an attempt to produce more cells. In subadults, the main locations for RBC production are the vault elements, and marrow hyperplasia in the skull results in expansion of the diploë, causing resorption of the outer table and porosity (Walker *et al*. 2009: 111-12).

Some anaemias are inherited, while others are acquired (Garn 2002). Historically, CO and PH have been considered representative of iron deficiency anaemia specifically (Goodman and Armelagos 1989). Acquired iron deficiency anaemia (IDA) is common in low-income countries (Stoltzfus 2003; WHO 2004: 31, 112). It usually results from insufficient dietary intake of iron or mal-absorption of iron in the gut (Lewis 2007: 113-4). Iron deficiency can also occur due to pathogen-load, as the body may become hypoferremic as a means of inhibiting bacterial metabolism (Stuart-Macadam 1992). Many palaeopathologists have used the prevalence of CO/PH as an indicator of an iron deficient diet (e.g. El-Najjar *et al*. 1976), but this hypothesis has been questioned. Some studies suggests that IDA does not induce the sustained marrow hyperplasia required for the development of porosity precisely because iron is required for the production of red blood cells

(Rothschild 2012; Walker *et al*. 2009). Instead, it has been argued that an increase in RBC production (brought about by marrow hyperplasia) is actually a cause of IDA, as iron stores are depleted more rapidly (Rothschild 2012: 157). This argument has been rejected in turn (Oxenham and Cavill 2010: 2000) and, at present, the clinical evidence is disputed regarding the link between iron deficiency and marrow hyperplasia (Mays 2012b: 293).

Walker *et al*. (2009: 112) consider anaemias that arise from blood loss, excess haemolysis or ineffective erythropoiesis more likely causes of PH. This includes inherited genetic anaemias such as thalassaemia and sickle cell anaemia (Hershkovitz *et al*. 1997; Lagia *et al*. 2007). Megaloblastic anaemia involves the production of faulty red blood cells that undergo premature death, and is caused by deficiency of vitamin B12 and/or folic acid (Ortner 2003: 369; Waldron 2009: 137). Walker *et al*. (2009) and others (e.g. Dupras and Tocheri 2007; Fairgrieve and Molto 2000) have argued that PH probably represents megaloblastic anaemia arising from a combination of low dietary intake of vitamin B12/folic acid, intestinal mal-absorption due to persistent diarrhoeal disease, and blood loss caused by parasitic gut infestations.

In recent years, some researchers have questioned whether CO and PH are manifestations of the same condition. Rothschild (2012: 158) states that vault and orbital roof porosity exhibit an inverse relationship, *contra* Stuart-Macadam (1989). Mays (2012b: 292) considers that, since the diploë of the orbital roofs is continuous with that of the frontal squama, to argue that CO and PH are manifestations of the same process is logical. Walker *et al*. (2009: 120) suggested that some cases of cribra orbitalia might actually represent remodelled scorbutic lesions or traumatic sub-periosteal haematomas. In light of the difficulties in interpreting orbital and vault lesions, at present CO and PH are often treated as proxies of general stress, rather than specific disease processes (Bennike *et al*. 2005; Facchini *et al*. 2004; Keenleyside and Panayotova 2006; Piontek and Kozlowksi 2002; Walker 1986).

4.2.6.5.2.2 Diagnosis

Cribra orbitalia was identified as porosity of the orbital roofs. Healed cribra orbitalia was identified from the presence of smooth-edged lesions. Active lesions were identified from sharp edges (Mensforth *et al*. 1978: 23). Cribra orbitalia was recorded for each orbit using the grading system of Stuart-Macadam (1991). Porotic hyperostosis was identified as pitting/porosity of the ectocranial surfaces of the cranial vault bones occurring in conjunction with marrow hyperplasia, evident as hyperostosis (thickening) of the vault bones (Mann and Hunt 1995: 22; Mays 2012b: 292-3; Waldron 2009: 137).

4.2.6.5.3 Dental enamel hypoplasia

4.2.6.5.3.1 Aetiology

Hypoplasia refers to developmental defects of dental enamel resulting from a disruption in enamel formation (amelogenesis) during childhood (Hillson 1996: 165). Defects take the form of linear bands or areas of pitting in the tooth enamel, and typically affect the canines and incisors (Goodman and Rose 1990: 91; Lewis 2007: 105). DEH can reflect episodes of nutritional or disease stress during childhood (Hillson 1996: 291; Lewis and Roberts 2004: 581). Other forms of stress, including psychological stress, and physical trauma to the developing dentition, can also cause defects (Lewis 2007: 105).

Various bioarchaeological studies have examined the relationship between hypoplasia and aspects of the social and physical environment, including social status, socio-political instability, and diet and subsistence (Cucina 2002; El-Najjar *et al*. 1978; Goodman 1989; Littleton 2005; Palubeckaité *et al*. 2002; Starling and Stock 2007; van Gerven *et al*. 1990). Since the timing of tooth crown mineralisation is known, the age at which defects form can be estimated (e.g. Goodman and Rose 1990), although there is debate as to which method provides the most accurate results (Goodman and Armelagos 1985b; Hillson and Bond 1997; Ritzman *et al*. 2008). Many studies have identified a tendency for defect formation to peak at 2-4 years (Goodman *et al*. 1984, 1987; King *et al*. 2005; Moggi-Cecchi *et al*. 1994), which is often ascribed to weaning stress (Katzenberg *et al*. 1996). However, it is known that lesions are more likely to form at this age owing to the age-related pattern of enamel formation and timing of dental development (Goodman and Armelagos 1985a; Lewis 2007: 106-7).

4.2.6.5.3.2 Diagnosis

Hypoplasia was identified as linear defects, pitting, or grooves in the enamel of teeth (Waldron 2009: 244). It was recorded at the individual tooth level and the type of defect noted. The distance of each defect from the cemento-enamel junction (CEJ) was measured to the nearest 0.1 mm using digital sliding callipers. Age of defect formation was determined using the method of Goodman and Rose (1990).

4.2.6.6 Other skeletal pathology

4.2.6.6.1 Diffuse idiopathic skeletal hyperostosis

Diffuse idiopathic skeletal hyperostosis (DISH) is a condition involving ossification at the site of ligament attachments, resulting in fusion of the vertebrae and (often) the sacroiliac joints (Resnick and Niwayama 1976; Resnick *et al*. 1975). Clinical evidence points to an underlying metabolic aetiology. In contemporary populations, DISH is often associated with obesity, diabetes mellitus and older age (Denko and Malemud 2006; Kiss *et al*. 2002; Sreedharan and Li 2005). Bioarchaeological studies of DISH have focused on the apparent link with diet, with several studies identifying higher prevalences in ‘high status’ groups (Fornaciari *et al*. 2009; Jankauskas 2003; Müldner and Richards 2007b; Oxenham *et al*. 2006; Rogers *et al*. 1985; Rogers and Waldron 2001; Waldron 1985). DISH is diagnosed from the fusion of four or more contiguous vertebrae by ‘candlewax’ ossifications of the anterior longitudinal ligament with retention of the intervertebral disc space and no involvement of the posterior facet joints. This is usually confined to the right side in the thoracic region due to the pressure of blood flow in the descending aorta on the left. Additional features often seen in DISH include the presence of widespread ossifications into extra-spinal entheses, including possible ankylosis of the SIJs. Where fewer than four vertebrae are fused, incipient/subclinical DISH may be diagnosed (Waldron 2009: 77).

4.2.6.6.2 Neoplastic disease

Tumours arise due to genetic mutations that result in the loss of normal regulatory control of cell growth and division. They are classified as benign or malignant according to their mitotic rate and ability to metastasise. A large proportion of cancers are environmental in aetiology, although many have a strong hereditary component (Underwood 2000: 238). Ivory or ‘button’ osteomata on the frontal and parietal bones are relatively common (Mann and Hunt 1995: 21), but have little clinical or palaeopathological significance. Neoplasms were identified with reference to Waldron (2009: 170-90) and Ortner (2003: Ch.20) and were classified as benign or malignant, and according to the tissue of origin.

4.2.6.6.3 Congenital anomalies

Congenital anomalies are defects present from birth. Some are genetic in origin, while others may arise in the foetal period due to exposure to environmental agents (Ortner 2003: 453). Certain defects are incompatible with life, but many are benign and/or sub-clinical. The latter group includes spinal anomalies such as spina bifida occulta (Waldron 2009: 419).

4.2.6.7 Dental diseases

Along with joint disease and trauma, dental pathology is commonly observed in skeletal populations, and is widely used to inform reconstruction of past dietary habits and oral hygiene (Freeth 2000).

4.2.6.7.1 Caries

4.2.6.7.1.1 Aetiology

Dental caries result from the demineralisation of tooth enamel by acids in the oral environment produced by bacteria that metabolise carbohydrates (Hillson 1996: 269; Waldron 2009: 236-37). The prevalence of caries in skeletal samples is widely used to reconstruct diet, in particular the consumption of carbohydrates (Hillson 1979: 150). However, the relationship between the carbohydrate content of a diet and its cariogenicity is not straightforward, and other factors, such as the abrasiveness of a diet and use of teeth as tools, also contribute to caries development (Hillson 1996: 278). Caries susceptibility is also influenced by factors such as the composition of dental enamel, fluoride intake and oral hygiene (Grobleri *et al*. 2001; Ismail and Hasson 2008; Molnar and Molnar 1985; Schneider 1986).

Various factors complicate simple comparisons of caries prevalence rates between populations. Attrition and ante-mortem tooth loss complicate the estimation of prevalence rates (Hillson 2001: 256; Lukacs 1995). Accumulation of soil in occlusal surface fissures may be mistaken for incipient caries (Roberts and Connell 2004: 38-9). In the early stage of formation, caries can be very difficult to identify without the aid of magnification (Hillson 2001: 258), and error in identifying caries can affect prevalence data (Liebe-Harkort *et al*. 2010).

4.2.6.7.1.2 Diagnosis

Caries were recognised as focal destruction of tooth enamel (Waldron 2009: 237-8) and were recorded by tooth position. Lesion size was estimated as small, medium, large, or massive (=complete destruction of the crown; *cf*. Hillson 1979: Fig. 3). Caries were recorded as affecting the crown or CEJ/root. Coronal caries were further subdivided according to the aspect of the crown affected (occlusal, buccal, labial, mesial inter-proximal, or distal inter-proximal surface) after Roberts and Connell (2004).

4.2.6.7.2 Calculus

4.2.6.7.2.1 Aetiology

Calculus is a composite substance formed from mineralised bacterial plaque (Brothwell 1981: 159; Hillson 1996: 255). The aetiology of calculus is complex. As calculus is formed by mineralisation, it is more likely to develop when the oral environment is more alkaline (Lieverse 1999: 219). Diets high in protein increase oral alkalinity, thus calculus has often been linked to protein consumption (Hillson 1979: 150). However, many other factors are also known to influence calculus formation, including the chemical composition of drinking water, the abrasiveness of the diet, and physiology (Lieverse 1999). The prevalence of calculus can be difficult to determine in skeletal samples, as deposits are easily dislodged by cleaning and handling (Waldron 2009: 241).

4.2.6.7.2.2 Diagnosis

Calculus was identified as greyish-white mineralised deposits on the crowns and/or roots of teeth (Waldron 2009: 240-1). Severity was recorded as slight, moderate or severe (Brothwell 1981: 155). The location of deposits was recorded as buccal or lingual, and supra- or sub-gingival (Lieverse 1999). Calculus was recorded by tooth position.

4.2.6.7.3 Periodontal disease

4.2.6.7.3.1 Aetiology

Periodontal disease (periodontitis) is an inflammatory disease of the tissues surrounding the teeth, including bone (Waldron 2009: 239). In advanced cases, inflammation results in vertical (localised) and/or horizontal (generalised) resorption of the alveolar bone, ultimately resulting in tooth loss (Hillson 1996: 260-5). Periodontal disease is caused by the bacteria present in dental plaque (Dumitrescu and Kawamura 2010a, 2010b). Individual immune response is believed to play a role in the development of periodontal disease (Lavigne and Molto 1995). Irritation of the gingiva by calculus can contribute to the progression of periodontitis, and the two conditions are often correlated (e.g. Littleton and Frohlich 1993). Clinical studies have noted a strong correlation between periodontal disease and a number of serious illnesses, including cardiovascular and pulmonary conditions, in modern populations (e.g. Beck *et al*. 1996; Scannapieco *et al*. 2003). It is unclear whether the link between periodontal disease and these conditions is one of causation, perhaps relating to the entry of periodontitis-causing bacteria into the blood-stream, or correlation (Genco *et al*. 2002). Several bioarchaeological studies have also identified a link between periodontal disease and earlier mortality (DeWitte 2012; DeWitte and Bekvalac 2010, 2011).

4.2.6.7.3.2 Diagnosis

Periodontal disease was diagnosed when the distance between the alveolar margin and cemento-enamel junction (CEJ) was greater than 2-3 mm (Roberts and Connell 2004: 39). More complex recording systems exist (e.g. Brothwell 1981; Lavigne and Molto 1995), but are not widely employed. The presence of pitting and/or lipping of the alveolar process was also considered indicative of periodontal disease (Roberts and Connell 2004: 39; Waldron 2009: 240). Periodontal disease was recorded by tooth position. It should be noted that recording the presence of periodontal disease on the basis of the distance between the CEJ and alveolar junction is potentially problematic, as the teeth continue to erupt with increasing age, particularly when attrition is severe (Hillson 1996: 138).

4.2.6.7.4 Peri-apical lesions

4.2.6.7.4.1 Aetiology

Peri-apical lesions (‘abscesses’) represent focal destruction of the alveolar bone arising from infection of the tooth’s pulp cavity. Lesions may result from the formation of a tissue mass (granuloma) that causes resorption. An apical cyst can develop from a granuloma, and refers to the accumulation of fluid (Dias *et al*. 2007). True abscesses develop when infection leads to the accumulation of pus that eventually tracks through the bone, and exits into the oral cavity or (in the case of the upper dentition) maxillary sinus, via a fistula (Dias *et al*. 2007; Dias and Tayles 1997). Many peri-apical lesions go undetected, especially those exiting into the maxillary sinus cavity where the maxilla is intact (Waldron 2009: 242-3). The most common causes of peri-apical lesions are caries, attrition and periodontal disease (Dias and Tayles 1997; Waldron 2009: 241-2).

4.2.6.7.4.2 Diagnosis

Peri-apical lesions were identified by the presence of a sinus in the alveolar bone (Waldron 2009: 241-2), and recorded by tooth position. Sinus location was noted as external, internal or maxillary (Roberts and Connell 2004).

4.2.6.7.5 Ante-mortem tooth loss

4.2.6.7.5.1 Aetiology

Older individuals frequently exhibit ante-mortem loss of one or more teeth. The primary causes of ante-mortem tooth loss (AMTL) are caries, periodontal disease and abscesses, although trauma, continuous eruption, and extraction of teeth are also possible causes (Levers and Darling 1983; Lukacs 2007; Lunt 1992; Waldron 2009: 238). In bioarchaeological studies, AMTL is often linked to the cariogenicity of diets (e.g. Nelson *et al*. 1999), but it is also strongly correlated with age, and almost all adults aged over *c*. 50 years exhibit some degree of tooth loss (Gilmore and Crote 2012).

4.2.6.7.5.2 Diagnosis

AMTL was distinguished from post-mortem tooth loss by the presence of evidence for resorption of the socket (Waldron 2009: 239) and was recorded by tooth position.

Where third molars were absent, it was not always possible to determine whether teeth had been lost ante-mortem or were congenitally absent/unerupted.

4.2.7 *Problems and limitations in bioarchaeology*

4.2.7.1 Intrinsic and extrinsic sample biases

Skeletal populations are subject to numerous potential biases that limit interpretation (Mays 2010b: Ch.2). The initial composition of a cemetery assemblage – who is buried when, where and how – depends on a range of variables including age, gender, status, ethnicity and religious belief. Subsequently, processes occurring within the burial environment may further alter the composition of an assemblage (Waldron 2007: 28-9). Soil pH and drainage in particular exert a significant influence on the survival of human remains (Gordon and Buikstra 1981; Walker *et al*. 1988). Many other aspects of the burial environment (e.g. temperature, biotic activity and grave depth) are also important (Smith *et al*. 2007; Surabian 2011).

The survival of skeletal remains is also considerably dependent upon intrinsic properties of bone, such as size, shape, density, and the ratio of cortical-to-cancellous bone (Bello *et al*. 2006; Djurić *et al*. 2011; Guy *et al*. 2007; Stojanowski *et al*. 2002; Willey *et al*. 1997). Size exerts a fundamental influence on bone survival, as small elements have greater surface area-to-volume and lower cortical-to-cancellous bone ratios, making them more susceptible to the effects of leaching (Von Endt and Ortner 1984). Subadults tend to be under-represented in archaeological assemblages. It has been suggested that they should comprise at least *c*. 30% of a skeletal sample (Weiss 1973), but the proportions recovered are often smaller (Brothwell 1972: 82-3). This might indicate that they were less likely to receive formal burial (e.g. Ucko 1969: 270-1), but it is also probable that the intrinsic properties of subadult bones mean they survive less well. Bone mineral density is lowest in infancy, increasing throughout childhood and adolescence, and peaking between the third and fifth decades (Davies *et al*. 2005). Studies have shown that the survival of skeletal remains increases with age, and elements with a higher ratio of cortical-to-cancellous bone survive better (Bello *et al*. 2006; Djurić *et al*. 2011; Guy *et al*. 1997; Manifold 2002; Mays 1992; Paine and Harpending 1998; Walker *et al*. 1988). Marginal soil environments (very low pH and/or free draining) exacerbate poor preservation of subadult remains (Buckberry 2000). The remains of females, especially elderly women, may survive less well compared to male skeletal remains (Walker 1995: 35), as peak bone mass is greater for males and declines less rapidly in later life (Stini 1990).

Further biases can be introduced during excavation and post-excavation. Sieving grave deposits improves the retrieval of smaller adult bones, teeth and subadult remains (Payne 1972; Mays 2010b: 19-20; Mays *et al*. 2012b; Waldron 2007: 30-1), but is not always feasible. Assemblages excavated prior to the development of modern techniques are more likely to suffer from recovery biases (Buckberry 2000). Total cemetery excavations are rare; hence, any segregation of burials according to age, sex, identity and/or social status, etc., may skew findings (Mays 2010b: 17). Repeated handling of remains can result in damage and the loss of fragile elements (Caffell *et al*. 2001; Roberts and Mays 2011: 629).

4.2.7.2 The 'osteological paradox'

There are several issues concerning the relationship between living and deceased populations that have implications for the interpretation of skeletal data. Collectively, these have been termed the 'osteological paradox' (Wood *et al*. 1992). Since the skeletal and dental lesions associated with many conditions take time to develop, individuals dying in the early stages of illness may not exhibit lesions. In particular, 'frail' individuals less well adapted to survive illness are likely to die early and present no skeletal or dental manifestations of disease (Boldsen and Milner 2012: 119-20). Consequently, the true prevalence of many diseases is probably under-estimated. Wood *et al*. (1992: 345-9) refer to this problem as 'hidden heterogeneity', as osteologists cannot know the biological and social factors affecting individual frailty. A second element of the osteological paradox is selective mortality (Boldsen and Milner 2012: 120-2). Since the individuals within each age cohort in a population represent those who died at that age, they do not constitute a representative sample of all those who survived to that age and beyond (Wood *et al*. 1992: 344). For this reason, the frequency of pathological lesions in skeletal remains can also over-estimate the actual prevalence of disease in the past. Another problem in the interpretation of mortality and morbidity data concerns the demographic structure of ancient communities. Wood *et al*. (1992: 344) suggest that the pattern of age-at-death in skeletal populations is primarily influenced by fertility (rather than mortality) when populations are increasing. In a growing (non-stationary) population with high fertility, infants and children will form an increasingly large proportion of the total population. Therefore, a secular increase in the proportion of subadult deaths over time (and resultant decline in average life expectancy) could arise due to an increase in the relative size of the subadult population, but might be interpreted erroneously as indicating an increase in subadult mortality.

To illustrate the problems of the osteological paradox in bioarchaeological interpretation, Wood *et al*. (1992: 356-7) reinterpreted the skeletal evidence for changes in population health at the transition from hunter-gatherer to agricultural subsistence economies. It has been widely noted that, in general, Mesolithic hunter-gatherer populations frequently present fewer signs of infection, dental disease and general stress compared to Neolithic farmers (Larsen 1995). The traditional interpretation of this has been that Neolithic communities experienced a decline in health status due to the lower nutritional value of a cereal-based diet compared to broad-spectrum hunter-gatherer diets. In addition, agricultural communities are typically larger and denser, aiding the transmission of infectious disease (Armelagos *et al*. 1991; Cohen 1989; Cohen and Armelagos 1984; Larsen 1995). According to the ‘osteological paradox’, however, an alternative interpretation of the skeletal evidence would be that early agricultural communities were healthier than preceding Mesolithic groups and that more individuals overcame periods of ill-health and/or survived long enough to develop lesions. In response to Wood *et al*. (1992), some researchers have highlighted the fact that osteological evidence for mortality and morbidity in past societies frequently conforms to what one would expect, according to epidemiological theory (Cohen 1994; Cohen and Armelagos 1984; Goodman 1993). Furthermore, it has been argued that the problem may not be as intractable as it at first appears, since biocultural approaches that take into consideration historical and archaeological context can differentiate between mutually exclusive interpretations of skeletal data (e.g. Bennike *et al*. 2005).

4.2.8 *Data presentation and statistical analysis*

Methods of data presentation and statistical analysis used in the present study follow the recommendations of Mays *et al*. (2004). Pathology frequencies are presented in the form of crude prevalence rates (CPRs; percentage of individuals affected) and true prevalence rates (TPRs; percentage of elements/sub-elements/teeth/sockets affected), as recommended by Mays *et al*. (2004: 7). For CPRs, prevalences are calculated as the number of individuals affected as a percentage of those for whom the condition could theoretically have been observed (e.g. individuals with at least one surviving tooth for caries prevalence). CPRs for subadults exclude perinates since individuals of this age are highly unlikely to exhibit skeletal lesions and, as the Winchester sample includes significantly more perinates, including this age group would have the effect of artificially lowering subadult prevalences for this sample.

Age distributions are compared using the Kolmogorov-Smirnov statistic (after Steele 2005: 408). Adult stature means are compared between females and males, and between the samples using the *t*-test statistic (Mays *et al*. 2004: 11). To determine whether there are any differences within and between the samples in pathology prevalence, the chi-square (χ^2) statistic is used (Mays *et al*. 2004; Shennan 1997: 104-18). The level of significance was set at 5%, meaning a *p*-value of less than 0.05 indicates a 95% probability that any difference between samples is not due to chance. Yates' correction for continuity has been used for tests with one degree of freedom (d.f.=1). Unless otherwise indicated, the degree of freedom is one. Where any expected value is less than one, or 20% of expected values are less than five, the chi-squared test is invalid with or without Yates' correction.

Mays *et al*. (2004: 7) state that statistical comparisons within and between samples should only be conducted using CPRs because, 'observations on several bones or teeth from a given individual cannot be considered independent for statistical purposes'. CPRs can be problematic as they may over- or under-estimate the prevalence of a condition, if skeletal material is poorly preserved. As CPRs have been calculated to take account of skeletal completeness, this issue should be minimal. Statistical tests using TPRs have not been carried out for the reasons outlined above, with the exception of extra-spinal OA and fractures since each individual only has one right hip, left femur, etc. Many pathological conditions are positively correlated with age- and/or are sex-related. For this reason, CPRs were compared within and between samples by age and sex where possible. The results of most statistical tests are presented in Volume 2, Appendix 5.

All data recorded are contained in an Access database on the accompanying CD, and additional data for some figures are provided in Excel spreadsheets. Appendix 7 provides details on the forms and tables contained therein and instructions for using the database.

4.2.9 *Comparisons with other Romano-British populations*

To assess the extent to which the study samples are representative of public and small towns more generally, the study findings are compared with published data for contemporaneous populations. Comparanda were selected based on burial type (inhumations), sample size (preferably *c*. 50+ burials), and the quality of published data. Suitable data were available for four small towns and seven public towns (Table 9)[16]. Prevalence rates are compared between individual samples and between small and public towns using the chi-squared statistic.

Regarding chronology, the majority of assemblages, including the study samples, are of later third-to-early fifth century date, with small numbers of earlier burials. The population from Dorchester-on-Thames, Oxon, includes some later fifth and sixth century burials (Chambers *et al*. 1987). The sample from Ilchester also includes some fifth century burials. Conversely, London and Gloucester are somewhat atypical in that a relatively greater proportion of *dated* burials at these sites are of second and third century date (Barber and Bowsher 2000: 10; Simmonds *et al*. 2008: 9-13).

Raw prevalence data for comparative populations are collated in Appendix 6. In many cases, data from one or more sites could not be included for comparison due incompatible methodologies.

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[16] It should be noted that the sample from Dorchester-on-Thames, Oxon, is referred to as ‘Dorchester’ throughout the remainder of the text, and the population from Dorchester (*Durnovaria*), Dorset, is referred to as ‘Poundbury’ (Farwell and Molleson 1993).

Table 9. Details of other Romano-British populations used for comparison.

Public Towns*	**Cemetery**	**Date (cents. AD)**	**Sample Size[1]**	**Reference[2]**
Cirencester (Gloucs)	Bath Gate (South of Fosse Way)	Late 3rd-early 5th	362	McWhirr *et al*. 1982; Wells 1982
Colchester (Essex)	Butt Road (Phase 2)	Early 4th-early 5th	669	Crummy *et al*. 1993; Pinter-Bellows 1993
Dorchester[3] (Dorset)	Poundbury (Late Roman)	Late 3rd–early 5th	1074	Farwell and Molleson 1993; Molleson 1993
Gloucester[4] (Gloucs)	London Road	Late 1st-4th	63	Simmonds *et al*. 2008; Márquez-Grant and Loe 2008
Leicester (Leics)	Newarke Street	4th	54	Cooper 1996; Wakely and Carter 1996
London[5]	West	Mid-1st-early 5th	137	MoL West
York[6] (N Yorks)	Trentholme Drive	2nd-4th	262	Peck 2009
Small Towns**	**Cemetery**	**Date**	**Sample Size[1]**	**Reference[2]**
Baldock (Herts)	California Cemetery (BAL-1)	Late 2nd- 6th	132	Fitzpatrick-Matthews and Burleigh 2007; Roberts 2007
Dorchester-on-Thames (Oxon)[7]	Queenford Farm Queenford Mill	4th-6th	162	Chambers *et al*. 1987; Harman 1987; Harman *et al*. 1979
Godmanchester (Cambs)	The Parks	4th	64	Jones 2003; Brickley 2003
Ilchester[8] (Somer)	Little Spittle and Townsend Close	4th-early 5th	59	Leach 1982; Everton and Rogers 1982

[1] Inhumations only.

[2] First reference is for the site report; second citation refers to the bone report.

[3] It should be noted that, while the majority of burials at Poundbury derived from the Main Late Roman cemetery, the total sample studied by Molleson (1993) included some earlier burials and some late Roman burials from peripheral burial areas that may or may not have been part of the Main cemetery. Molleson does not always make clear whether these earlier burials and late Roman peripheral burials were included in prevalence data.

[4] This does not include the burials from the late second/early third century mass burial.

[5] The largest sample of burials from London is from the Eastern Cemetery (550 individuals). However, the published bone report (Conheeney 2000) provides limited data, as it summarises data collected by several researchers. Therefore, data for the Western Cemetery provided in the Museum of London Wellcome database are used.

[6] The original report on the human remains from Trentholme Drive (Warwick 1968) is somewhat dated; Peck's (2009) study has been used, as the methods of analysis and data presentation are more comparable with the present study.

[7] The samples from the 1972 and 1981 excavations have been combined in most instances.

[8] Burials excavated from the two sites have been combined.

*The sample from Lankhills recently analysed by Clough and Boyle (2010) is not generally included in the discussion. Assuming that the sample analysed in the present study, and the Lankhills sample, are both representative of the same community, to include the latter would effectively result in duplication.

**A sample of 112 individuals excavated at Dunstable provides one of the largest assemblages from a small town after Ancaster, Baldock and Ashton (the last of which is unpublished). Unfortunately, osteological data provided in the published report (Matthews *et al*. 1981) are very limited; hence, this site could not be included.

5 Results

5.1 Preservation

5.1.1 *Skeletal completeness*

In both samples, the majority of individuals are at least 50% complete (Table 10 and Table 11). Subadults (particularly perinates) are less complete than adults, and females are slightly less well preserved than males, although there are no statistically significant differences in preservation between age groups or the sexes within either sample (Test 1). When the study samples are compared, the Ancaster sample is better preserved than the Winchester sample (Figure 15), and the difference in completeness is statistically significant in the case of adults (Test 2).

Table 10. Skeletal completeness: Ancaster.
(N^1=number of individuals in category; N^2=total number of individuals.)

		1 (≥75%)		**2 (50-74.9%)**		**3 (25-49.9%)**		**4 (<25%)**	
Subadults	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Perinate	18	1	5.6	6	33.3	7	38.9	4	22.2
<1	6	0	0.0	2	33.3	2	33.3	2	33.3
1-5	24	7	29.2	7	29.2	6	25.0	4	16.7
6-11	18	8	44.4	6	33.3	0	0.0	4	22.2
12-17	5	3	60.0	0	0.0	0	0.0	2	4.0
US	4	0	0.0	0	0.0	0	0.0	4	100.0
Total subadults	75	19	25.3	21	28.0	15	20.0	20	26.7
Adults	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	17	4	23.5	7	41.2	4	23.5	2	11.8
25-34	59	24	40.7	17	28.8	12	20.2	6	10.2
35-49	49	16	32.7	21	42.9	8	16.3	4	8.2
≥50	35	13	37.1	13	37.1	5	14.3	4	11.4
UA	36	2	5.6	3	8.3	13	36.1	18	50.0
Total adults	196	59	30.1	61	31.1	42	21.4	34	17.3
Females	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	9	1	11.1	3	33.3	4	44.4	1	11.1
25-34	25	11	44.0	5	20.0	7	28.0	2	8.0
35-49	16	4	25.0	8	50.0	3	18.8	1	6.3
≥50	15	4	26.7	5	33.3	3	20.0	3	20.0
UA	13	1	7.7	2	15.4	7	53.8	3	23.1
Total females	78	21	26.9	23	29.5	24	30.8	10	12.8
Males	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	8	3	37.5	4	50.0	-	-	1	12.5
25-34	34	13	38.2	12	35.3	5	14.7	4	11.8
35-49	32	12	37.5	13	40.6	5	15.6	2	6.3
≥50	18	9	50.0	7	38.9	2	11.1	-	-
UA	13	1	7.7	1	7.7	4	30.8	7	53.8
Total males	105	38	36.2	37	35.2	16	15.2	14	13.3
Total sample	**271**	**78**	**28.8**	**82**	**30.2**	**57**	**21.0**	**54**	**19.9**

Table 11. Skeletal completeness: Winchester.
(N^1=number of individuals in category; N^2=total number of individuals.)

		1 (≥75%)		2 (50-74.9%)		3 (25-49.9%)		4 (<25%)	
Subadults	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Perinate	56	4	7.1	24	42.9	14	25.0	14	25.0
<1	12	2	16.7	5	41.7	4	33.3	1	8.3
1-5	24	2	8.3	10	41.7	6	25.0	6	25.0
6-11	18	4	22.2	7	38.9	3	16.7	4	22.2
12-17	17	10	58.8	3	17.6	3	17.6	1	5.9
US	3	0	0.0	0	0.0	0	0.0	3	100.0
Total subadults	130	22	16.9	49	37.7	30	23.1	29	22.3
Adults	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	31	8	25.8	10	32.3	9	29.0	4	12.9
25-34	36	14	38.9	13	36.1	7	19.4	2	5.6
35-49	36	15	41.7	5	13.9	11	30.6	5	13.9
≥50	32	10	31.3	15	46.9	5	15.6	2	6.3
UA	65	2	3.1	7	10.8	12	18.5	44	67.7
Total adults	200	49	24.5	50	25.0	44	22.0	57	28.5
Females	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	14	1	7.1	7	50.0	4	28.6	2	14.3
25-34	18	8	44.4	6	33.3	4	22.2	-	-
35-49	10	4	40.0	1	10.0	4	10.0	1	10.0
≥50	12	4	33.3	6	50.0	1	8.3	1	8.3
UA	13	2	15.4	3	23.1	3	23.1	5	38.5
Total females	67	19	28.4	23	34.3	16	23.9	9	13.4
Males	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	15	7	46.7	3	20.0	5	33.3	-	-
25-34	16	6	37.5	7	43.8	2	12.5	1	6.3
35-49	25	11	44.0	4	16.0	7	28.0	3	12.0
≥50	19	6	31.6	9	47.4	3	15.8	1	5.3
UA	18	-	-	4	22.2	7	38.9	7	38.9
Total males	93	30	32.3	27	29.0	24	25.8	12	12.9
Total sample	**330**	**71**	**21.5**	**99**	**30.0**	**74**	**22.4**	**86**	**26.1**

Figure 15. Graph comparing skeletal completeness between the samples.

5.1.2 *Bone surface preservation*

In both populations, adults exhibit better preservation than subadults (Table 12 and Table 13). In contrast to skeletal completeness, perinates and infants are better preserved than older subadults. Ancaster males are better preserved than females, while the opposite is true for Winchester. There are no statistically significant differences in preservation between age groups within either sample. The difference between the sexes is statistically significant for Ancaster but not Winchester (Test 3). Overall, preservation is better for Winchester (Figure 16) and the difference between the samples is statistically significant (Test 4).

Table 12. Bone surface preservation: Ancaster.
(N^1=number of individuals in category; N^2=total number of individuals.)

		1 (Good)		**2 (Moderate)**		**3 (Poor)**	
Subadults	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Perinate	18	15	83.3	2	11.1	1	5.6
<1	6	5	83.3	0	0.0	1	16.7
1-5	24	16	16.7	8	33.3	0	0.0
6-11	18	13	72.2	5	27.8	0	0.0
12-17	5	3	60.0	2	40.0	0	0.0
US	4	2	50.0	1	25.0	1	25.0
Total subadults	75	54	72.0	18	24.0	3	4.0
Adults	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	17	12	70.6	5	29.4	0	0.0
25-34	59	45	76.3	12	20.3	2	3.4
35-49	49	42	85.7	6	12.2	1	2.1
≥50	35	25	71.4	10	28.6	0	0.0
UA	36	20	55.6	12	33.3	4	11.1
Total adults	196	144	73.5	45	23.0	7	3.5
Females	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	9	5	55.6	4	44.4	-	-
25-34	25	16	64.0	8	32.0	1	4.0
35-49	16	13	81.3	3	18.7	-	-
≥50	15	10	66.7	5	33.3	-	-
UA	13	5	38.5	6	46.2	2	15.4
Total females	78	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Males	**N^2**	**N**	**%**	**N**	**%**	**N**	**%**
18-24	8	7	87.5	1	12.5	-	-
25-34	34	29	85.3	4	11.8	1	2.9
35-49	32	28	87.5	3	9.4	1	3.1
≥50	18	13	72.2	5	27.8	-	-
UA	13	8	61.5	3	23.1	2	15.4
Total males	105	85	81.0	16	15.2	4	3.8
Total sample	**271**	**198**	**73.1**	**63**	**23.2**	**10**	**3.7**

Table 13. Bone surface preservation: Winchester.
(N^1=number of individuals in category; N^2=total number of individuals.)

		1 (Good)		**2 (Moderate)**		**3 (Poor)**	
Subadults	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Perinate	56	55	98.2	1	1.8	0	0.0
<1	12	10	83.3	1	8.3	1	8.3
1-5	24	23	95.8	1	4.2	0	0.0
6-11	18	9	50.0	7	38.9	2	11.1
12-17	17	13	76.5	3	17.6	1	5.9
US	3	3	100.0	0	0.0	0	0.0
Total subadults	130	113	86.9	13	10.0	4	3.1
Adults	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	31	27	87.1	4	12.9	0	0.0
25-34	36	32	88.9	3	8.3	1	2.8
35-49	36	33	91.7	3	8.3	0	0.0
≥50	32	29	90.6	3	9.4	0	0.0
UA	65	54	83.1	9	13.8	2	3.1
Total adults	200	175	87.5	22	11.0	3	1.5
Females	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	14	12	85.7	2	14.3	-	-
25-34	18	17	94.4	1	5.9	-	-
35-49	10	10	100.0	-	-	-	-
≥50	12	11	91.7	1	9.1	-	-
UA	13	13	13.0	-	-	-	-
Total females	67	63	94.0	4	6.0	0	0.0
Males	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
18-24	15	13	86.7	2	13.3	-	-
25-34	16	14	87.5	2	12.5	-	-
35-49	25	23	92.0	2	8.0	-	-
≥50	19	19	100.0	-	-	-	-
UA	18	15	83.3	2	11.1	1	5.6
Total males	93	82	88.2	10	10.8	1	1.1
Total sample	**330**	**288**	**87.3**	**35**	**10.6**	**7**	**2.1**

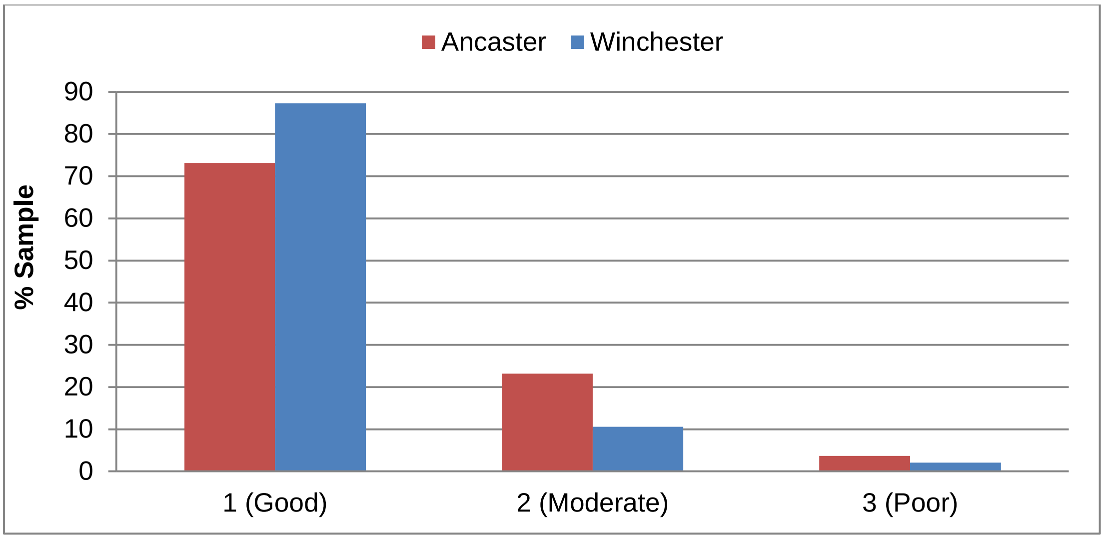

Figure 16. Graph comparing bone surface preservation between the samples.

5.1.3 *Skeletal element survival rates*[17]

In both samples, subadult elements are less well represented than adult elements (Figure 17 and Figure 18). The representation of perinatal/infant elements is particularly poor, especially for the bones of the face. The major elements, such as the femur, are better represented. Among the adults, small elements (e.g. carpals), fragile elements (e.g. scapular body, sternum) and those with a higher ratio of cancellous:cortical bone (e.g. articular ends of long bones) are poorly preserved. Female elements are less well represented than male elements in both samples, and the difference is statistically significant in several cases (Test 5). The pattern of element survival is similar for both samples, with the exception of survival rates for the zygomatic, although survival rates are higher for Ancaster in most cases (Figure 19). The difference in survival rates is statistically significant for many elements/element groups (Test 6 and Test 7). In the case of subadults, the preponderance of perinates in the Winchester sample should be borne in mind, particularly regarding the representation of cranio-facial elements.

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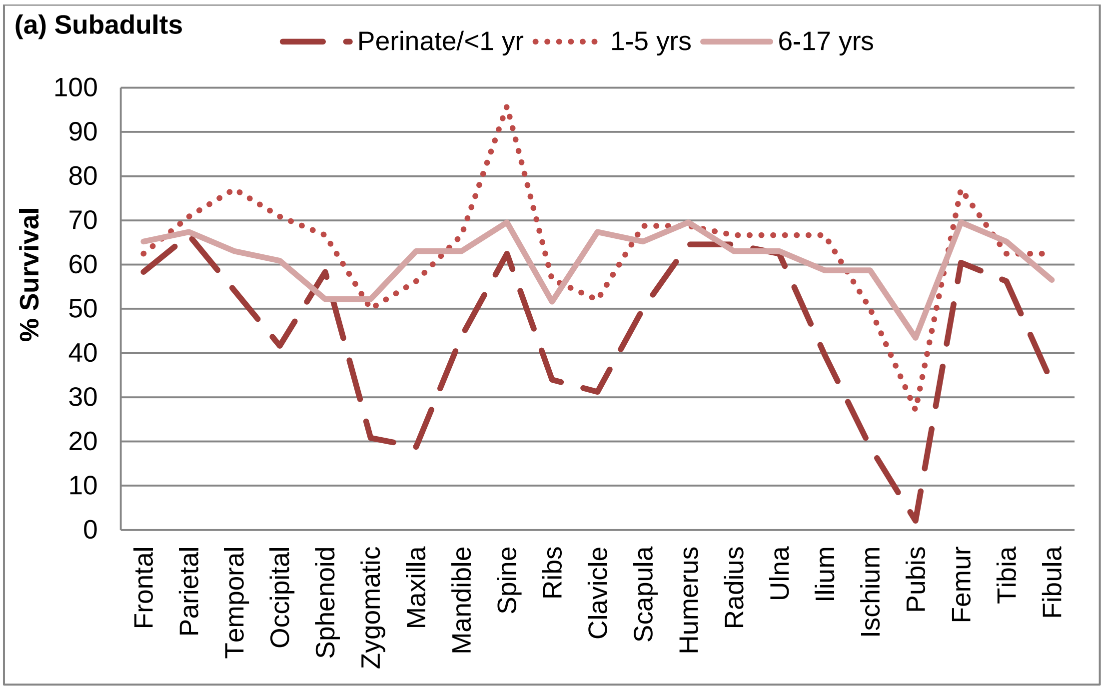
[17] Data for perinates/infants, and older children/adolescents have been combined for manageability. Detailed data by skeletal (sub)-element by individual age group are provided on the accompanying CD.



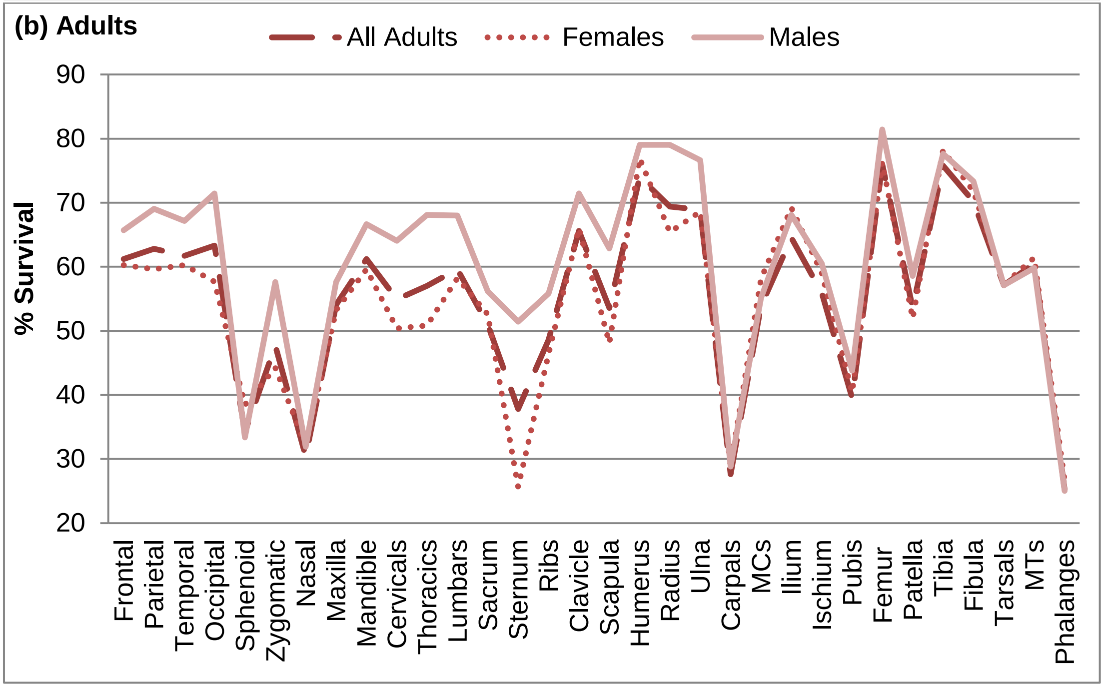


Figure 17. Graphs showing skeletal element survival rates for (a) subadults and (b) adults in the Ancaster sample.
(N.B. Subadults: spine, ribs, hands/feet=percentage of individuals with at least one element; Adults: spine, ribs, hands/feet=percentage of elements.)

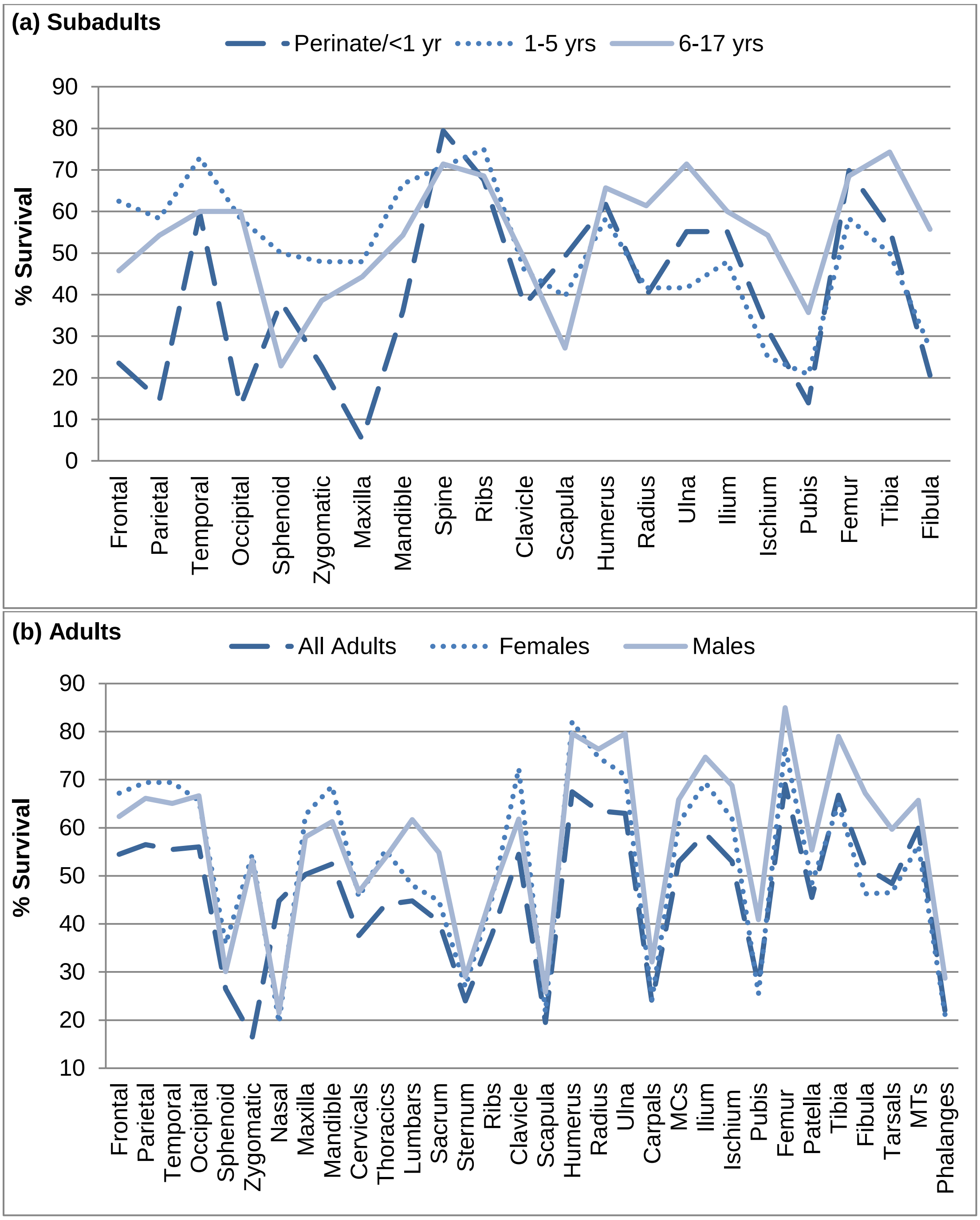
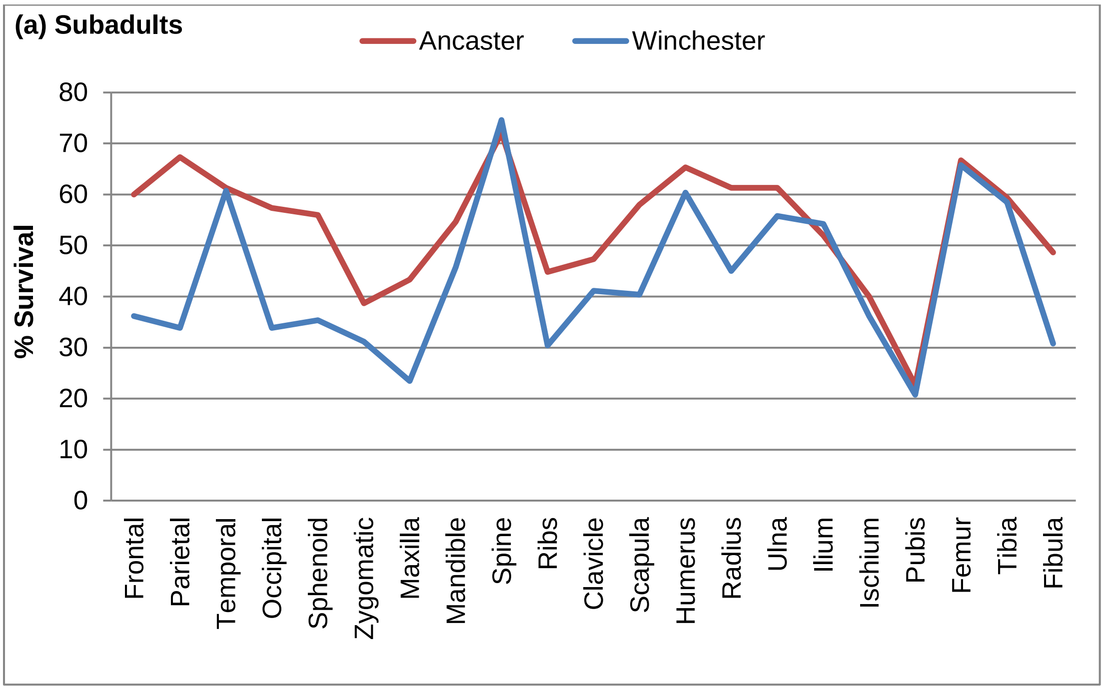


Figure 18. Graphs showing skeletal element survival rates for (a) subadults and (b) adults in the Winchester sample.
(N.B. Subadults: spine, ribs, hands/feet=percentage of individuals with at least one element; Adults: spine, ribs, hands/feet=percentage of elements.)



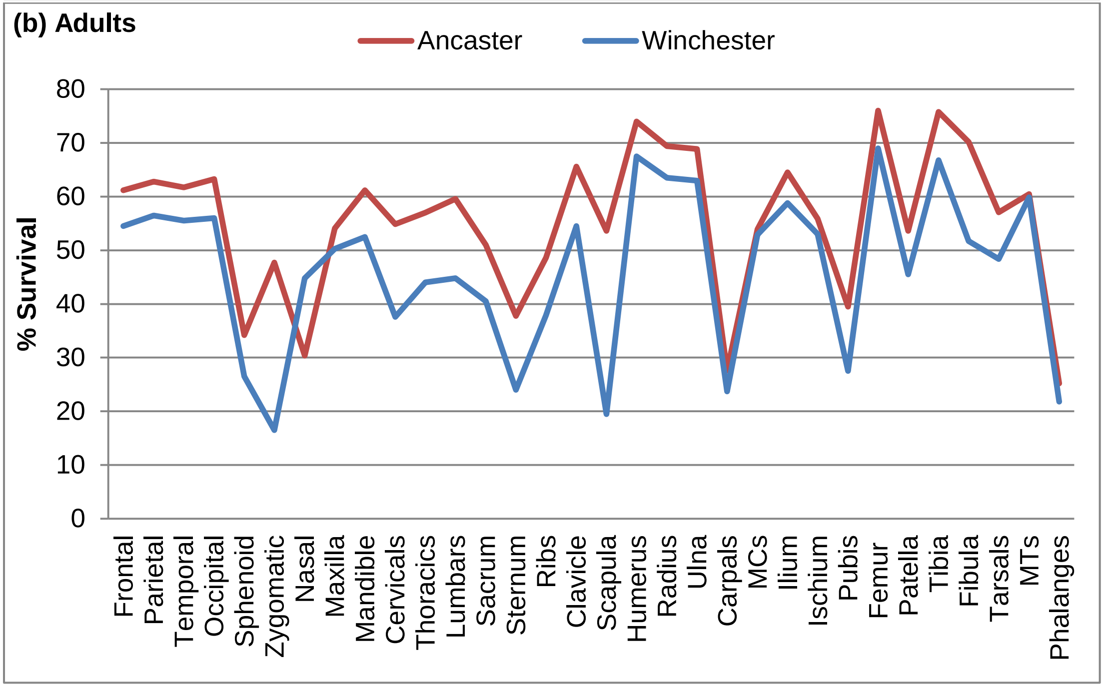


Figure 19. Graphs comparing element survival rates between (a) subadults and (b) adults in the study samples.
(N.B. Subadults: spine, ribs, hands/feet=percentage of individuals with at least one element; Adults: spine, ribs, hands/feet=percentage of elements.)

5.2 Demography

5.2.1 *Total samples*

There are 271 individuals from Ancaster, and 330 from Winchester (Table 14 and Table 15). In both samples, adults outnumber subadults. In the Ancaster sample the adult-to-subadult ratio is 2.6 and the ratio of subadults aged <1-to-1-17 yrs is 0.5. In the Winchester sample, the adult-to-subadult ratio is 1.5 and the ratio of subadults aged <1-to-1-17 yrs is 1.2. Compared to an approximate adult-to-subadult ratio of 2.0 (Weiss 1973), the ratio for Ancaster is not quite statistically significant (χ^2=3.638, d.f.=1, *p*=0.056), but it is significant for Winchester (χ^2=5.185, d.f.=1, *p*=0.023). When the adult-to-subadult ratios are compared between the samples, the difference is statistically significant (χ^2=8.578, d.f.=1, *p*=0.003). The difference in the ratios of subadults <1-to-1-17 yrs is also statistically significant (χ^2=6.363, d.f.=1, *p*=0.012). The difference in the distribution of aged individuals (i.e. the total samples excluding unaged individuals) is statistically significant (D_{max}=0.22, KSZ=2.438, *p*=0.979). This may be largely due to the greater number of subadults (especially perinates) in the Winchester sample.

Males outnumber females in both samples. The sex ratio for Ancaster is 1.3 and for Winchester it is 1.4. When compared to an expected sex ratio of 1.0 (Brothwell 1981: 74), the Ancaster sex ratio is not quite significantly different (χ^2=3.694, d.f.=1, *p*=0.055), but the Winchester sex ratio is significantly higher (χ^2=3.906, d.f.=1, *p*=0.048). The difference between the samples is not statistically significant (χ^2=0.001, d.f.=1, *p*=0.975). Figure 20 compares mortality and survivorship[18]. The subadult age distributions are similar despite the greater number of perinates from Winchester. The most notable difference between the samples in adult mortality is the greater proportion of prime and mature adults at Ancaster. The proportion of unaged adults is greater in the Winchester sample, reflecting poorer preservation. Life expectancy at birth is 29.3 years for Ancaster and 25.4 for Winchester. When adult age-at-death is compared, the difference is not statistically significant (D_{max}=0.14, KSZ=0.2, *p*=0.999).

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[18] See Appendix 3 for life table data (Chamberlain 2006: 27-31).

Table 14. Age and sex composition: Ancaster.
(N=number of individuals; %^{1}=percentage of subadults/adults; %^{2}=percentage of total sample.)

	N/%^{1}						**N/%^{2}**
Subadults	**F**	**F?**	**I**	**M?**	**M**	**U**	**Total**
Perinate	-	-	-	-	-	18/24.0	**18/6.6**
<1	-	-	-	-	-	6/8.0	**6/2.2**
1-5	-	-	-	-	-	24/32.0	**24/8.9**
6-11	-	-	-	-	-	18/24.0	**18/6.6**
12-17	-	-	-	-	-	5/6.7	**5/1.8**
US	-	-	-	-	-	4/5.3	**4/1.5**
Total (N/%^{1})	-	-	-	-	-	75/100.0	**75/27.7**
Adults	**F**	**F?**	**I**	**M?**	**M**	**U**	
18-24	6/3.1	3/1.5	0/0.0	3/1.5	5/2.6	0/0.0	**17/6.3**
25-34	18/9.2	7/3.6	0/0.0	13/6.6	21/10.7	0/0.0	**59/21.8**
35-49	11/5.6	5/2.6	0/0.0	8/4.1	24/12.2	1/0.5	**49/18.1**
≥50	12/6.1	3/1.5	2/1.0	5/2.6	13/6.6	0/0.0	**35/12.9**
UA	5/2.6	8/4.1	3/1.5	11/5.6	2/1.0	7/3.6	**36/13.3**
Total (N/%^{1})	52/26.5	26/13.3	5/2.6	40/20.4	65/33.2	8/4.1	**196/72.3**
Total (N/%^{2})	**52/19.2**	**26/9.6**	**5/1.8**	**40/14.8**	**65/24.0**	**83/30.6**	**271/100**

Table 15. Age and sex composition: Winchester.
(N=number of individuals; %^{1}=percentage of subadults/adults; %^{2}=percentage of total sample.)

	N/%^{1}						**N/%^{2}**
Subadults	**F**	**F?**	**I**	**M?**	**M**	**U**	
Perinate	-	-	-	-	-	56/43.1	**56/17.0**
<1	-	-	-	-	-	12/9.2	**12/3.6**
1-5	-	-	-	-	-	24/18.5	**24/7.3**
6-11	-	-	-	-	-	18/13.8	**18/5.5**
12-17	-	-	-	-	-	17/13.1	**17/5.2**
US	-	-	-	-	-	3/2.3	**3/0.9**
Total (N/%^{1})	-	-	-	-	-	130/100	**130/39.4**
Adults	**F**	**F?**	**I**	**M?**	**M**	**U**	
18-24	6/3.0	8/4.0	0/0.0	6/3.0	9/4.5	2/1.0	**31/9.4**
25-34	13/6.5	5/2.5	2/1.0	5/2.5	11/5.5	0/0.0	**36/10.0**
35-49	6/3.0	4/2.0	0/0.0	5/2.5	20/10.0	1/0.5	**36/10.9**
≥50	10/5.0	2/1.0	0/0.0	6/3.0	13/6.5	1/0.5	**32/9.7**
UA	5/2.5	8/4.0	2/1.0	14/7.0	4/2.0	32/16.0	**65/19.7**
Total (N/%^{1})	40/20.0	27/13.5	4/2.0	36/18.0	57/28.5	36/18.0	**200/60.6**
Total (N/%^{2})	**40/12.1**	**27/8.3**	**4/1.2**	**36/10.9**	**57/17.3**	**166/50.3**	**330**

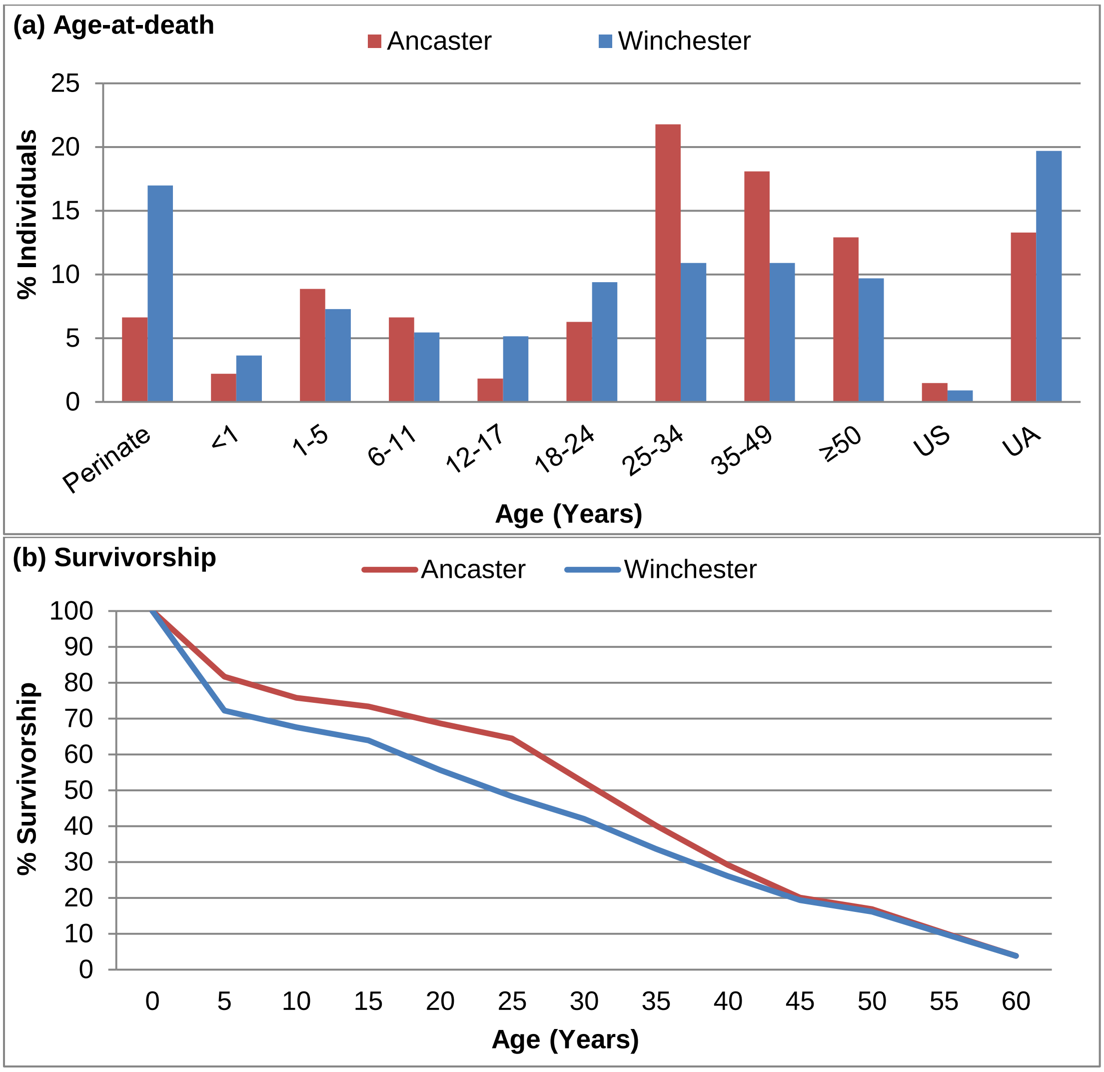


Figure 20. Graphs comparing age-at-death and survivorship curves between the samples.

5.2.2 *Subadult age-at-death*

The subadult age categories used in the present study are relatively broad, and may conceal subtler differences between the samples. Therefore, subadult mortality is also compared using narrower age categories (Figure 21). In both samples, mortality peaks in the first year of life. In the Ancaster sample, there is a second smaller peak at 2.6-6.5 years, while for Winchester, subadult deaths are more evenly distributed across the remaining age groups. In terms of perinatal/infant mortality, there are more premature perinates in the Winchester sample, while there are more post-neonates in the Ancaster sample (Figure 22).

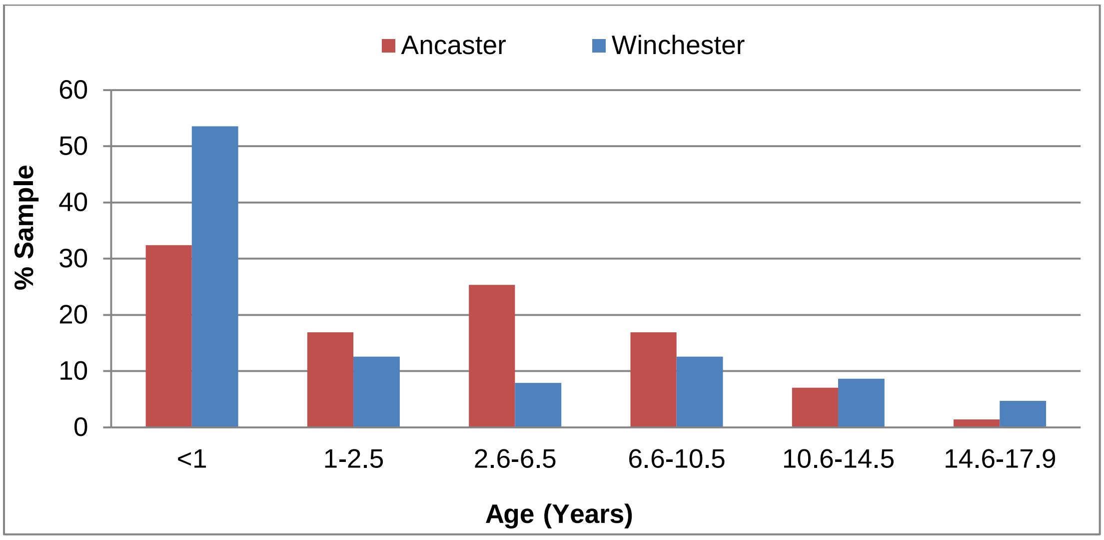


Figure 21. Graph comparing subadult age-at-death between the samples.
(N.B. Where age estimates crossed ranges, the mid-point was used, e.g. 6-8 yrs=7 yrs.)

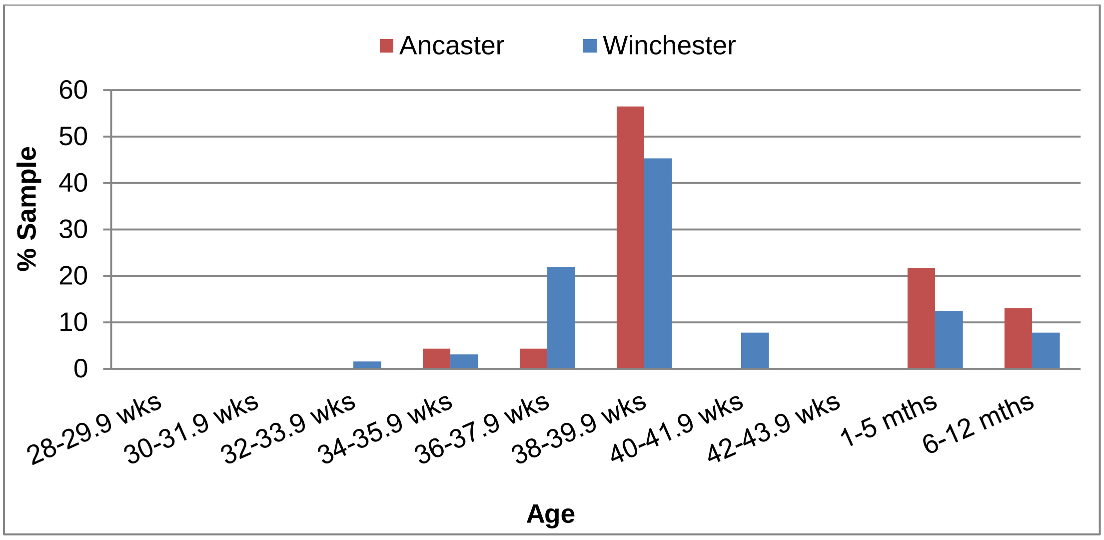


Figure 22. Graph comparing perinatal and infant age-at-death between the samples.
(N.B. Some individuals could be identified only as 'perinates', and have been excluded.)

5.2.3 *Adult age-at-death*

In the Ancaster sample, females and males exhibit a similar pattern of mortality and survivorship (Figure 23). Proportionally, there are more young and prime females, but there are also more elderly females. Life expectancy is 23.3 years for females and 23.4 years for males (see life table data, Appendix 3). Survivorship curves are similar for both sexes. Male survivorship is slightly greater up to 40 years, from which point it is overtaken by female survivorship.

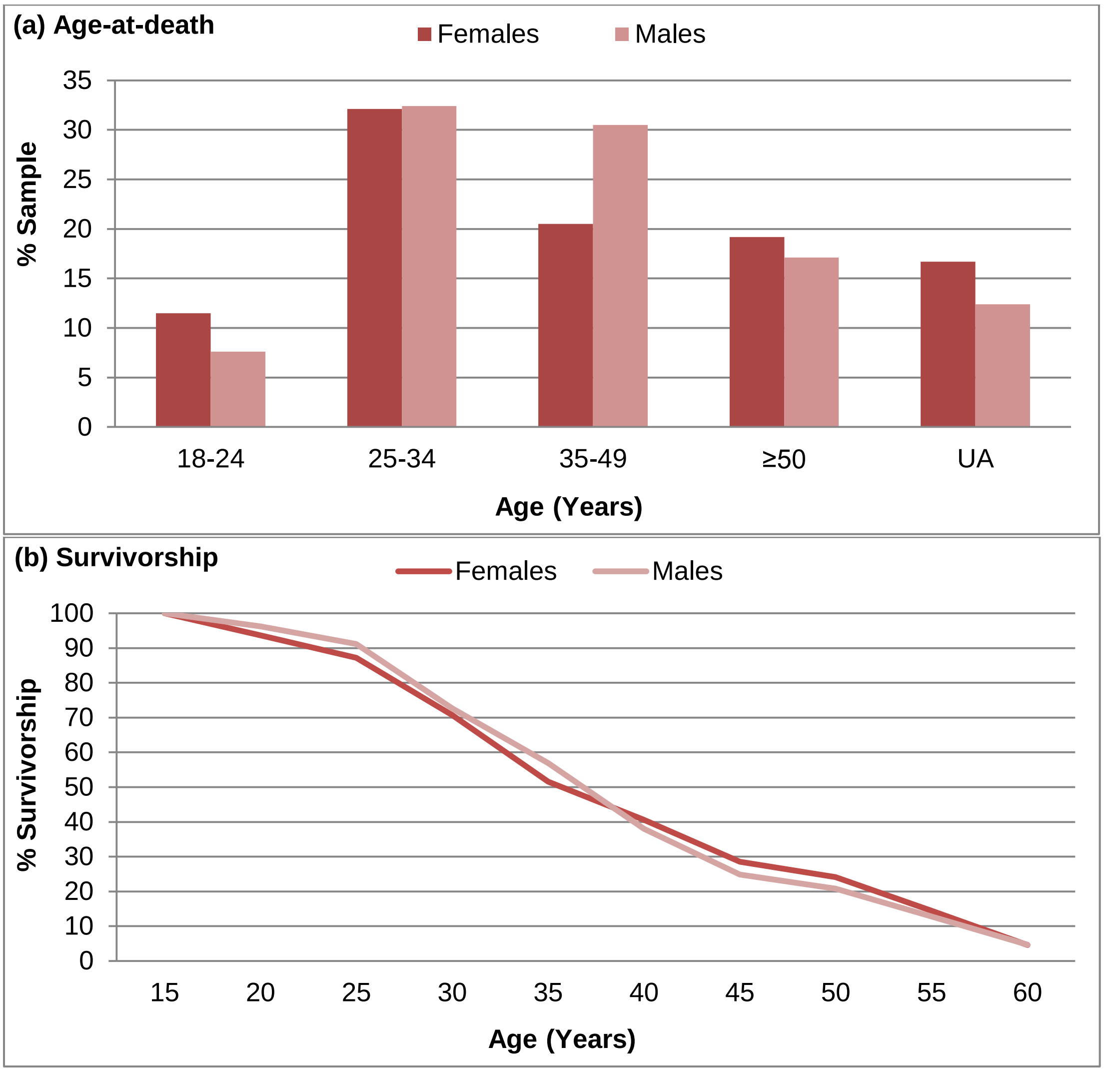
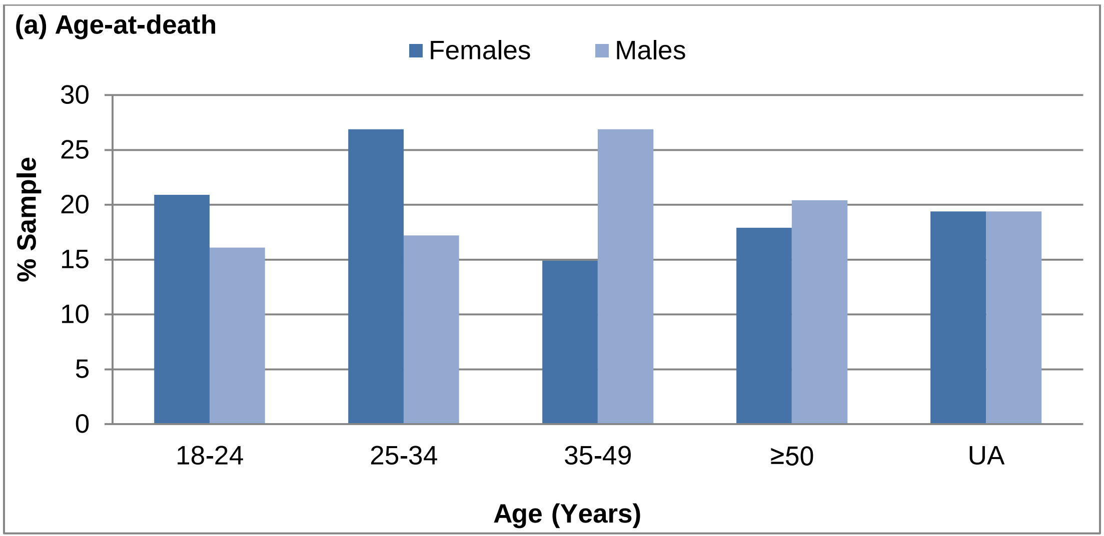
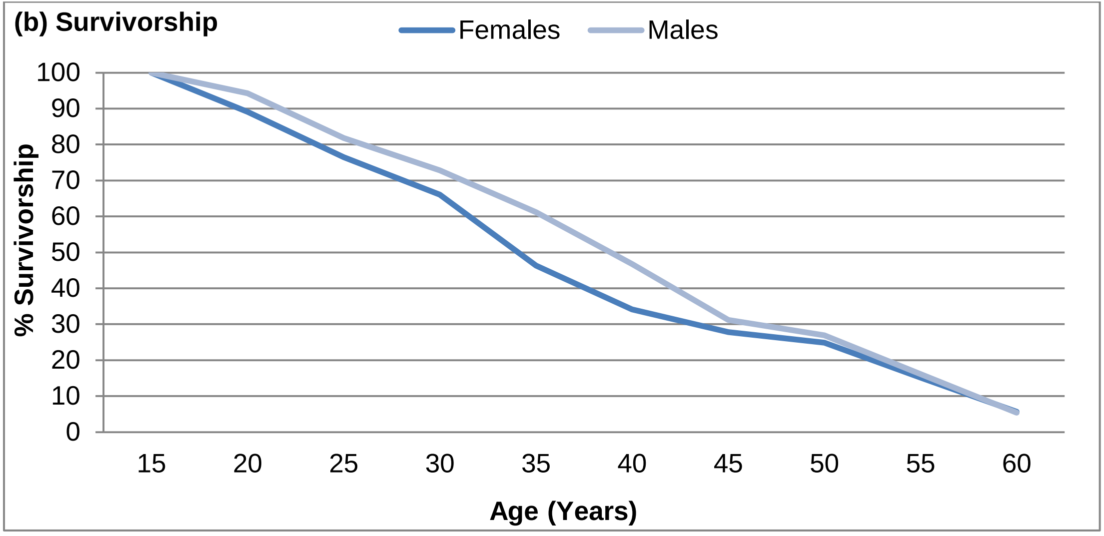


Figure 23. Graphs comparing age-at-death and survivorship curves between females and males: Ancaster.

In the Winchester sample, the majority of females fall into the prime age group, while most males fall into the mature age group (Figure 24). At 15 years, life expectancy for females is 21.8 years, compared to 24.3 years for males (see life table data, Appendix 3). Figure 24 compares survivorship curves for females and males.



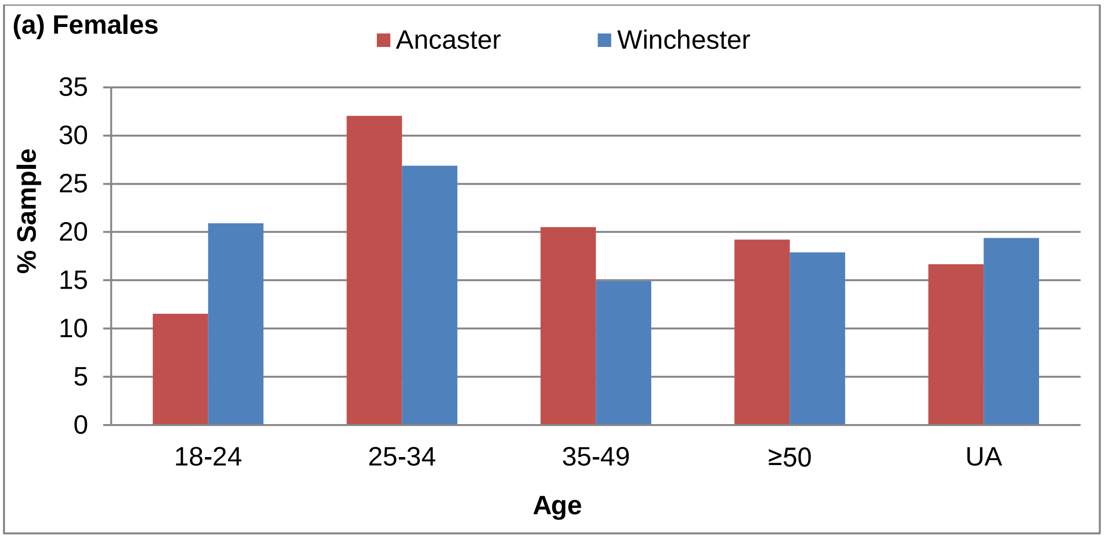
(a) Age-at-death



(b) Survivorship

Figure 24. Graphs comparing age-at-death and survivorship curves between females and males: Winchester.

Figure 25 compares female and male age-at-death between the samples. The pattern of female mortality differs little between the samples, with the exception that the relative proportions of young and prime females are reversed, and fewer Winchester females survived to elderly adulthood. The Winchester sample differs from Ancaster in that proportionally more males died in young adulthood, but more survived to elderly adulthood.



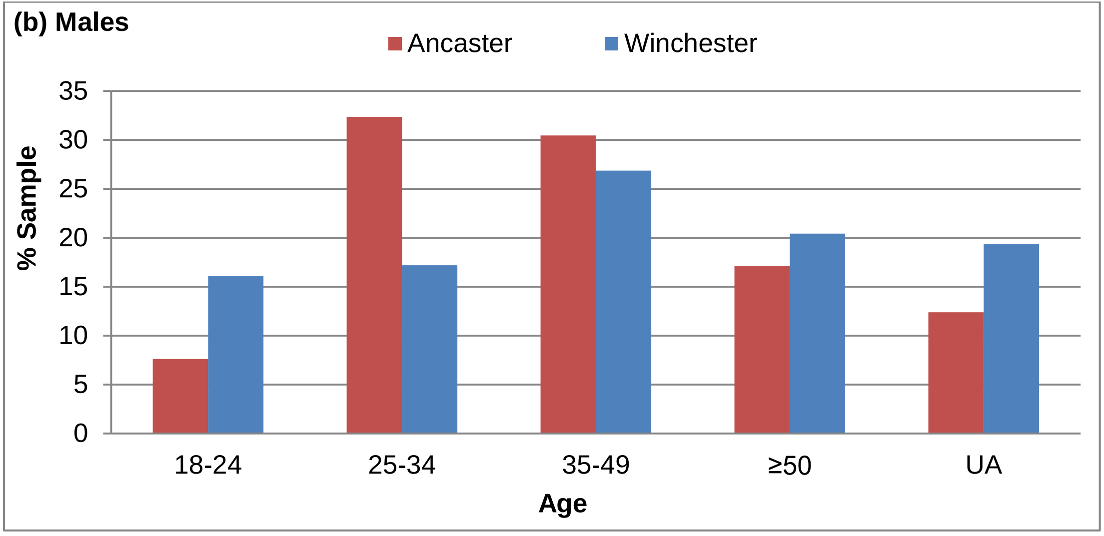


Figure 25. Graphs comparing the distribution of female and male age-at-death between the samples.

5.3 Growth and Stature

5.3.1 *Subadult growth curves*

Dental, epiphyseal and metric age estimates are available for 27 subadults from Ancaster and 31 from Winchester. Figure 26 compares subadult growth curves. Broadly speaking, Ancaster subadults exhibit growth retardation from *c.* 6.5 years onwards in comparison to the Winchester sample. The small number of individuals for whom both dental age estimates and complete long bone lengths are available should be borne in mind.

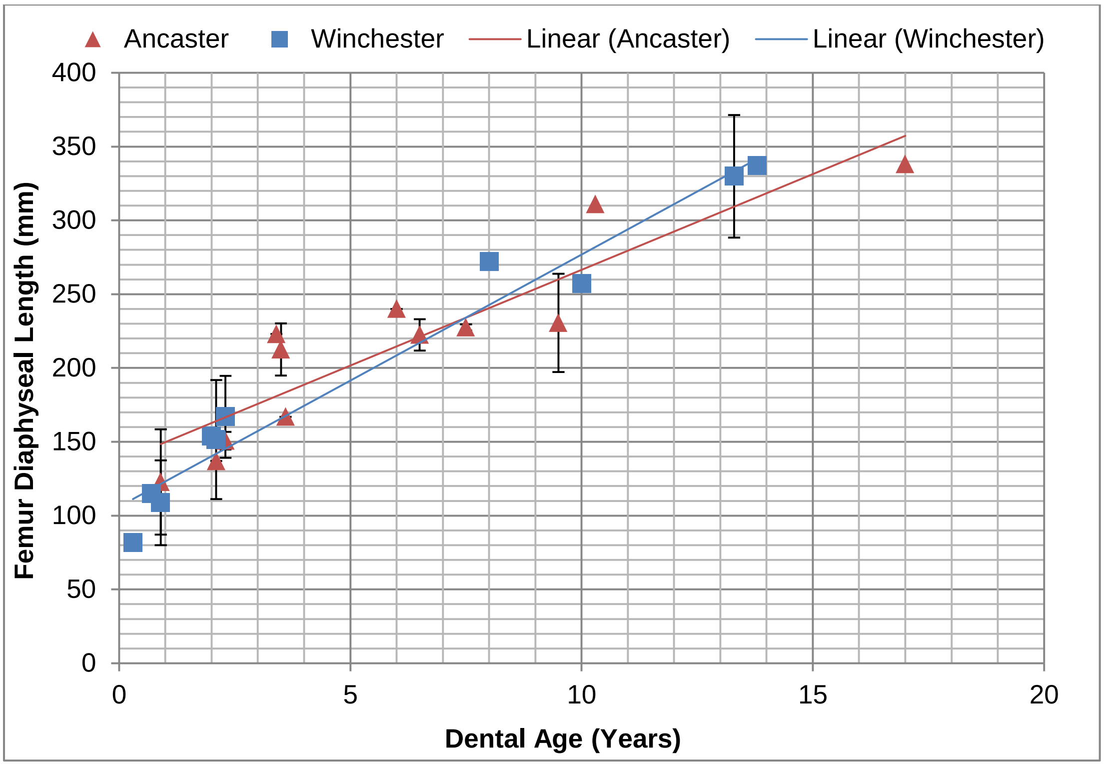


Figure 26. Graph comparing subadult growth curves between the samples.
(N.B. Data points represent mean femoral diaphyseal length plotted against dental age. The solid lines represent linear fit. Many data points represent a single individual only.)

5.3.2 *Adult stature*

Table 16 summarises the data for stature. Figure 27 and Figure 28 illustrate the range and distribution of female and male statures in the study samples. The difference in mean female and male statures is statistically significant for both populations (Ancaster: *t*=13.432, d.f.=127, *p*=<0.0001; Winchester: *t*=11.112, d.f.=96, *p*=<0.0001).

Table 16. Stature means, standard deviations and ranges, in centimetres.

		N	**Mean**	**1 SD**	**Minimum**	**Maximum**	**Range**
Ancaster	Females	56	155.4	5.7	144.3	168.5	24.2
	Males	73	169.0	5.7	157.8	179.5	21.7
Winchester	Females	38	156.4	4.8	144.3	165.7	21.4
	Males	60	167.6	4.9	153.3	176.6	23.3

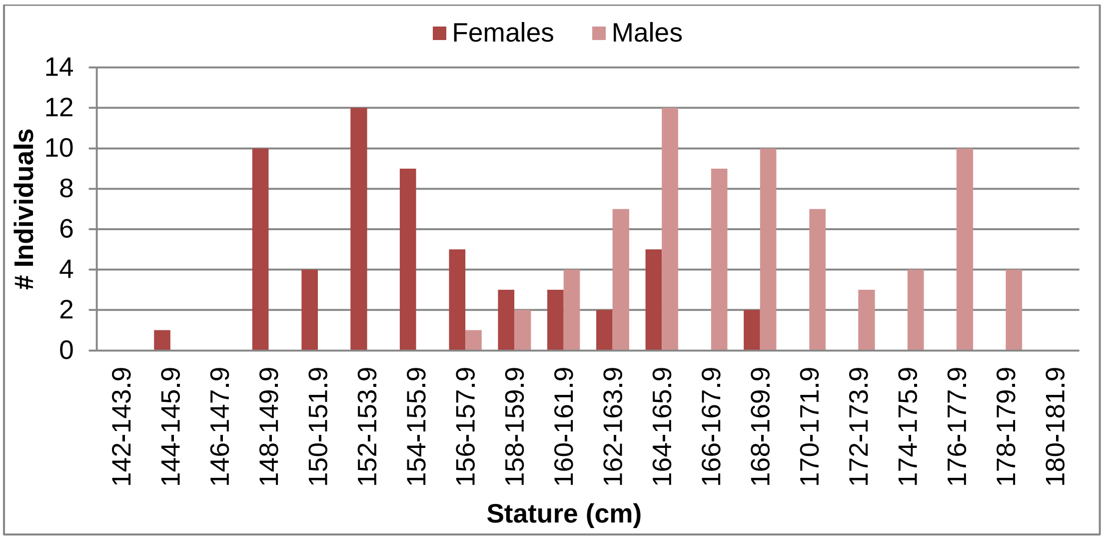


Figure 27. Graph showing the distribution of stature: Ancaster.

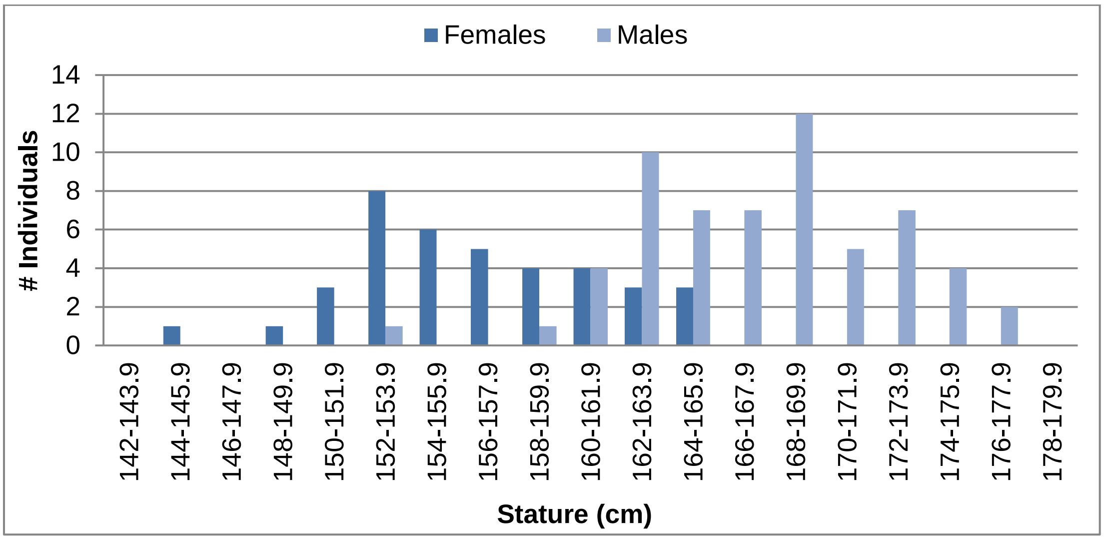
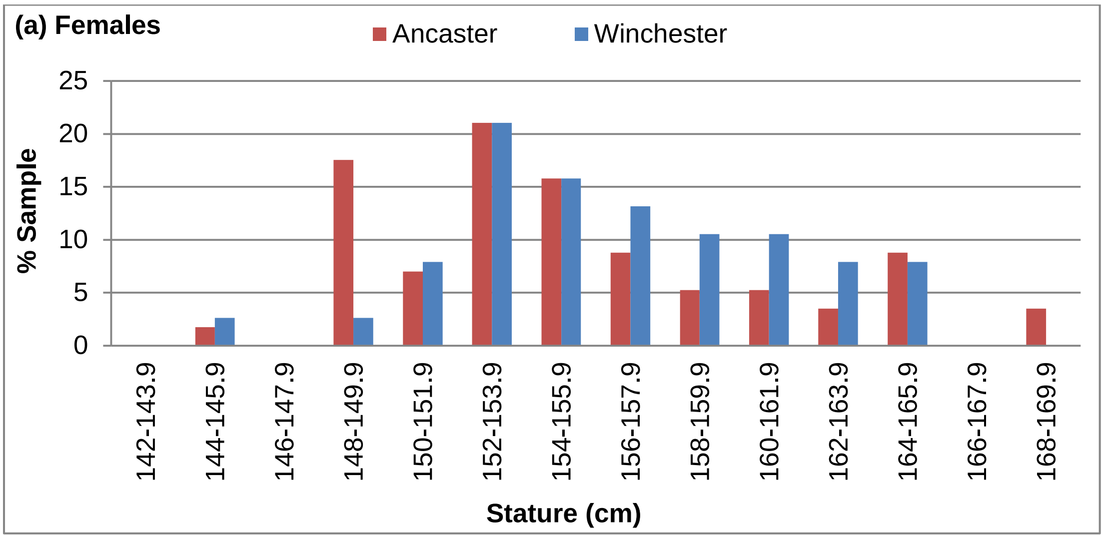


Figure 28. Graph showing the distribution of stature: Winchester.

Ancaster females have the lowest average stature, but there are also more tall females compared to Winchester. The average stature of Ancaster males is greater than Winchester (Figure 29). There are more tall males in the Ancaster sample. The difference in statures between the samples is not statistically significant for either sex (females: t=0.888, d.f.=92, p=0.377; males: t=1.500, d.f.=131, p=0.136).



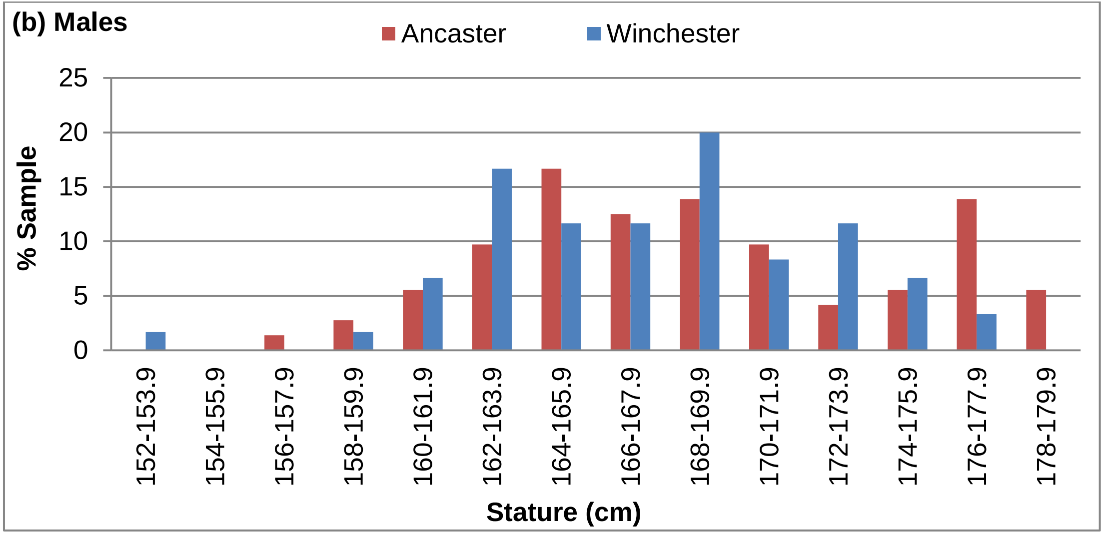


Figure 29. Graphs comparing the distribution of stature between the samples.

5.4 Pathology

5.4.1 *Joint disease*

5.4.1.1 Spinal osteoarthritis

Table 17 summarises data for the prevalence of spinal OA. In both samples, the CPR increases with age, and the difference between age groups (excluding unaged adults) is statistically significant (Ancaster: χ^2=51.721, d.f.=3, *p*=0.000; Winchester: χ^2=28.645, d.f.=3, p=0.000). Males are more affected than females in both samples, although the difference between the sexes is only statistically significant for the Ancaster sample (Test 8). Crude and true prevalence rates are higher for Ancaster than Winchester, and the difference in CPRs between the samples is statistically significant for the total samples and males (Test 9).

Table 17. Overall prevalence of spinal OA.
(N^1=number of joints affected; N^2=number of joints present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/16	0.0	0/8	0.0	0/8	0.0
25-34	5/54	9.3	1/23	4.3	4/31	12.9
35-49	26/44	59.1	8/14	57.1	18/30	60.0
≥50	23/33	69.7	7/13	53.8	15/18	83.8
UA	5/22	22.7	1/11	9.1	4/9	44.4
Total	59/169	34.9	17/69	24.6	41/96	42.7
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/469	0.0	0/166	0.0	0/303	0.0
25-34	22/1866	1.2	5/694	0.7	17/1172	1.5
35-49	128/1879	6.8	19/601	3.2	109/1278	8.5
≥50	160/1147	13.9	44/393	11.2	112/723	15.5
UA	13/332	3.9	3/210	1.4	10/116	8.6
Total	323/5693	5.7	71/2064	3.4	148/3592	6.9
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/28	0.0	0/14	0.0	0/14	0.0
25-34	3/33	9.2	1/7	14.3	2/16	12.5
35-49	9/34	26.5	2/9	22.0	7/24	29.2
≥50	14/25	56.0	5/9	55.6	9/16	56.3
UA	5/19	26.3	2/9	22.2	3/8	37.5
Total	31/139	22.3	10/58	17.2	21/78	26.9
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/527	0.0	0/186	0.0	0/341	0.0
25-34	26/1055	2.5	1/566	1.8	25/489	5.1
35-49	36/897	4.0	11/224	4.9	25/671	3.7
≥50	85/679	12.5	16/234	6.8	69/445	15.5
UA	24/356	6.7	6/190	3.2	18/160	11.3
Total	171/3514	4.9	34/1400	2.4	137/2106	6.5

Table 18 presents prevalence data by spinal region. Both samples are similar in that the overall CPR is highest for the cervical region, and lowest for the lumbar region, except for Ancaster females. The overall difference in CPRs between all three regions is statistically significant for Ancaster, but not Winchester (Test 10). Ancaster males have a significantly higher prevalence of cervical OA compared to females, but the differences between the sexes by spinal region are otherwise not significant (Test 11). CPRs and TPRs are higher for Ancaster in all three regions, but the differences in CPRs are not significant (Test 12).

Table 18. Prevalence of OA by spinal region.
(N^1=number of individuals/vertebrae affected; N^2=number of individuals with at least one vertebra/number of vertebrae present (C1 to L5, complete and isolated neural arches.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cervical	42/132	31.8	9/50	18.0	32/81	39.5
Thoracic	37/131	28.2	9/49	18.4	27/81	33.3
Lumbar	24/130	18.5	13/54	24.1	11/76	14.5
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cervical	141/748	18.9	37/272	13.6	102/469	21.7
Thoracic	131/1331	9.8	23/469	4.9	104/856	12.1
Lumbar	49/584	8.4	28/227	12.3	21/357	5.9
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cervical	25/104	24.0	8/42	19.0	17/60	28.3
Thoracic	23/114	20.3	6/47	12.8	16.3	25.4
Lumbar	12/103	11.7	5/40	12.5	7/63	11.1
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cervical	88/510	17.3	15/211	7.1	72/291	25.0
Thoracic	65/947	6.9	14/401	3.5	50/539	9.3
Lumbar	29/424	6.8	9/150	6.0	20/274	7.3

To examine laterality, separate prevalence rates were calculated for the right and left joints (Table 19). In the Ancaster sample, prevalence rates are higher for the right joints, while left joints are more affected at Winchester, but the difference between sides is not statistically significantly for either sample, overall or by sex (Test 13). When right and left CPRs are compared between the samples, the difference in CPRs for the right joints is statistically significant (Test 14).

Table 19. Prevalence of spinal OA by side.
(N^1=number of individuals/joints affected; N^2=number of individuals with at least one spinal joint/number of joints present (C1-2 to L5-S1.)

ANCASTER	**Right**		**Left**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**
All adults	54/151	35.8	45/151	29.8
Females	16/62	25.8	12/63	19.0
Males	37/95	38.9	33/86	38.4
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**
All adults	167/2644	6.3	147/2653	5.5
Females	39/957	4.1	28/956	2.9
Males	126/1672	7.5	118/1682	7.0
WINCHESTER	**Right**		**Left**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**
All adults	23/124	18.5	27/126	21.4
Females	7/49	14.3	8/52	15.4
Males	16/73	21.9	19/72	26.4
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**
All adults	66/1612	4.1	84/1609	5.2
Females	19/642	3.0	16/642	3.5
Males	69/968	7.1	69/965	7.2

Figure 30, Figure 31 and Figure 32 illustrate the pattern of joint involvement. In both samples, there are peaks in prevalence in the mid-cervical, upper/mid-thoracic and mid/lower lumbar regions. OA of the median atlanto-axial (atlanto-odontoid, A-O) joint is only present at Ancaster, and the pattern of lumbar involvement differs between the samples. The distribution of OA differs more noticeably between females, with Ancaster females exhibiting peaks in prevalence at the A-O, C4-5, L4-5 and L5-S1, while Winchester females exhibit more pronounced peaks at the C7-T1 and L3-4[19].

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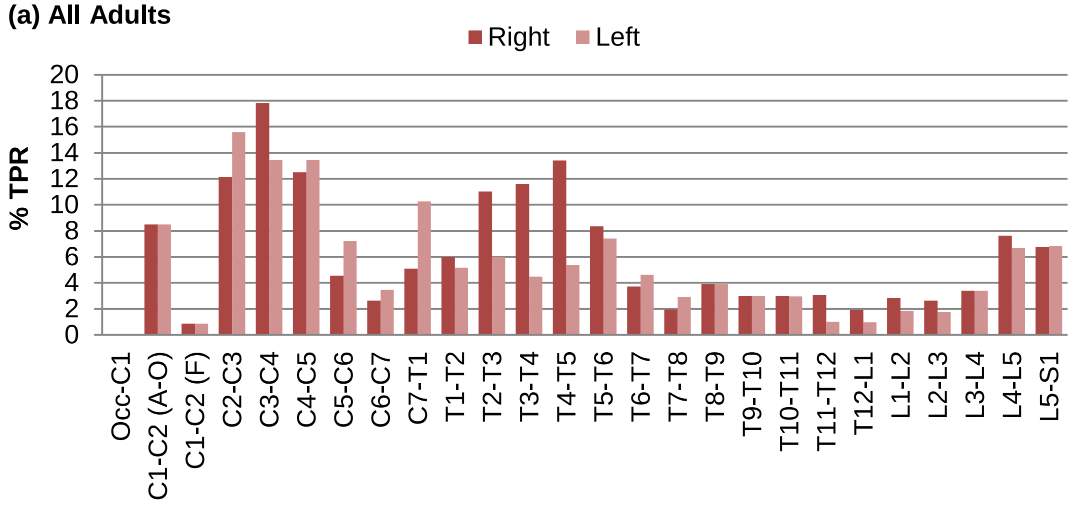
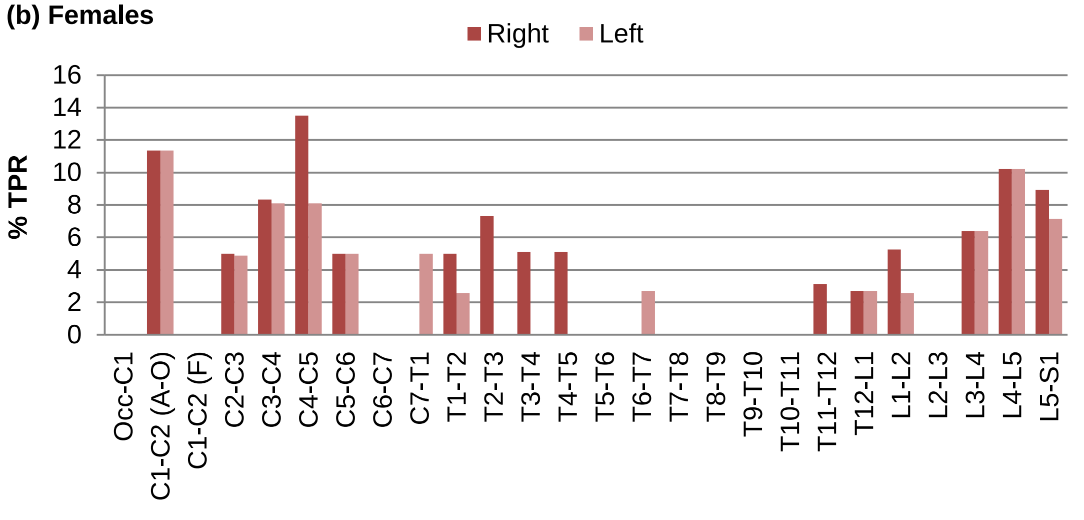
[19] TPR data are provided on the accompanying CD.

(a) All Adults



(b) Females



(c) Males

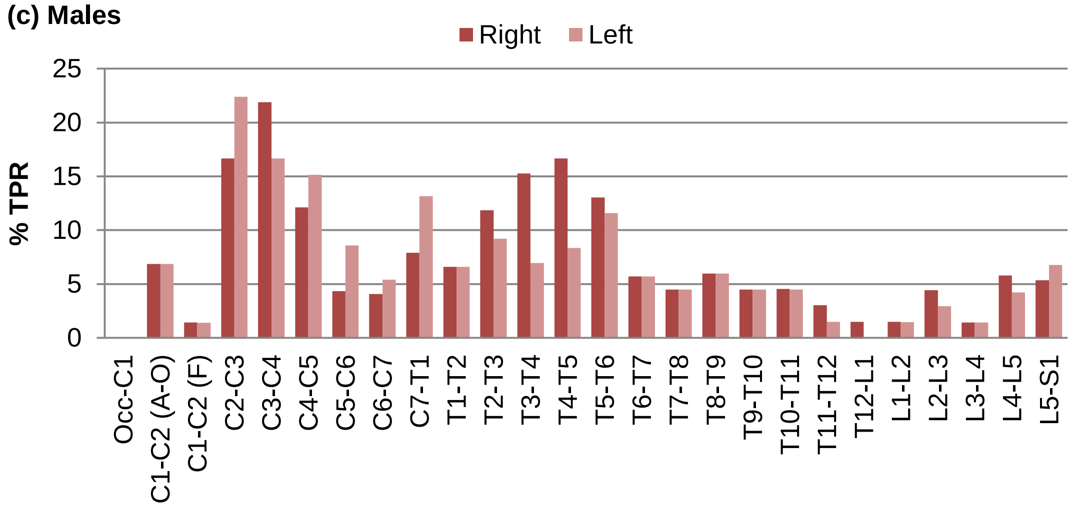
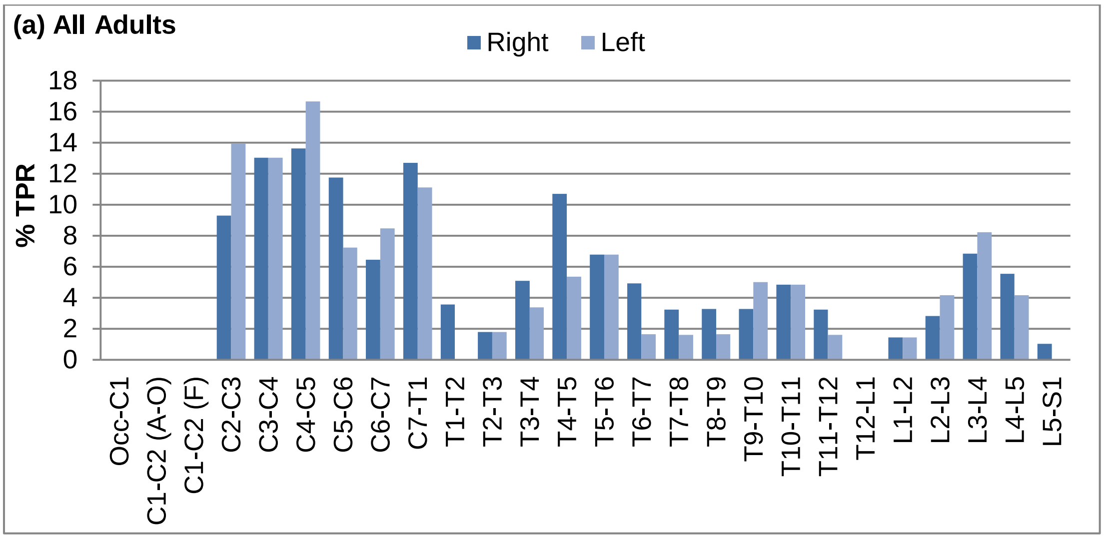
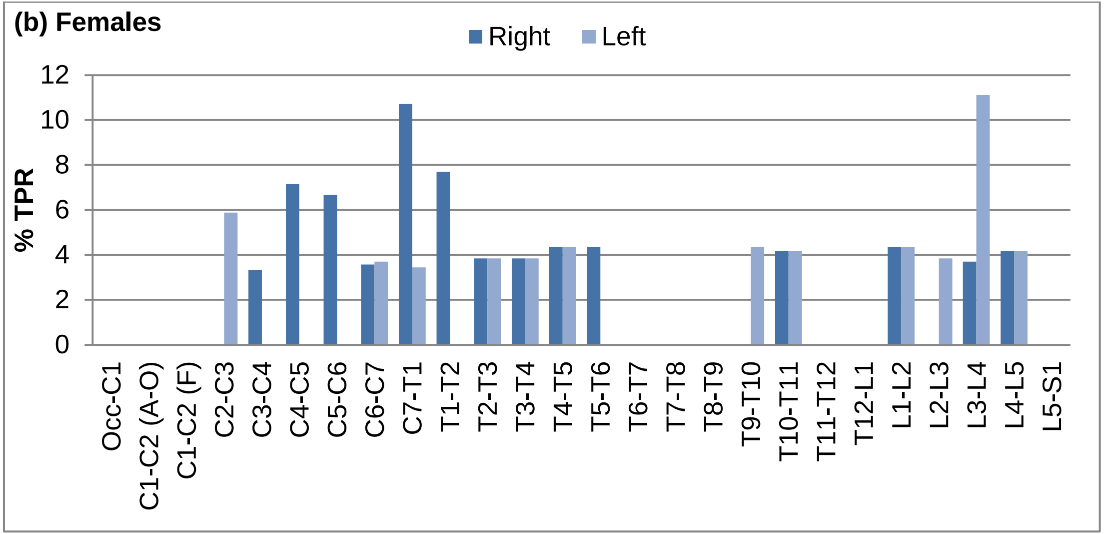


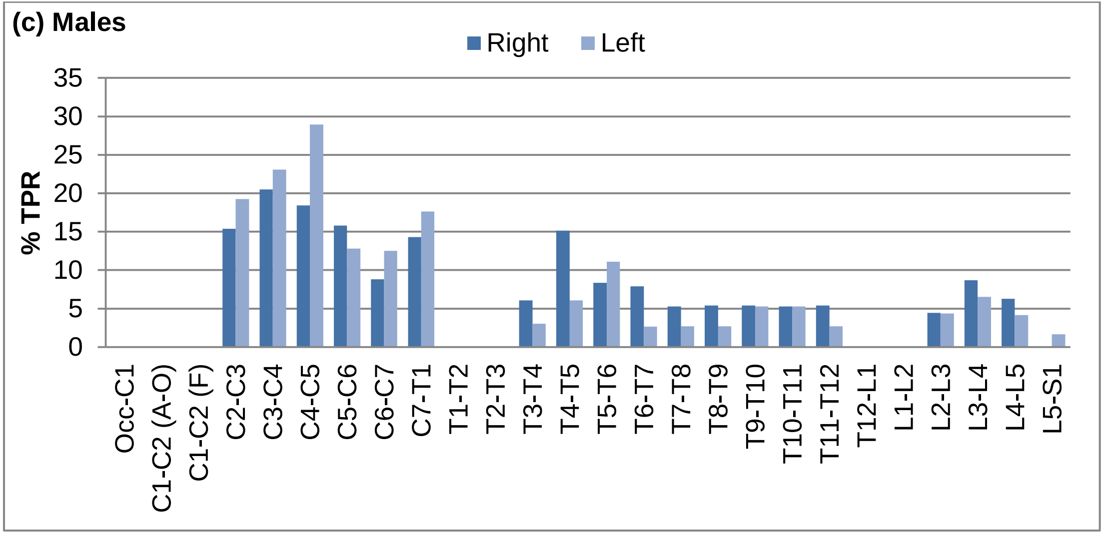
Figure 30. Graphs showing the true prevalence of spinal OA by joint in the Ancaster sample.



(a) All Adults

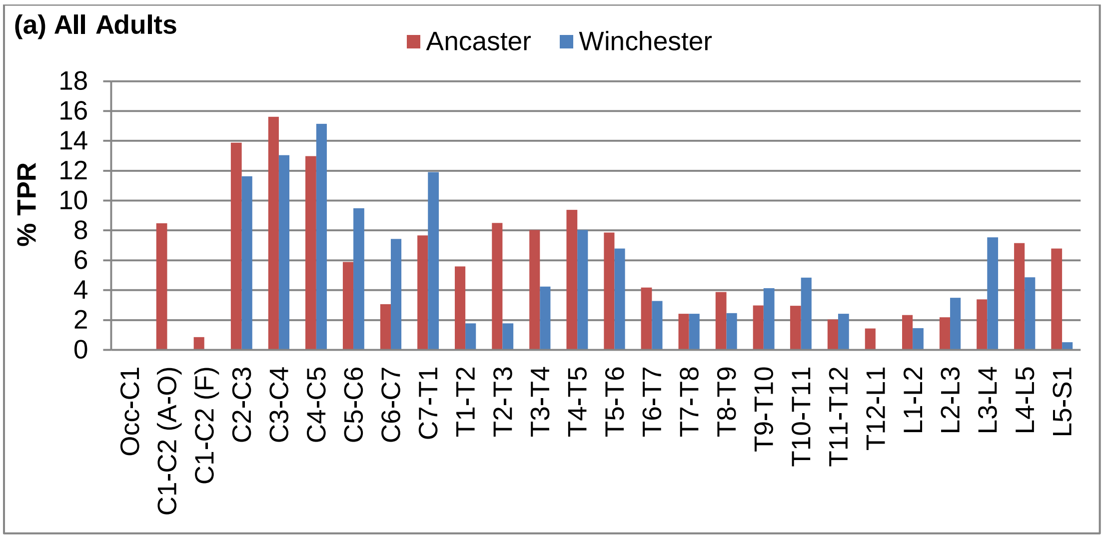


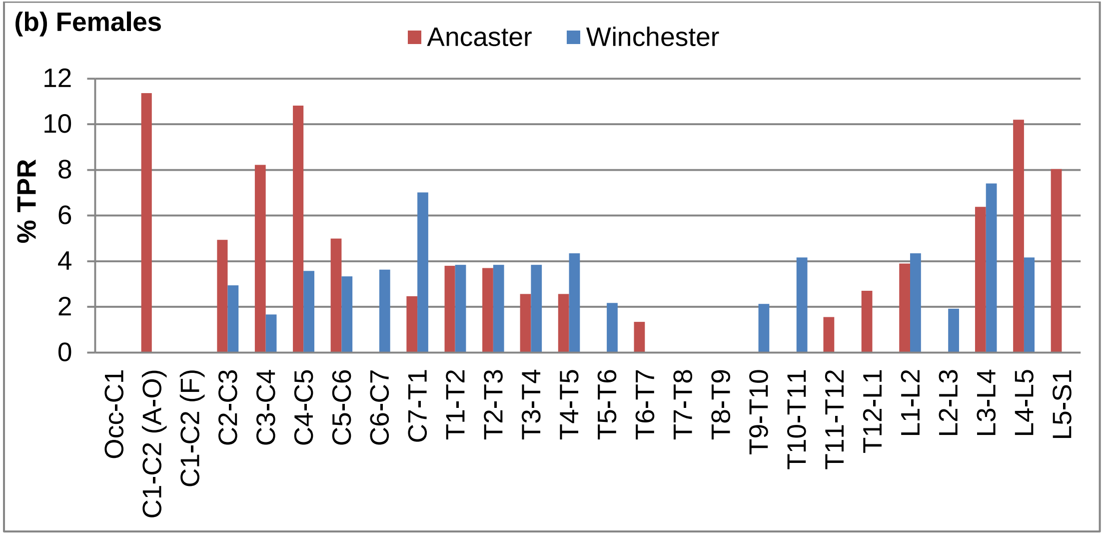
(b) Females



(c) Males

Figure 31. Graphs showing the true prevalence of spinal OA by joint in the Winchester sample.





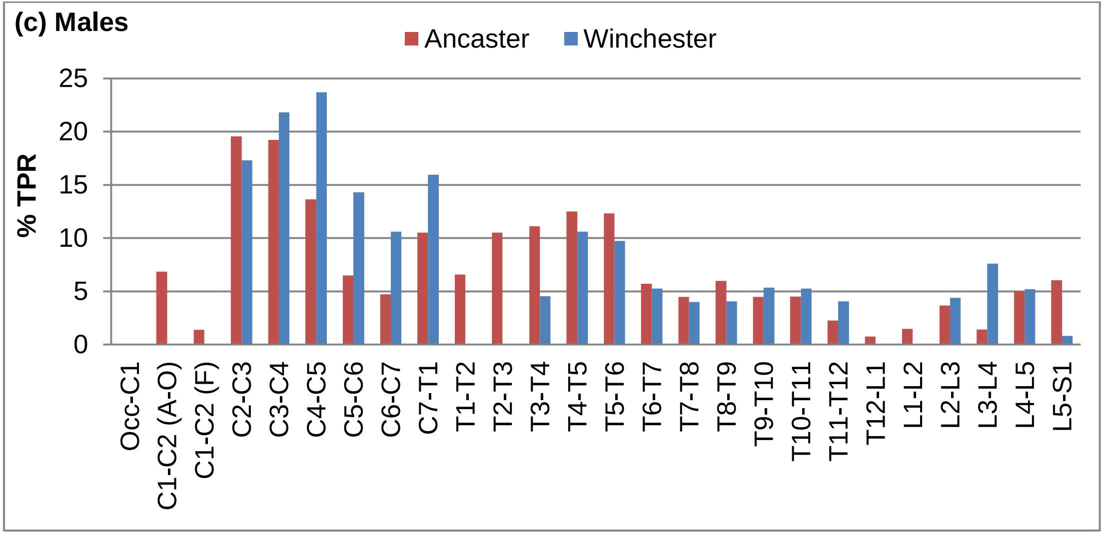


Figure 32. Graphs comparing the true prevalence of spinal OA by joint (right and left combined) between the samples.

5.4.1.2 Disc disease

Table 20 presents prevalence data for disc disease. In both samples, the CPR increases with age and the difference between age groups (excluding unaged adults) is statistically significant (Ancaster: χ^2=53.506, d.f.=3, *p*=0.000; Winchester: χ^2=33.798, d.f.=3, *p*=0.000). The prevalence rate is higher for males than females, but the difference is not statistically significant for either sample (Test 15). The overall prevalence rates are higher for Ancaster and the difference in CPRs between samples is statistically significant for the total samples and males (Test 16).

Table 20. Overall prevalence of disc disease.
(N^1=number of individuals/joints affected; N^2=number of individuals with at least one intervertebral joint/number of joints present, C2-3 to L5-S1.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	1/14	7.1	0/7	0.0	1/7	14.3
25-34	22/47	46.8	6/19	31.6	16/28	57.1
35-49	38/40	95.0	14/14	100.0	24/26	92.3
≥50	28/31	90.3	9/12	75.0	18/18	100.0
UA	9/18	50.0	6/10	60.0	3/6	50.0
Total	98/150	65.3	35/62	56.5	62/85	72.9
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	4/205	2.0	0/61	0.0	4/144	2.8
25-34	124/824	15.0	33/299	11.0	91/525	17.3
35-49	343/841	40.7	69/271	25.5	273/570	47.9
≥50	354/524	57.6	105/174	60.3	242/338	71.9
UA	48/150	32.0	37/96	38.5	11/51	21.6
Total	872/2544	34.3	244/901	27.1	622/1628	38.2
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	1/21	4.8	0/9	0.0	1/12	8.2
25-34	10/32	31.3	5/17	29.4	5/15	33.3
35-49	20/29	69.0	6/7	85.7	14/21	66.7
≥50	19/24	79.2	7/9	77.8	12/15	80.0
UA	9/16	56.3	4/7	57.1	5/9	55.6
Total	59/122	48.4	22/49	44.9	37/72	51.4
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	3/228	1.3	0/74	0.0	3/154	1.9
25-34	32/448	7.1	12/250	4.8	20/198	10.1
35-49	172/414	41.5	31/106	29.2	141/307	45.9
≥50	175/317	55.2	40/111	36.0	135/206	65.5
UA	46/165	27.9	11/85	12.9	35/80	43.8
Total	428/1572	27.2	94/626	15.0	334/945	35.3

Table 21 presents separate prevalence rates for each spinal region. In both samples, the prevalence rate is highest for the thoracic region and lowest for the cervical region. The differences in CPRs between spinal regions are significant in most cases in the Ancaster sample, but they are generally not significant for Winchester (Test

17). Male prevalence rates are generally higher than female CPRs, but the difference between the sexes is not significant for any spinal region in either sample (Test 18). When prevalences are compared between the samples, CPRs and TPRs are higher for Ancaster in most cases, and the difference between the samples in the overall CPR is statistically significant for the thoracic and lumbar regions (Test 19).

Table 21. Prevalence of disc disease by spinal region.
N^1=number of individuals/vertebrae affected; N^1=number of individuals with at least one vertebra/number of vertebrae present, complete and isolated centra, C2 to L5.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cervical	46/133	34.6	17/51	33.3	28/81	34.6
Thoracic	80/132	60.6	27/49	55.1	52/82	63.4
Lumbar	71/128	55.5	27/54	50.0	44/74	59.5
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cervical	144/640	22.5	50/231	21.6	89/403	22.1
Thoracic	538/1331	40.4	160/459	34.9	375/856	43.8
Lumbar	246/579	42.5	77/226	24.1	169/353	47.9
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cervical	30/106	28.3	10/43	23.3	20/61	32.8
Thoracic	51/119	43.7	17/48	35.4	35/67	52.2
Lumbar	41/106	38.7	10/42	23.8	31/64	48.4
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cervical	96/441	21.8	27/183	14.8	69/254	27.2
Thoracic	282/1026	27.5	78/430	18.1	204/587	34.8
Lumbar	144/443	32.5	21/161	13.0	123.282	43.6

To explore in detail the distribution of disc disease throughout the spine, individual TPRs were calculated for each joint level (Figure 33)[20]. In the Ancaster sample, there are three peaks in the mid/lower cervical (C5-6), lower thoracic (T8-9) and lower lumbar region (L4-5). The most affected joint is the T8-9. In the Winchester sample, there are three peaks in the mid-cervical (C6-7), mid-thoracic (T8-9) and upper/mid-lumbar (L2-3) regions. The most affected joint is the T8-T9. In both samples, the difference between the sexes is minimal. The overall pattern of joint involvement is broadly similar in both samples, being greatest in the thoracic region, followed by the lumbar and cervical regions. The pattern of male joint involvement is very similar, but the female pattern differs quite noticeably for the lower thoracic and lumbar region.

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[20] TPR data are provided on the accompanying CD.

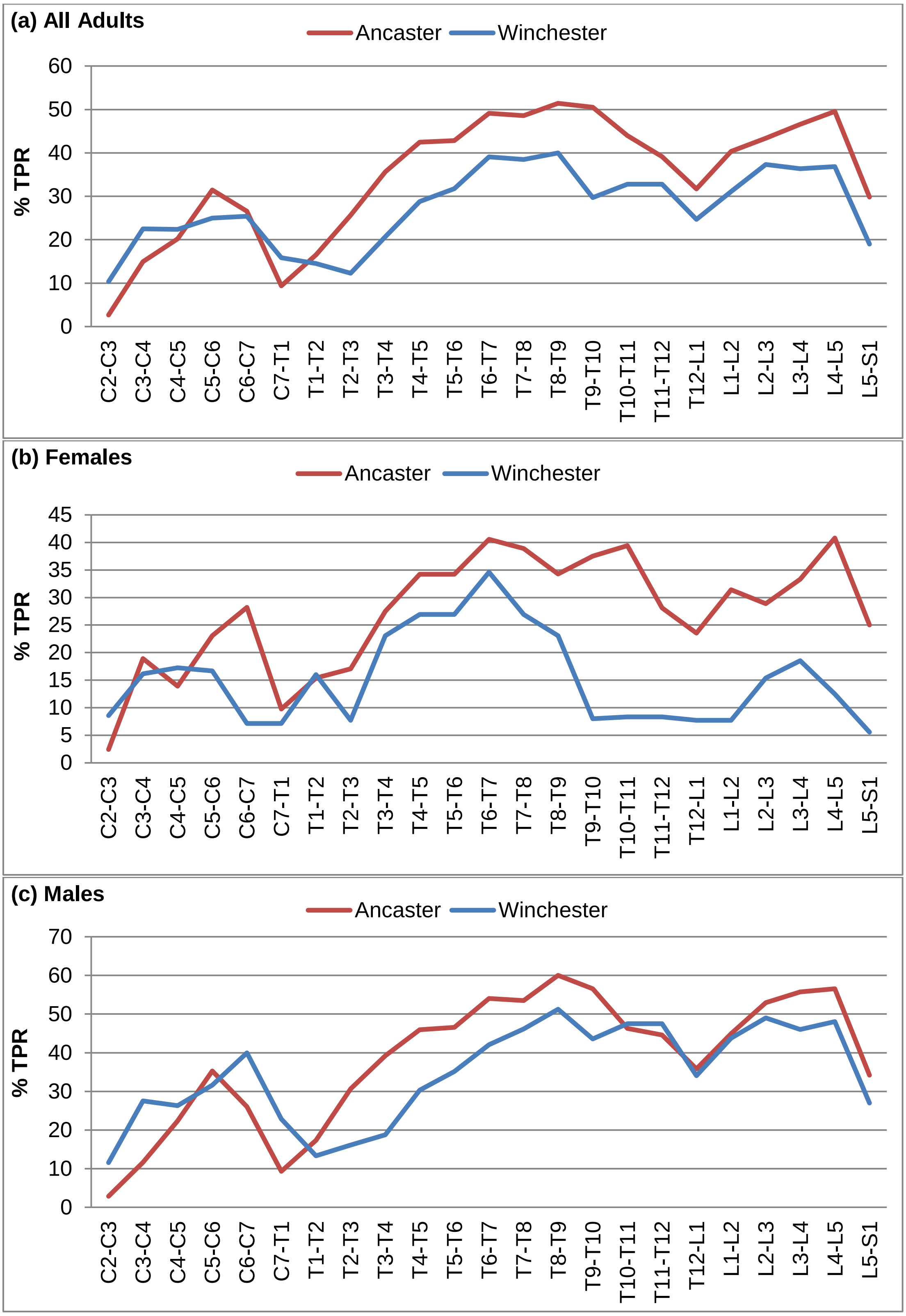

Figure 33. Graphs comparing the true prevalence of disc disease by joint between the samples.

5.4.1.3 Schmorl's nodes

Table 22 presents prevalence data for Schmorl's nodes. The differences in CPRs between age groups are not statistically significant for either sample (Ancaster: χ^2=1.590, d.f.=3, *p*=0.662; Winchester: χ^2=5.456, d.f.=3, *p*=0.141). Males are more affected than females in both samples, and the difference in CPRs between the sexes is statistically significant in both cases (Test 20). The overall CPR is higher for Ancaster (48.3% *vs.* 40.2%), but the TPR is higher for Winchester (17.3% *vs.* 16.3%). The difference in CPRs between the samples is not statistically significant (Test 21).

Table 22. Overall prevalence of Schmorl's nodes.
(N^1=number of individuals/joints affected; N^2=number of individuals with at least one intervertebral joint/number of joints present, C7-T1 to L5-S1.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	5/13	38.5	2/6	33.3	3/7	42.9
25-34	24/46	52.2	4/18	22.2	20/28	71.4
35-49	23/40	57.5	7/14	50.0	16/26	61.5
≥50	15/31	48.4	3/12	25.0	12/18	66.7
UA	3/15	20.0	2/8	25.0	1/5	20.0
Total	70/145	48.3	18/58	31.0	52/83	61.9
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	26/151	17.2	8/44	18.2	18/107	16.8
25-34	121/609	19.9	26/223	11.7	95/386	24.6
35-49	90/633	14.2	23/207	11.1	67/426	15.7
≥50	60/385	15.6	3/124	2.4	57/255	22.4
UA	11/106	10.4	8/70	11.4	3/33	9.1
Total	308/1884	16.3	68/668	10.2	140/1207	19.9
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	6/19	31.6	0/8	0.0	6/11	54.5
25-34	12/30	40.0	5/15	33.3	7/15	46.7
35-49	17/29	58.6	3/7	42.9	14/21	66.7
≥50	7/23	30.4	0/8	0.0	7/15	46.7
UA	3/11	7.3	1/5	20.0	2/6	33.3
Total	45/112	40.2	9/43	20.9	36/68	52.9
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	31/161	19.9	0/49	0.0	32/112	28.6
25-34	54/315	17.1	21/172	12.2	33.143	23.1
35-49	62/324	19.1	9/78	11.5	53/245	21.6
≥50	34/227	15.0	0/81	0.0	34/146	23.3
UA	17/126	13.5	7/65	10.8	10/61	16.4
Total	199/1153	17.3	37/445	8.3	162/707	22.9

Table 23 presents separate prevalence data for each spinal region. In both samples, prevalences are highest for the thoracic region, and the difference in CPRs between regions is statistically significant for Ancaster, but not Winchester (Test 22). CPRs are significantly higher for males than females in both samples (Test 23). Prevalence rates are higher for Ancaster with the exception of the male lumbar TPR, but the difference in CPRs between the samples is not statistically significant for either region (Test 24).

Table 23. Prevalence of Schmorl's nodes by spinal region.
(N^1=number of individuals/vertebrae affected; N^2=number of individuals with at least one vertebra/ number of vertebrae present, complete vertebrae and isolated centra, T1 to L5.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Thoracic	62/132	47.0	13/49	26.5	49/82	59.8
Lumbar	37/128	28.9	10/54	18.5	27/74	36.5
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Thoracic	236/1321	17.9	49/459	10.7	187/856	21.8
Lumbar	84/579	14.5	18/226	8.0	66/353	18.7
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Thoracic	46/119	38.7	9/48	18.8	36/67	53.7
Lumbar	28/106	26.4	4/42	9.5	26/64	40.6
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Thoracic	151/1026	14.7	29/430	6.7	121/587	20.6
Lumbar	63/443	14.2	7/161	4.3	56/282	19.9

Figure 34 compares the pattern of joint involvement between the samples[21]. In both samples, prevalence peaks in the lower thoracic region, the most affected joint being the T11-12 in the Ancaster sample, and T10-11 in the Winchester sample. Joint involvement differs little between the sexes. There is also little difference in joint involvement between the study samples, although Ancaster females have a more pronounced peak in prevalence in the lower thoracic region.

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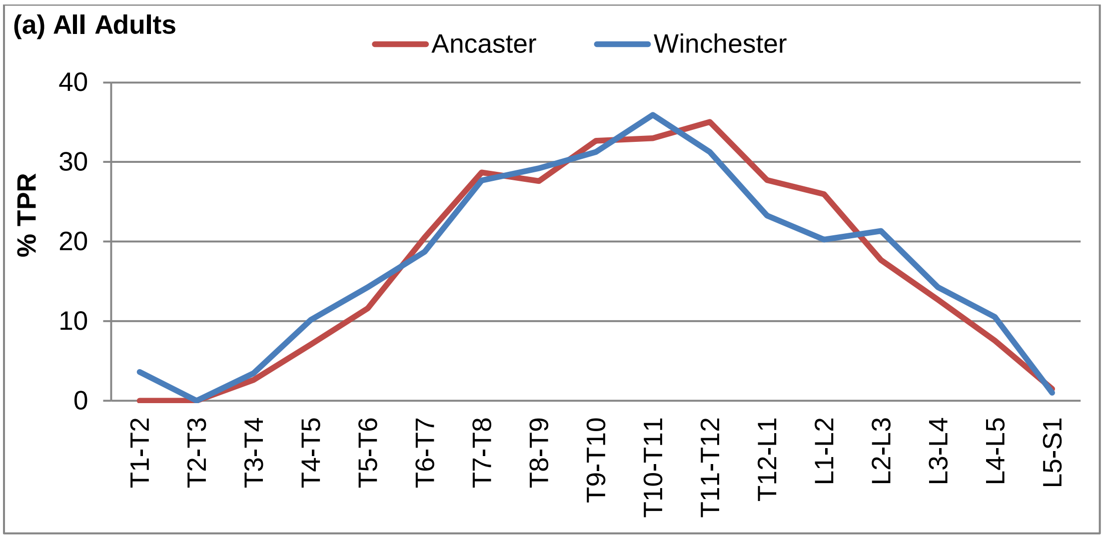
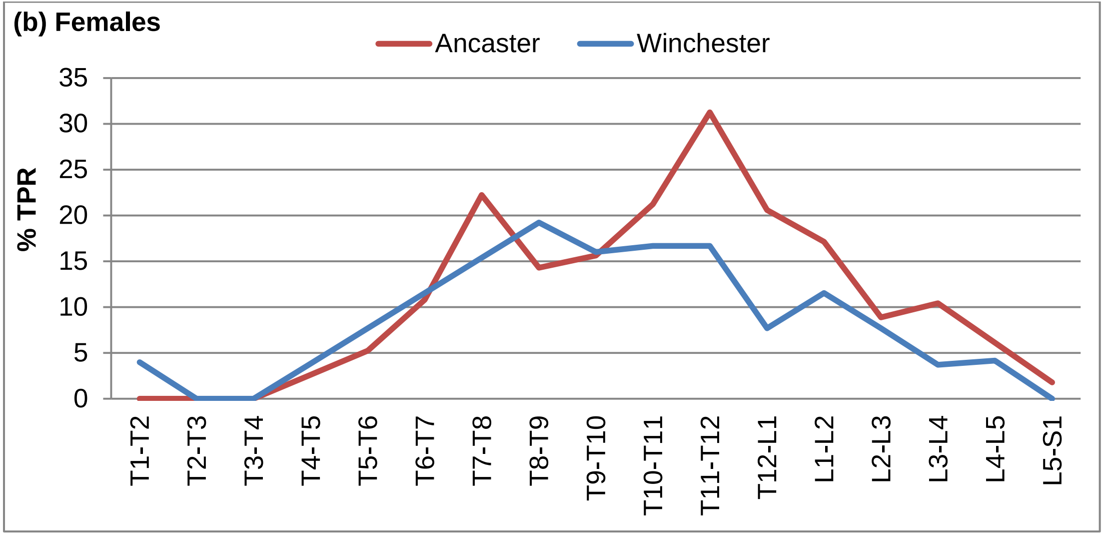
[21] TPR data are provided on the accompanying CD.





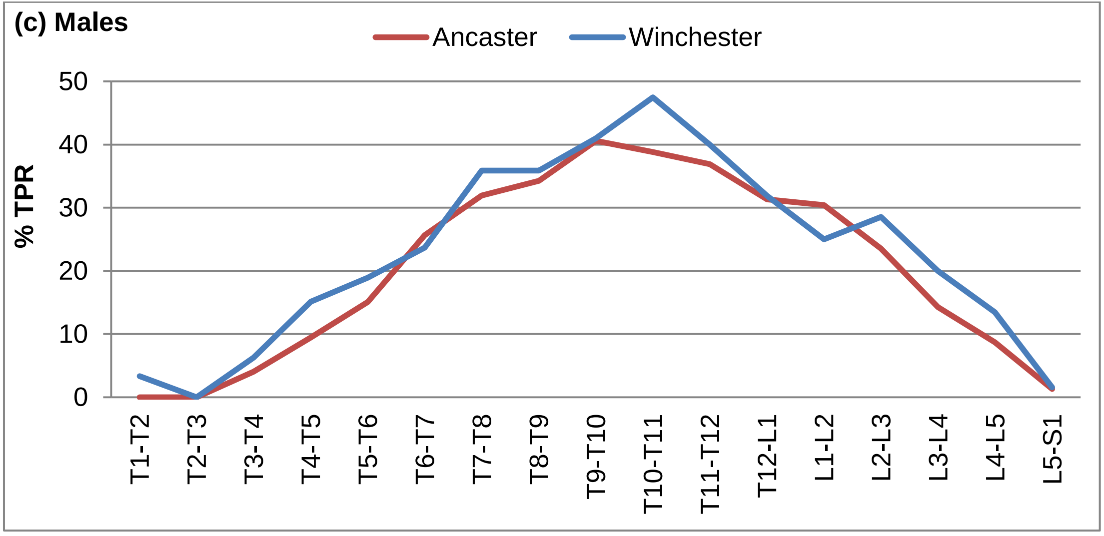


Figure 34. Graphs comparing the true prevalence of Schmorl's nodes by joint between the samples.

5.4.1.4 Extra-spinal osteoarthritis

Table 24 presents prevalence data for extra-spinal OA. There is a statistically significant increase in prevalence with age in both samples (Ancaster: $\chi^2=49.277$, d.f.=3, *p*=0.000; Winchester: $\chi^2=34.479$, d.f.=3, *p*=0.000). In both samples, the prevalence rate is higher for males, but the differences between the sexes are not significant (Test 25). The crude prevalence is higher for Ancaster, and the difference between the samples is statistically significant (Test 26).

Table 24. Overall prevalence of extra-spinal OA.
(N^1=number of individuals/joints affected; N^2=number of individuals with at least one extra-spinal joint/number of joints present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/17	0.0	0/9	0.0	0/9	0.0
25-34	7/59	11.9	1/25	4.0	6/34	17.6
35-49	22/49	44.9	7/16	43.8	15/32	46.9
≥50	26/35	74.3	9/15	60.0	16/18	88.9
UA	6/36	16.7	2/13	15.4	2/13	15.4
Total	61/196	31.1	19/78	24.4	38/105	36.2
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/255	0.0	0/128	0.0	0/127	0.0
25-34	10/997	1.0	2/413	0.5	8/584	1.4
35-49	50/907	5.6	15/294	5.1	35/611	5.7
≥50	94/604	15.6	30/240	12.5	61/342	17.8
UA	7/350	2.0	3/166	1.8	2/116	1.7
Total	164/3113	5.3	50/1241	4.0	109/1780	6.1
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	2/31	6.5	1/14	7.1	0/15	0.0
25-34	4/36	11.1	1/17	5.9	3/16	18.8
35-49	8/36	22.2	4/10	40.0	4/25	16.0
≥50	20/32	62.5	5/12	41.7	15/19	78.9
UA	9/68	14.3	3/14	21.4	5/18	27.8
Total	43/198	21.7	14/67	20.9	27/93	29.0
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	3/489	0.6	2/220	0.9	0/262	0.0
25-34	9/605	1.5	1/303	0.3	8/286	2.8
35-49	12/581	2.1	5/160	3.1	7/416	1.7
≥50	59/571	10.3	14/211	6.6	46/344	13.4
UA	24/527	4.6	7/182	3.8	16/202	7.9
Total	107/2773	3.9	29/1076	2.7	79/1510	5.2

Table 25 presents separate prevalence data for the joints of the upper and lower body. In both samples, the prevalence of OA is significantly higher for the upper body joints, with the exception of Winchester females (Test 27). There are no significant differences between the sexes in either sample when upper and lower body CPRs are compared separately (Test 28). The CPR is generally higher for Ancaster, but there are no significant differences between the samples (Test 29).

Table 25. Prevalence of extra-spinal OA by upper *vs.* lower body joints.
(N¹=number of individuals/joints affected; N²=number of individuals with at least one extra-spinal joint/number of joints present; Upper body=excludes TMJ.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Upper	50/168	29.8	17/69	24.6	31/95	32.6
Lower	20/177	11.3	5/69	7.2	14/98	14.3
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Upper	130/1610	8.1	43/642	6.7	83/941	8.8
Lower	29/1226	2.4	7/497	1.4	21/673	3.1
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Upper	36/167	21.6	12/65	18.5	22/86	25.6
Lower	16/183	8.7	5/64	7.8	11/88	12.5
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Upper	78/1416	5.5	21/572	3.7	55/779	7.1
Lower	24/1125	2.1	6/405	1.5	21/609	3.5

Table 26 presents separate prevalence rates by side. In the Ancaster sample, CPRs are slightly higher for the left joints, while the right joints are more affected in the Winchester sample. None of the differences in CPRs between right and left sides within samples is statistically significant (Test 30). When CPRs for the right and left joints are compared between the sexes, there are no significant differences (Test 31). CPRs are higher for Ancaster than Winchester in all cases, and the difference between the samples in CPRs for the left joints is statistically significant (Test 32).

Table 26. Prevalence of extra-spinal OA by side.
(N¹=number of individuals/joints affected; N²=number of individuals with at least one extra-spinal joint/number of joints present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Right	47/196	24.0	15/78	19.2	30/105	28.6
Left	51/196	26.0	16/78	20.5	33/105	31.4
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Right	83/1561	5.3	24/626	3.8	56/890	6.3
Left	81/1552	5.2	26/615	4.2	53/890	6.0
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Right	35/194	18.0	11/67	16.4	24/93	25.8
Left	28/194	14.4	9/67	13.4	17/93	18.3
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Right	62/1380	4.5	16/542	3.0	46/753	6.1
Left	45/1393	3.2	13/534	2.4	30/757	4.0

Table 27 and Figure 35 compare the crude prevalence of osteoarthritis by joint unit in the study samples. Both populations exhibit a similar pattern of joint involvement in that the acromioclavicular joints, sternoclavicular joints and hands are the most affected, while the elbow and temporomandibular joints are least affected. No individuals exhibited OA of the ankle. Of the major joints (shoulder, elbow, hip and knee), the hip is most affected in both samples and the elbow is least affected (Test 22). Ancaster females exhibit a wider range of joint involvement compared to Winchester females. The hand and knee are the only joints for which females in both samples have higher CPRs than males. For the majority of joints, the numbers of individuals affected are too small to compare CPRs between the sexes within each sample. Exceptions are the ACJ and hand joints, but there are no significant differences between the sexes for either joint in either study sample (Test 33). In the case of those joints for which sufficient numbers of individuals are affected for comparisons between the study samples, there are no statistically significant differences (Test 34).

Table 27. Crude prevalence of extra-spinal OA by joint.
(N^1=number of individuals affected; N^2=number of individuals with at least one joint.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Temporomandibular	3/145	2.1	0/55	0.0	3/85	3.5
Sternoclavicular	11/123	8.9	1/47	2.1	9/75	12.0
Acromioclavicular	31/140	22.1	11/56	19.6	20/82	24.4
Glenohumeral	6/146	4.1	2/58	3.4	4/85	4.7
Elbow	1/146	0.7	1/61	1.6	0/83	0.0
Wrist	9/149	6.0	2/59	3.4	7/87	8.0
Hand	23/151	15.2	10/62	16.1	11/85	12.9
Hip	7/154	4.5	1/63	1.6	6/88	6.8
Knee	2/157	1.3	1/65	1.5	1/86	1.2
Ankle	0/161	0.0	0/64	0.0	0/87	0.0
Foot	11/156	7.1	2/62	3.2	8/84	9.5
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Temporomandibular	3/122	2.5	1/52	1.9	2/62	3.2
Sternoclavicular	8/102	7.8	1/42	2.4	7/56	12.5
Acromioclavicular	20/116	17.2	8/50	16.0	12/61	19.7
Glenohumeral	2/134	1.6	0/53	0.0	2/72	2.8
Elbow	1/145	0.7	0/56	0.0	1/80	1.3
Wrist	7/138	5.1	0/54	0.0	6/76	7.9
Hand	17/144	11.8	7/55	12.7	9/78	11.5
Hip	5/144	3.5	1/58	1.7	4/81	4.9
Knee	5/150	3.3	3/52	5.8	2/84	2.4
Ankle	0/145	0.0	0/49	0.0	0/73	0.0
Foot	9/151	6.0	1/51	2.0	8/77	10.4

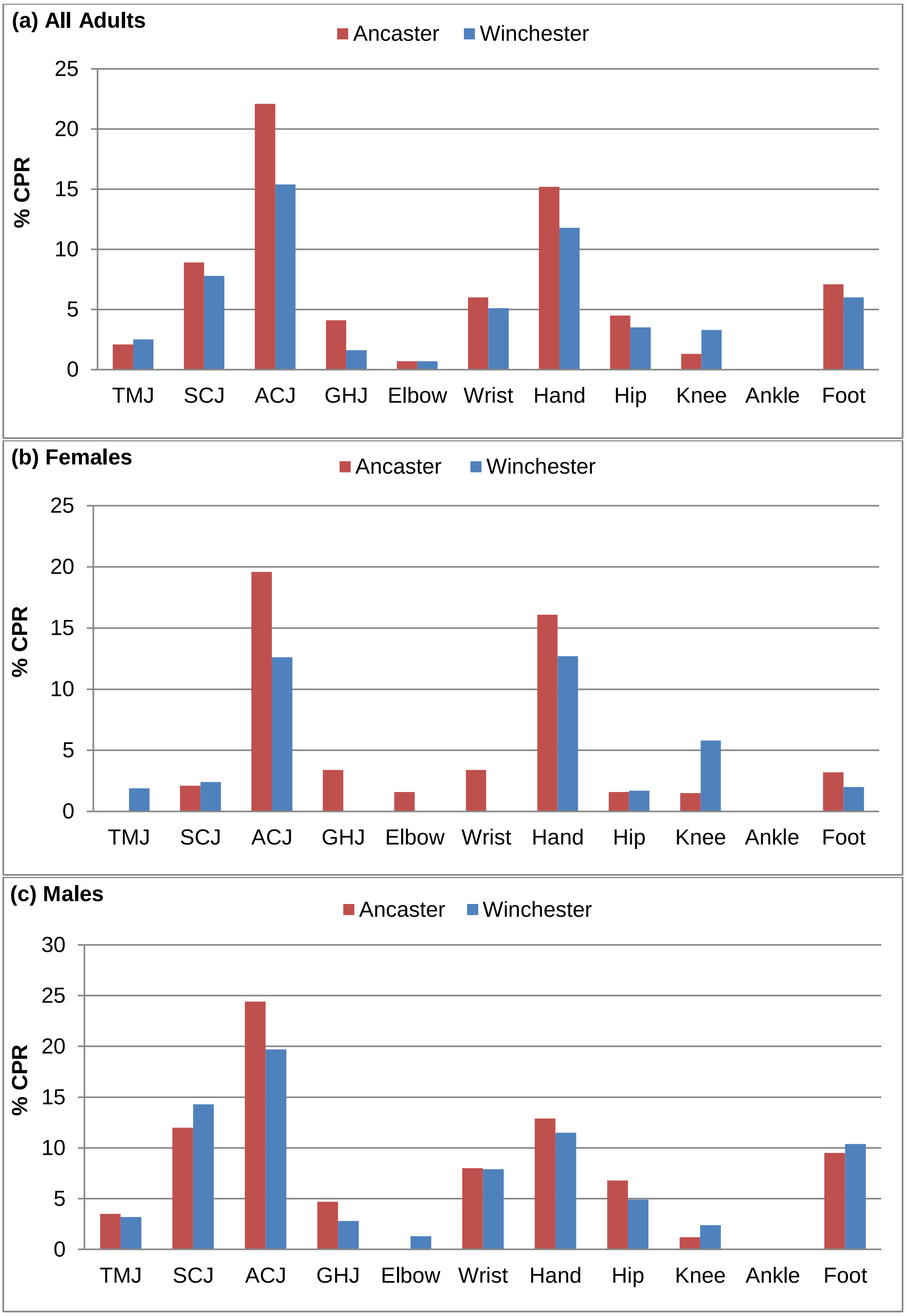


Figure 35. Graphs comparing the crude prevalence of extra-spinal OA by joint between the samples.

To determine whether there is any laterality in the distribution of extra-spinal osteoarthritis, separate TPRs (=CPRs) were calculated for each joint by side (Table 28; Figure 36 and Figure 37). In both samples, the right and left joints are generally equally affected, or the TPR is slightly higher for the right side. For many joints, the numbers affected are too small for meaningful comparisons between right and left TPRs within each sample. In the case of those joints for which TPRs can be compared between sides, there are no significant differences (Test 35). The only joints for which individual right and left TPRs can be compared between the samples are the SCJ, ACJ, hand and foot, and the differences are not significant in any case (Test 36).

Table 28. True prevalence of extra-spinal OA by joint.
(N^1=number of joints affected; N^2=number of joints present.)

	All Adults				**Females**				**Males**			
	Right		**Left**		**Right**		**Left**		**Right**		**Left**	
ANC	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
TMJ	3/140	2.1	2/137	1.5	0/52	0.0	0/50	0.0	3/83	3.6	2/83	2.4
SCJ	11/118	9.3	10/111	9.0	1/44	2.3	1/41	2.4	9/73	12.3	8/69	11.6
ACJ	31/131	23.7	26/125	20.8	11/52	21.2	9/47	19.1	20/77	26.0	17/76	22.4
GHJ	5/140	3.6	4/141	2.8	2/56	3.6	1/55	1.8	3/82	3.7	3/83	3.6
Elbow	1/141	0.7	1/135	0.7	1/60	1.7	1/55	1.8	0/80	0.0	0/78	0.0
Wrist	7/133	5.3	5/141	3.5	1/53	1.9	2/56	3.6	6/78	7.7	3/82	3.7
Hand	11/148	7.4	18/146	12.3	5/62	8.1	8/61	13.1	5/82	6.1	9/81	11.1
Hip	6/147	4.1	6/151	4.0	1/60	1.7	1/62	1.6	5/85	6.1	5/86	5.8
Knee	1/151	0.7	2/155	1.3	0/63	0.0	1/63	1.6	1/82	1.2	1/86	1.2
Ankle	0/158	0.0	0/157	0.0	0/63	0.0	0/63	0.0	0/85	0.0	0/85	0.0
Foot	7/154	4.5	7/153	4.6	2/61	3.3	2/62	3.2	4/83	4.8	5/81	6.2
	All Adults				**Females**				**Males**			
	Right		**Left**		**Right**		**Left**		**Right**		**Left**	
WIN	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
TMJ	3/116	2.6	2/116	1.7	1/51	2.0	1/48	2.1	2/60	3.3	1/62	1.6
SCJ	7/88	8.0	4/95	4.2	1/38	2.6	0/38	0.0	6/49	12.2	4/53	7.5
ACJ	18/98	18.4	13/103	12.6	7/44	15.9	4/43	9.3	11/52	21.2	9/56	16.1
GHJ	2/120	1.2	1/122	0.8	0/50	0.0	0/50	0.0	2/66	3.0	1/65	1.5
Elbow	1/129	0.9	0/133	0.0	0/52	0.0	0/51	0.0	1/73	1.4	0/74	0.0
Wrist	4/121	3.3	6/126	4.8	0/49	0.0	0/50	0.0	4/68	5.9	0/70	7.1
Hand	13/141	9.2	9/138	6.5	6/53	11.3	3/54	5.6	7/77	9.1	5/76	6.6
Hip	4/139	2.9	2/133	1.5	0/57	0.0	1/54	1.9	4/79	5.1	1/74	1.4
Knee	3/142	2.1	4/140	2.9	1/50	2.0	3/48	6.3	2/81	2.5	1/80	1.3
Ankle	0/136	0.0	0/138	0.0	0/58	0.0	0/47	0.0	0/72	0.0	0/70	0.0
Foot	7/148	4.7	4/149	2.7	0/50	0.0	1/51	2.0	7/76	9.2	3/77	3.9

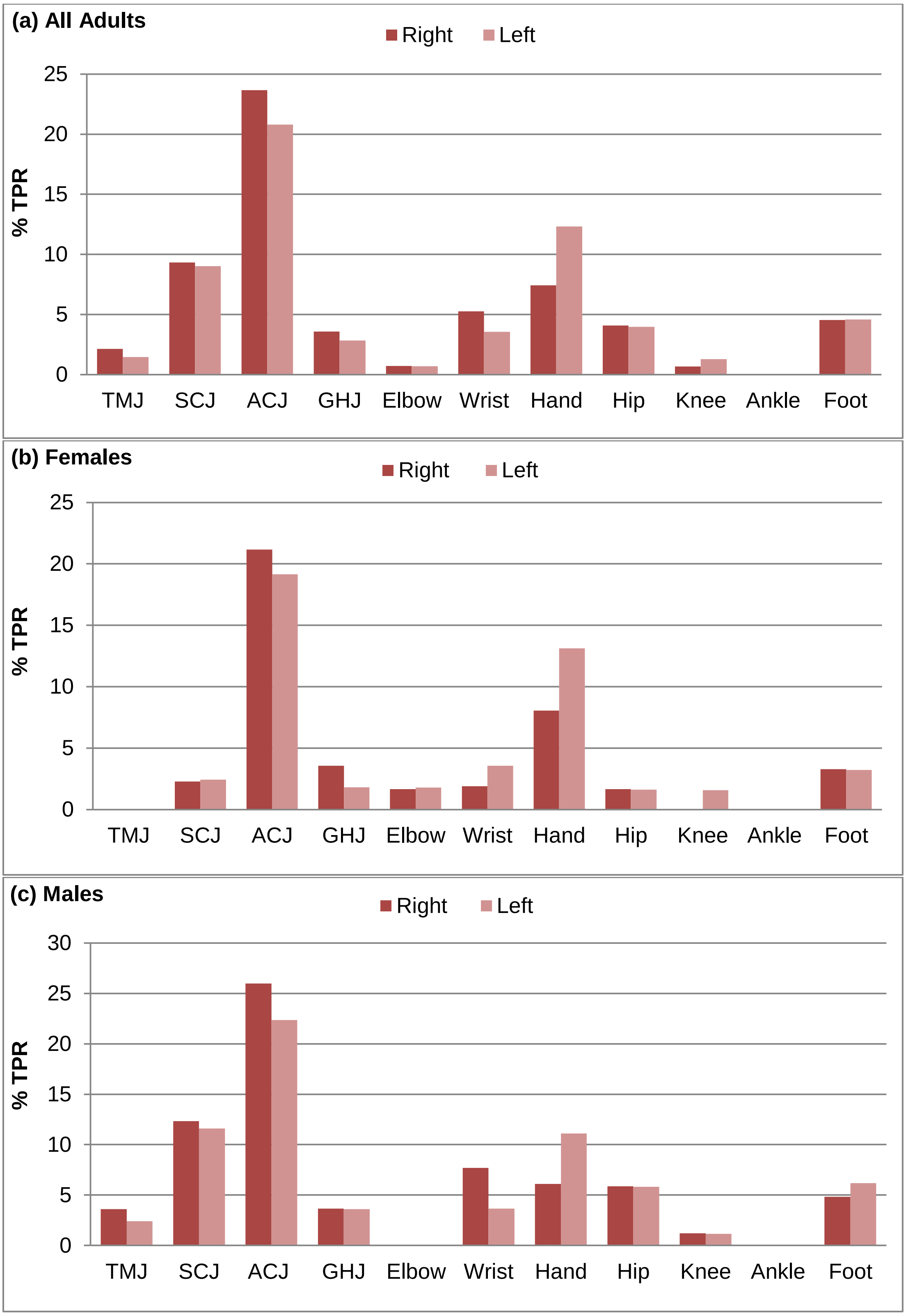


Figure 36. Graphs showing the true prevalence of extra-spinal OA by joint in the Ancaster sample.

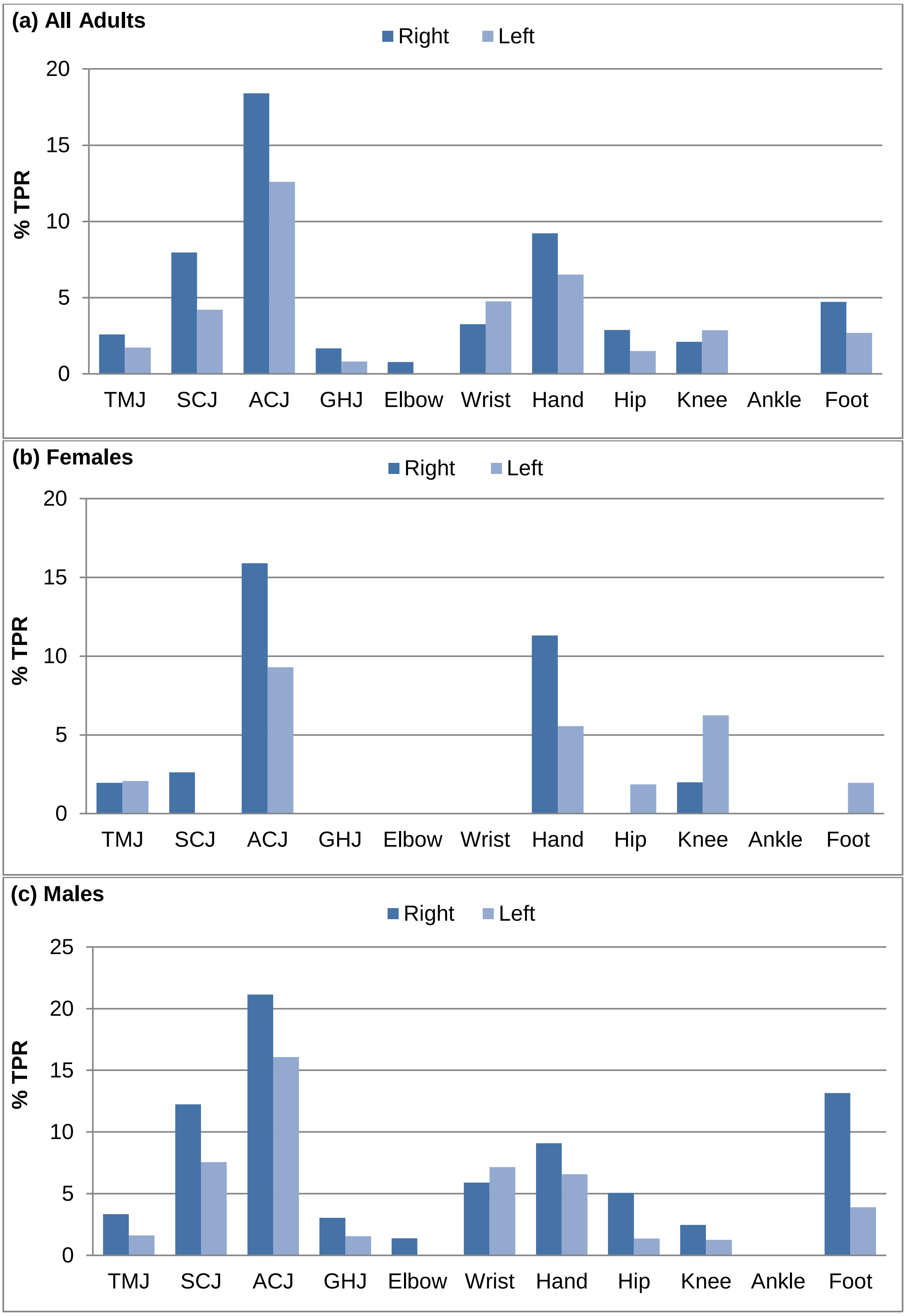


Figure 37. Graphs showing the true prevalence of extra-spinal OA by joint in the Winchester sample.

5.4.1.5 Rotator cuff disease

Table 29 presents CPR data for rotator cuff disease. No individuals from Winchester exhibit degenerative changes at the rotator cuff. Three individuals from Ancaster are affected (Figure 87 to 89). The numbers of individuals affected are too small for statistical comparison.

Table 29. Crude prevalence of rotator cuff disease.
(N^1=number of individuals affected; N^2=number of individuals with at least one GHJ.)

	All Adults		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/12	0.0	0/6	0.0	0/6	0.0
25-34	0/46	0.0	0/18	0.0	0/28	0.0
35-49	1/46	2.2	1/16	6.3	0/31	0.0
≥50	2/28	7.1	1/15	6.7	1/16	6.3
UA	0/15	0.0	0/8	0.0	0/5	0.0
Total	3/147	2.0	2/57	3.5	1/86	1.2
	All Adults		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/25	0.0	0/13	0.0	0/12	0.0
25-34	0/32	0.0	0/15	0.0	0/16	0.0
35-49	0/27	0.0	0/8	0.0	0/19	0.0
≥50	0/26	0.0	0/9	0.0	0/16	0.0
UA	0/24	0.0	0/8	0.0	0/10	0.0
Total	0/134	0.0	0/53	0.0	0/73	0.0

5.4.1.6 Other joint disease

A number of individuals in both samples exhibit other joint pathology, which could not be diagnosed in some cases. Details are provided in the Access database (Table F2iv). Several individuals exhibit changes of particular note (ANC 24, ANC 110, ANC 122, ANC 177, ANC 188, ANC 238, VR 35, VR 45, VR 54); descriptions and differential diagnoses are provided in Appendix 4, Table 99 (see also Figure 130 and Figure 131).

5.4.2 *Trauma*[22]

5.4.2.1 Fractures

5.4.2.1.1 General characteristics

Table 30 presents prevalence data for fractures. Overall, the CPR increases with age in both samples, although in the Winchester sample, it decreases between mature and

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[22] Examples of possible haematomas and ossifications secondary to trauma are listed in the Access database, Table F3ii, 'Other Trauma'. No definitive diagnoses were possible, therefore no prevalence data are presented.

elderly adulthood. The difference between age groups (excluding unaged adults) is statistically significant for Ancaster (χ^2=23.367, d.f.=3, *p*=0.000), but not Winchester (χ^2=4.780, d.f.=3, *p*=0.189). Prevalence rates are higher for males than females in both samples, and the difference between the sexes is statistically significant for Winchester (Test 37). There is no significant difference in CPRs between the samples (Test 38)[23].

Table 30. Overall crude prevalence of fractures.
(N^1=number of individuals affected; N^2=total number of individuals present.)

	All Adults		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	1/17	5.9	0/9	0.0	1/8	12.5
25-34	7/59	11.9	1/25	4.0	6/34	17.6
35-49	18/49	36.7	5/16	31.3	13/32	40.5
≥50	18/35	51.4	7/15	46.7	10/18	55.6
UA	2/36	5.6	1/13	7.7	0/13	0.0
Total	46/196	23.5	14/78	17.9	30/105	28.6
	All Adults		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	6/31	19.4	3/14	21.4	3/15	20.0
25-34	7/36	19.4	2/18	11.1	4/16	25.0
35-49	14/36	38.8	5/10	50.0	9/25	36.0
≥50	10/32	31.3	1/12	8.3	8/25	32.0
UA	9/54	13.8	1/13	7.7	7/18	38.9
Total	46/200	23.0	12/67	17.9	31/93	33.3

Table 31 presents separate CPRs for each element/skeletal region. In the case of most elements, the numbers of individuals affected are too small for intra-sample comparisons between the sexes; hence, no tests have been conducted.

In both samples, the ribs, lumbar vertebrae and long bones are the most frequently fractured elements. The prevalence of cranial trauma is similar. The samples differ in terms of the pattern of long bone trauma. In the Winchester sample, the tibia and fibula are most affected, while fractures of the clavicle and lower arm are more common at Ancaster. Humeral and femoral fractures only occur at Winchester. In the case of those elements for which CPRs can be statistically compared, there are no significant differences (Test 39).

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[23] Table F3i in the Access database contains a list of all fractures observed, including details relating to healing, secondary pathology, etc.

Table 31. Crude prevalence of fractures by element.
(N^1=number of individuals affected; N^2=number of individuals with at least one element present; *Includes compression fractures and spondylolysis.)

ANCASTER	**All Adults**		**Females**		**Males**	
	N^1/N^2	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Frontal	1/120	0.8	0/47	0.0	1/69	1.4
Parietal	4/126	3.2	0/48	0.0	3/74	4.1
Occipital	1/125	0.8	0/46	0.0	1/75	1.3
Mandible	0/123	0.0	0/47	0.0	0/72	0.0
Thoracics	2/132	1.5	1/49	2.0	1/82	1.2
Lumbars*	8/130	6.2	4/54	7.4	4/76	5.3
Sternum	2/74	2.7	0/20	0.0	2/54	3.7
Ribs	15/145	10.3	6/59	10.2	9/84	10.7
Clavicle	8/139	5.8	0/56	0.0	8/81	9.9
Scapula	1/122	0.8	1/47	2.1	0/73	0.0
Pelvis	0/129	0.0	0/56	0.0	0/72	0.0
Humerus	0/149	0.0	0/60	0.0	0/86	0.0
Radius	8/145	5.5	5/56	8.9	3/86	3.5
Ulna	5/143	3.5	2/57	3.5	3/84	3.6
Metacarpals	1/143	0.7	0/61	0.0	1/78	1.3
Femur	0/154	0.0	0/62	0.0	0/88	0.0
Patella	1/123	0.8	0/49	0.0	1/71	1.4
Tibia	6/153	3.9	1/63	1.6	4/83	4.8
Fibula	8/148	5.4	2/61	3.3	5/82	6.1
Tarsals	0/151	0.0	0/60	0.0	0/81	0.0
Metatarsals	0/147	0.0	0/60	0.0	1/81	1.2
Phalanges	0/157	0.0	0/64	0.0	0/85	0.0
WINCHESTER	**All Adults**		**Females**		**Males**	
	N^1/N^2	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Frontal	0/109	0.0	0/45	0.0	0/58	0.0
Parietal	5/115	4.3	2/48	4.2	3/62	4.8
Occipital	1/112	0.9	1/44	2.3	0/62	0.0
Mandible	0/110	0.0	0/47	0.0	0/58	0.0
Thoracics	3/121	2.5	0/50	0.0	3/67	4.5
Lumbars	8/109	7.3	2/42	4.8	6/67	9.0
Sternum	0/48	0.0	0/18	0.0	0/27	0.0
Ribs	9/143	6.3	1/56	1.8	6/75	8.0
Clavicle	3/119	2.5	0/52	0.0	3/62	4.8
Scapula	1/50	2.0	0/19	0.0	1/31	3.2
Pelvis	0/122	0.0	0/49	0.0	0/72	0.0
Humerus	2/146	1.4	0/58	0.0	2/80	2.5
Radius	4/142	2.8	1/55	1.8	3/79	3.8
Ulna	3/140	2.1	1/52	1.9	2/81	2.5
Metacarpals	2/141	1.4	0/54	0.0	2/77	2.6
Femur	3/149	2.0	2/57	3.5	0/84	0.0
Patella	0/116	0.0	0/40	0.0	0/66	0.0
Tibia	6/142	4.2	1/46	2.2	5/77	6.5
Fibula	12/118	10.2	2/36	5.6	10/69	14.5
Tarsals	0/145	0.0	0/50	0.0	0/75	0.0
Metatarsals	2/140	1.4	0/48	0.0	2/75	2.7
Phalanges	1/149	0.7	0/53	0.0	1/79	1.3

Separate TPRs were calculated by side for paired elements to explore laterality (Table 32; Figure 38 and Figure 39), excluding the ribs (see section 5.4.2.1.4, below) and phalanges, which were not sided. No attempt has been made to compare TPRs within-samples by side/sex, as the numbers of elements affected are too small in most cases.

Table 32. True prevalence of fractures (paired elements).
(N^1=number of fractured elements; N^2=total number of elements present.)

	All Adults				**Females**				**Males**			
	Right		**Left**		**Right**		**Left**		**Right**		**Left**	
ANC	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Parietal	4/123	3.3	0/123	0.0	0/47	0.0	0/46	0.0	3/72	4.2	0/73	0.0
Nasal	0/60	0.0	0/59	0.0	0/25	0.0	0/25	0.0	0/34	0.0	0/34	0.0
Zygom	0/92	0.0	0/95	0.0	0/33	0.0	0/36	0.0	0/59	0.0	0/62	0.0
Maxilla	0/106	0.0	0/106	0.0	0/43	0.0	0/40	0.0	0/59	0.0	0/62	0.0
Mandib	0/121	0.0	0/119	0.0	0/47	0.0	0/46	0.0	0/70	0.0	0/70	0.0
Clavicle	2/130	1.5	6/127	4.7	0/52	0.0	0/51	0.0	2/76	2.6	6/74	8.1
Scapula	1/105	1.0	0/105	0.0	1/38	2.6	0/37	0.0	0/66	0.0	0/66	0.0
Pelvis	0/123	0.0	0/115	0.0	0/55	0.0	0/48	0.0	0/68	0.0	0/66	0.0
Humerus	0/145	0.0	0/145	0.0	0/60	0.0	0/60	0.0	0/84	0.0	0/82	0.0
Radius	4/137	2.9	4/135	3.0	3/55	5.5	2/47	3.6	1/81	1.2	2/85	2.4
Ulna	3/136	2.2	2/134	1.5	2/55	3.6	0/52	0.0	1/81	1.2	2/80	2.5
MCs	0/533	0.0	1/523	0.2	0/237	0.0	0/216	0.0	0/287	0.0	1/292	0.3
Femur	0/152	0.0	0/146	0.0	0/62	0.0	0/57	0.0	0/86	0.0	0/85	0.0
Patella	0/107	0.0	1/103	1.0	0/41	0.0	0/40	0.0	0/63	0.0	1/60	1.7
Tibia	2/148	1.4	4/149	2.7	0/61	0.0	1/61	1.6	2/81	2.5	2/82	2.4
Fibula	4/136	2.9	4/139	2.9	1/57	1.8	1/55	1.8	3/75	4.0	2/79	2.5
Tarsals	0/791	0.0	0/777	0.0	0/323	0.0	0/302	0.0	0/415	0.0	0/425	0.0
MTs	0/577	0.0	0/609	0.0	0/229	0.0	0/250	0.0	0/305	0.0	0/323	0.0
	All Adults				**Females**				**Males**			
	Right		**Left**		**Right**		**Left**		**Right**		**Left**	
WIN	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Parietal	4/113	3.5	3/113	2.7	2/47	4.3	2/46	4.3	2/61	3.3	1/62	1.6
Nasal	0/33	0.0	0/33	0.0	0/13	0.0	0/13	0.0	0/20	0.0	0/20	0.0
Zygom	0/99	0.0	0/80	0.0	0/42	0.0	0/31	0.0	0/54	0.0	0/45	0.0
Maxilla	0/104	0.0	0/97	0.0	0/44	0.0	0/40	0.0	054	0.0	0/54	0.0
Mandib	1/107	0.9	0/105	0.0	0/47	0.0	0/45	0.0	1/57	1.8	0/57	0.0
Clavicle	2/109	1.8	1/109	0.9	2/50	4.0	0/47	0.0	0/57	0.0	1/58	1.7
Scapula	1/39	2.6	0/38	0.0	0/15	0.0	0/14	0.0	1/24	4.2	0/24	0.0
Pelvis	0/115	0.0	0/109	0.0	0/45	0.0	0/44	0.0	0/69	0.0	0/65	0.0
Humerus	1/130	0.8	1/140	0.7	0/56	0.0	0/54	0.0	1/70	1.4	1/78	1.3
Radius	1/123	0.8	3/131	2.3	1/49	2.0	0/51	0.0	0/69	0.0	3/73	4.1
Ulna	1/125	0.8	3/127	2.4	1/48	2.1	1/47	2.3	0/73	0.0	2/74	2.7
MCs	2/535	0.4	0/523	0.0	0/206	0.0	0/202	0.0	2/307	0.7	0/305	0.0
Femur	0/141	0.0	3/135	2.2	0/52	0.0	2/51	3.8	0/82	0.0	0/76	0.0
Patella	0/87	0.0	0/95	0.0	0/31	0.0	0/34	0.0	0/49	0.0	0/54	0.0
Tibia	4/135	3.0	2/132	1.5	0/43	0.0	1/44	2.3	4/76	5.3	1/71	1.4
Fibula	7/99	7.1	6/108	5.6	0/29	0.0	2/33	6.1	7/62	11.3	4/63	6.3
Tarsals	0/680	0.0	0/674	0.0	0/222	0.0	0/214	0.0	0/388	0.0	0/389	0.0
MTs	1/608	0.2	1/590	0.2	0/191	0.0	0/187	0.0	1/310	0.3	1/301	0.3

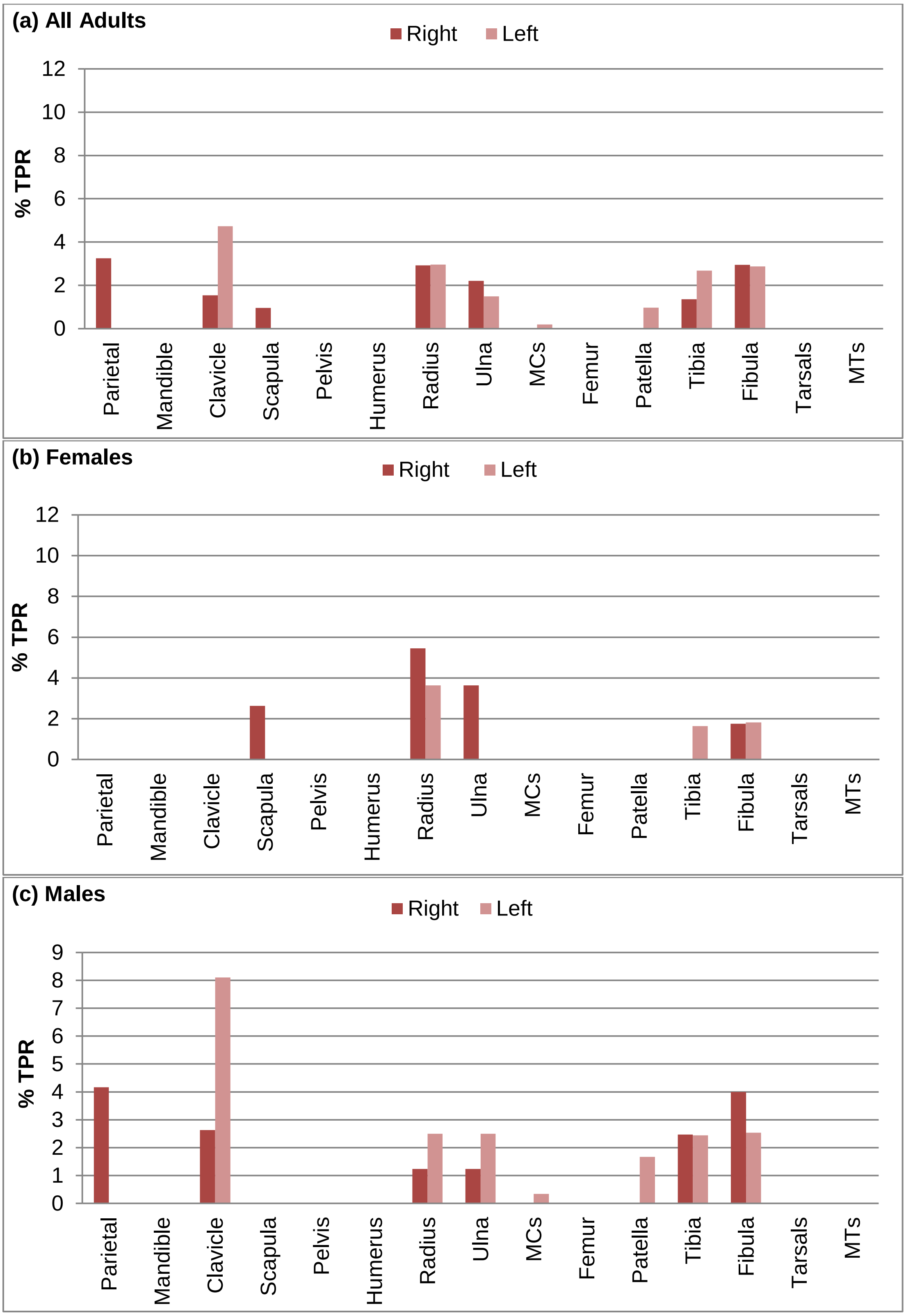

Figure 38. Graphs showing the true prevalence of fractures by element in the Ancaster sample.

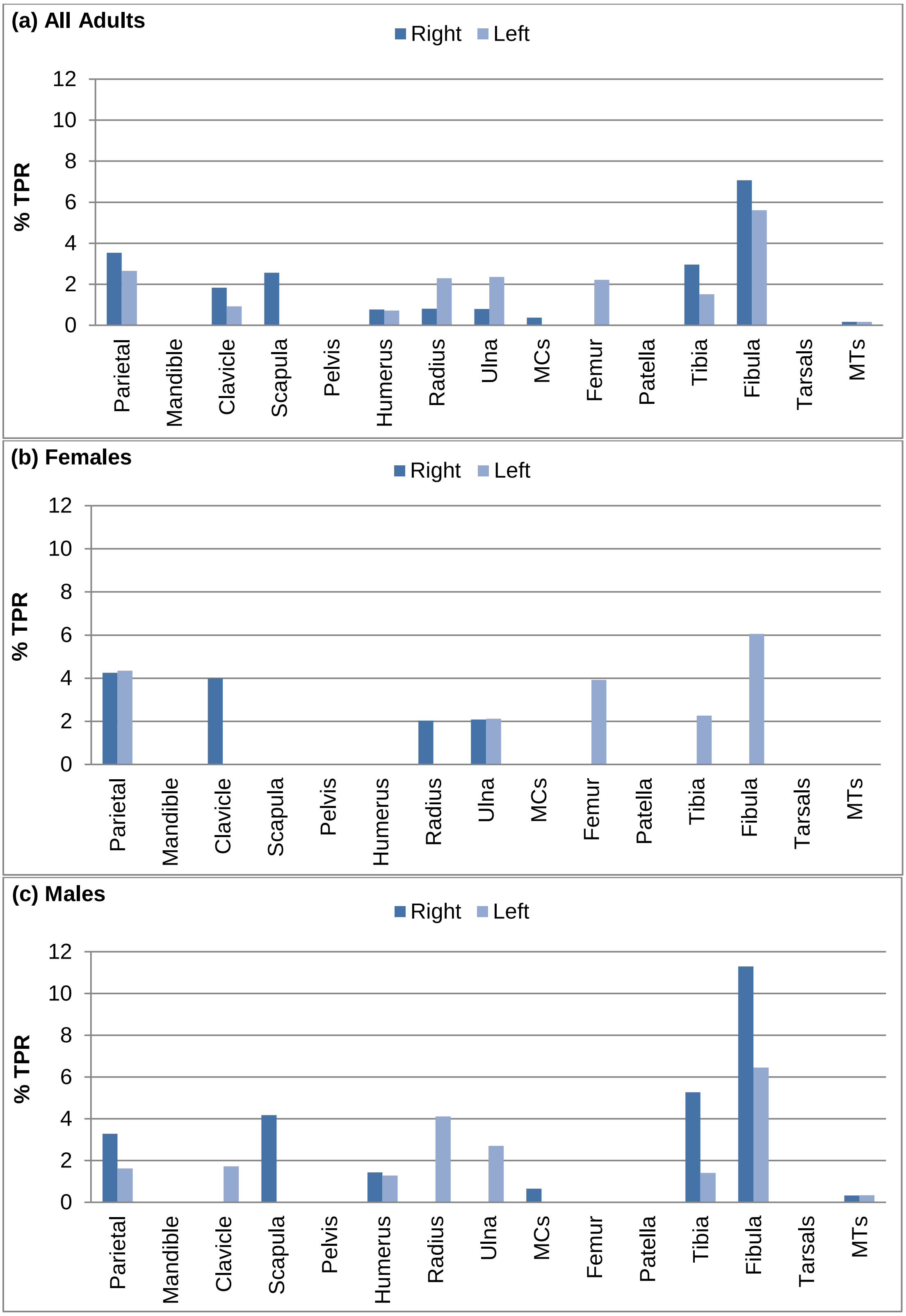

Figure 39. Graphs showing the true prevalence of fractures by element in the Winchester sample.

5.4.2.1.2 Skull fractures

Injuries to the cranial vault were classified as blunt or sharp force (Table 33). All but one of the injuries observed are the result of blunt force trauma. Only one case of sharp force trauma was observed in an individual from Ancaster (ANC 209, M?). With the exception of the peri-mortem radiating fractures observed in VR 66 and 67, all other blunt force injuries are healed depression fractures. Figure 40 illustrates the approximate size and location of depression fractures observed in the study samples. The majority of fractures occur at the parietals.

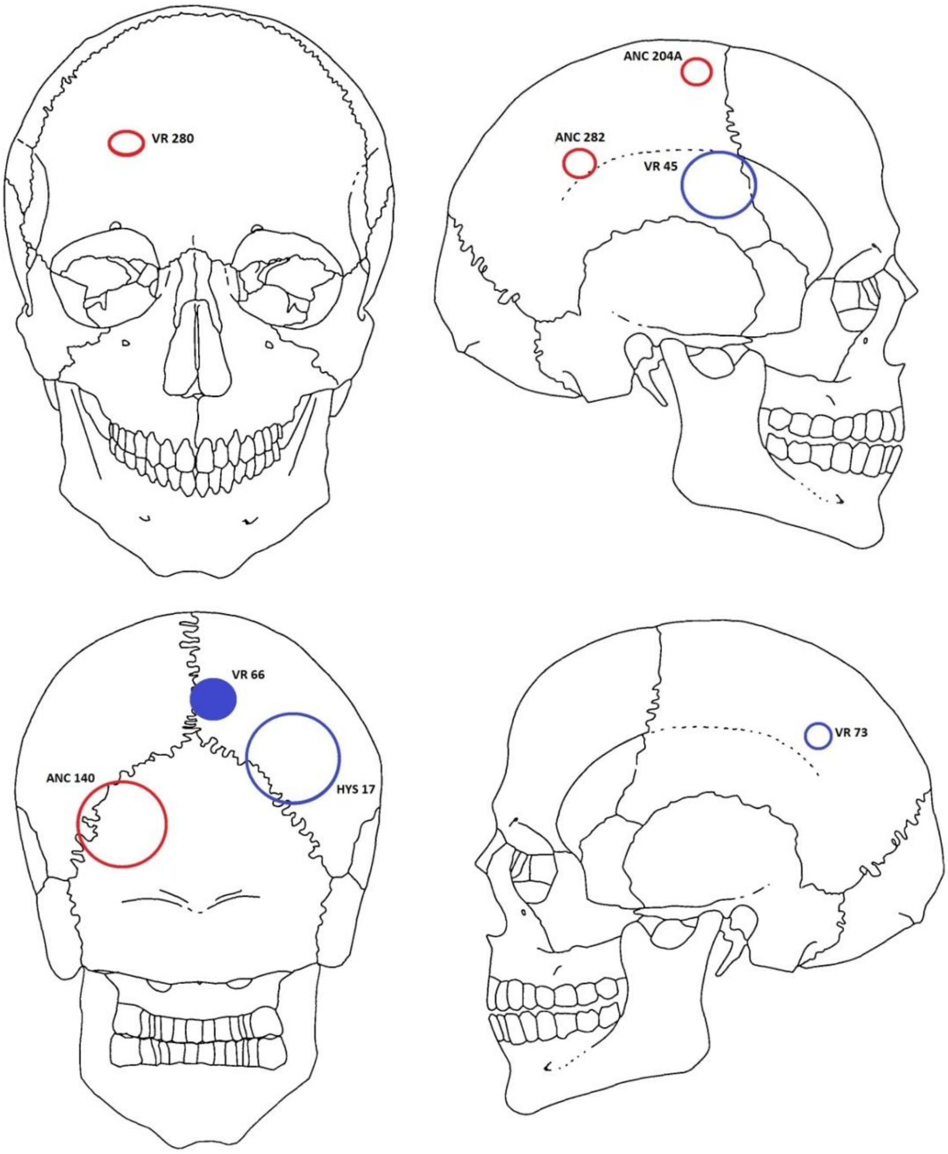

Figure 40. Diagrams showing the locations of depression fractures of the cranial vault.
(Red circles=Ancaster; blue circles=Winchester; open circles=males; solid circles=females.)

Table 33. Cranial vault fractures.
(N^1=number of fractures; N^2=total number of cranial vault fractures.)

		Blunt force				**Sharp force**			
		Healed		**Unhealed**		**Healed**		**Unhealed**	
ANCASTER	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Frontal	1	1	100.0	-	-	-	-	-	-
Parietal R	4	3	75.0	-	-	1	25.0	-	-
Parietal L	0	-	-	-	-	-	-	-	-
Occipital	1	1	100.0	-	-	-	-	-	-
Total	6	5	83.3	-	-	1	16.7	-	-
WINCHESTER	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Frontal	0	-	-	-	-	-	-	-	-
Parietal R	4	3	75.0	1	25.0	-	-	-	-
Parietal L	3	1	33.3	2	66.7	-	-	-	-
Occipital	1	-	-	1	100.0	-	-	-	-
Total	8	4	50.0	4	50.0	-	-	-	-

5.4.2.1.3 Vertebral fractures

Table 34 presents data for the prevalence of different types of vertebral fractures. In the Ancaster sample, the majority of fractures are compression injuries and one individual had sustained a burst fracture. In contrast, compression fractures are less common than spondylolysis at Winchester, and compression fractures are absent in Winchester females. All compression fractures affect the thoracic or lumbar vertebrae (Table 35). No statistical tests have been carried out because of the small numbers of individuals affected.

Table 34. Distribution of vertebral fractures by type.
(N^1=number of compression/bursts/spondylolysis fractures; N^2=total number of fractures.)

		Compression		**Burst**		**Spondylolysis**	
ANCASTER	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
All adults	10	7	70.0	1	10.0	2	20.0
Females	5	4	80.0	-	-	1	20.0
Males	5	3	60.0	1	20.0	1	20.0
WINCHESTER	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
All adults	11	4	36.4	-	-	7	63.6
Females	2	-	-	-	-	2	100.0
Males	9	4	44.4	-	-	5	55.6

Table 35. Crude prevalence of vertebral compression fractures.
(N^1=number of individuals affected; N^2=number of individuals with at least one vertebra – complete vertebrae and isolated centra.)

	All Adults		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Thoracics	2/132	1.5	1/49	2.0	1/82	1.2
Lumbars	6/128	4.7	3/54	5.6	3/74	4.1
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Thoracics	3/119	2.5	0/48	0.0	3/67	4.5
Lumbars	1/106	0.9	0/42	0.0	1/64	1.6

Table 36. Prevalence of spondylolysis.
(N^1=number of vertebrae affected; N^2=number of vertebrae present – complete vertebrae and isolated neural arches.)

	All Adults		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
All	2/130	1.5	1/54	1.9	1/76	1.3
L1	0/105	0.0	0/35	0.0	0/70	0.0
L2	0/110	0.0	0/39	0.0	0/71	0.0
L3	0/118	0.0	0/47	0.0	0/71	0.0
L4	1/119	0.8	1/47	2.1	0/72	0.0
L5	1/120	0.8	0/51	0.0	1/69	1.4
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
All	7/109	6.4	2/42	4.8	5/67	7.5
L1	0/73	0.0	0/26	0.0	0/47	0.0
L2	1/74	1.4	0/26	0.0	1/48	2.1
L3	0/76	0.0	0/26	0.0	0/50	0.0
L4	0/77	0.0	0/27	0.0	0/50	0.0
L5	6/80	7.5	2/28	7.1	4/52	7.7

5.4.2.1.4 Rib fractures

Table 37 presents prevalence rates for rib fractures by side and location. The samples are similar in that the vertebral ends are more affected than the sternal ends overall. Left vertebral ribs are more affected than right in females, while the opposite is true for males. CPRs are higher for the Ancaster sample in most cases. No statistical tests have been carried out due to the small numbers of individuals affected.

Table 37. Prevalence of rib fractures: Ancaster.
(N^1=number of individuals/ribs affected; N^2=number of individuals with at least one rib/number of ribs present.)

	All Adults		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Vertebral R+L	7/136	5.1	3/56	5.4	4/78	5.1
Vertebral R	5/132	3.8	1/54	1.9	4/76	5.3
Vertebral L	4/130	3.1	2/51	3.9	2/78	2.6
Sternal R+L	5/128	3.9	1/50	2.0	5/77	6.5
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Vertebral R+L	16/2288	0.7	3/868	0.3	13/1405	0.9
Vertebral R	11/1158	0.9	1/444	0.2	10/706	1.4
Vertebral L	5/1130	0.4	2/424	0.5	3/699	0.4
Sternal R+L	7/1378	0.5	1/547	0.2	6/823	0.7

Table 38. Prevalence of rib fractures: Winchester.
(N^1=number of individuals/ribs affected; N^2=number of individuals with at least one rib/number of ribs present.)

	All Adults		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Vertebral R+L	4/132	3.0	1/52	1.9	2/73	2.7
Vertebral R	2/125	1.6	0/51	0.0	1/70	1.4
Vertebral L	2/122	1.6	1/49	2.0	1/67	1.5
Sternal R+L	1/109	0.9	0/45	0.0	1/60	1.7
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Vertebral R+L	10/1821	0.5	4/728	0.5	5/1036	0.5
Vertebral R	5/921	0.5	0/375	0.0	4/522	0.8
Vertebral L	5/900	0.6	4/353	1.1	1/514	0.2
Sternal R+L	2/655	0.3	0/255	0.0	2/383	0.5

5.4.2.1.5 Long bone fractures

Table 39 presents data for the prevalence of upper *versus* lower long bone fractures. The Ancaster sample exhibits more fractures of the upper limb, while the lower limb is more affected in the Winchester sample. However, the differences in upper *versus* lower limb CPRs is not significant for either site, nor is there a difference in upper/lower limb CPRs between the samples (Test 40 and Test 41).

Table 39. Prevalence of fractures of upper *vs.* lower long bones.
(Upper=includes the clavicle; N^1=number of individuals/elements affected; N^2=number of individuals with at least one upper/lower long bone/number of bones present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Upper	17/160	10.6	5/66	7.6	12/91	13.2
Lower	10/162	6.2	2/66	3.0	7/90	7.8
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Upper	21/1089	1.9	7/432	1.6	14/643	2.2
Lower	14/870	1.6	3/353	0.8	9/488	1.8
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Upper	11/156	7.1	4/60	6.7	7/85	8.2
Lower	15/169	8.9	4/58	6.9	10/85	11.8
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Upper	13/994	1.3	5/402	1.2	8/552	1.4
Lower	22/750	2.9	5/252	2.0	16/430	3.7

The majority of fractures in both samples occur at the distal/lateral third, no fractures occur at the proximal/medial extremities, and all clavicle fractures occur at the mid/lateral shaft (Table 40). In the Ancaster sample, the second most common fracture location is the mid third, while the proximal third is more affected at Winchester, largely due to the prevalence of proximal fibula fractures. The prevalence of distal extremity fractures is higher for Ancaster and fractures of the radius and ulna exhibit greater diversity in location. All tibia fractures in the Ancaster sample occur at the distal third shaft, while the mid-shaft is more affected in the Winchester sample.

Table 40. Location of long bone fractures.
(N^1=number of fractures; N^2=total number of fractures.)

		Prox/Med End		**Prox/Med 1/3**		**Mid 1/3**		**Dist/Lat 1/3**		**Dist/Lat End**	
ANC	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Clav R	2	-	-	-	-	2	100.0	-	-	-	-
Clav L	6	-	-	-	-	4	66.7	2	33.3	-	-
Hu R	0	-	-	-	-	-	-	-	-	-	-
Hu L	0	-	-	-	-	-	-	-	-	-	-
Rad R	4	-	-	1	25.0	1	25.0	2	50.0	-	-
Rad L	4	-	-	-	-	1	25.0	3	75.0	-	-
Ulna R	3	-	-	1	33.3	-	-	-	-	2	67.7
Ulna L	2	-	-	-	-	1	50.0	1	50.0	-	-
Fe R	0	-	-	-	-	-	-	-	-	-	-
Fe L	0	-	-	-	-	-	-	-	-	-	-
Tib R	2	-	-	-	-	-	-	2	100.0	-	-
Tib L	4	-	-	-	-	-	-	4	100.0	-	-
Fib R	4	-	-	1	25.0	1	25.0	2	50.0	-	-
Fib L	4	-	-	3	75.0	-	-	-	-	1	25.0
Total	35	-	-	6	17.1	10	28.6	16	45.7	3	8.6
		Prox/Med End		**Prox/Med 1/3**		**Mid 1/3**		**Dist/Lat 1/3**		**Dist/Lat End**	
WIN	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Clav R	2	-	-	-	-	1	50.0	1	50.0	-	-
Clav L	1	-	-	-	-	1	100.0	-	-	-	-
Hu R	1	-	-	--	-	-	-	-	-	1	100.0
Hu L	1	-	-	-	-	1	100.0	-	-	-	-
Rad R	1	-	-	-	-	-	-	1	100.0	-	-
Rad L	3	-	-	-	-	1	33.3	2	66.7	-	-
Ulna R	1	-	-	1	100.0	-	-	-	-	-	-
Ulna L	3	-	-	-	-	-	-	3	100.0	-	-
Fe R	0	-	-	-	-	-	-	-	-	-	-
Fe L	3	-	-	1	33.3	-	-	2	66.7	-	-
Tib R	4	-	-	-	-	3	75.0	1	25.0	-	-
Tib L	2	-	-	-	-	1	50.0	1	50.0	-	-
Fib R	7	-	-	6	85.7	-	-	1	14.3	-	-
Fib L	6	-	-	2	33.3	1	16.7	3	50.0	-	-
Total	35	-	-	10	28.6	9	25.7	15	42.9	1	2.8

In both samples, oblique fractures are the most common type of break, followed by transverse fractures (Table 41). The ‘other’ category includes two fractures of the ulnar styloid process observed in the Ancaster sample, and a healed fracture of the distal humerus in an individual from Winchester. Spiral and greenstick fractures are uncommon. Table 42 presents data for the proportion of radius and ulna fractures that meet the criteria for Colles’ and ‘parry’ fractures.

Table 41. Types of long bone fractures.
(N^1=number of fractures; N^2=total number of fractures; *Includes fractures where type could not be determined.)

		Transverse		**Oblique**		**Spiral**		**Greenstick**		**Other***	
ANC	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Clav R	2	-	-	1	50.0	-	-	-	-	1	50.0
Clav L	6	-	-	2	33.3	-	-	-	-	4	66.7
Hu R	0	-	-	-	-	-	-	-	-	-	-
Hu L	0	-	-	-	-	-	-	-	-	-	-
Rad R	4	3	75.0	1	25.0	-	-	-	-	-	-
Rad L	4	3	75.0	1	25.0	-	-	-	-	-	-
Ulna R	3	1	33.3	-	-	-	-	-	-	2	66.7
Ulna L	2	1	50.0	1	50.0						
Fe R	0	-	-	-	-	-	-	-	-	-	-
Fe L	0	-	-	-	-	-	-	-	-	-	-
Tib R	2	-	-	2	100	-	-	-	-	-	-
Tib L	4	-	-	3	75.0	1	25.0	-	-	-	-
Fib R	4	1	25.0	3	75.0	-	-	-	-	-	-
Fib L	4	-	-	3	75.0	1	25.0	-	-	-	-
Total	35	9	25.7	17	48.6	2	5.7	-	-	7	20.0
		Transverse		**Oblique**		**Spiral**		**Greenstick**		**Other***	
WIN	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Clav R	2	-	-	1	50.0	-	-	-	-	1	50.0
Clav L	1	-	-	1	100	-	-	-	-	-	-
Hu R	1	-	-	-	-	-	-	-	-	1	100
Hu L	1	-	-	-	-	-	-	-	-	1	100
Rad R	1	-	-	1	100	-	-	-	-	-	-
Rad L	3	3	100	-	-	-	-	-	-	-	-
Ulna R	1	-	-	-	-	-	-	-	-	1	100
Ulna L	3	2	66.7	1	33.3	-	-	-	-	-	-
Fe R	0	-	-	-	-	-	-	-	-	-	-
Fe L	3	-	-	1	33.3	-	-	1	33.3	1	33.3
Tib R	4	-	-	3	75.0	1	25.0	-	-	-	-
Tib L	2	-	-	2	100	-	-	-	-	-	-
Fib R	7	-	-	4	57.1	1	14.3	-	-	2	28.6
Fib L	6	1	16.7	4	83.3	-	-	1	16.7	-	-
Total	35	6	17.1	18	51.4	2	5.7	2	5.7	7	20.0

Table 42. Forearm fractures.
(N^1=number of fractures; N^2=total number of fractures.)

	ANCASTER		**WINCHESTER**	
	N^1/N^2	%	**N^1/N^2**	%
Radius: Colles’	5/8	62.5	2/4	50.0
Ulna: ‘parry’	1/5	20.0	2/4	50.0

5.4.2.2 Osteochondritis dissecans

No Winchester individuals are affected. ANC 93 and 185A, exhibit lesions at the right knee and right ankle, respectively (Figure 109 and 109). The overall CPR for Ancaster is 1.0% (2/196 individuals). No statistical test has been conducted due to the small number of individuals affected.

5.4.3 *Metabolic disease*[24]

5.4.3.1 Scurvy

Lesions suggestive of scurvy were observed in two individuals from Winchester sample (VR 9 and VR 15), but none from Ancaster (Table 44; Figure 113 and 114; see also Appendix 4, Table 99 for differential diagnoses). The number of individuals affected is too small for statistical comparison.

Table 43. Crude prevalence of scurvy.
(N^1=number of individuals affected; N^2=total number of individuals; %=CPR.)

	ANCASTER		**WINCHESTER**	
	N^1/N^2	**%**	**N^1/N^2**	**%**
<1	0/6	0.0	1/12	8.3
1-5	0/24	0.0	1/24	4.2
6-11	0/18	0.0	0/18	0.0
12-17	0/5	0.0	0/17	0.0
US	0/3	0.0	0/3	0.0
Total	0/57	0.0	2/74	2.7

5.4.3.2 Rickets and osteomalacia

Osteomalacia was not observed in either study sample. No subadults from Winchester exhibit signs of rickets. One subadult from Ancaster (ANC 208) does exhibit probable rickets (Table 45; Figure 115). Descriptions and differential diagnoses are provided in Appendix 4, Table 99. The number of individuals affected is too small for statistical comparison.

Table 44. Crude prevalence of rickets.
(N^1=number of individuals affected; N^2=total number of individuals; %=CPR.)

	ANCASTER		**WINCHESTER**	
	N^1/N^2	**%**	**N^1/N^2**	**%**
<1	1/6	16.7	0/12	0.0
1-5	0/24	0.0	0/24	0.0
6-11	0/18	0.0	0/18	0.0
12-17	0/5	0.0	0/17	0.0
US	0/3	0.0	0/3	0.0
Total	1/57	1.8	0/74	0.0

5.4.3.3 Osteoporosis

No femoral neck fractures were observed in either sample[25]. Of the elderly adults in the study samples, five from Ancaster and two from Winchester have vertebral

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[24] See Table F4 in the Access database.

[25] Mays (2006a) reported an example in an elderly female from Ancaster who was not included in the present study.

compression fractures and/or Colles' fractures. Two individuals, ANC 241 and AR 312, exhibit both radial and vertebral fractures. One unaged female (ANC 263) has a definite osteoporotic fracture of the third lumbar vertebra and has been included (Figure 116). Table 45 presents CPR data. The CPR is higher for Ancaster. At Ancaster, females are more affected than males, while the opposite is true for Winchester. The numbers of individuals affected are too small for statistical comparison.

Table 45. Crude prevalence of osteoporosis.
(N^1=number of individuals affected; N^2=number of individuals present.)

	All Adults		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/17	0.0	0/9	0.0	0/8	0.0
25-34	0/59	0.0	0/25	0.0	0/34	0.0
35-49	0/49	0.0	0/16	0.0	0/32	0.0
≥50	5/35	14.3	3/15	0.0	2/18	11.1
UA	1/36	0.0	1/13	7.7	0/13	0.0
Total	6/196	3.1	4/78	5.1	2/105	1.9
	All Adults		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/31	0.0	0/14	0.0	0/15	0.0
25-34	0/36	0.0	0/18	0.0	0/16	0.0
35-49	0/36	0.0	0/10	0.0	0/25	0.0
≥50	2/32	6.3	0/12	0.0	2/19	10.5
UA	0/65	0.0	0/13	0.0	0/18	0.0
Total	2/200	1.0	0/67	0.0	2/93	2.2

5.4.4 *Specific infections*[26]

5.4.4.1 Tuberculosis

There are three definite cases of TB in the Ancaster sample and one definite case from Winchester (Figure 41, Figures 116, 117 and 120). Three further individuals from Ancaster exhibit possible evidence for TB (ANC 46, ANC 82 and ANC 210). Several individuals in both study samples exhibit visceral rib periostitis[27] and/or

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[26] See Table F5 in the Access database.

[27] It should be noted that when the Winchester sample was examined by the author, no rib lesions were observed. Roberts and Buikstra (2003) reported five individuals with rib periostitis, and it subsequently came to light that ribs exhibiting new bone formation at the visceral surfaces had been removed from VR 96, VR 129, CHR 512A, and CHR 636 for pathogenic DNA analysis. Rib lesions were also observed in a fifth individual not included in the present study sample (CHR 512B=535). Although the relevant bones could not be examined directly, pictures were obtained illustrating the location and nature of lesions; hence, these elements are included in the data for non-specific rib periostitis. Only the sample from CHR 512B/535 tested positive for possible pathogenic DNA although the quality of the genetic material was poor. None of the samples from the four individuals

widespread symmetrical deposits of woven bone, possibly representing hypertrophic pulmonary osteopathy (ANC 47, ANC 48B, ANC 55, ANC 62, ANC 143, ANC 240; VR 96, CHR 512A, CHR 636; Figures 118, 121 to 123). Although these lesions may represent TB, no diagnoses could be made (descriptions and differential diagnoses are provided in Appendix 4, Table 99); hence, only ANC 1, ANC 11, ANC 218 and VR 129 are included in the prevalence data (cases of rib periostitis and/or HPO are included under non-specific periostitis). The crude prevalence rate is higher for the Ancaster sample (Table 46). The numbers of individuals affected are too small for statistical comparison.

Table 46. Crude prevalence of tuberculosis.
(Definite cases only; N^1=number of individuals affected; N^2=total number of individuals present.)

	All Adults		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	1/17	5.9	1/9	11.1	0/8	0.0
25-34	1/59	1.7	1/25	4.0	0/34	0.0
35-49	1/49	2.0	0/16	0.0	1/32	3.1
≥50	0/35	0.0	0/15	0.0	0/18	0.0
UA	0/36	0.0	0/13	0.0	0/13	0.0
Total	3/196	1.5	2/78	2.6	1/105	1.0
	All Adults		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/31	0.0	0/14	0.0	0/15	0.0
25-34	1/36	2.8	1/18	5.6	0/16	0.0
35-49	0/36	0.0	0/10	0.0	0/25	0.0
≥50	0/32	0.0	0/12	0.0	0/19	0.0
UA	0/65	0.0	0/13	0.0	0/18	0.0
Total	1/200	0.5	1/67	1.5	0/93	0.0

5.4.4.2 Other specific infections

5.4.4.2.1 Poliomyelitis

One individual from Winchester (VR 95) exhibits changes that may be the result of childhood poliomyelitis (Figure 126). Poliomyelitis, caused by the poliovirus, is an enterovirus acquired via ingestion of faecal matter. Most infected individuals (*c.* 95% or more) are asymptomatic, but a small percentage develops complications, including paralysis (Smallman-Raynor *et al.* 2006: 33-5). Skeletally, this manifests as disuse atrophy, osteoporosis and (if individuals contract the virus in childhood) shortening of the affected limb(s) (Aufderheide and Rodríguez-Martín 1998: 212;

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included in the present study tested positive for *M. tuberculosis* complex (R. Müller, personal communication).

Waldron 2009: 109). The changes observed in VR 95 are consistent with poliomyelitis, but definitive diagnosis is not possible because the majority of the skeleton is absent (see Appendix 4, Table 99, for differential diagnosis).

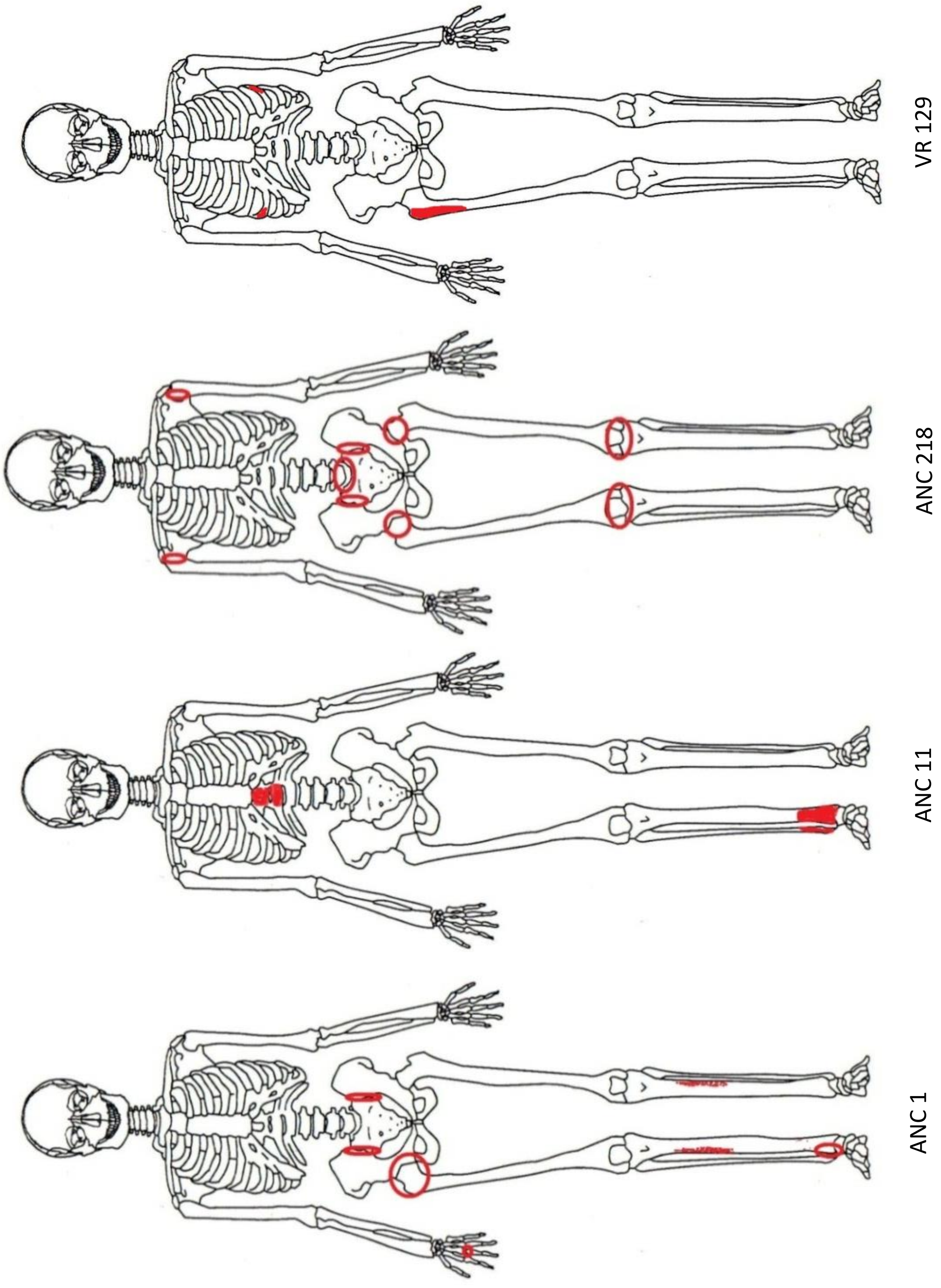

Figure 41. Diagrams showing the locations of lesions in individuals with tuberculosis.

5.4.5 *Non-specific indicators of health*

5.4.5.1 Periostitis[28]

5.4.5.1.1 General characteristics

Table 47 presents data for non-specific periostitis (Figure 127 and Figure 128). In both samples, adults are slightly more affected than subadults. The subadult CPR is slightly higher for Ancaster (5.3% *vs.* 4.1%), but the adult CPR is slightly greater for Winchester (12.0% *vs.* 10.7%). There are no statistically significant differences between the sexes within samples (Ancaster: χ^2=0.798, d.f.=1, *p*=0.372; Winchester: χ^2=0.238, d.f.=1, *p*=0.626), and there is no significant difference between the study samples in terms of the overall CPR (Test 42).

Table 47. Overall prevalence of periostitis.
(N^1=number of individuals affected; N^2=total number of individuals present.)

	All		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/6	0.0	-	-	-	-
1-5	1/24	4.2	-	-	-	-
6-11	2/18	11.1	-	-	-	-
12-17	0/5	0.0	-	-	-	-
US	0/3	0.0	-	-	-	-
Total subadults	3/57	5.3	-	-	-	-
18-24	6/17	35.3	2/9	22.2	4/8	50.0
25-34	5/59	8.5	2/25	8.0	3/34	8.8
35-49	5/49	10.2	1/16	6.3	4/32	12.5
≥50	3/35	8.6	0/15	0.0	3/18	16.7
UA	2/36	5.6	1/13	7.7	1/13	7.7
Total adults	21/196	10.7	6/78	7.7	15/105	14.3
Total sample	24/253	9.5	-	-	-	-
	All		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/12	0.0	-	-	-	-
1-5	1/24	4.2	-	-	-	-
6-11	1/18	5.6	-	-	-	-
12-17	1/17	5.0	-	-	-	-
US	0/3	0.0	-	-	-	-
Total subadults	3/74	4.1	-	-	-	-
18-24	5/31	16.1	2/14	14.3	3/15	20.0
25-34	6/36	16.7	4/18	22.2	2/16	12.5
35-49	4/36	11.1	1/10	10.0	3/25	12.0
≥50	5/32	15.6	1/12	8.3	3/19	15.8
UA	3/65	4.6	1/13	7.7	0/18	0.0
Total adults	24/200	12.0	9/67	13.4	9/93	9.7
Total sample	27/274	9.9	-	-	-	-

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[28] See Table F6i in the Access database.

5.4.5.1.2 Rib periostitis

Table 48 presents prevalence data for rib periostitis. The crude prevalence of rib periostitis is greater for Ancaster in the case of both subadults and adults[29]. The numbers of individuals affected are too small for statistical comparison.

Table 48. Prevalence of rib periostitis.
(N^1=number of individuals affected; N^2=number of individuals with at least one rib/rib fragment.)

	All		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/6	0.0	-	-	-	-
1-5	0/20	0.0	-	-	-	-
6-11	1/13	7.7	-	-	-	-
12-17	0/3	0.0	-	-	-	-
US	0/0	-	-	-	-	-
Total subadults	1/42	2.4	-	-	-	-
18-24	1/13	7.7	0/6	0.0	1/7	14.3
25-34	1/50	2.0	0/22	0.0	1/28	3.6
35-49	2/41	4.9	0/14	0.0	2/27	7.4
≥50	0/29	0.0	0/11	0.0	0/17	0.0
UA	1/12	8.3	1/6	16.7	0/5	0.0
Total adults	5/145	3.5	1/59	1.7	4/84	4.8
Total sample	6/187	3.2	-	-	-	-
	All		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/8	0.0	-	-	-	-
1-5	0/18	0.0	-	-	-	-
6-11	1/11	9.1	-	-	-	-
12-17	0/13	0.0	-	-	-	-
US	0/0	-	-	-	-	-
Total subadults	1/50	2.0	-	-	-	-
18-24	0/23	0.0	0/11	0.0	0/11	0.0
25-34	3/34	8.8	2/18	11.1	1/15	6.7
35-49	0/29	0.0	0/8	0.0	0/21	0.0
≥50	0/29	0.0	0/10	0.0	0/18	0.0
UA	0/29	0.0	0/9	0.0	0/10	0.0
Total adults	3/144	2.1	2/56	3.6	1/75	1.3
Total sample	4/194	2.1	-	-	-	-

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[29] Several cases of periostitis in the Ancaster sample were not previously recorded by Cox (1989), and are not listed by Roberts and Buikstra (2003: 132).

5.4.5.1.3 Tibia periostitis

Table 49 presents crude prevalence data for tibia periostitis. The overall CPR (subadults and adults combined) is greater for Ancaster, but the difference is not statistically significant (Test 43). Unilateral periostitis may represent localised infection or trauma; hence, CPRs were also calculated for bilateral tibia periostitis (Table 50). Once again, the CPR is higher for Ancaster, although the numbers of individuals affected are too small for statistical comparison.

Table 49. Crude prevalence of tibia periostitis.
(N^1=number of individuals affected; N^2=number of individuals with one or both tibia.)

	All		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/4	0.0	-	-	-	-
1-5	0/17	0.0	-	-	-	-
6-11	2/12	16.7	-	-	-	-
12-17	0/3	0.0	-	-	-	-
US	0/1	0.0	-	-	-	-
Total subadults	2/37	5.4	-	-	-	-
18-24	4/13	30.8	2/7	28.6	2/6	33.3
25-34	3/46	6.4	2/20	10.0	1/26	3.8
35-49	4/42	9.5	1/16	6.3	3/26	11.5
≥50	1/28	3.6	0/11	0.0	1/16	6.3
UA	2/23	8.7	1/9	11.1	1/9	11.1
Total adults	14/152	9.2	6/63	9.5	8/83	9.6
Total sample	16/189	8.5	-	-	-	-
	All		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/8	0.0	-	-	-	-
1-5	0/14	0.0	-	-	-	-
6-11	0/13	0.0	-	-	-	-
12-17	1/16	6.3	-	-	-	-
US	0/0	-	-	-	-	-
Total subadults	1/51	2.0	-	-	-	-
18-24	2/24	8.2	1/10	10.0	1/13	7.7
25-34	2/25	8.0	1/11	9.2	1/13	7.7
35-49	2/28	7.1	0/8	0.0	2/20	10.0
≥50	2/26	7.7	0/8	0.0	2/17	11.8
UA	2/39	5.1	1/9	11.1	0/14	0.0
Total adults	10/142	7.0	3/46	6.5	6/77	7.9
Total sample	11/193	5.7	-	-	-	-

Table 50. Crude prevalence of bilateral tibia periostitis.
(N^1=number of individuals affected; N^2=number of individuals with both tibiae present.)

	All		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/3	0.0	-	-	-	-
1-5	0/13	0.0	-	-	-	-
6-11	2/12	16.7	-	-	-	-
12-17	0/3	0.0	-	-	-	-
US	0/2	0.0	-	-	-	-
Total subadults	2/32	6.3	-	-	-	-
18-24	3/12	25.0	2/7	28.6	1/5	20.0
25-34	1/46	2.2	0/20	0.0	1/26	3.8
35-49	1/38	2.6	0/14	0.0	1/24	4.2
≥50	0/27	0.0	0/10	0.0	0/16	0.0
UA	0/22	0.0	0/8	0.0	0/9	0.0
Total adults	5/145	3.5	2/59	3.4	3/80	3.8
Total sample	7/188	3.7	-	-	-	-
	All		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/7	0.0	-	-	-	-
1-5	0/10	0.0	-	-	-	-
6-11	0/12	0.0	-	-	-	-
12-17	0/11	0.0	-	-	-	-
US	0/0	-	-	-	-	-
Total subadults	0/40	0.0	-	-	-	-
18-24	0/20	0.0	0/8	0.0	0/12	0.0
25-34	0/22	0.0	0/9	0.0	0/12	0.0
35-49	0/25	0.0	0/7	0.0	0/18	0.0
≥50	1/23	4.3	0/8	0.0	1/14	7.1
UA	0/35	0.0	0/9	0.0	0/14	0.0
Total adults	1/125	0.8	0/41	0.0	1/70	1.4
Total sample	1/165	0.6	-	-	-	-

5.4.5.2 Cribra orbitalia[30]

Table 51 and Table 52 present prevalence data for cribra orbitalia. In both samples, subadults are more affected than adults. The difference in CPRs between subadults and adults is statistically significant for Ancaster (χ^2=11.624, d.f.=1, *p*=0.001), but not Winchester (χ^2=3.738, d.f.=1, *p*=0.053). Males are more affected than females in both samples, but the difference in CPRs between the sexes is not significant for either site (Test 44). Ancaster has the highest subadult CPR, while the adult CPR and overall CPR are highest for Winchester. None of the differences between the samples, either overall or by age group/sex, is statistically significant (Test 45).

Table 53 presents data for the activity of lesions. In both samples, only subadults exhibit active lesions and the prevalence of active lesions declines with age. When the proportions of individuals with healed *vs.* active lesions are compared

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[30] See Table F6ii in the Access database.

between the samples (adults and subadults combined), the difference is not statistically significant (χ^2=0.839, d.f.=1, *p*=0.360). Table 54 presents data for lesion severity[31]. Both samples are similar in that the majority of individuals have only slight (grade 1) lesions, and no individuals exhibit the most severe (grade 5) lesions. The majority of Ancaster subadults have grade 1 lesions, but at Winchester grade 2 lesions are more common, and there are more subadults with grade 3 and 4 lesions. Among adults in both samples, most lesions are slight. In the Ancaster sample, more adults have grade 3 than grade 2 lesions, while fewer Winchester adults have grade 3 lesions. When the proportions of individuals with grade 1/2 *vs.* grade 3/4 lesions are compared between the samples (adults and subadults combined), the difference is not statistically significant (χ^2=2.952, d.f.=1, *p*=0.086).

Table 51. Overall prevalence of cribra orbitalia: Ancaster.
(N^1=number of individuals/orbits affected; N^2=number of individuals with at least one orbit/number of orbits.)

	All		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	1/2	50.0	-	-	-	-
1-5	6/18	33.3	-	-	-	-
6-11	9/13	69.2	-	-	-	-
12-17	0/3	0.0	-	-	-	-
US	0/0	-	-	-	-	-
Total subadults	16/36	44.4	-	-	-	-
18-24	1/9	11.1	0/5	0.0	1/4	25.0
25-34	9/46	19.6	3/22	13.6	6/24	25.0
35-49	4/30	13.3	1/9	11.1	3/21	14.3
≥50	3/21	14.3	0/7	0.0	2/12	16.7
UA	2/15	13.3	1/6	16.7	1/7	14.3
Total adults	19/121	15.7	5/49	10.2	13/68	19.1
Total sample	35/157	22.3	-	-	-	-
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	2/4	50.0	-	-	-	-
1-5	11/35	31.4	-	-	-	-
6-11	18/25	72.0	-	-	-	-
12-17	0/6	0.0	-	-	-	-
US	0/0	-	-	-	-	-
Total subadults	38/70	54.3	-	-	-	-
18-24	2/18	11.1	0/10	0.0	2/8	25.0
25-34	14/85	16.5	5/42	11.9	9/43	20.9
35-49	8/57	14.0	2/17	11.8	6/40	15.0
≥50	6/37	16.2	0/11	0.0	4/23	17.4
UA	4/27	14.8	2/11	18.2	2/13	15.4
Total adults	34/224	15.2	9/91	9.9	23/127	18.1
Total sample	72/294	24.5	-	-	-	-

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[31] Where the severity of lesions differed between right and left orbits, the more severe expression was used.

Table 52. Overall prevalence of cribra orbitalia: Winchester.
(N^1=number of individuals/orbits affected; N^2=number of individuals with at least one orbit/number of orbits.)

	All		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	1/5	20.0	-	-	-	-
1-5	7/12	58.3	-	-	-	-
6-11	5/10	50.0	-	-	-	-
12-17	2/9	22.2	-	-	-	-
US	0/0	-	-	-	-	-
Total subadults	15/36	41.7	-	-	-	-
18-24	6/25	24.0	2/12	16.7	4/13	30.8
25-34	6/26	23.2	3/14	21.4	3/11	27.4
35-49	4/19	21.1	1/5	20.0	3/14	21.4
≥50	7/25	28.0	3/11	27.3	4/14	28.6
UA	2/13	15.4	1/6	16.7	1/5	20.0
Total adults	25/108	23.1	10/48	20.8	15/56	26.8
Total sample	40/144	27.8	-	-	-	-
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	2/9	22.2	-	-	-	-
1-5	12/22	54.5	-	-	-	-
6-11	8/16	50.0	-	-	-	-
12-17	4/15	26.7	-	-	-	-
US	0/0	-	-	-	-	-
Total subadults	26/62	41.9	-	-	-	-
18-24	12/47	25.5	4/21	19.0	8/26	30.8
25-34	12/50	24.0	6/26	23.1	6/22	27.3
35-49	7/38	18.4	2/10	20.0	5/28	17.9
≥50	13/44	29.5	5/18	27.8	8/24	33.3
UA	4/24	16.7	2/11	18.2	2/10	20.0
Total adults	69/265	26.0	19/86	22.1	29/110	26.4
Total sample	95/327	29.1	-	-	-	-

Table 53. Activity of cribra orbitalia lesions.
(N^1=number of individuals affected; N^2=total number of individuals with cribra orbitalia.)

ANCASTER						**WINCHESTER**					
	N^2	**Healed**		**Active**			**N^2**	**Healed**		**Active**	
		N^1	**%**	**N^1**	**%**			**N^1**	**%**	**N^1**	**%**
<1	1	-	-	1	100.0	<1	1	-	-	1	100.0
1-5	6	-	-	6	100.0	1-5	7	-	-	7	100.0
6-11	9	1	11.1	8	88.9	6-11	5	2	40.0	3	60.0
12-17	0	-	-	-	-	12-17	2	1	50.0	1	50.0
US	0	-	-	-	-	US	0	-	-	-	-
Total S	16	1	6.2	15	93.8	Total S	15	3	20.0	12	80.0
18-24	1	1	100.0	-	-	18-24	6	6	100.0	-	-
25-34	9	9	100.0	-	-	25-34	6	6	100.0	-	-
35-49	4	4	100.0	-	-	35-49	4	4	100.0	-	-
≥50	3	3	100.0	-	-	≥50	7	7	100.0	-	-
UA	2	2	100.0	-	-	UA	2	2	100.0	-	-
Total A	19	19	100.0	-	-	Total A	25	25	100.0	-	-
Total	35	20	57.1	15	42.9	Total	40	28	70.0	12	30.0

Table 54. Severity of cribra orbitalia lesions.
(N^1=number of individuals affected; N^2=total number of individuals with cribra orbitalia.
N.B. No individuals in either sample exhibited grade 5 lesions.)

		Grade 1		**Grade 2**		**Grade 3**		**Grade 4**	
ANCASTER	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
<1	1	1	100.0	-	-	-	-	-	-
1-5	6	3	50.0	2	33.3	1	16.7	-	-
6-11	9	3	33.3	1	11.1	2	22.2	3	33.3
12-17	0	-	-	-	-	-	-	-	-
US	0	-	-	-	-	-	-	-	-
Total subadults	16	7	43.8	3	18.8	3	18.8	3	18.8
18-24	1	-	-	-	-	1	100.0	-	-
25-34	9	5	55.5	2	22.2	2	22.2	-	-
35-49	4	3	75.0	-	-	1	25.0	-	-
≥50	3	2	66.7	1	33.3	-	-	-	-
UA	2	1	50.0	-	-	1	50.0	-	-
Total adults	19	12	63.2	3	15.8	4	21.1	-	-
Total sample	35	19	54.3	6	17.1	7	20.0	3	8.6
		Grade 1		**Grade 2**		**Grade 3**		**Grade 4**	
WINCHESTER	**N^2**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
<1	1	1	100.0	-	-	-	-	-	-
1-5	7	1	14.3	2	28.6	2	28.6	2	28.6
6-11	5	2	40.0	2	40.0	1	20.0	-	-
12-17	2	1	50.0	1	50.0	-	-	-	-
US	0	-	-	-	-	-	-	-	-
Total subadults	15	5	33.3	5	33.3	3	20.0	2	13.3
18-24	6	2	33.3	3	50.0	1	16.7	-	-
25-34	6	4	66.7	1	16.7	1	16.7	-	-
35-49	4	3	75.0	1	25.0	-	-	-	-
≥50	7	4	57.1	3	42.9	-	-	-	-
UA	2	1	50.0	1	50.0	-	-	-	-
Total adults	25	14	56.0	9	36.0	2	8.0	-	-
Total sample	40	19	47.5	14	35.0	5	12.8	2	5.0

5.4.5.3 Porotic hyperostosis[32]

Only a small number of individuals in each sample exhibit genuine porotic hyperostosis (vault porosity and expansion of the diploë; Figure 129). Several individuals in each sample have slight pitting of the vault bones of the type described by Mann and Hunt (1995). This was particularly common in the Ancaster sample, but does not represent genuine porotic hyperostosis.

Table 55 and Table 56 present prevalence data for porotic hyperostosis. In the Ancaster sample, only one adult is affected. In the Winchester sample, three subadults are affected. The numbers of individuals affected are too small for statistical comparison.

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[32] See Table F6ii in the Access database.

Table 55. Prevalence of porotic hyperostosis: Ancaster.
(N^1=number of individuals/elements affected; N^2=number of individuals with at least one element present/number of elements present, frontal, parietals or supraocciput.)

	All		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/4	0.0	-	-	-	-
1-5	0/19	0.0	-	-	-	-
6-11	0/13	0.0	-	-	-	-
12-17	0/3	0.0	-	-	-	-
US	0/3	0.0	-	-	-	-
Total subadults	0/42	0.0	-	-	-	-
18-24	0/11	0.0	0/5	0.0	0/6	0.0
25-34	0/46	0.0	0/20	0.0	0/26	0.0
35-49	0/32	0.0	0/10	0.0	0/22	0.0
≥50	1/24	4.2	0/8	0.0	1/14	7.1
UA	0/19	0.0	0/7	0.0	0/10	0.0
Total adults	1/132	0.8	0/50	0.0	1/78	1.3
Total sample	1/174	0.6	-	-	-	-
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/14	0.0	-	-	-	-
1-5	0/66	0.0	-	-	-	-
6-11	0/48	0.0	-	-	-	-
12-17	0/12	0.0	-	-	-	-
US	0/7	0.0	-	-	-	-
Total subadults	0/147	0.0	-	-	-	-
18-24	0/37	0.0	0/18	0.0	0/19	0.0
25-34	0/176	0.0	0/79	0.0	0/97	0.0
35-49	0/120	0.0	0/35	0.0	0/85	0.0
≥50	2/91	2.2	0/29	0.0	2/54	3.7
UA	0/66	0.0	0/24	0.0	0/34	0.0
Total adults	2/490	0.4	0/185	0.0	2/289	0.7
Total sample	2/637	0.3	-	-	-	-

Table 56. Prevalence of porotic hyperostosis: Winchester.
(N^1=number of individuals/elements affected; N^2=number of individuals with at least one element present/number of elements present, frontal, parietals or supraocciput.)

	All		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/7	0.0	-	-	-	-
1-5	2/18	11.1	-	-	-	-
6-11	1/12	8.3	-	-	-	-
12-17	0/12	0.0	-	-	-	-
US	0/0	-	-	-	-	-
Total subadults	3/49	8.2	-	-	-	-
18-24	0/26	0.0	0/13	0.0	0/13	0.0
25-34	0/29	0.0	0/15	0.0	0/12	0.0
35-49	0/20	0.0	0/5	0.0	0/15	0.0
≥50	0/27	0.0	0/11	0.0	0/15	0.0
UA	0/18	0.0	0/7	0.0	0/8	0.0
Total adults	0/120	0.0	0/51	0.0	0/63	0.0
Total sample	3/169	1.8	-	-	-	-
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/15	0.0	-	-	-	-
1-5	5/57	8.8	-	-	-	-
6-11	2/38	5.3	-	-	-	-
12-17	0/37	0.0	-	-	-	-
US	0/0	-	-	-	-	-
Total subadults	7/147	4.8	-	-	-	-
18-24	0/97	0.0	0/45	0.0	0/52	0.0
25-34	0/110	0.0	0/55	0.0	0/47	0.0
35-49	0/78	0.0	0/19	0.0	0/59	0.0
≥50	0/100	0.0	0/40	0.0	0/56	0.0
UA	0/62	0.0	0/23	0.0	0/29	0.0
Total adults	0/447	0.0	0/182	0.0	0/243	0.0
Total sample	7/594	1.2	-	-	-	-

5.4.5.4 Dental enamel hypoplasia[33]

Table 57 presents prevalence data for hypoplasia. Few subadults are affected in either sample. In subadults, CPRs increase with age, while adult CPRs increase and later decline. The difference in CPRs between adult age groups is not significant for Ancaster (χ^2=6.271, d.f.=3, *p*=0.099), but is significant for Winchester (χ^2=8.445, d.f.=3, *p*=0.038). There are no overall differences in CPRs between the sexes in either sample (Test 46).

The subadult CPR is higher for Ancaster (12.8% *vs.* 7.4%). The Winchester sample has a higher adult CPR (27.2% *vs.* 15.1%), but the TPR is slightly higher for Ancaster (6.6% *vs.* 5.5%). The combined CPR is higher for Winchester (20.8% *vs.* 14.6%). The difference in the overall CPR is not statistically significant, but there is a significant difference in the overall adult and male CPRs (Test 47).

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[33] See Table F1 in the Access database.

Table 57. Prevalence of dental enamel hypoplasia.
(N^1=number of individuals/teeth affected; N^2=number of individuals with at least one tooth/number of teeth present, excluding teeth with complete carious destruction of the crown or severe supra-gingival calculus deposits.)

ANCASTER	**All**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/3	0.0	-	-	-	-
1-5	2/18	11.1	-	-	-	-
6-11	2/15	13.3	-	-	-	-
12-17	1/3	33.3	-	-	-	-
US	0/0	0.0	-	-	-	-
Total subadults	5/39	12.8	-	-	-	-
18-24	0/12	0.0	0/5	0.0	0/6	0.0
25-34	13/52	25.0	6/22	27.3	7/30	23.3
35-49	5/35	14.3	2/9	22.2	3/25	12.0
≥50	2/23	8.7	1/10	10.0	1/12	8.3
UA	1/17	5.9	0/8	0.0	1/8	12.5
Total adults	21/139	15.1	10/54	18.5	11/81	13.6
Total sample	26/178	14.6	-	-	-	-
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	0/229	0.0	0/94	0.0	0/109	0.0
25-34	110/1066	10.3	37/417	8.9	73/649	11.2
35-49	23/487	4.7	12/94	12.8	11/392	2.8
≥50	5/168	3.0	3/46	6.5	2/115	1.7
UA	1/148	0.7	0/66	0.0	1/77	1.3
Total adults	139/2098	6.6	52/717	7.3	87/1342	6.5
WINCHESTER	**All**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/7	0.0	-	-	-	-
1-5	0/21	0.0	-	-	-	-
6-11	2/12	8.3	-	-	-	-
12-17	2/14	16.7	-	-	-	-
US	0/0	0.0	-	-	-	-
Total subadults	4/54	7.4	-	-	-	-
18-24	8/29	27.6	2/15	13.3	8/13	61.5
25-34	13/28	46.4	6/15	40.0	5/11	45.5
35-49	7/20	35.0	0/4	0.0	7/15	46.7
≥50	2/22	9.1	1/8	12.4	1/13	7.7
UA	1/15	6.7	1/6	16.7	0/5	0.0
Total adults	31/114	27.2	10/48	20.8	19/57	33.3
Total sample	35/168	20.8	-	-	-	-
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	28/658	4.3	4/308	1.3	23/344	7.0
25-34	41/616	6.7	22/338	6.5	12/249	4.8
35-49	33/355	9.3	0/36	0.0	33/294	11.2
≥50	6/207	2.9	1/55	1.8	5/149	3.4
UA	2/147	1.4	2/65	3.1	0/59	0.0
Total adults	110/1983	5.5	29/802	3.6	74/1095	6.8

Figure 42 and Figure 43 illustrate TPRs by tooth type. The samples are similar in that the canine is the most affected tooth, followed by the incisors. However, when the samples are compared by sex, there are some notable differences. In the Ancaster sample, almost five times as many female incisors are affected compared to males, while in the Winchester sample the TPRs for the incisors are similar for both sexes. In the Winchester sample, almost twice as many male canines are affected compared to female canines, while the canine is more affected in Ancaster females.

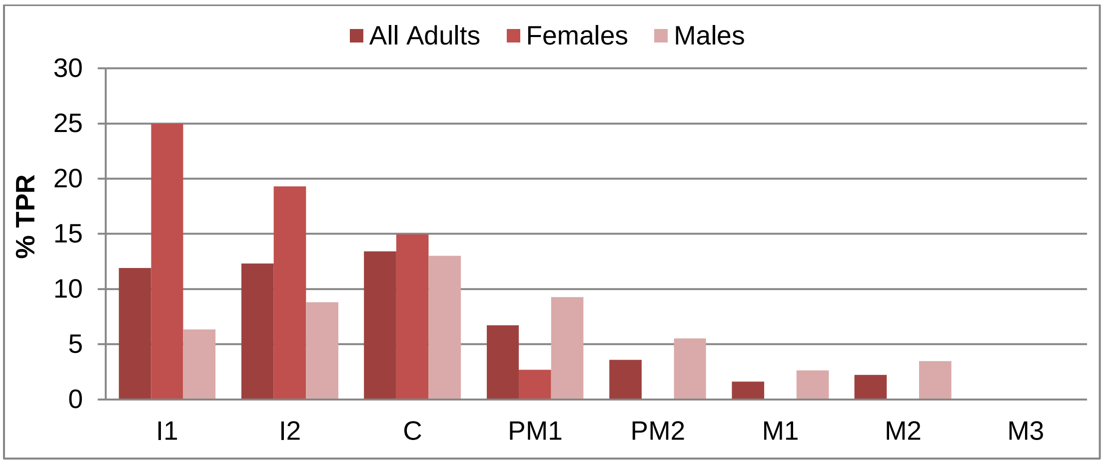

Figure 42. Graph showing the true prevalence of hypoplasia by tooth: Ancaster.

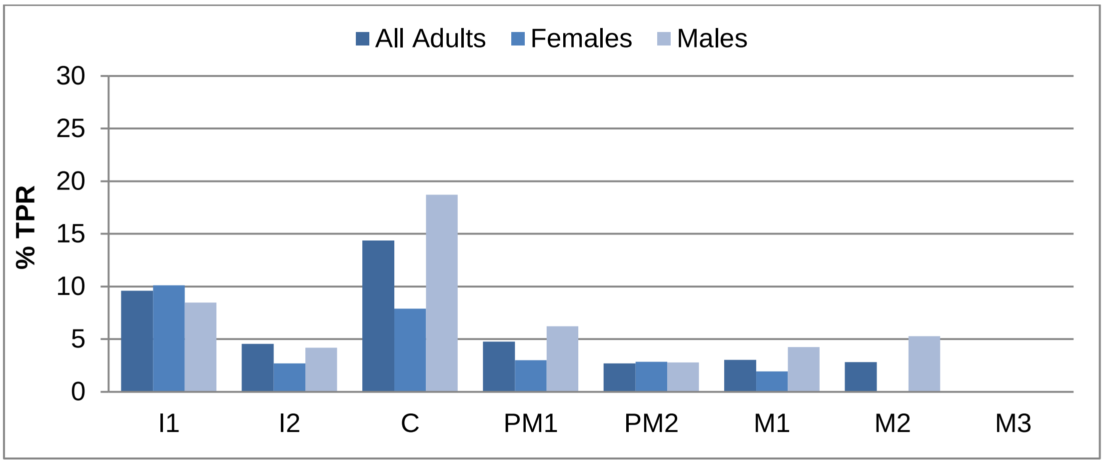

Figure 43. Graph showing the true prevalence of hypoplasia by tooth: Winchester.

Figure 44 compares age of defect formation[34]. Overall, the formation of defects peaks at 3.0-3.4 yrs in the Ancaster sample, with a lesser peak at 4.0-5.4 yrs. In the Winchester sample, there are peaks in formation at 2.5-2.9 and 4.0-4.4 yrs. Peak formation occurs at an earlier age in the Winchester sample, but more defects also formed in later childhood. For females in both samples defect formation peaks at 2.5-3.5 yrs, although Winchester females exhibit a second peak. The pattern for males differs, with the main peak in Ancaster males occurring at 3.0-3.4 yrs, while peak formation in Winchester males occurs at 4.0-4.4 yrs.

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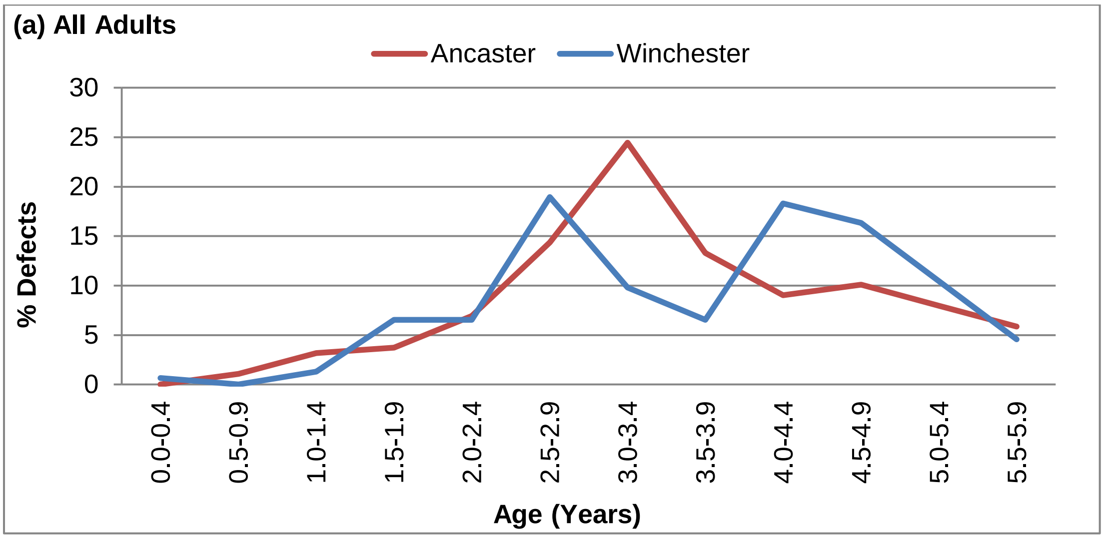
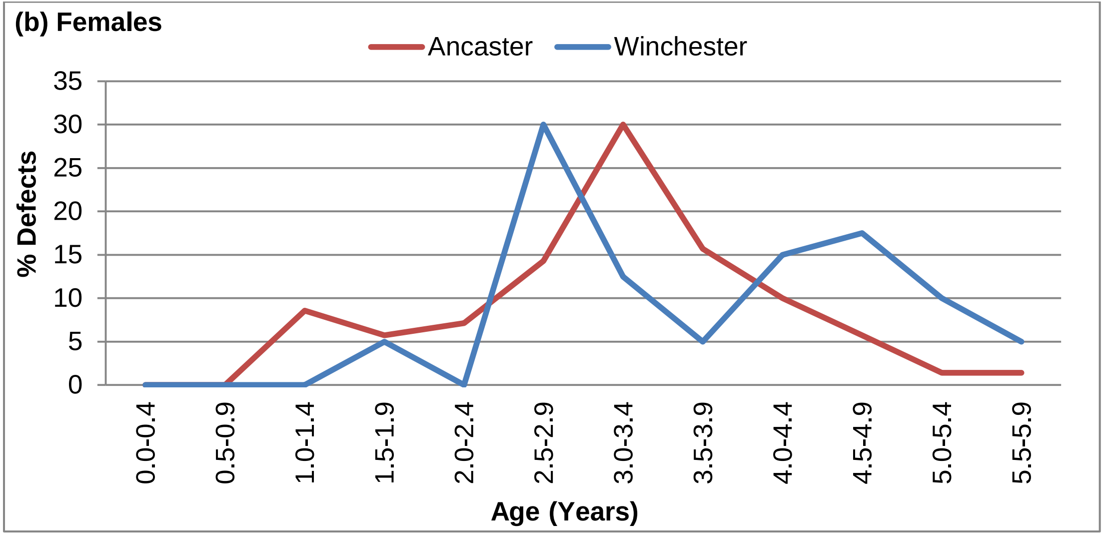
[34] Adult individuals only. Data are provided on the accompanying CD.

(a) All Adults



(b) Females



(c) Males

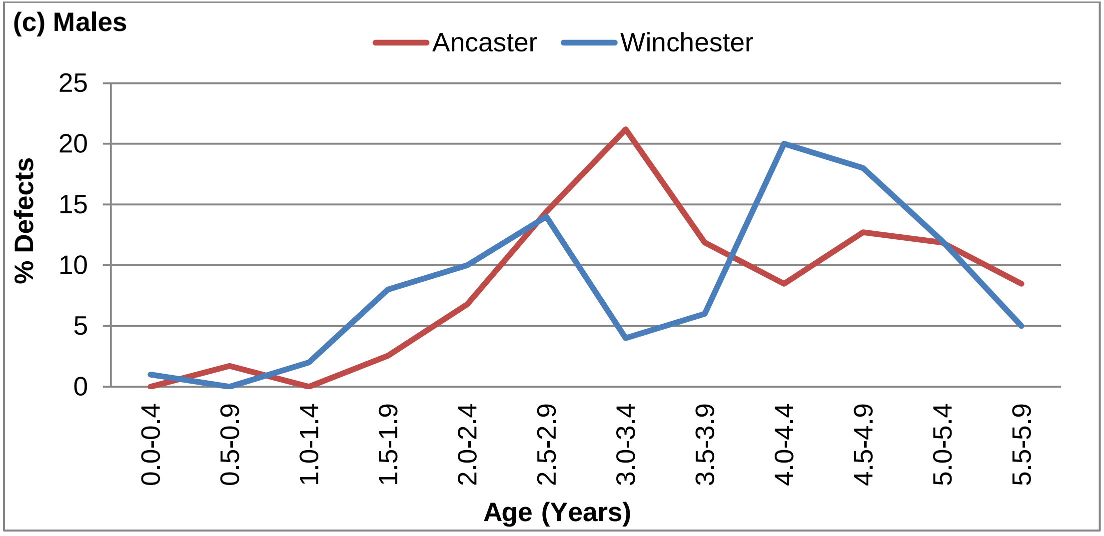


Figure 44. Graphs comparing the age of formation of hypoplasia between the samples. (N.B. Ancaster=188 defects observed in 139 teeth; Winchester=153 defects observed in 110 teeth.)

5.4.6 *Other skeletal pathology*

5.4.6.1 Diffuse idiopathic skeletal hyperostosis

There are two cases of DISH in the Ancaster sample and one from Winchester (ANC 45, ANC 230A, AR 318). Four Ancaster and two Winchester individuals exhibit probable sub-clinical DISH (ANC 11, ANC 12B, ANC 156, ANC 252, VR 88, CHR 527; see Appendix 4, Table 99; Figure 133 to Figure 135; also see the Access database, Table F4). The overall CPR for Ancaster is 1.0% (2/196 individuals), and for Winchester it is 0.5% (1/200 individuals). The numbers of individuals affected are too small for statistical comparison.

5.4.6.2 Neoplastic disease

All neoplasms observed are benign. The majority are small ivory/button osteomata at the frontal or parietals. A number of possible osteochondromas and meningiomas were observed (Figure 136; see Access database, Table F7). The overall CPR for Ancaster is 5.6% (11/196 individuals) and for Winchester it is 5.5% (11/200 individuals). The difference is not significant (χ^2=0.002, d.f.=1, *p*=0.961).

5.4.6.3 Congenital anomalies

The majority of congenital defects observed would have been asymptomatic. See the Access database (Table F8) for details (see Figure 137 to Figure 143).

5.4.6.4 Vertebral endplate lesions

Three individuals from Ancaster (ANC 1, ANC 179 and ANC 201; CPR 2.0%) exhibit lesions of the vertebral endplates that are of uncertain aetiology (see Figure 144 to Figure 146). Superficially, the lesions resemble those identified elsewhere as vertebral epiphysitis caused by brucellosis (Anderson 2003; Capasso 1999; Curate 2006; D'Anastasio *et al*. 2009; Etxeberria 1994), a zoonotic bacterial disease contracted from infected livestock and animal products (Christopher *et al*. 2010; Corbel 2006; Doganay and Aygen 2003). However, there is much dispute regarding the interpretation of such lesions as relating to brucellosis, and others have proposed a traumatic aetiology for endplate lesions (Maat and Mastwijk 2000; Mays 2007a). The lesions may represent avulsion injuries of the epiphyseal rings (see Appendix 4, Table 99 for differential diagnosis; see also Table F3ii in the Access database).

5.4.7 *Dental disease*[35]

5.4.7.1 Caries

Table 58 and Table 59 present caries prevalence data. Very few subadults exhibit caries (Ancaster CPR 2.6%, Winchester CPR 7.4%) and for this reason, in addition to the difficulties in calculating true prevalence due to loss of deciduous teeth, no TPR data are provided. At both sites, there is no overall increase in the CPR with age (Ancaster: χ^2=0.874, d.f.=3, *p*=0.832; Winchester: χ^2=2.602, d.f.=3, *p*=0.457), although the TPR does broadly increase with age. Males are slightly more affected than females in both samples, although the difference in CPRs between the sexes is not significant in either case (Test 48). The overall CPR is higher for Ancaster (43.8% *vs.* 41.7%), but this is primarily due to the larger number of infants and young children at Winchester, which effectively lowers the CPR. The Winchester sample has the highest adult CPR, but the difference is not statistically significant (Test 49).

Table 58. Overall prevalence of caries: Ancaster.
(N^1=number of individuals/teeth affected; N^2=number of individuals with at least one tooth/ number of teeth present.)

	All		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/3	0.0	-	-	-	-
1-5	1/18	5.6	-	-	-	-
6-11	0/15	0.0	-	-	-	-
12-17	0/3	0.0	-	-	-	-
US	0/0	0.0	-	-	-	-
Total subadults	1/39	2.6	-	-	-	-
18-24	7/12	58.3	1/5	20.0	5/6	83.3
25-34	29/52	55.8	15/22	68.2	14/30	46.7
35-49	21/35	60.0	7/9	77.8	14/25	56.0
≥50	11/23	47.8	4/10	40.0	7/12	58.3
UA	9/17	52.9	4/8	50.0	4/8	50.0
Total adults	77/139	55.4	30/54	55.6	44/81	54.3
Total sample	78/178	43.8	-	-	-	-
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	24/238	10.1	4/94	4.3	18/118	15.3
25-34	77/1080	7.1	40/424	9.4	37/656	5.6
35-49	48/498	9.6	18/95	18.9	30/402	7.5
≥50	19/173	11.0	5/47	10.6	13/119	10.9
UA	18/160	11.3	6/74	8.1	11/81	13.6
Total adults	186/2149	8.7	73/734	9.9	109/1376	7.9

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[35] All dental pathology data are contained in Table F1 in the Access database.

Table 59. Overall prevalence of caries: Winchester.
(N^1=number of individuals/teeth affected; N^2=number of individuals with at least one tooth/ number of teeth present.)

	All		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
<1	0/7	0.0	-	-	-	-
1-5	0/21	0.0	-	-	-	-
6-11	3/12	25.0	-	-	-	-
12-17	1/14	7.1	-	-	-	-
US	0/0	0.0	-	-	-	-
Total subadults	4/54	7.4	-	-	-	-
18-24	18/29	62.1	10/15	66.7	8/13	61.5
25-34	19/28	67.9	11/15	73.3	8/11	72.7
35-49	13/20	65.0	4/4	100.0	8/15	53.3
≥50	11/22	50.0	3/8	37.5	7/13	53.8
UA	5/15	33.3	3/6	50.0	2/5	40.0
Total adults	66/114	57.9	31/48	64.5	33/57	57.9
Total sample	70/168	41.7	-	-	-	-
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	44/665	6.6	23/309	7.4	21/350	6.0
25-34	51/634	8.0	25/348	7.2	26/256	10.1
35-49	31/364	8.5	4/37	10.8	25/302	8.3
≥50	27/223	12.1	7/45	12.5	18/164	11.0
UA	11/151	7.3	6/66	9.1	5/62	8.2
Total	164/2037	8.1	65/816	8.0	95/1135	8.4

To explore the distribution of adult caries throughout the dentition in further detail, separate CPRs were calculated for the upper and lower arches (Table 60). In the Ancaster sample, the mandibular dentition is more affected than the maxillary dentition, while the opposite pattern is observed for Winchester. The difference in CPRs between the upper and lower arches is statistically significant for Ancaster, but not Winchester (Test 50). There are no significant differences in maxillary/mandibular CPRs between the sexes in either sample (Test 51). When CPRs for each arch are compared between the samples, there are no significant differences (Test 52).

Table 60. Prevalence of maxillary *vs.* mandibular caries.
(N^1=number of individuals/teeth affected; N^2=number of individuals with at least one tooth/ number of teeth present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	38/114	33.3	16/45	35.6	20/65	30.8
Mandible	60/122	49.2	25/46	54.3	33/73	45.2
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	74/927	8.0	30/342	8.8	42/567	7.4
Mandible	112/1222	9.2	43/392	11.0	67/809	8.3
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	46/107	43.0	18/44	40.9	27/55	49.1
Mandible	42/106	39.6	20/44	45.5	20/55	36.4
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	84/997	8.4	27/387	7.0	56/554	10.1
Mandible	80/1040	8.1	38/429	8.9	39/581	6.7

The distribution of caries can also be examined in detail by considering the prevalence rate for each tooth position (Figure 45). The TPRs and pattern of tooth involvement are similar for both samples. The molars are the most affected teeth, followed by the premolars, while prevalence rates for the incisors and canines are low. In both samples, the maxillary premolars are more affected than the mandibular premolars. The pattern of tooth involvement in females differs between the samples in that the most affected tooth in Ancaster females is the M3, while the M2 is more affected in Winchester females.

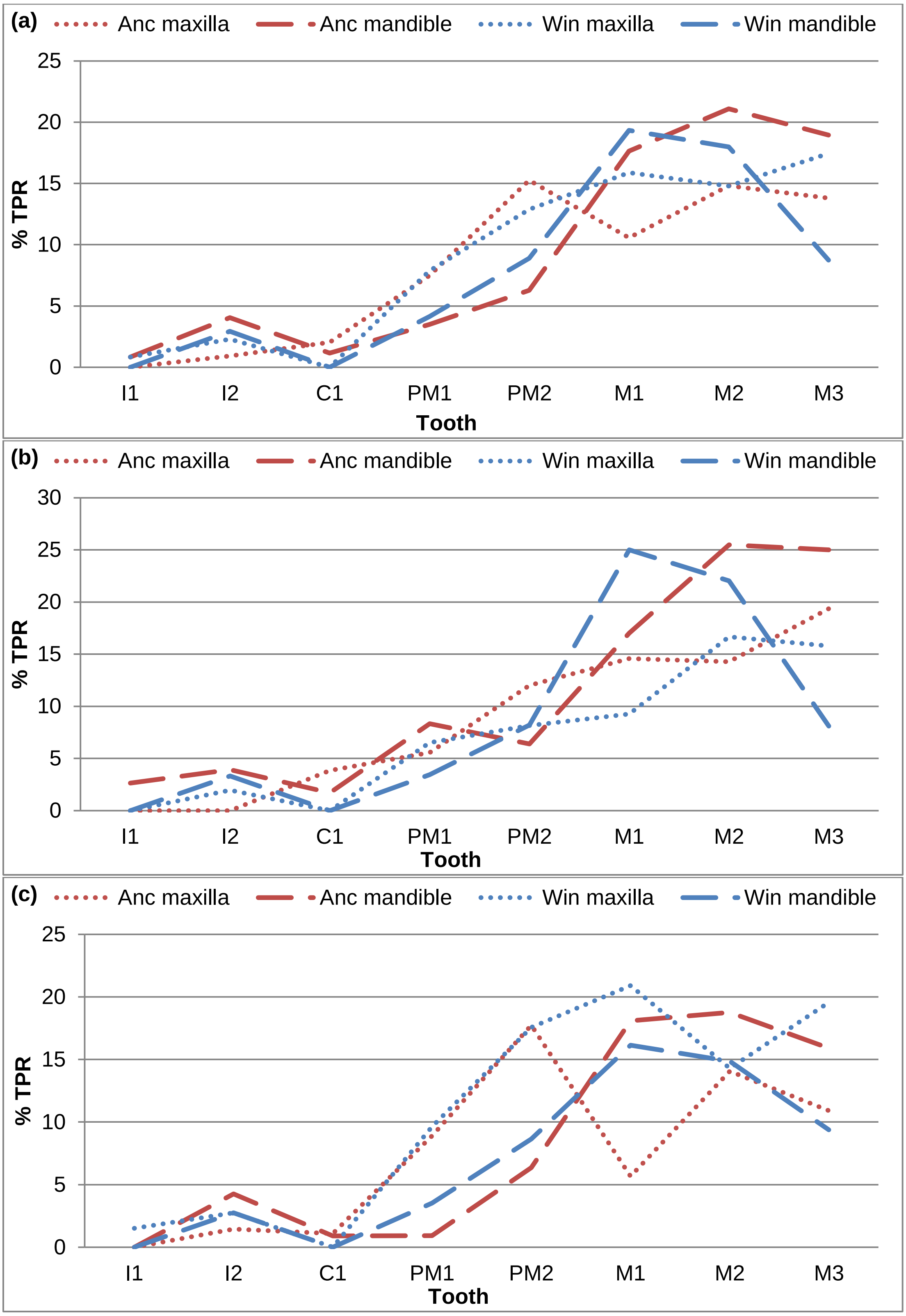

Figure 45. Graphs comparing the true prevalence of caries by tooth between the samples (a=all adults, b=females, c=males).

Similarities in the overall prevalence of caries may mask differences in the distribution of lesions in terms of which part of the tooth is affected. For this reason, separate prevalence rates were calculated for coronal and cemento-enamel junction/root caries to examine whether the samples exhibit similar patterning (Table 61). In both samples, the majority of caries affect the crown. There are no significant differences between the sexes (Test 53). In the Ancaster sample, the difference in CPRs for coronal *vs.* CEJ/root caries is not statistically significant, but it is statistically significant in the Winchester sample (Test 54). The CPR for CEJ/root caries is greater for Ancaster. When CPRs are compared between the samples, the difference between overall CPRs of CEJ/root caries just reaches the level of significance (Test 55).

Table 61. Prevalence of coronal *vs.* CEJ/root caries.
(N^1=number of individuals with coronal or CEJ/root caries, excluding teeth with complete carious destruction of the crown; N^2=number of individuals with at least one tooth.)

	All Adults		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Coronal	51/139	36.7	21/54	38.9	29/81	35.8
CEJ/Root	43/139	30.9	19/54	35.2	22/81	27.2
	All Adults		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Coronal	46/114	40.4	23/48	47.9	22/57	38.6
CEJ/Root	22/114	19.3	10/48	20.8	10/57	17.5

The distribution of caries by location can be examined in further detail by considering the aspect of the tooth affected by tooth position (Table 62 and Table 63). In the Ancaster sample, the majority of coronal caries occur at the occlusal surface. At Winchester, the mesial inter-proximal surface is the most affected aspect of the crown.

Table 62. Location of caries: Ancaster.
(N^1=number of teeth affected; N^2=total number of teeth with caries.)

	N^2	**Location (N^1/%)**							
		Occlusal	**Buccal**	**Lingual**	**Mesial**	**Distal**	**Crown Destroyed**	**CEJ**	**Root**
I^1	0	-	-	-	-	-	-	-	-
I^2	1	-	-	-	-	-	1/100.0	-	-
C^1	3	-	-	-	-	-	1/33.3	1/33.3	1/33.3
PM^1	11	-	-	-	0.5/4.5	5.5/50.0	3/27.3	2/18.2	-
PM^2	20	0.5/2.5	-	-	2/10.0	4/20.0	7/35.0	6.5/32.5	-
M^1	11	3/27.3	-	-	4.5/40.9	0.5/4.5	3/27.3	-	-
M^2	16	1/6.3	1/6.3	-	-	1/6.3	2/12.5	11/68.8	-
M^3	12	4.5/37.5	0.5/4.2	1/8.3	1/8.3	-	1/8.3	4/33.3	-
I_1	1	-	-	-	-	-	-	1/100.0	-
I_2	6	-	-	-	1/16.7	-	2/33.3	3/50.0	-
C_1	2	-	-	-	-	-	2/100.0	-	-
PM_1	6	-	-	-	1/16.7	-	1/16.7	4/66.7	-
PM_2	10	-	-	-	-	4/40.0	2/20.0	4/40.0	-
M_1	27	3/11.1	4/14.8	-	5/18.5	3/11.1	4/14.8	7/25.9	1/3.7
M_2	35	5/14.3	10/28.6	-	1/2.9	2/5.7	2/5.7	12/34.3	3/8.6
M_3	25	8/32.0	7/28.0	0.5/2.0	-	1/4.0	1/4.0	6.5/26.0	1/4.0
Total	186	25/13.4	22.5/12.1	1.5/0.8	16/8.6	21/11.3	32/17.2	68/36.6	6/3.2

Table 63. Location of caries: Winchester.
(N^1=number of teeth affected; N^2=total number of teeth with caries.)

	N^2	Location (N^1/%)							
		Occlusal	**Buccal**	**Lingual**	**Mesial**	**Distal**	**Crown Destroyed**	**CEJ**	**Root**
I^1	1	-	-	-	-	-	-	1/ 100.0	-
I^2	3	1/ 33.3	-	-	-	1/ 33.3	1/ 33.0	-	-
C^1	0	-	-	-	-	-	-	-	-
PM^1	11	-	-	-	-	1/ 9.1	7/ 63.6	3/ 27.3	-
PM^2	17	-	-	-	1/ 5.9	3/ 17.6	11/ 64.7	1/ 50.0	1/ 50.0
M^1	20	3/ 15.0	-	1/ 5.0	8/ 40.0	-	6/ 30.0	2/ 10.0	-
M^2	17	2/ 11.8	1/ 9.1	-	2/ 11.8	7/ 41.2	1/ 9.1	3/ 17.6	1/ 5.9
M^3	15	4/ 26.7	1/ 6.7	1/ 6.7	3/ 20.0	1/ 6.7	1/ 6.7	4/ 26.7	-
I_1	0	-	-	-	-	-	-	-	-
I_2	4	-	-	-	2/ 50.0	-	-	2/ 50.0	-
C_1	0	-	-	-	-	-	-	-	-
PM_1	6	-	-	-	-	1/ 16.7	3/ 50.0	2/ 33.3	-
PM_2	13	-	-	-	1/ 7.7	3/ 23.1	5/ 38.5	4/ 30.8	-
M_1	23	2/ 8.7	5/ 21.7	-	4/ 17.4	4/ 17.4	6/ 26.1	2/ 8.7	-
M_2	25	2/ 8.0	7/ 28.0	-	7/ 28.0	1/ 4.0	2/ 8.0	5/ 20.0	1/ 5.0
M_3	9	5/ 55.6	2/ 22.2	-	1/ 11.1	-	-	1/ 11.1	-
Total	164	19/ 11.6	16/ 9.8	2/ 1.2	29/ 17.7	22/ 13.4	43/ 26.2	30/ 18.3	3/ 1.8

5.4.7.2 Calculus

Table 64 presents prevalence data for calculus. At both sites, the crude prevalence of calculus increases between young and prime/mature adulthood, but declines in elderly adulthood. The difference between age groups (excluding unaged adults) is statistically significant (Ancaster: χ^2=15.905, d.f.=3, p=0.001; Winchester: χ^2=9.333, d.f.=3, p=0.025). Males are more affected than females in both cases, and the difference is statistically significant for Ancaster (Test 56). The overall CPRs and TPRs are higher for Ancaster, but the difference in CPRs is not significant (Test 57).

Table 64. Overall prevalence of calculus.
(N^1=number of individuals/teeth affected; N^2=number of individuals with at least one tooth/number of teeth present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	4/12	33.3	1/5	20.0	3/6	50.0
25-34	37/52	71.2	13/22	59.1	24/30	80.0
35-49	21/35	60.0	2/9	22.2	19/25	76.0
≥50	6/23	26.1	1/10	10.0	5/12	42.7
UA	9/17	52.9	6/8	75.0	3/8	37.5
Total	77/139	55.4	23/54	42.6	55/81	67.9
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	28/238	11.8	7/94	7.4	21/118	17.8
25-34	372/1080	34.4	125/424	29.5	247/656	37.7
35-49	192/498	38.6	7/95	7.4	185/402	46.0
≥50	60/173	34.7	3/47	6.4	57/119	47.9
UA	50/160	31.3	27/74	36.5	23/81	28.4
Total	702/2149	32.7	169/734	23.0	533/1376	38.7
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	12/29	41.4	6/15	40.0	6/13	46.2
25-34	16/28	57.1	10/15	66.7	5/11	45.5
35-49	15/20	75.0	2/24	50.0	12/15	80.0
≥50	7/22	31.8	1/8	12.5	6/13	46.2
UA	6/15	40.0	1/6	16.7	4/5	80.0
Total	56/114	49.1	20/48	41.7	33/57	57.9
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	128/665	19.2	69/309	22.3	59/350	16.9
25-34	155/634	24.4	103/348	29.6	51/257	19.8
35-49	121/364	33.2	19/37	51.4	99/302	32.8
≥50	66/223	29.6	1/56	1.8	65/164	39.6
UA	49/151	32.5	13/66	19.7	31/62	50.0
Total	519/2037	25.5	205/816	25.1	305/1135	26.9

Table 65 contains prevalence data for maxillary *vs.* mandibular calculus. The mandibular dentition is more affected in both samples, but the difference between arches is significant for Ancaster only (Test 58). In both samples, male prevalences are generally higher than female prevalences, and Ancaster males have a significantly higher rate of mandibular calculus compared to Ancaster females (Test 59). Prevalences are higher for Ancaster in all cases, but there are no significant differences between samples (Test 60).

Table 65. Prevalence of maxillary *vs.* mandibular calculus.
(N^1=number of individuals/teeth affected; N^2=number of individuals with at least one tooth/number of teeth present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	41/114	36.0	16/45	35.6	25/65	40.0
Mandible	65/122	53.3	17/46	37.0	48/73	65.8
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	259/927	27.9	81/342	23.7	178/567	31.4
Mandible	443/1222	36.3	88/392	22.4	355/809	43.9
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	38/107	35.5	14/44	31.8	21/55	38.2
Mandible	49/106	46.2	17/44	38.6	30/55	54.5
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	202/997	20.3	76/387	19.6	120/554	21.7
Mandible	317/1040	30.5	129/429	30.1	185/581	31.8

Figure 46 compares the distribution of calculus in the study samples by tooth position. Overall, tooth involvement is similar for both samples, the M1 being the most affected tooth. Incisors are more affected than canines. For females, the pattern differs in that the incisors are relatively more affected in the Winchester sample. There is little difference between males, although in Ancaster males the I2 is more affected than the C, while the opposite is the case for Winchester.

Table 66 contains crude prevalence data for supra- *vs.* sub-gingival deposits. In both samples, the great majority of calculus deposits are supra-gingival and the differences between CPRs for supra- and sub-gingival calculus are significant (Test 61). In both samples, male CPRs are higher than female CPRs, and Ancaster males have significantly more supra-gingival calculus than females from the same site (Test 62). Sub-gingival deposits are more prevalent in the Winchester sample (9.6% *vs.* 5.0%). The numbers of individuals with sub-gingival deposits are too small for statistical comparison. When CPRs for supra-gingival calculus are compared between the samples, the difference is not statistically significant in any case (Test 63).

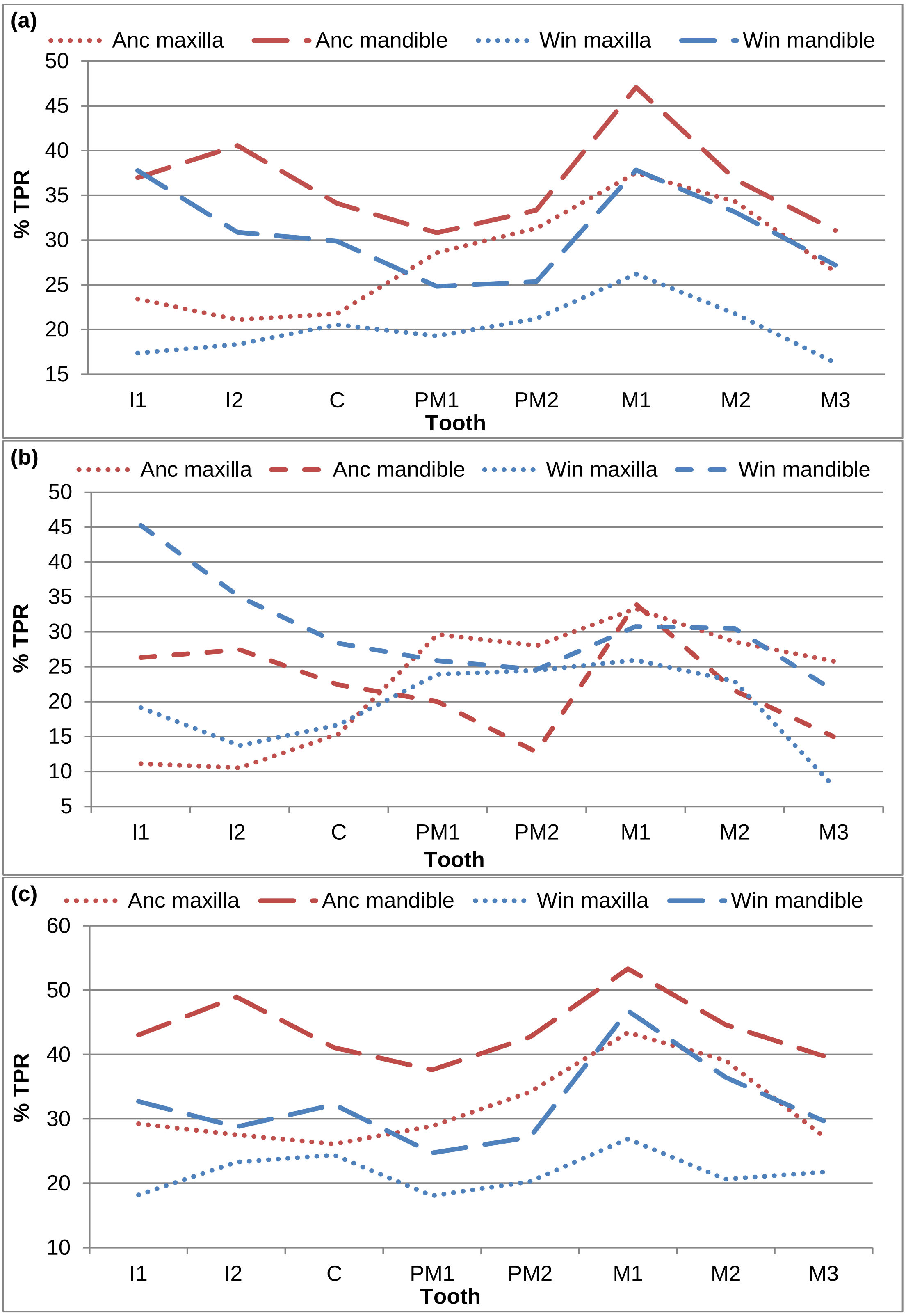

Figure 46. Graphs comparing the true prevalence of calculus by tooth between the samples (a=all adults, b=females, c=males).

Table 66. Prevalence of supra- *vs.* sub-gingival calculus.
(N^1=number of individuals with supra- or sub-gingival calculus; N^2=number of individuals with at least one tooth.)

	All Adults		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Supra-gingival	76/139	54.7	23/54	42.6	53/81	65.4
Sub-gingival	7/139	5.0	2/54	3.7	5/81	6.2
	All Adults		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Supra-gingival	49/114	43.0	19/48	39.6	27/57	47.4
Sub-gingival	11/114	9.6	4/48	8.3	7/57	12.3

Table 67 presents crude prevalence data for each grade of severity. In both samples, the majority of deposits are slight. Less than 5% of individuals in both samples exhibit severe calculus build-up. Male CPRs are higher than female CPRs in all cases, but the difference is only significant for slight deposits in the Ancaster sample (Test 64). When the crude prevalence of slight, moderate and severe deposits is compared between the samples, the difference is not statistically significant in any case (Test 65).

Table 67. Prevalence of slight, moderate and severe calculus.
(N^1=number of individuals with slight, moderate or severe calculus; N^2=number of individuals with at least one tooth; Supra- and sub-gingival combined.)

	All Adults		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Slight	61/139	43.9	17/54	31.5	44/81	54.3
Moderate	34/139	24.5	11/54	20.7	23/81	28.4
Severe	6/139	4.3	2/54	3.7	4/81	4.9
	All Adults		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Slight	45/114	39.5	18/48	37.5	26/57	45.6
Moderate	27/114	23.7	9/48	18.8	15/57	26.3
Severe	5/114	4.4	1/48	2.1	4/57	7.0

Table 68 presents detailed data for the location (supra- *vs.* sub-gingival) and severity of calculus by tooth position. The majority of deposits in both samples are slight, with only a small proportion of teeth exhibiting the most severe grade of deposit. Sub-gingival deposits are slightly more common in the mandibular dentition. Sub-gingival deposits are slightly more prevalent in the Winchester population.

Table 68. Calculus location (supra- *vs.* sub-gingival) and severity.
(N^1=number of teeth affected; N^2=total number of teeth with calculus.)

ANC	**N^2**	**Supra-gingival**						**Sub-gingival**					
		Slight		**Moderate**		**Severe**		**Slight**		**Moderate**		**Severe**	
		N^1	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
I^1	22	11	50.0	9	40.9	2	9.1	-		-		-	
I^2	23	13	56.5	9	39.1	1	4.3	-		-		-	
C^1	32	17	53.1	13	40.6	2	6.3	-		-		-	
PM^1	42	26	61.9	13	31.0	2	4.8	1	2.4	-		-	
PM^2	41	24	58.5	12	29.3	3	7.3	2	4.9	-		-	
M^1	39	28	71.8	9	23.1	1	2.6	1	2.6	-		-	
M^2	37	29	78.4	8	21.6	-		-		-		-	
M^3	23	17	73.9	5	21.7	1	4.3	-		-		-	
I_1	44	37	84.1	5	11.4	1	2.3	-		1	2.3	-	
I_2	60	51	85.0	8	13.3	1	1.7	-		-		-	
C_1	59	44	74.6	12	20.3	2	3.4	-		1	1.7	-	
PM_1	53	43	81.1	6	11.3	1	1.9	2	3.8	1	1.9	-	
PM_2	53	41	77.4	8	15.1	1	1.9	2	3.8	1	1.9	-	
M_1	72	50	69.4	16	22.2	2	2.8	2	2.8	2	2.8	-	
M_2	61	47	77.0	12	19.7	-		-		-		2	3.3
M_3	41	30	73.2	8	19.5	1	2.4	2	4.9	-		-	
Total	702	508	72.4	153	21.8	21	3.0	12	1.7	6	0.9	2	0.3
WIN	**N^2**	**Supra-gingival**						**Sub-gingival**					
		Slight		**Moderate**		**Severe**		**Slight**		**Moderate**		**Severe**	
		N^1	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
I^1	21	14	66.7	6	28.6	-		1	4.8	-		-	
I^2	24	16	66.7	8	33.3	-		-		-		-	
C^1	30	16	53.3	11	36.7	-		2	6.7	1	3.3	-	
PM^1	27	12	44.4	14	51.9	1	3.7	-		-		-	
PM^2	28	12	42.9	15	53.6	1	3.6	-		-		-	
M^1	33	13	39.4	16	48.5	2	6.1	1	3.0	-		1	3.0
M^2	25	15	60.0	7	28.0	3	12.0	-		-		-	
M^3	14	7	50.0	6	42.9	1	7.1	-		-		-	
I_1	37	23	62.2	10	27.0	-		2	5.4	2	5.4	-	
I_2	42	25	59.5	12	28.6	-		5	11.9	-		-	
C_1	46	28	60.9	13	28.3	1	2.2	5	10.9	-		-	
PM_1	36	23	63.9	10	27.8	-		2	5.6	-		-	
PM_2	37	22	59.5	9	24.3	-		4	10.8	2	5.4	-	
M_1	45	32	71.1	9	20.0	-		4	8.9	-		-	
M_2	46	31	67.4	10	21.7	-		5	10.9	-		-	
M_3	28	18	64.3	7	25.0	-		3	10.7	-		-	
Total	519	307	59.2	163	31.4	9	1.7	34	6.6	5	1.0	1	0.2

Table 69 presents prevalence data for the crude prevalence of buccal, lingual and inter-proximal calculus. Both samples are similar in that the majority of deposits occur at the buccal aspect of the crown and no occlusal deposits are present. Male CPRs are higher than female CPRs in almost all cases, but the difference is only significant for buccal deposits at Ancaster (Test 66). The most notable difference between the samples is the absence of inter-proximal deposits in the Winchester sample, although the numbers of individuals affected are too small to compare CPRs.

When buccal and lingual CPRs are compared, the difference is not statistically significant (Test 67).

Table 69. Prevalence of buccal, lingual and inter-proximal calculus.
(N^1=number of individuals with buccal, lingual or inter-proximal calculus; N^2=number of individuals with at least one tooth.)

	All Adults		**Females**		**Males**	
ANCASTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Buccal	60/139	43.3	17/54	31.5	43/81	53.1
Lingual	46/139	33.1	14/54	25.9	32/81	39.5
Inter-proximal	2/139	1.4	1/54	1.9	1/81	1.2
	All Adults		**Females**		**Males**	
WINCHESTER	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Buccal	51/114	44.7	18/48	37.5	30/57	52.6
Lingual	31/114	27.2	11/48	22.9	19/57	33.3
Inter-proximal	0/114	0.0	0/48	0.0	0/57	0.0

Table 70 and Table 71 present data for the location of calculus by tooth surface. The samples are similar in that approximately half of teeth have buccal calculus only. Buccal deposits are most common at the incisors while lingual deposits mostly affect the molars. Inter-proximal deposits only occur in the Ancaster sample.

Table 70. Calculus location (aspect of crown): Ancaster.
(N^1=number of teeth affected; N^2=total number of teeth with calculus.)

	N^2	**Buccal**		**Lingual**		**Buccal+ Lingual**		**Inter-proximal**		**Occlusal**	
		N^1	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
I^1	22	19	86.4	-		2	9.1	1	4.5	-	-
I^2	23	18	78.3	2	8.7	2	8.7	1	4.3	-	-
C^1	32	26	81.3	2	6.4	2	6.3	2	6.3	-	-
PM^1	42	35	83.3	3	7.1	2	4.8	2	4.8	-	-
PM^2	41	33	80.5	2	4.9	4	9.8	2	4.9	-	-
M^1	39	24	61.5	5	12.8	9	23.1	1	2.6	-	-
M^2	37	22	59.5	7	18.9	7	18.9	1	2.7	-	-
M^3	23	12	52.2	4	17.4	6	26.1	1	4.3	-	-
I_1	44	20	45.5	7	15.9	16	36.4	1	2.3	-	-
I_2	60	31	51.7	7	11.7	21	35.0	1	1.7	-	-
C_1	59	29	49.2	9	15.3	19	32.2	2	3.4	-	-
PM_1	53	15	28.3	19	35.8	17	32.1	2	3.8	-	-
PM_2	53	14	26.4	19	35.8	18	34.0	2	3.8	-	-
M_1	72	17	23.6	29	40.3	22	30.6	4	5.6	-	-
M_2	61	13	21.3	23	37.7	21	34.4	4	6.6	-	-
M_3	41	13	31.7	12	29.3	12	29.3	4	9.8	-	-
Total	702	341	48.6	150	21.4	180	25.6	31	4.4	-	-

Table 71. Calculus location (aspect of crown): Winchester.
(N^1=number of teeth affected; N^2=total number of teeth with calculus.)

	N^2	**Buccal**		**Lingual**		**Buccal+ Lingual**		**Inter-proximal**		**Occlusal**	
		N^1	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
I^1	21	16	76.2	2	9.5	3	14.3	-	-	-	-
I^2	24	21	87.5	-	-	3	12.5	-	-	-	-
C^1	30	28	90.0	-	-	3	10.0	-	-	-	-
PM^1	27	21	77.8	2	7.4	4	14.8	-	-	-	-
PM^2	28	22	78.6	1	3.6	5	17.9	-	-	-	-
M^1	33	20	60.6	4	12.1	9	27.3	-	-	-	-
M^2	25	14	56.0	4	16.0	7	28.0	-	-	-	-
M^3	14	10	71.4	2	14.3	2	14.3	-	-	-	-
I_1	37	22	59.4	-	-	15	40.5	-	-	-	-
I_2	42	20	47.6	4	9.5	18	42.9	-	-	-	-
C_1	46	25	54.3	5	10.9	17	37.0	-	-	-	-
PM_1	36	15	41.7	3	8.3	17	47.2	-	-	-	-
PM_2	37	16	43.2	7	18.9	14	37.8	-	-	-	-
M_1	45	10	22.2	14	31.1	21	46.7	-	-	-	-
M_2	46	14	30.4	13	28.3	19	41.3	-	-	-	-
M_3	28	9	32.1	8	28.6	11	39.2	-	-	-	-
Total	519	282	54.3	69	13.3	168	32.4	-	-	-	-

5.4.7.3 Periodontal disease

Table 72 presents prevalence data for periodontal disease. Overall, the CPR increases with age in both samples, although there is a decline in elderly adulthood at Ancaster. The difference in CPRs between age groups (excluding unaged adults) is statistically significant for both samples (Ancaster: χ^2=11.117, d.f.=3, *p*=0.011; Winchester: χ^2=23.944, d.f.=3, *p*=0.000). The prevalence rate is higher for males than females, although the difference between the sexes is not statistically significant in either sample (Test 68). Both the CPR and TPR are greater for Ancaster than Winchester. The difference in the overall CPRs is significant (Test 69).

Table 73 presents prevalence data for maxillary *vs.* mandibular periodontal disease. In both samples, the CPR is higher for the mandibular dentition, although the difference between maxillary and mandibular CPRs is not statistically significant in either case (Test 70). There are no significant differences between the sexes in either sample (Test 71). The prevalences are greater for the Ancaster sample, and the differences in CPRs between the samples are statistically significant (Test 72).

Figure 47 compares the pattern of socket involvement in the samples by tooth position. From the graphs, it is evident that the pattern of periodontal disease differs quite noticeably between the two samples. At Ancaster, the molar sockets are the most affected, while they are least affected in the Winchester sample. Likewise, the canine socket is least affected among Ancaster individuals, while it is the most affected socket for the Winchester sample.

Table 72. Overall prevalence of periodontal disease.
(N^1=number of individuals/sockets affected; N^2=number of individuals with at least one tooth *in situ*/number of sockets with teeth *in situ.*)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	4/12	33.3	1/5	20.0	3/6	50.0
25-34	38/51	74.5	16/21	76.2	22/30	73.3
35-49	24/33	72.7	5/9	55.6	19/23	82.6
≥50	11/12	47.8	5/10	50.0	6/12	50.0
UA	7/15	56.7	5/8	62.5	2/6	33.3
Total	84/134	62.7	32/53	60.4	52/77	67.5
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	54/233	23.2	23/91	25.3	31/116	26.7
25-34	552/1057	52.2	210/409	51.3	343/648	52.8
35-49	304/483	62.9	56/94	59.6	248/388	63.9
≥50	94/163	57.7	25/42	59.4	69/114	60.5
UA	69/129	53.5	46/70	65.7	23/56	41.1
Total	1073/2065	52.0	360/706	51.0	713/1322	53.9
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	4/29	13.8	3/15	20.0	1/13	7.7
25-34	10/28	35.7	7/15	46.7	3/11	27.3
35-49	13/20	65.0	3/4	75.0	10/15	66.7
≥50	16/21	76.2	6/7	85.7	9/12	69.2
UA	3/11	27.3	1/5	10.0	2/4	50.0
Total	46/109	42.2	20/46	43.5	25/46	44.6
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	32/617	5.2	26/272	9.6	6/339	1/8
25-34	116/618	18.8	94/341	27.6	22/252	8.7
35-49	158/337	46.9	27/35	77.1	131/290	45.2
≥50	132/209	63.2	25/49	51.0	105/157	66.9
UA	29/122	23.8	11/53	20.8	18/53	34.0
Total	467/1903	24.5	183/750	24.4	282/1091	25.8

Table 73. Prevalence of maxillary *vs.* mandibular periodontal disease.
(N^1=number of individuals/sockets affected; N^2=number of individuals with at least one tooth *in situ*/number of sockets with teeth *in situ.*)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	55/106	51.9	24/43	55.8	31/59	52.5
Mandible	73/115	63.5	25/43	58.1	48/69	69.6
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	413/895	46.1	161/331	48.6	252/546	46.2
Mandible	660/1170	56.4	199/375	53.1	461/776	59.4
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	31/102	30.4	12/41	29.3	18/54	33.3
Mandible	34/99	34.3	14/41	34.1	19/53	35.8
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	204/928	22.0	75/355	21.1	128/526	24.3
Mandible	263/975	27.0	108/395	27.3	154/565	27.3

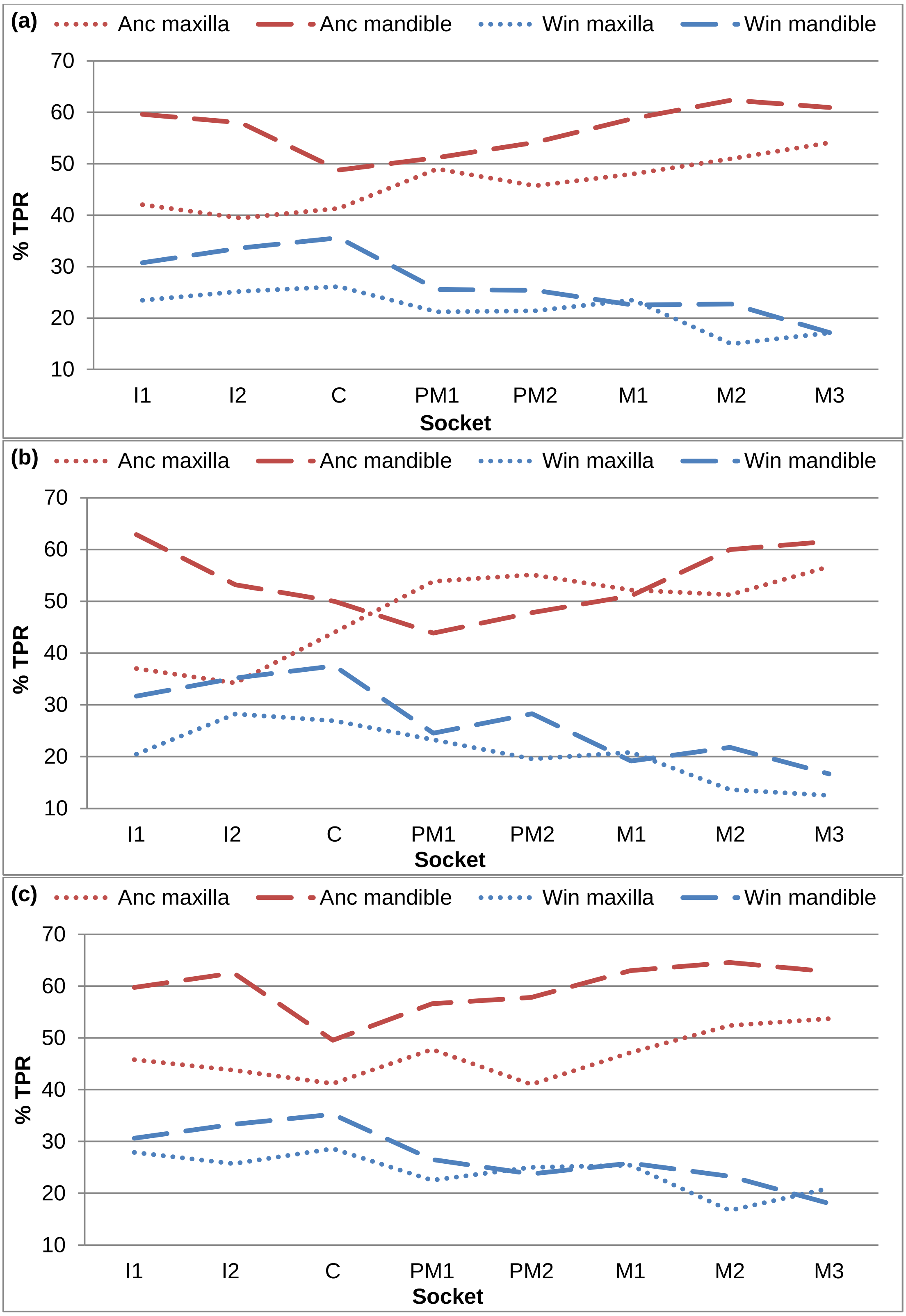

Figure 47. Graphs comparing the true prevalence of periodontal disease by socket between the samples (a=all adults, b=females, c=males).

5.4.7.4 Peri-apical lesions

Table 74 presents prevalence data for peri-apical lesions. Broadly speaking, the CPR increases with age in both samples, although the difference in CPRs between age groups (excluding unaged adults) is not statistically significant (Ancaster: χ^2=2.017, d.f.=3, *p*=0.569; Winchester: χ^2=4.969, d.f.=3, *p*=0.174). The crude prevalence rate is greater for females at Ancaster, while males are more affected than females in the Winchester sample, although the differences between the sexes are not significant (Test 73). Both the CPR and TPR are higher for Ancaster (CPR 36.0%, TPR 2.3%) compared to Winchester (CPR 23.5%, TPR 1.6%). The difference in overall CPRs is statistically significant (Test 74).

Table 74. Overall prevalence of peri-apical lesions.
(N^1=number of individuals/sockets affected; N^2=number of individuals with at least one maxilla or mandible/number of sockets present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	2/11	18.2	1/5	20.0	1/6	16.7
25-34	17/51	33.3	9/21	42.9	8/30	26.7
35-49	14/34	41.2	2/10	20.0	12/23	52.2
≥50	9/27	33.3	5/10	50.0	4/15	26.7
UA	8/16	50.0	5/8	62.5	3/6	50.0
Total	50/139	36.0	22/54	40.7	28/80	35.0
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	8/298	2.7	2/122	1.6	6/146	4.1
25-34	21/1368	1.5	11/565	1.9	10/803	1.2
35-49	23/785	2.9	3/198	1.5	20/586	3.4
≥50	16/541	3.0	8/193	4.1	8/315	2.5
UA	10/301	3.3	5/171	2.9	5/104	4.8
Total	78/3293	2.3	29/1249	2.3	49/1954	2.5
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	4/28	14.3	1/14	7.1	3/13	23.1
25-34	11/29	37.9	7/16	43.8	4/11	36.4
35-49	5/20	25.0	0/5	0.0	5/15	33.3
≥50	7/27	25.9	1/11	9.1	5/15	33.3
UA	4/28	14.3	3/5	60.0	1/4	25.0
Total	31/132	23.5	12/51	23.5	18/58	31.0
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	7/727	0.9	1/349	0.3	6/392	1.5
25-34	15/801	1.9	9/435	2.1	6/325	1.8
35-49	6/499	1.2	0/65	0.0	4/418	1.4
≥50	13/639	2.0	2/249	0.8	10/376	2.7
UA	6/238	2.5	3/104	2.9	3/102	2.9
Total	47/2924	1.6	15/1202	1.2	31/1613	1.9

Separate prevalence data have been calculated for the upper and lower dentitions, and by individual tooth position to explore the patterning of peri-apical lesions in further detail (Table 75). In both samples, maxillary sockets are more affected than mandibular sockets, but the difference is not statistically significant (Test 75). There are no significant differences between the sexes in either sample (Test 76). The difference in CPRs between the Ancaster and Winchester samples reaches the level of significance for the mandibular sockets (Test 77).

Table 75. Prevalence of maxillary *vs.* mandibular peri-apical lesions.
(N^1=number of individuals/sockets affected; N^2=number of individuals with at least one maxilla or mandible/number of sockets present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	29/112	25.9	11/45	24.4	18/63	28.6
Mandible	29/123	23.6	11/47	23.4	18/72	25.0
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	38/1516	2.5	12/578	2.1	26/890	2.9
Mandible	40/1777	2.3	17/671	2.5	23/1064	2.2
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	20/109	18.3	6/47	12.8	13/56	23.2
Mandible	14/110	12.7	6/47	12.8	8/58	13.8
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	30/1415	2.1	7/572	1.2	22/771	2.9
Mandible	17/1509	1.1	8/630	1.3	9/842	1.1

Figure 48 compares socket involvement between the samples by tooth position. In both samples, the first molar is generally most affected, except for Winchester males. The most notable difference between the samples is the higher first molar TPR relative to other teeth in the Ancaster sample. Broadly speaking, the incisors and canines are more affected in the Ancaster sample, while lesions at the premolars are more common among the Winchester sample. The statistically significant difference in overall CPRs for peri-apical lesions is presumably primarily due to the greater prevalence of lesions at the first molar.

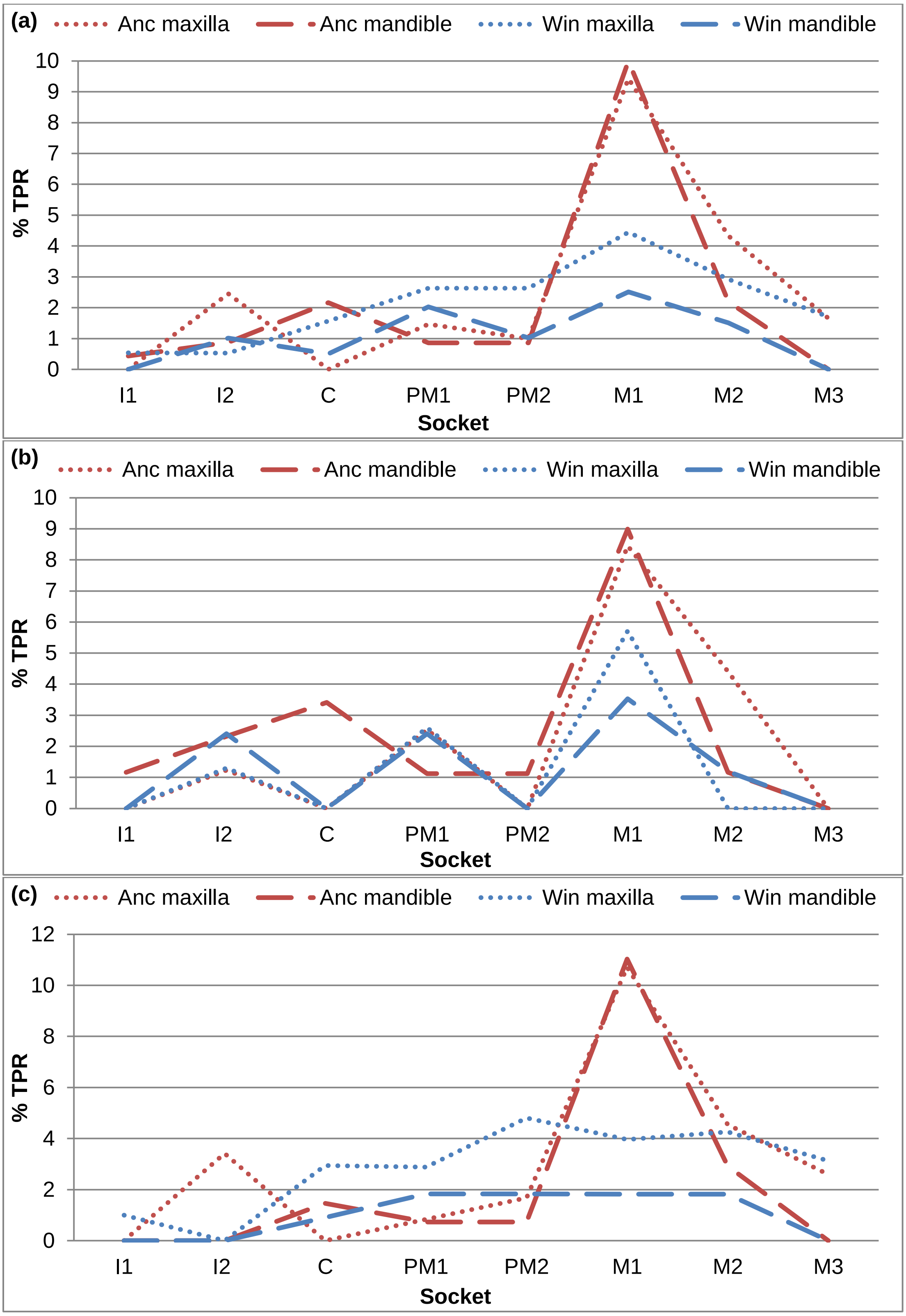

Figure 48. Graph comparing the true prevalence of peri-apical lesions by socket between the samples (a=all adults, b=females, c=males).

5.4.7.5 Ante-mortem tooth loss

Table 76 presents prevalence data for AMTL. At both sites, the prevalence increases markedly with age, with all sexed adults aged ≥50 years affected, and the difference in CPRs between age groups is statistically significant (Ancaster: χ^2=30.662, d.f.=3, *p*=0.000; Winchester: χ^2=32.947, d.f.=3, *p*=0.000). In both samples, CPRs are higher for males than females, but the difference in CPRs between the sexes is not statistically significant for either sample (Test 78). The overall and female CPRs are higher for Ancaster. Overall TPRs are greater for Winchester. None of the differences in CPRs between the samples is statistically significant (Test 79).

Table 76. Overall prevalence of ante-mortem tooth loss.
(N^1=number of individuals/sockets affected; N^2=number of individuals with at least one maxilla or mandible/number of sockets present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	2/11	18.2	0/5	0.0	1/6	16.7
25-34	24/51	47.1	10/21	47.6	14/30	46.7
35-49	26/34	76.5	9/10	90.0	17/23	73.9
≥50	26/27	96.3	10/10	100.0	15/15	100.0
UA	9/16	56.3	4/8	50.0	4/6	66.7
Total	87/139	62.6	33/54	61.1	50/80	62.5
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	5/298	1.7	0/122	0.0	2/146	1.4
25-34	67/1368	4.9	31/565	5.5	36/803	4.5
35-49	99/785	12.6	35/198	17.7	64/586	10.9
≥50	217/541	40.1	89/193	46.1	108/315	34.3
UA	47/301	15.6	22/171	12.9	21/104	20.2
Total	435/3293	13.2	177/1249	14.2	231/1954	11.8
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	7/28	25.0	2/14	14.3	5/13	38.5
25-34	14/29	48.3	8/16	50.0	6/11	54.5
35-49	11/20	55.0	3/5	60.0	8/15	53.3
≥50	27/27	100.0	11/11	100.0	15/15	100.0
UA	11/28	39.3	5/5	100.0	4/4	100.0
Total	70/132	53.0	29/51	56.9	38/58	65.5
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
18-24	17/747	2.3	8/349	2.3	9/292	2.3
25-34	47/801	5.9	23/435	5.3	24/325	7.4
35-49	48/499	9.6	14/65	21.3	34/418	8.1
≥50	278/639	43.5	125/249	50.2	148/376	39.4
UA	51/238	21.4	29/104	27.9	10/102	9.8
Total	441/2924	15.1	199/1202	16.6	225/1613	13.9

Table 77 presents prevalence data for maxillary *vs.* mandibular ante-mortem tooth loss. In the Ancaster sample, the CPR for the total sample and males is greater for the maxillary sockets, and the difference is statistically significant for males. In the Winchester sample, the prevalence rate is higher for the mandibular dentition in all cases, but the difference between the upper and lower arches is not significant (Test 80). In the Winchester sample, male CPRs are higher than female CPRs for the maxillary and mandibular sockets. Ancaster males have a higher maxillary CPR compared to females, but significantly more Ancaster females have mandibular AMTL (Test 81). The difference in CPRs between the samples is statistically significant for male mandibular tooth loss (Test 82).

Table 77. Prevalence of maxillary *vs.* mandibular ante-mortem tooth loss.
(N^1=number of individuals/sockets affected; N^2=number of individuals with at least one maxilla or mandible/number of sockets present.)

ANCASTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	58/112	51.8	19/45	42.2	36/63	57.1
Mandible	56/123	45.5	28/47	59.6	26/72	36.1
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	221/1516	14.6	73/578	12.6	129/890	14.5
Mandible	214/1777	12.0	104/671	15.5	102/1064	9.6
WINCHESTER	**All Adults**		**Females**		**Males**	
CPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	48/109	44.0	19/47	40.4	26/56	46.4
Mandible	59/110	53.6	23/47	48.9	34/58	58.6
TPR	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Maxilla	188/1415	13.3	84/572	14.7	93/771	12.1
Mandible	253/1509	16.8	115/630	18.3	132/842	15.7

Figure 49 compares socket involvement between the samples by tooth position. There is very little difference between the populations. In both samples, the TPR is greatest for the first molar, followed by the second molar. The TPR for the third molar is relatively low. The incisors and canines are least affected.

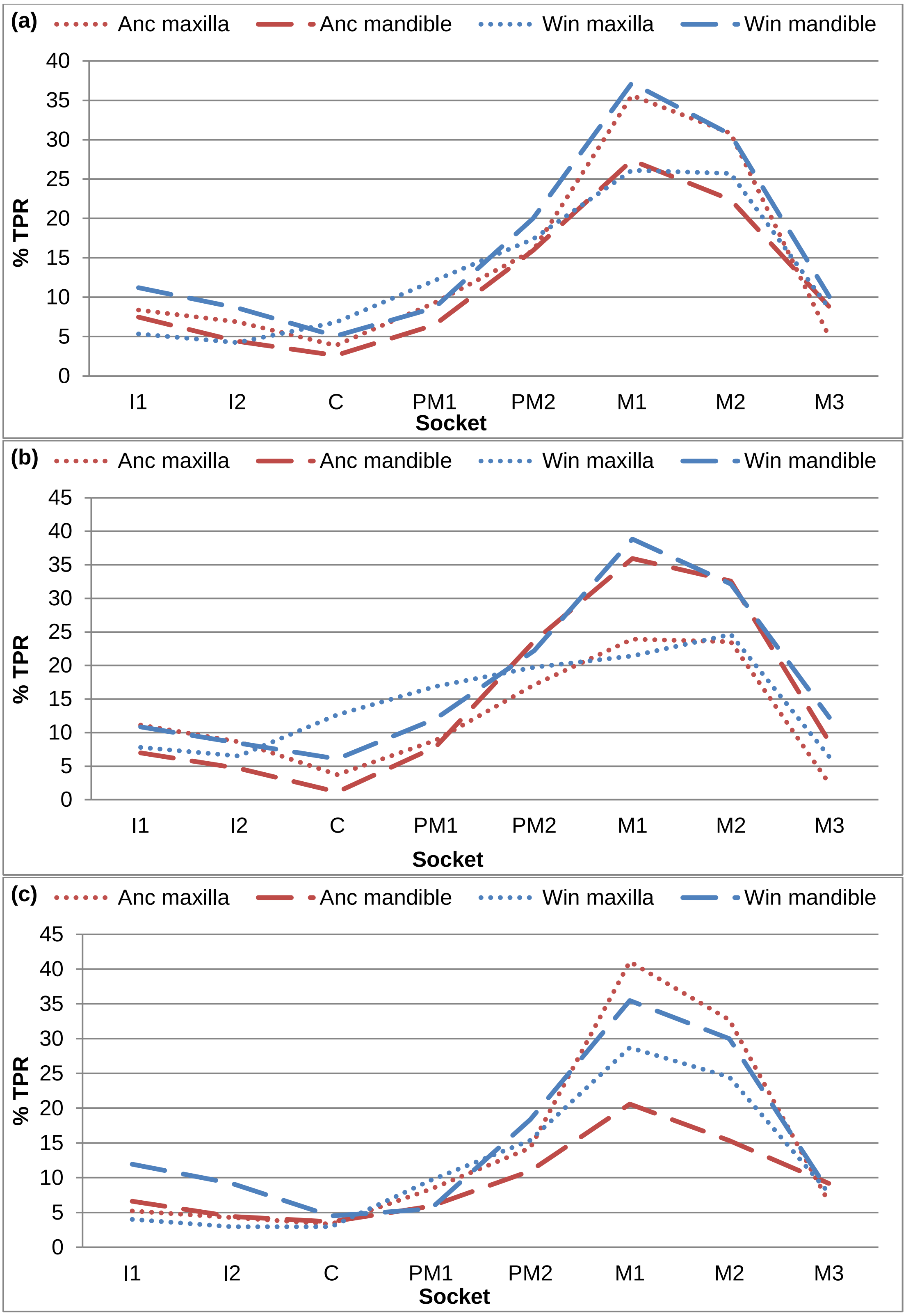

Figure 49. Graphs comparing the true prevalence of ante-mortem tooth loss by socket between the samples (a=all adults, b=females, c=males).

6 Discussion

This chapter presents a discussion and interpretation of the results presented in Chapter 5. For each category of data (demography, growth and stature, and pathology), the study findings are summarised and compared with data for the comparative populations listed in Chapter 4 (section 4.2.9). Summary data for other skeletal populations are presented in graph form, with statistical tests and data provided in Appendices 5 and 6. For many categories of pathology, data could not be included for one or more sites because methods of data analysis and/or presentation used by other researchers were incompatible with the present study. In order to avoid repetition, explanations regarding the exclusion of data for a particular site(s) are provided in footnotes beneath the relevant table in Appendix 6.

6.1 Demography

6.1.1 *Sex ratio*

Males outnumbered females in both samples, although when compared with an expected sex ratio of 1.0, only the sex ratio for Winchester was significantly high, and there was no difference between the samples when sex ratios were compared. Table 78 compares the sex ratios of the study samples with other Romano-British populations. The sex ratio is slightly high for the majority of sites, but women outnumber men at Poundbury, Leicester, Baldock and Dorchester. The overall sex ratio for the public towns is 1.3, and for the small towns it is 1.1. When compared with an expected sex ratio of 1.0, the ratio for the public towns is significantly higher (χ^2=25.654, d.f.=1, p=0.000), but it is not significantly high for the small towns (χ^2=1.145, d.f.=1, p=0.285). Compared against one another, the sex ratios for the public and small towns are not significantly different (χ^2=1.706, d.f.=1, p=0.192).

Table 78. Sex ratios of Romano-British populations.

Public Towns	**Total Adults**	**# Males**	**# Females**	**Sex Ratio**
Cirencester[1]	306	207	93	2.2
Colchester	467	170	140	1.2
Poundbury[2]	706	326	346	0.9
Gloucester[3]	51	24	10	2.4
Leicester	43	11	12	0.9
London	105	30	27	1.1
Winchester	200	93	67	1.4
York[4]	215	104	59	1.8
TOTAL Public towns	2093	965	754	1.3
Small Towns	**Total Adults**	**# Males**	**# Females**	**Sex Ratio**
Ancaster	196	105	78	1.3
Baldock	117	44	55	0.8
Dorchester[5]	107	46	51	0.9
Godmanchester	47	19	17	1.1
Ilchester	50	29	18	1.6
TOTAL Small towns	517	243	219	1.1

[1] There are inconsistencies in Wells' (1982) data in terms of the proportion of 'unsexed' individuals that were adults and subadults. The sexed sample includes seven individuals aged 12-17 yrs.
[2] Includes late Roman burials only.
[3] Includes one adolescent sexed as male.
[4] Adults defined as ≥15 years. Warwick (1968) reported a much higher sex ratio of 4.4 for Trentholme Drive, but this included many individuals who were sexed despite being extremely incomplete.
[5] Figures based on burial catalogue (1972 and 1981 burials combined).

6.1.2 *Age-at-death*

A statistically significant difference was observed in the overall distribution of age-at-death, but this is likely a product of the larger number of subadults (particularly perinates) in the Winchester population. The samples were significantly different in terms of the ratio of adults-to-subadults and the ratio of infants (<1 yrs) to older subadults (1-17 yrs), reflecting the large number of perinates present in the Winchester sample. While not significantly different, the adult age distributions varied slightly between the samples, with more young adults being identified in the Winchester sample. However, the fact that a substantial proportion of Winchester adults could not be assigned to an age category should be taken into consideration.

Comparing the age profiles of the study samples with other populations is very difficult for several reasons. Firstly, different researchers often use different ageing methods and reference standards. Secondly, the age categories employed are rarely the same (particularly for subadults), meaning straightforward comparisons are almost impossible. For these reasons, age structures can only be compared in very broad terms. Table 79 compares the adult-to-subadult ratio of the study samples with other Romano-British populations. The majority of populations resemble the

Ancaster study sample in respect of the relative proportions of adults-to-subadults present, with subadults generally being under-represented compared with expected proportions. However, the ratio of adults-to-subadults varies considerably. The site with the highest ratio of adults-to-subadults is York (9.0), while the lowest ratio occurs at Winchester (1.5), followed by Dorchester (1.7) and Poundbury (1.9). The overall ratio for the public towns is 2.8 and for the small towns it is 2.9. The difference between settlement categories is not statistically significant (χ^2=0.065, d.f.=1, *p*=0.798).

Table 79. Ratio of adults-to-subadults in Romano-British populations.

Public Towns	**# Adults**	**# Subadults**	**Ratio**
Cirencester[1]	306	56	5.5
Colchester[2]	467	108	4.3
Poundbury[3]	706	368	1.9
Gloucester	51	9	5.7
Leicester	43	11	3.9
London	105	32	3.3
Winchester	200	130	1.5
York[4]	215	24	9.0
TOTAL Public towns	2093	738	2.8
Small Towns	**# Adults**	**# Subadults**	**Ratio**
Ancaster	196	75	2.6
Baldock[5]	117	15	7.8
Dorchester[6]	107	62	1.7
Godmanchester	47	17	2.8
Ilchester	50	8	6.3
TOTAL Small towns	517	177	2.9

[1] Total number of adults includes seven adolescents that were sexed.

[2] Subadults defined as <20 years.

[3] Late Roman cemetery only. Subadults defined as ≤17 years.

[4] Subadults defined as <15 years; Warwick (1968) identified 290 adults and 20 subadults, giving a ratio of 12.1.

[5] There is a discrepancy in the figures given by Roberts (2005: 236) – the text states that there were 15 subadults, but the figures provided in Table 90 indicate there were 12; data presented elsewhere suggest the first figure is correct.

[6] There is a slight discrepancy in the figures given between the burial catalogue and the tabulated demographic data as the latter sets the lower age limit for adults at 20 years rather than 18 years; the figures above are based on the burial catalogue data (1972 and 1981 samples combined).

Table 80 compares the age distribution of the study samples with other populations across four broad age categories – subadult, young adult, mature adult and elderly adult (demographic data for each site are provided in Appendix 6). The proportion of subadults ranges from a low of just 10.0% at York, to 50.8% at London, but in the latter case this partly reflects the large number of adults that could not be aged. In all populations, the majority of aged adults fall into the mature age category, which is to be expected to some extent, given that it covers a wider age range, in years, than the young adult category. The sites with the lowest proportion of young adults are York (4.6%), Ancaster (7.2%), and London and Cirencester (7.9%), while the site with the largest proportion is Gloucester at 28.6%. The proportion of elderly adults ranges from 4.8% at London to 22.2% at Poundbury. Despite the relatively marked variations between individual sites, when the figures for the public towns and small towns are combined, the proportions of individuals falling into the four age categories appear similar. However, it is important to note that the proportions of unaged adults varied considerably between sites.

Table 80. Comparison of the age distribution of Romano-British populations.
(N^1=number of individuals in age category; N^2=total number of aged individuals; % of total number of individuals; YA=young adult; MA=mature adult; EA=elderly adult*.)

	N^2	**Subadult**		**YA**		**MA**		**EA**	
Public Towns		**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Cirencester	303	63	20.8	24	7.9	151	49.8	65	21.5
Colchester	393	121	30.8	76	19.3	153	38.9	43	10.9
Poundbury	1030	368	35.7	94	9.1	339	32.9	229	22.2
Gloucester	42	9	32.1	12	14.3	14	39.3	7	14.3
Leicester	28	9	25.1	4	7.3	11	54.0	4	13.6
London	63	32	50.8	5	7.9	23	36.5	3	4.8
Winchester	265	130	49.1	31	11.7	72	27.2	32	12.1
York	239	24	10.0	11	4.6	188	78.7	16	6.7
TOTAL Public	2363	756	28.5	257	9.5	951	43.1	399	19.0
	N^2	**Subadult**		**YA**		**MA**		**EA**	
Small Towns		**N^1**	**%**	**N^1**	**%**	**N^1**	**%**	**N^1**	**%**
Ancaster	235	75	31.9	17	7.2	108	46.0	35	14.9
Baldock	77	15	19.5	9	11.7	46	59.7	7	9.1
Dorchester	140	62	44.3	24	17.1	31	22.1	23	16.4
Godmanchester	60	17	28.3	6	10.0	21	35.0	16	26.7
Ilchester	38	8	21.1	8	21.1	19	50.0	3	7.9
TOTAL Small	550	177	30.9	64	12.6	225	40.7	84	15.9

*See Appendix 6, Table 101 to Table 111 for data.

6.1.3 *Discussion*

6.1.3.1 Sample bias

Skeletal populations are rarely representative of the living communities from which they derive. Numerous cultural biases and taphonomic factors influence the composition of archaeological assemblages, in addition to the unknown demographic variables that contribute to the 'osteological paradox' (Wood *et al*. 1992). The potential impact of these biases must be considered before attempting any biocultural interpretations of demographic data.

One of the most notable differences between the study samples is the ratio of adults-to-subadults and the large number of perinates present in the Winchester sample. In this respect, Ancaster is more similar to other Romano-British populations in having an under-representation of subadults, and Winchester is atypical (see Table 79). There are three potential explanations for this difference. Firstly, it is possible the Winchester population had a higher rate of perinatal mortality. Secondly, the greater proportion of perinates at Winchester could reflect a higher fertility rate, i.e. the perinatal mortality rate was similar but more babies were being born, thus more entered the burial record numerically speaking. Thirdly, the difference may be the result of one or more intrinsic and/or extrinsic sample biases influencing the visibility of perinatal burials. The first explanation seems unlikely to account for the difference between the samples. High neonatal mortality rates tend to be accompanied by high mortality rates among infants and young children, as these age groups are susceptible to the same extrinsic factors responsible for high neonatal mortality, such as infectious disease and malnutrition (Weiss 1973: 26). This was not observed in the Winchester population and there were, in fact, proportionally more young children in the Ancaster sample. It is possible that some aspect of neonatal care specific to the Winchester population resulted in an unusually high perinatal mortality rate. The adoption of practices such as those described by Soranus (*Gynaecology* 2.17-18), who advocated the denial of breast milk in the first few days of life, could have greatly increased the risk of death. However, the likelihood that this was practiced outside of elite circles is questionable (Prowse *et al*. 2008: 297). In any case, it would be difficult to explain why such practices should result in a high perinatal mortality rate at Winchester but not any of the other public towns, where perinates are invariably under-represented (see Appendix 6, Table 101 to Table 111).

The likelihood that the greater proportion of perinates at Winchester reflects higher fertility also seems improbable. High fertility rates usually result in population growth (Chamberlain 1994: 20; Meindl and Russell 1998: 391), which seems improbable for the later Roman period, unless this was matched by higher mortality rates and/or loss of population through migration. Once more, one would have to explain why this situation existed at Winchester, but not Ancaster nor other sites. If anything, the fertility rate is likely to have been slightly lower at Winchester and the other public towns compared to the small towns. Studies of urban populations in recently industrialised and industrialising regions of the world suggest that fertility rates tend to be lower in large towns and cities as economic migrants tend to delay parenthood or limit family size for occupational and social reasons (e.g. White *et al*. 2008; Yi and Vaupel 1989). If, as is suggested by isotopic evidence, Winchester and other public towns included a relatively greater proportion of migrants compared to smaller settlements, fertility levels are likely to have been lower (Eckardt 2010; Eckardt *et al*. 2009; Leach *et al*. 2009; Müldner *et al*. 2011). Lower fertility rates in major towns and cities in the past have also been suggested as a key factor in the so-called ‘urban graveyard’ phenomenon (Woods 2003), discussed in Chapter 2 (2.2.1.3.1).

It is therefore more likely that the difference in the adult-to-subadult ratios of the Winchester and Ancaster samples and, indeed, the marked variation between sites within both categories, is the result of preservation and/or cultural biases influencing the relative visibility of perinate burials. The survivorship curves for both Ancaster and Winchester exhibit a shallow slope between birth and five years, which is more pronounced in the Ancaster sample. This has been noted in other skeletal populations with an under-representation of infants (Chamberlain 1994: Fig. 12). In both samples, subadult remains were generally less well preserved than adult remains (sections 5.1.1 and 5.1.3). The pattern of subadult element representation seen in both study samples has consistently been observed by other researchers, which strongly suggests that preservation was significantly influenced by intrinsic factors, primarily bone density and size (Bello *et al*. 2006; Djurić *et al*. 2011; Guy *et al*. 1997; Manifold 2010; Mays 1992; Walker *et al*. 1988). While intrinsic biases might be expected to affect the survival of perinatal remains in both populations equally, studies have shown that subadult bones are most vulnerable in ‘marginal’ burial environments, especially low pH and/or free draining soils (Buckberry 2000; Gordon and Buikstra 1981). In the case of the skeletal sample from Butt Road, Colchester (which was considered to be poorly preserved), approximately 11.0% of grave cuts produced no human remains, and a disproportionate number of these were ‘child-sized’ graves (Pinter-Bellows 1993: 63). This suggests that burial conditions were less favourable for the preservation of subadult remains, although the possibility that some graves were never actually used should be borne in mind. It is possible that differences in local soil conditions led to perinates being less well represented at Ancaster. The Ancaster and Winchester regions differ in terms of soil morphology (sands/gravels *vs.* clay/chalks), although human bone can survive well in both soil types, depending on pH and drainage (Brothwell 1981: 7-8). No details on the precise nature of the soil conditions at Ancaster and Winchester are known. The fact that bone surface preservation was better at Winchester could suggest that conditions were somewhat more conducive to bone preservation. On the other hand, given that skeletal completeness and element survival rates were poorer for Winchester, it seems unlikely that burial environment fully accounts for the relative under-representation of perinates at Ancaster. Excavation biases and post-burial disturbance could account for the difference. The cemetery at Ancaster was excavated in the 1950s and ’60s and, although Wilson’s notes do not provide a detailed description of excavation methodology, it seems unlikely that grave deposits were routinely sieved, which may have led to smaller subadult remains being missed. Additionally, many Roman burials had been disturbed by modern gravediggers, and it is possible that shallower perinate graves were particularly vulnerable to destruction. Many of the Winchester excavations were also carried out under conditions that were probably no more conducive to the recovery of subadult bones (Ottaway *et al*. forthcoming). Conversely, during the recent excavations at Lankhills, grave deposits were routinely sieved in an attempt to increase the recovery of smaller remains, yet the number of perinates and infants recovered was very low (Booth *et al*. 2010: 12).

Thus, it is probable that cultural factors account for the difference, with perinates being less frequently interred in the formal cemetery at Ancaster. The funerary evidence for differential treatment of perinates in Roman Britain has already been discussed in Chapter 2 (see section 2.2.1.3.2.3). The large number of perinates at Winchester is unusual for a formal urban cemetery, and results from the concentration of burials in the Western Cemetery (Carfax and New Road). Browne (forthcoming) suggested that shallower perinate burials in the Oram's Arbour ditch might have been protected from post-burial disturbance by the depth of accumulated deposits above, but considered it more likely that the Oram's Arbour ditch was specifically selected for the burial of perinates, as relatively few older children and adults were interred in the ditch. The reasons for this are unclear, although a symbolic association of perinates/infants with the pre-Roman settlement or the idea of liminality has been suggested (Ottaway *et al*. forthcoming). In this sense, the perinate/infant burials in the Oram's Arbour ditch may represent an urban analogue to burials in foundation trenches at rural sites (Pearce 1999b, 2001). In contrast, individuals at Ancaster dying in the perinatal period were perhaps more likely to be buried within the settlement itself. It is also important to remember that neither burial ground, nor indeed any other major Romano-British cemetery, has been excavated in its entirety, therefore, any cultural influences on burial location will have biased the skeletal assemblages. The area excavated at Ancaster was largely confined to the boundaries of the modern-day cemetery, and it is unclear what proportion of the total burial ground was actually explored. Areas reserved primarily for subadult burial may exist further west of the excavated area, or at another location to the north, east or south of the town. The low prevalences of perinates at most Romano-British sites can thus probably be explained by their general exclusion from burial, but, depending upon local soil conditions, the relative influence of burial environment *vs.* cultural factors on the representation of perinates may have varied between sites. Buckberry (2000) identified a possible link between the representation of subadults and soil conditions at early medieval sites in England, and a similar review of Romano-British cemetery assemblages might reveal such a relationship.

At both Ancaster and Winchester, and several other sites, the proportions of subadults falling into the infant age category (*c.* 1 month to <1 year) is smaller than expected, based on a hypothetical U-shaped mortality curve for pre-industrial populations (Chamberlain 1994: 19). It is possible that some infants have been under-aged and incorrectly identified as perinates. Two individuals from Winchester were identified as infants according to dental development, yet long bone lengths suggested a perinatal age, indicating that they, and possibly other individuals, were very small-for-age. This was also noted by Ingvarsson-Sundström (2003) in her analysis of subadults from Bronze Age Greece. An alternative (or additional) explanation for the relatively low numbers of infants is preservation bias, as it has been noted that post-neonatal infants can actually survive less well than perinates, due to the fact that bone mineral density declines slightly following birth (Guy *et al*. 2007: 224).

The subadult age distribution at most Romano-British sites (including Ancaster) thus differs from an expected mortality curve for pre-industrial populations, but resembles that often seen in archaeological samples (with subadults being under-represented), reflecting both taphonomic and cultural biases that reduce the visibility of the very young. Intrinsic biases may also have influenced adult age profiles. In both study samples, and all other Romano-British populations (Table 80), mature adults outnumber elderly adults, and it is possible that the size of over-50s age group has been under-estimated due to age-structure mimicry and other sources of error in available ageing techniques (Aykroyd *et al*. 1999; Chamberlain 1994: 20). In the present study, dental attrition appeared to under-age individuals relative to skeletal age. Of the 66 individuals (Ancaster and Winchester combined) with a dental attrition age of 17-25 years, 26 were older according to skeletal age indicators. As noted elsewhere (sections 4.2.3.2.3.2 and 6.1.3.1), this trend has also been observed in other Romano-British populations, including the Lankhills and Poundbury samples. In an attempt to correct for this, Molleson (1993: 207-9) developed a method of ageing for the Poundbury population based on adjustments for age-related variation in rates of molar enamel wear (Molleson and Cohen 1990), but the accuracy of this methodology is uncertain. Gowland (2007) utilised Bayesian statistics to construct mortality curves for the adult samples from Lankhills and Victoria Road, Winchester, which assigned more individuals to the upper age ranges.

Another factor that must be considered when interpreting adult mortality is the possibility that the remains of older individuals survived less well, and that a disproportionate number of elderly adults are present in the unaged category (e.g. Walker *et al*. 1988). The presence of metabolic bone diseases such as osteomalacia and osteoporosis, which increase in prevalence with age, has been found to influence preservation (Brickley *et al*. 2007: 75) and could contribute to the under-representation of the elderly. In the Ancaster population, there was little difference in skeletal completeness between younger (<35 years) and older adults, and older males were actually slightly better preserved than younger males. In the Winchester sample, older individuals were only slightly less well preserved than younger adults. However, it could be argued that the lack of a clear difference in preservation between young and older adults might actually be expected if only those elderly adults that were better preserved than average were complete enough to be aged/sexed.

Both study samples differ from a 'normal' human population profile in that females are under-represented, and the sex ratio for Winchester is significantly higher than the expected ratio of 1.0 (section 5.2.1). The sex ratio is not, strictly speaking, an 'indicator of health', but is of relevance as certain pathologies are more common in one or other sex. The under-representation of women in Romano-British cemeteries has already been referred to in Chapter 3 (section 3.3.1), and the phenomenon has been discussed by several researchers (e.g. Morris 1992: 82-8). Possible cultural biases have been reviewed by Davison (2001) and Watts (2001), but few studies have considered intrinsic preservation biases (Crowe 2001). In the present study, there was no difference in overall skeletal completeness between females and males when compared in terms of broad completeness categories (≥75%, 50-74.9%, etc.), but female element survival rates were, in many cases, significantly lower than those for males. Some studies have produced no evidence for differences in preservation between the sexes (e.g. Bello *et al*. 2006; Walker *et al*. 1988). Conversely, Walker (1995) found that female elements, especially the pubis, were less well preserved compared to male elements in a documented historical skeletal sample. At Ancaster, the survival rate for the female and male pubic bones were similar, at 40.0% and 43.8% respectively, but at Winchester, only 25.4% of female burials had a preserved pubis, compared to 40.9% of male burials. The poorer preservation of female pubic bones at Winchester could be due to the greater degree of post-burial disturbance at this site, as the pubis is particularly vulnerable to fragmentation (Mays 2010b: 43). It is therefore possible that the unaged and unsexed components of the Winchester population include a disproportionate number of elderly females. In addition to preservation biases, error in sexing may be a factor. A bias in favour of assigning individuals with incomplete or ambiguous sex characteristics to the male or probably male category has been noted by some researchers (e.g. Donlon 1993). The tendency for females to develop masculine cranial traits in later life means that older females may be misclassified as males, particularly if the pelvis is absent (Meindl *et al*. 1985a; Walker 1995). Greater sciatic notch morphology also becomes ‘more masculine’ with increasing age, and the degree of sexual dimorphism exhibited in the sciatic notch has been found to vary between populations (Walker 2005). In the Ancaster and Winchester samples, five females exhibited masculine cranial traits (VR 34, VR 80, ANC 78, ANC 178 and ANC 224), while only one male exhibited feminine traits (ANC 82). In these cases, the pelvis was obviously present, but some elderly females missing pelves could have been misclassified as male. It is interesting to note that, among the sample excavated as Lankhills by Clarke (1979), more males than females were originally identified (112 *vs.* 71). The remains have since been re-sexed, with 112 males and 119 females identified (Gowland 2001), which may be explained by improvements in diagnostic criteria.

6.1.3.2 Biocultural implications

Many aspects of the demographic composition of the study samples, such as the under-representation of subadults and elderly adults, are commonly observed in archaeological populations, and reflect intrinsic sample and methodological biases. In light of this, any interpretation of the demographic structure of the study samples must be treated with caution. Nevertheless, several aspects of the demographic data may have biocultural implications.

Among subadults at Ancaster, the proportion of deaths increased between the 1-2.5 and 2.6-6.5 year age groups, but no corresponding peak was seen in the Winchester sample. A peak in subadult mortality at this age could be attributed to weaning stress. Stable isotope analysis of subadults from Dorchester suggests that complete cessation of breast-feeding occurred between 2 and 4 years (Fuller *et al*. 2006). This is corroborated by stable isotope evidence from elsewhere in the Empire for the age of weaning (e.g. Dupras and Tocheri 2007; Prowse *et al*. 2008), and is supported by ancient medical text (Fildes 1986: 35). The subadults from Dorchester exhibited a similar peak in mortality at 2-3 years (Fuller *et al*. 2006: Fig. 4), and Lewis (2010: Fig. 3) also observed a slight peak in mortality at this age, suggesting that weaning stress contributed to deaths in this age group. The fact that no peak is observed in the Winchester population could indicate that young children at Ancaster were more susceptible to weaning stress because of factors such as the quality of weaning diet or poorer levels of sanitation. Alternatively, it is possible that the peak in Ancaster mortality at this age is actually an artefact of the under-representation of perinates and infants at this site. There is no evidence for an increase in morbidity among Ancaster subadults at this age in terms of general stress indicators (see below, section 6.7), although this could be due to the 'osteological paradox', whereby children died before lesions developed (Wood *et al*. 1992).

More females died in young adulthood in both samples, and there were more females in the prime adult group at Winchester. This pattern is commonly observed in skeletal samples, and is usually ascribed to greater female mortality during the childbearing years (Acsádi and Nemeskéri 1970; Wells 1975). Estimates for the mean age of first marriage in the Roman world vary, from a low estimate in the early teens to more recent suggestions that most women probably did not marry until the late teens and early twenties (Hopkins 1965; Scheidel 2005; Shaw 1987). Epigraphic evidence from Roman Britain is consistent with relatively late marriage for women (Allason-Jones 2005: 25). Pregnancy and childbirth represent periods of increased mortality risk for women, and the greater proportion of deaths of young females at Winchester in particular could be interpreted as evidence for a higher level of maternal mortality. Today in the developing world, most maternal deaths are due to blood loss during and following labour, hypertension and related disorders such as pre-eclampsia, and sepsis (WHO 2013). Descriptions in ancient medical texts regarding the handling of difficult births suggest that obstructed labours were common and the threat to the mother's life was recognised (Jackson 1988: 104, 106). It might be expected that women at the public towns would have had better access to midwives and medical treatment, as suggested by the embryotomy at Poundbury (Molleson and Cox 1989), which could have lowered death rates (Todman 2007: 85). However, the variables contributing to maternal mortality rates are complex, and the impact of better obstetric care may have been mitigated by other factors such as poorer nutrition and/or sanitation (see discussions of metabolic disease and general stress indicators). Direct evidence for deaths in childbirth in the form of foetal remains found *in situ* within the pelvic area was very limited at both sites[36], but archaeological evidence for dystocia (e.g. Cruz and Codinha 2010; Malgosa *et al*. 2004) is extremely rare in general, perhaps due to poor recovery of foetal bones (Mays *et al*. 2012b: 3253). If pregnancy-related deaths do not account for the greater numbers of young females in the study samples, the presence of more young women migrants at Winchester could explain the difference. At Winchester, more individuals of both sexes fell into the young adult age group, which could also support the idea that the larger towns continued to attract migrants even in the later Roman period (see section 2.2.1.3.2.2). Migrants from surrounding rural areas and abroad would have been more susceptible to the differing disease ecologies of Romano-British towns (*cf*. Gowland and Garnsey 2010: 132; Killgrove 2010b: 53-5), and would thus have a greater chance of entering the burial record at an earlier age.

Intrinsic biases that could have influenced the high sex ratios at both study sites, and other Romano-British cemeteries in general, have already been discussed. In terms of cultural explanations, the presence of the military almost certainly contributed to the imbalance at some towns, e.g. York (Mattingly 2006: 239). The fact that many sites with no historic connection to the army also exhibit an imbalanced sex ratio has led some to dismiss the military explanation (e.g. Morris 1992; Watts 2001), but in the context of late Roman Britain, it is possible that troops were increasingly billeted in towns (Esmonde Cleary 1989: 54).

The possibility that females are less visible in the burial record due to differences in burial location should be considered (Crowe 2001). Roman burial customs emphasised the public commemoration of the deceased (Toynbee 1996: 49-50), and it is possible that men were more likely to be buried in prominent locations close to town gates and main roads. There is little evidence for segregation of burials by sex at most sites (Quensel-von-Kalben 2000), although, as the boundaries of many cemeteries have yet to be identified, the possibility that more females were buried in peripheral areas cannot be ruled out. It is notable that the first series of excavations at Dorchester produced more male burials, while the second series

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[36] An adult female of undetermined age from Carfax (CFX 350A) had foetal remains in the pelvic area (=CFX 350B).

produced more female burials, creating a combined sample with a balanced sex ratio (Harman 1987; Harman *et al*. 1979). This highlights the potential for incomplete excavations to produce biased samples, even where no obvious groupings by sex are present.

The argument for excess female infanticide (Watts 2001, 2005) is controversial, and has not yet been supported by ancient DNA analyses of proposed infanticide victims (Faerman *et al*. 1998; Mays and Faerman 2001; Waldron *et al*. 1999). While it is impossible to know if, and how widely, infanticide was practiced in Roman Britain (*cf*. Harris 1994), Watts' (2001) contention that up to 60% of all female infants were killed at birth is questionable on demographic grounds. For example, almost all of the *c.* 80 burials excavated at Driffield Terrace, York, were males (Müldner *et al*. 2011). If this site were taken in isolation it would be unrealistic to propose that almost all females were victims of infanticide, and the concentration of male burials must be explained by other factors such as the presence of the military garrison or, as suggested by the excavators, the interment of gladiators. Some rural sites have very high sex ratios (e.g. 6.5 for the Roman burials at Owslebury; Collis 1977), which suggests they may comprise the burials of male agricultural labourers or slaves. Once certain sites (e.g. York) are excluded for such reasons, it becomes increasingly difficult to argue that female infanticide alone accounts for high sex ratios at other sites. A further problem with Watts' argument concerns her assertion that imbalanced sex ratios are not observed in the pre-Roman Iron Age, as both Redfern (2006) and Peck (2009) identified more males than females in Iron Age samples from Dorset and Yorkshire respectively. Finally, if Watts' thesis that infanticide was a largely Mediterranean phenomenon is correct, one would expect to see consistent imbalances in favour of males at Italian sites, and other more highly 'Romanised' parts of the Empire. Yet, among several recently reported Roman skeletal populations from Italy, sex ratios were relatively even or biased towards females (Belcastro *et al*. 2007; Cucina *et al*. 2006; Fattore *et al*. 2012; Minozzi *et al*. 2012; Paine *et al*. 2009; Sperduti 1997). Buccellato *et al*. (2003: 335) state that sex ratios of skeletal samples from the various necropolises of Rome itself are generally balanced, and Gowland and Garnsey (2010: 140) also report similar findings for Rome. It therefore seems unlikely that infanticide accounts for the sex ratio imbalance. Nevertheless, as subadults could not be sexed, it is possible that females experienced excess mortality in childhood due to preferential treatment of males, as has been observed in other cultures where there is a traditional preference for sons (e.g. Oster 2009; Rousham 1999: 40; Worthman 1996: 53-4), and this has been described as a form of ‘delayed infanticide’ (Johansson 1984).

6.2 Growth and stature

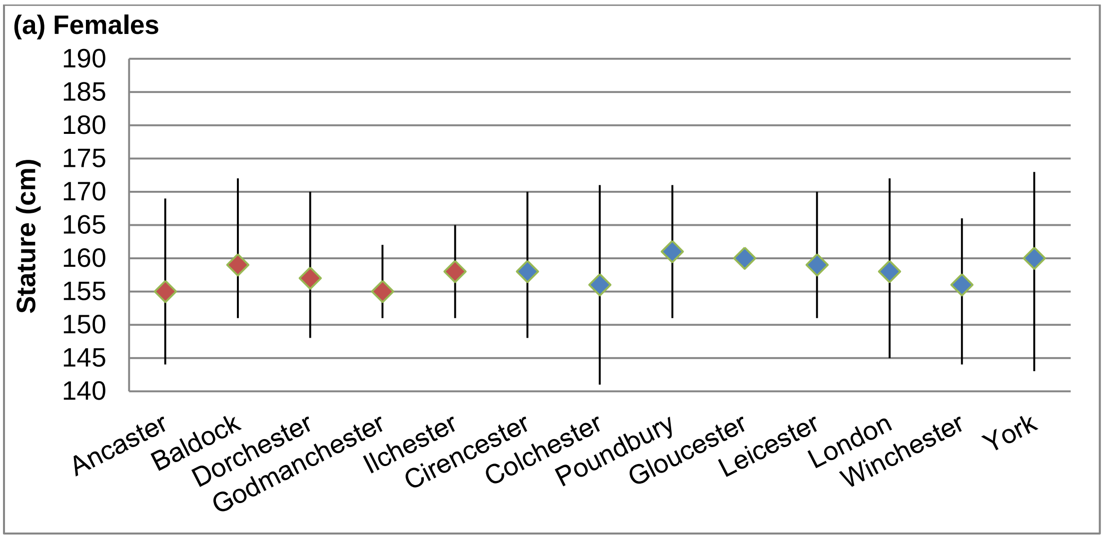
6.2.1 *Subadult growth*

The Ancaster sample exhibited slight growth retardation relative to Winchester. Unfortunately, many of the data points represent single individuals, and larger sample sizes would be necessary to confirm this difference. While long bone lengths and dental age could be correlated for relatively few subadults, other individuals were aged by both dental development/eruption and skeletal maturation. Fifteen individuals from Ancaster and 13 from Winchester had dental ages that were markedly higher than their metric or maturational ages (i.e. there was no overlap between the dental and skeletal age ranges). This suggests that some individuals in both samples did experience pronounced growth retardation relative to modern children, but this may be explained by mortality bias rather than reflecting the general health status of subadults (Saunders and Hoppa 1993). Data on growth rates are not available for any other populations, therefore no inter-site comparisons can be conducted.

6.2.2 *Adult stature*

No significant differences in mean stature were observed between the study samples. Figure 50 compares mean statures at Ancaster and Winchester with other populations (see Appendix 6, Table 112). At the public towns, mean female statures range from a minimum of 154 cm at York to 161 cm at Poundbury. Male stature means range from 166 cm at Poundbury to 171 cm at Leicester and York. Among the small town samples, Ancaster has the lowest mean female stature at 155 cm, while Baldock has the highest stature at 159 cm. Male stature is highest for Ilchester at 170 cm and lowest for Baldock at 167 cm. Comparisons of mean statures between populations are problematic for several reasons. Firstly, some researchers utilised whichever long bones were available (e.g. Márquez-Grant and Loe 2008), while others used only the femur (e.g. Peck 2009). In some cases (e.g. Harman 1987), it is unclear which long bones were used. Secondly, inter-observer error cannot be assessed. Thirdly, comparisons should ideally be based on mean femoral lengths rather than calculated statures (Brothwell and Zakrzewski 2004: 32). Finally, only some researchers provide standard deviations. For these reasons, no statistical comparisons of mean statures has been attempted.

(a) Females



(b) Males

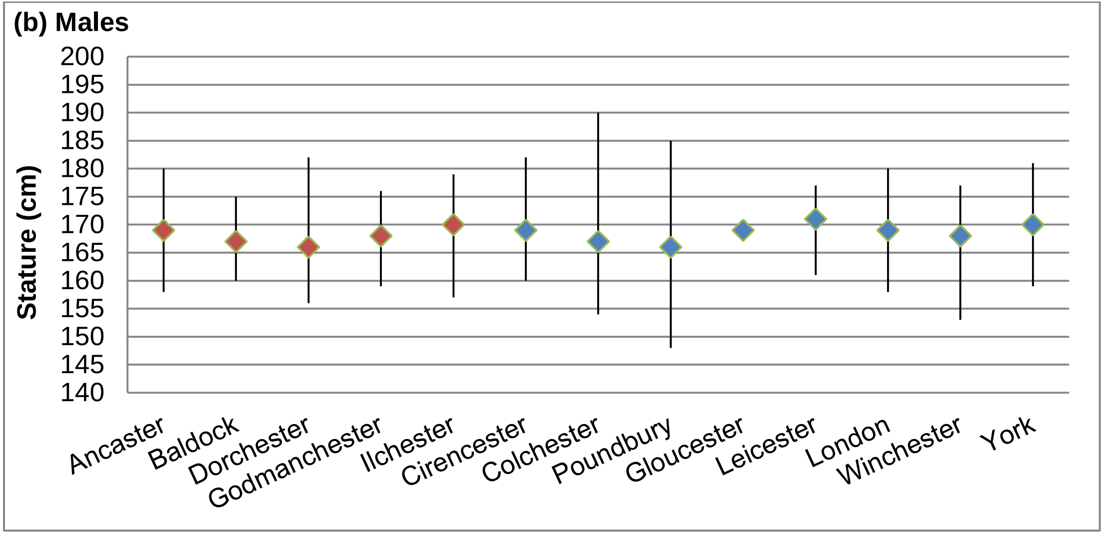


Figure 50. Graphs comparing female and male stature means and ranges in Romano-British populations.

6.2.3 *Discussion*

The similarity in mean statures for the study samples would suggest that subadults at both sites experienced similar levels of health and nutrition. This is broadly supported by the lack of a statistically significant difference in the prevalences of non-specific periostitis and cribra orbitalia, although the significantly higher prevalence of dental enamel hypoplasia in adults from Winchester points to greater levels of physiological stress in this population (see section 6.7.5.3, below). The possible impact of ‘catch-up’ growth should be considered (Wit and Boersma 2002). Unfortunately, in the absence of a larger number of data points for subadult growth, the potential contribution of compensatory growth cannot be assessed. In light of the potential sources of error in comparing and combining stature data collected by different researchers, any analysis of stature differences between the major and small towns must be treated with extreme caution. Superficially, there does not appear to be a tendency for populations from either the small or the public towns to be shorter/taller on average, although the tallest mean statures are reported for public towns. Statistical comparisons of stature estimates (or femoral lengths) would be necessary to confirm the presence or absence of any significant differences.

It has been argued that the degree of stature sexual dimorphism in a population (the ratio of male-to-female stature) is an indicator of general levels of health. Subadult males are generally more susceptible to dietary and disease stress compared to females, who are biologically ‘buffered’ to a greater extent due to enhanced immune responsivity (Ortner 1998; Stini 1969; Stinson 1985). Thus, highly stressed populations should exhibit a relatively greater reduction in male stature and lower sexual dimorphism in stature (Gustaffson *et al*. 2007). Gray and Wolfe (1980) identified a link between low dietary protein and reduced sexual dimorphism in human populations, although a different survey of male-female stature differences in populations experiencing nutritional stress found no overall trend for malnourished populations to exhibit lower stature sexual dimorphism (Stini 1979: 396). For the majority of samples from the public towns, the ratio of male-to-female stature was 1.07. Stature sexual dimorphism was lowest at Poundbury (1.04), and highest at York (1.11). Among the small town populations, the lowest ratio was for Baldock (1.05), and the highest was for Ancaster (1.09). Stini (1979: 396) suggests that the typical range for human populations is 1.04 to 1.09, and only the population from York falls outside this range. Once again, differences in methodology may mean that stature sexual dimorphism is not comparable between populations.

6.3 Joint disease

6.3.1 *Spinal joint disease*

In common with other archaeological populations, spinal joint disease was the most frequently observed pathology in both study samples (Waldron 2009: 35). In total, 121 Ancaster adults (61.7%) and 95 Winchester adults (47.5%) exhibited one or more spinal joint disease (OA, disc disease, Schmorl's nodes). The crude prevalence of spinal OA and disc disease was significantly greater in the Ancaster sample, primarily due to the higher prevalence of both conditions in Ancaster males, although Ancaster females were also more affected. The crude prevalence of Schmorl's nodes was also higher for Ancaster, but the difference was not statistically significant. When true prevalence rates were compared, the differences between the samples were less marked and, in the case of Schmorl's nodes, the TPR was actually higher for Winchester.

6.3.1.1 Spinal osteoarthritis

The crude prevalence of spinal OA was significantly greater for Ancaster, primarily due to the higher prevalence in Ancaster males. When true prevalence rates were compared, the differences between the samples were less marked. There are two potential explanations for this difference. Firstly, it is possible that individuals with spinal OA at Winchester tended to have more joints involved per person. Secondly, the lower CPRs for Winchester could be the result of poorer spinal preservation, as the spine was one region of the skeleton that was found to be significantly less complete in the Winchester sample. If spinal preservation were a factor, one would also expect the CPR for Schmorl's nodes at Ancaster to be similarly high relative to Winchester, unless poor spinal preservation disproportionately affected the posterior facet joints and margins of the vertebral body, rather than the endplates; but this is not the case (see above). Additionally, although the difference in TPRs for spinal

OA is less marked, the Ancaster sample is still affected to a greater extent. Therefore, the influence of preservation bias should not be overstated, but should be noted as a possible complicating factor.

Comparable data on spinal OA are available for few other populations (Figure 51; see Appendix 6, Table 113 for data). The highest prevalences are reported for Godmanchester and Cirencester. Gloucester has the lowest CPR. The combined CPR for the small towns is 36.8% and for the public towns it is 31.0%, but the difference is not statistically significant (Test 83). Differences in the demographic composition of populations should be taken into account when comparing CPRs. As males tend to be more affected by OA, a higher overall CPR could reflect a high sex ratio. Cirencester has one of the highest sex ratios of the public towns (2.2), which could account, in part, for the high CPR for this site; however, the CPR for Cirencester females is the highest reported for any site, suggesting the spinal OA was more prevalent in this population overall. The sex ratio of the Godmanchester sample is almost even (1.1), thus the high CPR for this site cannot be due to a surfeit of males. Ilchester has one of the highest sex ratios of the small towns, but no breakdown of prevalence by sex is available for this site. In terms of age structure, both the Cirencester and Godmanchester samples include proportionally more elderly adults relative to other sites (see Table 80, above), which could have contributed to the higher CPRs for these sites. However, the age profiles of the various sites may not be comparable because of differences in methodology.

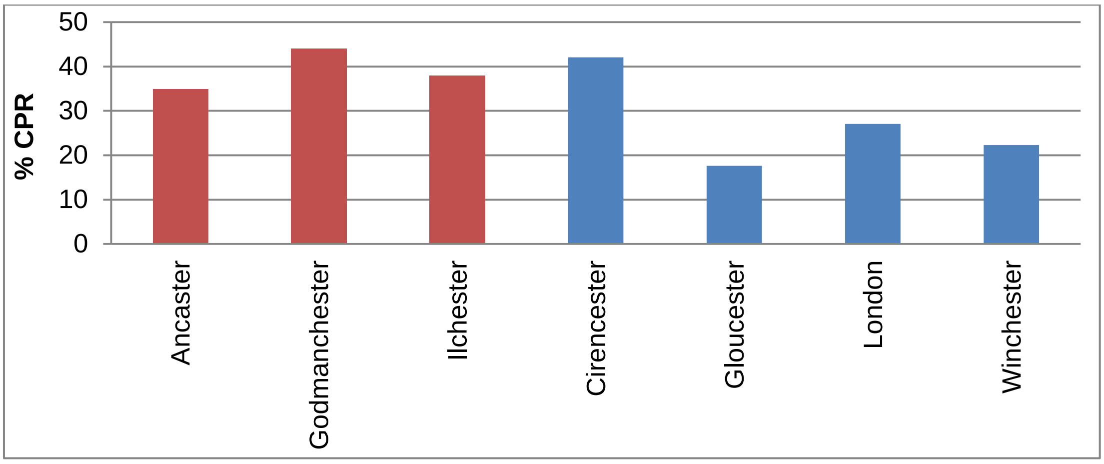


Figure 51. Graph comparing the crude prevalence of spinal OA in Romano-British populations.

6.3.1.2 Disc disease

Degeneration of the intervertebral joints was significantly more prevalent at Ancaster. As in the case of spinal OA, the difference in TPRs was less marked, and the same explanations outlined above could account for this observation.

Disc disease is more prevalent than spinal OA in all populations for which prevalence rates for both conditions are available (Figure 52; see Appendix 6, Table 114 for data). Baldock is the most affected population with a CPR of 79.4%, while the CPRs for Gloucester and Leicester are much lower than all other samples. The overall CPRs for the small towns and public towns are 69.5% and 45.0% respectively, and the difference is statistically significant (Test 84). As in the case of spinal OA, the high CPR for Cirencester may reflect the slightly older age profile of this sample. In this respect, the relatively high CPR for London is notable, given that the proportion of elderly adults in this sample is low (Table 80), although a significant number of adults in the Western Cemetery sample could not be aged at all. The sample from Baldock includes proportionally fewer elderly adults compared to other samples, but more mature adults. A degree of marginal osteophytosis is common in individuals aged *c.* 40 and over (Waldron 2009: 43), and the preponderance of mature adults in the Baldock sample may have contributed to the higher CPR. Another factor that should also be borne in mind concerns variation between researchers in relation to the point at which changes were considered severe enough to be classed as disc disease.

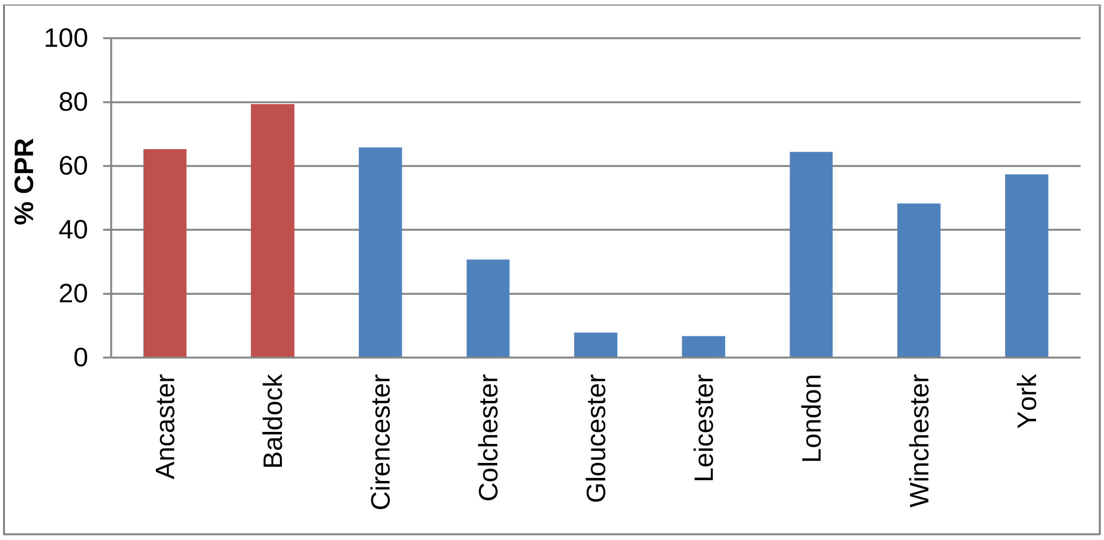


Figure 52. Graph comparing the crude prevalence of disc disease in Romano-British populations.

6.3.1.3 Schmorl's nodes

The Ancaster population exhibited a higher crude prevalence rate for Schmorl's nodes, although the difference was not statistically significant, and the Winchester population had a slightly higher TPR.

Figure 53 compares CPRs for Schmorl's nodes between Romano-British populations (see Appendix 6, Table 115 for data). The highest prevalence occurs in the Ancaster sample, while Gloucester is least affected. In those samples for which the distribution of lesions was described, peaks occurred in the lower thoracic region (Brickley 2003: 74; Roberts 2007: 268; Wells 1982: 155). The overall CPRs for the public towns and small towns are 36.7% and 45.7% respectively, and the difference is statistically significant (Test 85). However, this may be due in part to the poor condition of the skeletal material at Gloucester and Leicester, as CPRs were calculated from the total number of individuals present, rather than the number with preserved spines. As noted in Chapter 4 (section 4.2.6.1.3.1), there is conflicting evidence regarding the relationship between Schmorl's nodes and age, therefore it is difficult to assess the extent to which age might be a factor behind variations in prevalence between sites. Males tend to be more affected by Schmorl's nodes than females (e.g. Dar *et al*. 2010; Faccia and Williams 2008; Üstündağ 2009), and in all populations for which separate CPRs were provided for each sex, the male CPR is higher. When CPRs are compared between sites by sex, the pattern is broadly similar in terms of which populations are most and least affected, with the exception that the male CPR for Leicester is relatively high.

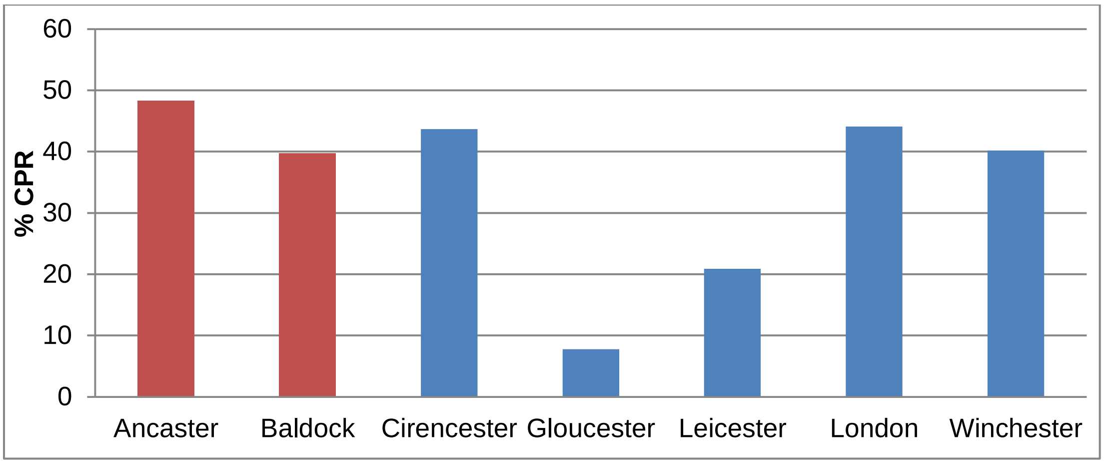


Figure 53. Graph comparing the crude prevalence of Schmorl's nodes in Romano-British populations.

6.3.2 *Extra-spinal osteoarthritis*

The crude prevalence of extra-spinal osteoarthritis was greater for the Ancaster sample, and the difference in CPRs between the samples was statistically significant (total samples and males). When CPRs were compared by joint, the prevalence was greater for the Ancaster sample in most cases (an exception being the knee), although none of the differences was statistically significant. In terms of individual TPRs for each joint, differences were less marked, although the Ancaster population was generally more affected. The joints of the upper body were significantly more affected than those of the lower body in both samples.

Figure 54 compares the prevalence of extra-spinal OA in the study samples with other populations (see Appendix 6, Table 116 for data). Cirencester has the highest CPR, followed by Ancaster, while the prevalence rates for Dorchester, Godmanchester and Ilchester are much lower. It is important to note that, while all researchers included the major joints (shoulder, elbow, hip and knee) in the calculation of prevalence rates, there was no consistency in terms of the inclusion of the acromioclavicular joints, sternoclavicular joints, wrists, hands, ankles and feet. Additionally, some researchers defined the shoulder as the glenohumeral joint, while others considered the shoulder to comprise the acromioclavicular joint and glenohumeral joint. In light of the fact that the acromioclavicular joint is one of the most frequently affected in skeletal populations (Waldron 2009: 31), excluding this joint from the calculation of prevalence will have resulted in significant under-estimation of the prevalence of extra-spinal OA at some sites. When overall CPRs are compared for major and small towns, the samples from the public towns are significantly more affected than the small towns (28.1% *vs.* 20.5%), contrary to spinal pathology (Test 86). However, the data for other small towns are not comparable with Ancaster, therefore the prevalence for the small towns as a category is almost certainly not an accurate indicator of the frequency of OA at this settlement category.

Given differences in the definition of joint units, and the fact that many other researchers included only the major joints, it is not possible to compare patterns of joint involvement between populations. Additionally, it is evident that some researchers diagnosed OA from the presence of marginal osteophytosis only. This is problematic, as variations in diagnostic criteria have been shown to influence the pattern of joint involvement (Arcini 1995).

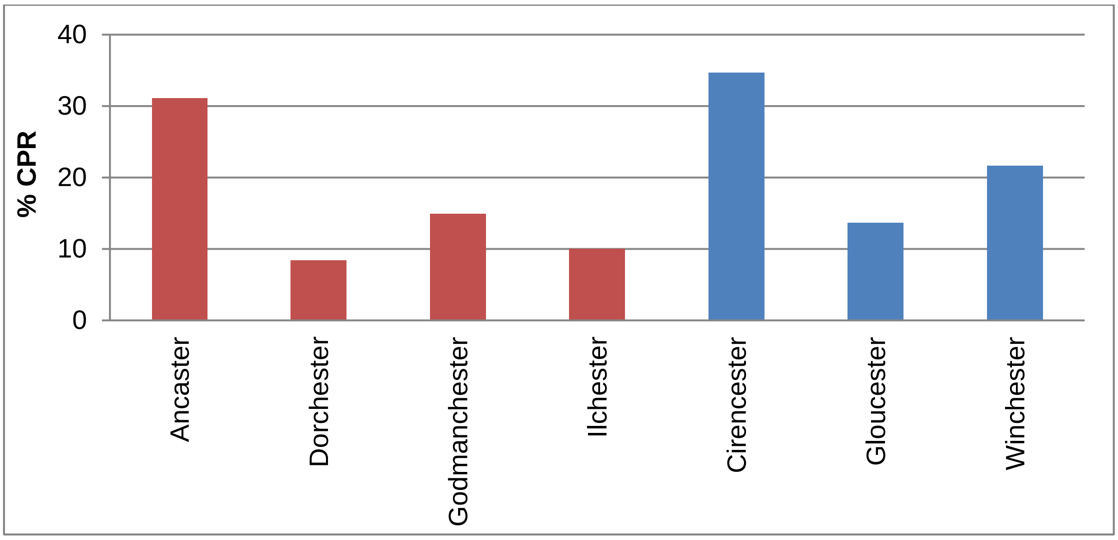


Figure 54. Graph comparing the crude prevalence of extra-spinal OA in Romano-British populations

6.3.3 *Rotator cuff disease*

Three individuals from Ancaster exhibited changes to the glenohumeral joint indicative of rotator cuff disease, two females (ANC 152 and 241) and a male (ANC 63). In all three individuals, the changes were bilateral, and all exhibited humeral impingement syndrome (Figure 87 to Figure 89). Two of the affected individuals (ANC 63 and 241) were elderly, and the third was a mature adult. No other studies provide data on the prevalence of rotator cuff disease, therefore no comparisons with other populations can be made.

6.3.4 *Discussion*

6.3.4.1 Intrinsic *vs.* extrinsic influences on joint disease

Bioarchaeological perspectives on joint disease have evolved considerably in recent years. While some researchers continue to view osteoarthritis as primarily a condition of wear and tear that can be used to reconstruct the ‘work’ habits of individuals and populations in the past (e.g. Goodman and Martin 2002: 44), others have become increasingly sceptical of simplistic interpretations of joint disease (Weiss and Jurmain 2007: 444). In particular, the value of utilising the patterning and prevalence of spinal joint disease to reconstruct activity in the past has been questioned, as more studies have identified consistent patterns of joint involvement (Weiss and Jurmain 2007: 440-1). Both study samples exhibited a similar pattern of joint involvement for all three conditions. Spinal OA generally peaked at the C3-4-5, C7-T1, T4-5 and L3-4-5, similar to the pattern observed in studies by Bridges (1994), Jakob (2004), Knüsel *et al.* (1997), and Waldron (1991b, 1991c, 1992). Peaks in the prevalence of disc disease occurred at the C5-6, T8-9 and L4-5 joints at Ancaster, and the C5-6-7, T8-9 and L2-3 joints at Winchester (e.g. Allbrook 1957; Jurmain and Kilgore 1995; Kahl and Ostendorf Smith 2000; Üstündağ 2009; Van der Merwe *et al.* 2006; H.A. Waldron 1991; T. Waldron 1991b). The distribution of Schmorl's nodes by vertebral level was almost identical for both study samples, and, once again, is similar to that reported for other skeletal samples (e.g. Üstündağ 2009).

The fact that the distributions of spinal joint diseases in both samples closely resemble patterns reported for other skeletal populations from diverse archaeological contexts suggests that joint involvement predominantly reflects the anatomy and normal biomechanical loading of the spine induced by upright posture and bipedalism (*cf.* Knüsel *et al.* 1997). The 'S' shaped curvature of the vertebral column serves to distribute efficiently the weight of the skull and maintain the body's centre of gravity (Jaanusson 1991; Lovejoy 2005: 99), and peaks in spinal OA broadly correspond with points of maximum curvature. The variable mobility of the spine, and differing distribution of compression/tension, shear and torsional forces, also help explain the patterning of spinal joint diseases. The cervical region has a relatively wide range of motion in all three planes, which may contribute to higher rates of cervical OA. The thoracic region has limited motion in the lateral plane, but the range of axial motion is greater. The lumbar region has a wide range of motion in the sagittal plane (flexion/extension), but limited range of axial rotation (Figure 55; Hsu *et al.* 2008; White and Panjabi 1994). Knüsel *et al.* (1997: 493) noted that peaks in the prevalence of disc disease/vertebral osteophytosis tend to exhibit a slightly inverse relationship with peaks in spinal OA, and this was also observed in the study samples to some extent. For example, in the Winchester sample the peak in disc disease in the cervical region occurs at the C6-7, which is the joint least affected by spinal osteoarthritis and the peak in disc disease prevalence between the T6 and

T9 also corresponds with low prevalence rates for spinal OA at these joints. Knüsel *et al.* (1997) suggested that the differences in the pattern of joint involvement for disc disease and spinal osteoarthritis can be explained by the differing functions of the intervertebral and apophyseal joints, the former serving primarily as load-bearing joints.

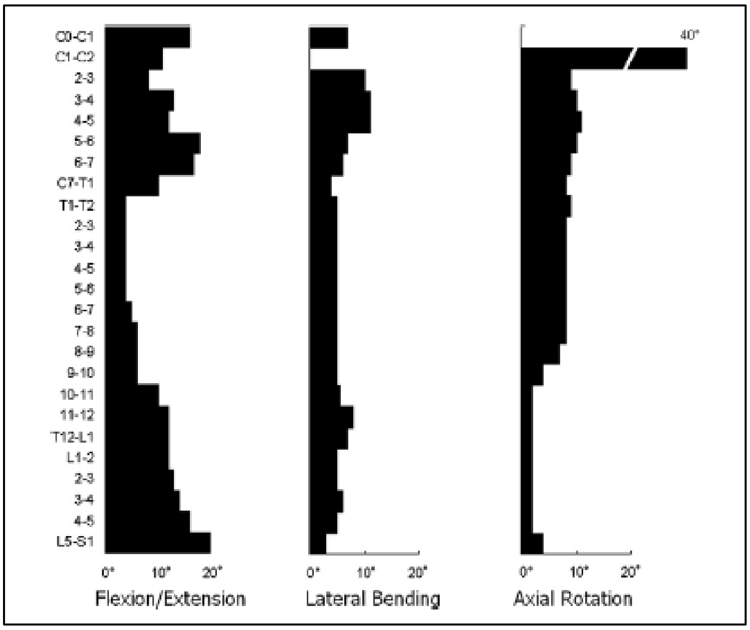


Figure 55. Diagram showing the range of motion of the spine (from Chen *et al.* 2011: Fig. 1).

The pattern of joint involvement in Schmorl's nodes differs from spinal OA and disc disease, suggesting that other factors influence the development of these lesions. Dar *et al.* (2010) proposed that the the caudal increase in Schmorl's nodes throughout the thoracic spine and subsequent decrease in the lumbar spine is explained with reference to the distribution of forces induced by upright posture and the greater range of axial rotation in the mid/lower thoracic region. Additionally, the discs between thoracic vertebrae are thinner relative to vertebral body size than those of the cervical and lumbar regions, and also possess a relatively smaller nuclear pulposus, making them more susceptible to herniation (Weyruther *et al.* 2006: 106).

Like spinal joint disease, the pattern of extra-spinal joint involvement observed in the study samples resembles that reported for other archaeological populations (e.g. Crubézy *et al.* 2002; Jakob 2004; Waldron 1992, 1995), with high CPRs for the acromioclavicular joint and hand, while the temporomandibular, ankle and elbow are least affected. The relatively consistent pattern of joint involvement in many skeletal samples can again be explained with reference to joint anatomy and function, in addition to genetics, activity and trauma. High prevalence rates for the acromioclavicular and sternoclavicular joints (Figure 79 and Figure 80) reflect their role in supporting and moving the upper limb. The fibrocartilaginous discs (menisci) that separate the medial and lateral ends of the clavicle from the sternum and acromion respectively experience age-related degeneration similar to the intervertebral discs of the spine, which accounts for the strong age-related prevalence of osteoarthritis of these joints and its near-ubiquity in elderly individuals (Waldron 2009: 35). Furthermore, the meniscus of the acromioclavicular joint is thinner than that of the sternoclavicular joint, which may also contribute to higher prevalence rates for the former (Yood and Goldenberg 1980). In terms of the four major joints, a greater prevalence of osteoarthritis of the hips and knees, relative to the elbow and shoulder, is often observed in modern populations, which may reflect the weight-bearing role of the lower joints (Coggon *et al*. 2001; Cooper *et al*. 1998; Cushnagan and Dieppe 1991; Jiang *et al*. 2011; Karlson *et al*. 2003; Manninen *et al*. 1996). The relative rarity of OA of the ankle is notable, given its weight-bearing role. Recent studies suggest that traumatic lesions of the ankle cartilage are less likely to progress to complete articular cartilage destruction than in the knee due to differences in the composition of cartilage (Huch 2001; Poole *et al*. 2007: 31).

Several other joint conditions may predispose individuals to developing OA. For example, congenital dysplasia is a known risk factor for OA of the shoulder. One individual from Ancaster, ANC 24, exhibited extreme OA of the glenohumeral joint with marked flattening of the proximal humerus, suggestive of dysplasia (Figure 81). Dysplasia is also associated with an increased risk of OA of the hip, as are conditions such as slipped capital femoral epiphysis and Legg-Calvé-Perthes disease (Carney and Weinstein 1996; Goodman *et al*. 1997; Harris-Hayes and Royer 2011; Jacobsen and Sonne-Holm 2005; Kim 2010; Lane *et al*. 2000; Loder *et al*. 1995; Wilcox *et al*. 1988). In the present study, two individuals (VR 54 and CHR 607) exhibited OA of the hips that may have developed due to congenital dysplasia. One individual from Ancaster, ANC 188 (25-34, M?) exhibited extreme osteoarthritis of the left hip possibly arising from a slipped femoral epiphysis or

Perthes disease (Figure 85). Trauma may also precipitate the development of OA. Two individuals with OA of the wrist (AR 312 and ANC 241) had sustained Colles' fractures of the radius and a third (ANC 225) had a possible 'parry' fracture of the distal ulna (Figure 100); in AR 312 and ANC 225, the OA was unilateral and probably developed secondary to the fractures.

In both populations, males were more affected by both spinal joint disease and extra-spinal OA compared to females, as is commonly observed in modern populations, at least below the age of *c*. 50 years (Srikanth *et al*. 2005). Physiological, anatomical and genetic factors could account for the difference, rather than gender-based differences in activity (Cicuttini *et al*. 1999; Jørgensen *et al*. 2011; Kinney *et al*. 2005; Maleki-Fischbach and Jordan 2010; Otterness and Eckstein 2007; Richette *et al*. 2003; Wei *et al*. 2011). A recent study of Schmorl's nodes in the lower lumbar region identified a positive correlation between the presence of lesions, larger vertebral body size, and pedicle shape, which could account for higher prevalence rates in males (Plomp *et al.* 2012). In the case of extra-spinal OA, females exhibited higher prevalence rates for the hands and knees, a trend also reported in the clinical literature (Srikanth *et al*. 2005). Osteoarthritis of the distal interphalangeal joints of the hands (DIPs) has long been recognised as an inherited trait that is dominant in females (Kellgren and Moore 1952; Stecher and Hersh 1944), and this could account for the greater female prevalence of hand OA in the study populations. Higher prevalences of knee osteoarthritis in females have been linked to the distribution of female body fat (Davis *et al*. 1988), differences in knee cartilage volume (Jones *et al.* 2000), and differences in gait and joint biomechanics (Sims *et al*. 2009).

In addition to the many intrinsic variables that influence the patterning of extra-spinal joint disease, there is some evidence that the manifestations of osteoarthritis vary by joint, which may also contribute to the generally consistent pattern of joint involvement. For example, Rando and Waldron (2012) suggest that eburnation rarely occurs in the temporomandibular joint, which may contribute to the low reported prevalences for this joint. In the present study, only one individial diagnosed with osteoarthritis of the temporomandibular joint exhibited eburnation. Similarly, Debono *et al*. (2004) have argued that elbow osteoarthritis is under-diagnosed in skeletal populations because marked marginal osteophytosis often occurs without significant changes to the joint surfaces (Cheung *et al*. 2008; Dalal *et al*. 2007; Gramstad and Galatz 2006).

6.3.4.2 Lifestyle and activity

Despite the assertions of earlier researchers, it is evident that joint disease cannot be used to reconstruct activity at the individual level in terms of specific occupations or activities (Waldron 2012: 520). While the patterning of joint involvement appears to be primarily influenced by intrinsic factors (Jurmain *et al*. 2012: 432), it has been suggested that more pronounced variations in overall prevalence rates and joint involvement may reflect differences in the magnitude or duration of generalised activities (Robson Brown *et al*. 2008; Weiss and Jurmain 2007: 444). In the present study, the higher prevalence rates for spinal joint disease at Ancaster and at the small towns combined, compared to Winchester and other public towns may tentatively be interpreted as evidence for some general difference in activity. This could be in terms of a difference in the types and intensities of activities being undertaken, or the cumulative duration of activity over the life course, or both (e.g. Andersen *et al*. 2012). This interpretation would be consistent with the impression gained from archaeological evidence and building types that communities at the small towns were involved to a greater extent in agricultural production, as farming is widely recognised as one of the most labour-intensive and accident-prone occupations (Angoules 2012). Romano-British agriculture was dominated by arable and livestock farming and textual sources indicate that Britain was a major exporter of grain, wool and animal hides (Ireland 2008: 215; Salway 1993: 191). Crop cultivation would have involved a wide range of activities, including ploughing, harvesting, and threshing (Applebaum 1958). While most ploughing was probably performed with the aid of horses or oxen, and mechanical devices for harvesting and threshing were developed during the Roman period (White 1967: 157), most of this work would have been carried out by hand using hoes, scythes and sickles, many examples of which have been found (Hingley 2006). Farming also involves many other laborious activities such as digging and maintaining drainage ditches, manure spreading, and carrying heavy loads, e.g. livestock feed, and close contact with livestock would have increased the risk of sustaining injuries to joints through kicks and falls (Busch *et al*. 1986). Animals and carts would have been used for the transport of bulky items, but loading items onto vehicles would itself have been a strenuous activity. Descriptions of agricultural practices and depictions on mosaics and tombstones also indicate that much carrying was done by individuals using buckets, baskets and other containers (White 1975: 51-2).

Although the pattern of joint involvement in joint disease is largely explained by posture and anatomy, extreme activity-related stresses might influence the distribution of changes (Knüsel *et al*. 1997: 494). A number of differences between the samples in the patterning of OA could be explained with reference to activity. In the Winchester sample, lumbar OA peaked in the mid-lumbar region, while the L5-S1 was more affected in the Ancaster sample. The Ancaster sample also exhibited a larger peak in disc disease in the lower lumbar region. The L5-S1 has a greater range of motion in flexion/extension than the other lumbar joints (Yamamoto *et al*. 1989). Flexion induces considerable shear forces on the lower lumbar and lumbo-sacral joints in particular (Kalichman and Hunter 2007: 72). Therefore, this difference could be an indicator of greater involvement in activities involving frequent bending and heavy lifting. In relation to extra-spinal OA, several differences were observed between the samples. The acromioclavicular joint was more affected in the Ancaster sample (particularly Ancaster females), but the prevalence rates for the sternoclavicular joints were generally similar for both populations. Again, this may point to some difference in general activities involving raising the arm, a movement in which the acromioclavicular joint in particular plays a primary role (Collins 2009: 463). A tendency towards greater symmetry in upper body joint disease was noted in the Ancaster sample, while laterality was more evident at Winchester. Prevalence rates for the right joints were broadly similar between the samples, but the left joints were less affected at Winchester. Right-side bias might be expected if osteoarthritis is linked to handedness and cumulative loading of the joints over the life-course (e.g. Thongngarm and McMurray 2000). Therefore, the tendency towards bilateralism at Ancaster might imply more equal use of the upper limbs. This, in addition to the higher prevalence of osteoarthritis of the glenohumeral joint and the presence of rotator cuff disease at Ancaster, could also indicate that this population undertook more activities involving both arms, such as heavy lifting and carrying (e.g. loading harvested crops onto carts), rather than lighter activities that might tend to primarily affect the dominant limb. Alternatively, as the numbers of individuals affected were relatively small, and none of the differences in extra-spinal joint involvement was actually statistically significant, these differences may simply reflect sample biases or random variation.

Despite the lack of statistically significant differences in overall CPRs between Ancaster and Winchester females, variations in the pattern of joint disease were more marked for women than was the case for males. For example, females at Ancaster and Winchester differed in the pattern of cervical and lumbar OA, and only Ancaster females exhibited osteoarthritis of the median atlanto-axial (atlanto-odontoid) joint (TPR 8.5%; Figure 75). Osteoarthritis of the cervical spine has been linked with carrying heavy objects on the head (Badve *et al*. 2010; Jäger *et al*. 1997), which is a common mode of portage primarily performed by women in traditional agricultural societies (e.g. Geer *et al*. 2010). Furthermore, Ancaster females had a significantly higher CPR for disc disease of the lumbar spine, which could suggest that they experienced greater stress on the lower spine compared to Winchester females. In terms of extra-spinal OA, only Ancaster females exhibited osteoarthritis of the shoulder, elbow and wrist joints. Weiss and Jurmain (2007) suggest that OA of the appendicular joints of the upper body is more likely to reflect activity levels, therefore this finding might point to differences in activity between females in the two samples. Alternatively, Ancaster females may have experienced a higher risk of joint trauma. There is an association between OA of the glenohumeral joint and rotator cuff disease, which is often traumatic in aetiology (Edelson 1995; Kerr *et al*. 1985). Two of the females with shoulder osteoarthritis in the Ancaster sample (ANC 63 and 241) exhibited severe rotator cuff disease (Figure 87 to Figure 89; also see Table 99). The differences in spinal OA and disc disease, coupled with the presence of rotator cuff disease among Ancaster females and relatively greater crude prevalence of upper body OA (24.6%, *vs.* 18.5% for Winchester), could suggest that Ancaster women undertook different and possibly more strenuous tasks. It has been suggested that the majority of heavy labour in societies dependent on plough agriculture is likely to have been undertaken by men, with women’s tasks more likely to be confined to the domestic sphere and activities such as milking (Bradley 1989; Ember 1983). However, in many agricultural societies women also contribute significantly to tasks such as planting and harvesting (FAO 2011). Ancient Roman sources, and ethnographic studies indicate that women in the Mediterranean region were frequently involved in the harvesting of crops and arboriculture (Scheidel 1995, 1996; J.B. Whittaker 2000: 63), and there is little reason to think that the same was not also true in Roman Britain.

The similarity in the prevalence of Schmorl's nodes in the study samples (and other Romano-British populations) is notable. As discussed earlier (section 4.2.6.1.3.1), the precise aetiology of Schmorl's nodes is uncertain. Broadly speaking, there is a consensus that lesions tend to develop in adolescence and early adulthood, and that trauma, both acute and repetitive, is probably a significant aetiological factor. If the population of Ancaster experienced a more physically strenuous lifestyle, one might thus expect to observe a greater prevalence of Schmorl's nodes in this sample. The lack of any difference in the prevalence of Schmorl's nodes between the samples could suggest that older children and adolescents in both populations experienced similar levels of stress and/or trauma, although this need not necessarily mean that the activities in which they were partaking were similar. Alternatively, the similarity in CPRs may indicate that activity was not a significant factor in the development of Schmorl's nodes.

Relative to farming, the occupational activities of the majority of the populace of the larger towns such as Winchester were probably less strenuous, although many craft activities are also labour intensive. Metalworking, especially blacksmithing, involves repeated hammering, as depicted in several funerary stele from Britain (Wacher 1995: 182, Fig. 83). The greater degree of laterality of upper body joint disease at Winchester could reflect more involvement in such activities, which favour the dominant (usually right) limb. Other urban occupations, such as construction, would also have been physically demanding (Ling 1985), but compared to farming, most urban occupations could probably be classed as 'light labour' (*cf.* Grauer and Roberts 1996: 539). Additionally, while certain urban occupations might not have differed significantly from farming in intensity, the cumulative duration of activity over the life-course is likely to have been greater among farmers.

While the evidence for greater levels of joint disease at Ancaster relative to Winchester supports views regarding the differing economic characters of the study sites, alternative explanations should not be ignored. For example, the difference could relate to the socio-economic makeup of the two populations. Reece (1980) and Faulkner (2000) have argued that the public towns of late Roman Britain were largely populated by members of the curial classes and government officials, while the size of the non-elite, artisan population had declined. Since the prevalence rate for any skeletal sample is inevitably an ‘average’, the lower rate of joint disease at Winchester could be interpreted as reflecting a relatively greater proportion of elite individuals in this sample, who are less likely to have engaged in physically laborious occupations. It could thus be argued that the evidence for greater levels of joint disease at the small towns reflects a more physically active artisan population. In light of the lack of archaeological evidence for large-scale production activities at Ancaster, the skeletal data are more likely to support the initial hypothesis.

6.4 Trauma

Traumatic lesions were the second most commonly observed skeletal pathology in both samples. Fifty-seven individuals from Ancaster (29.1% of adults) and 54 from Winchester (27.0% of adults) exhibited one or more trauma. The vast majority of injuries were fractures, and the proportion of adults exhibiting fracture trauma was similar in both samples – 23.5% for Ancaster and 22.5% for Winchester adults. Similar numbers of individuals from Winchester (15/200, 7.5%) and Ancaster (18/196, 9.2%) exhibited evidence for possible trauma other than fractures (Figure 109 to Figure 112). True osteochondritis dissecans was only observed in the Ancaster population (Figure 109 and Figure 110). Both individuals affected were males, and in both cases the lower limb was affected, which is consistent with clinical epidemiological data (Cahill 1995; Crawford and Safran 2006; Hefti 1999). Data on the prevalence of osteochondritis are unavailable for most other populations; hence, only fracture trauma can be compared.

6.4.1 *Fractures*

Figure 56 compares the crude prevalence of fractures in Romano-British populations[37] (see Appendix 6, Table 117 for data). The highest CPR reported is for Poundbury, followed by Cirencester, Ancaster and Winchester. The lowest prevalence rates reported are for Ilchester and Colchester. The very low CPR for Colchester could be due to poor skeletal preservation (Pinter-Bellows 1993: 62). When the total prevalence rates for the public and small towns are compared, the CPRs are very similar (18.4% *vs.* 18.2%), and the difference is not statistically significant (Test 87). As in the case of joint disease, demographic factors should be considered when interpreting variations in prevalence. In the Ancaster and Winchester samples, there was an overall increase in the CPR with age, and males were more affected than females. All other populations, with the exception of Leicester and Ilchester, are similar in that males are more affected than females. When prevalences are compared by sex, the findings are similar in terms of which are the most and least affected sites (Table 117). In relation to age, the higher CPRs for Cirencester and Poundbury could partly reflect the greater proportions of elderly individuals in these samples, although other sites with a relatively older age profile (e.g. Godmanchester) have lower CPRs (Table 80).

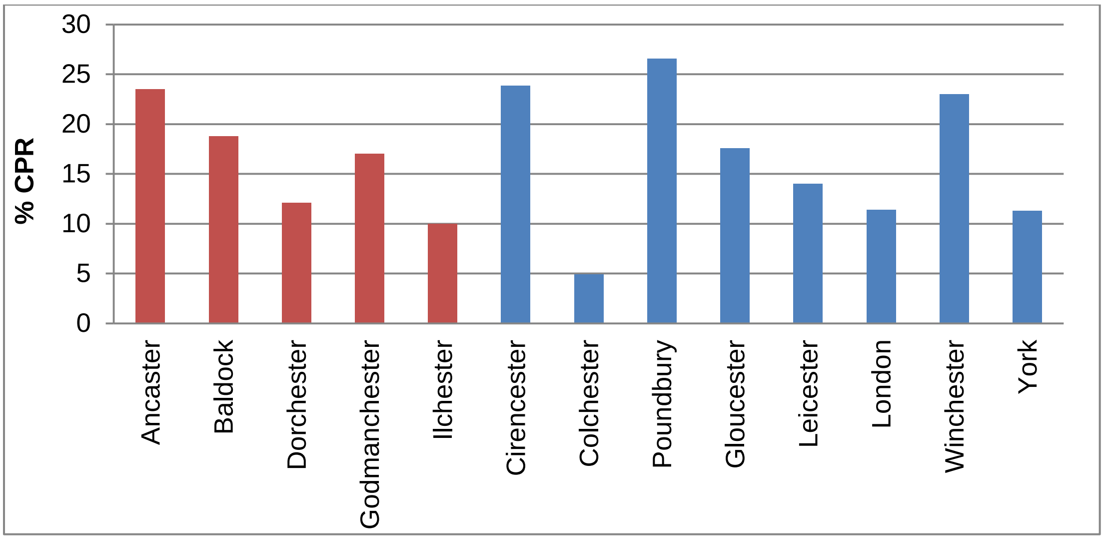


Figure 56. Graph comparing the crude prevalence of fracture trauma in Romano-British populations.

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[37] Cases of decapitation are not included.

Table 81 compares the crude prevalence of fractures between populations by skeletal region (skull, vertebrae, ribs, long bones, and hands/feet). Fractures of the skull are relatively uncommon in most populations. Excluding Ancaster, the prevalence of cranio-facial trauma is greater for populations from the public towns, with the highest CPRs reported for Leicester and Cirencester. The majority of skull fractures reported comprise blunt force depression fractures of the vault elements. Fractures of the maxillo-facial elements appear to be rare at most sites. Nasal fractures were observed in two males from Cirencester, two males from Poundbury, a female from London, and a female from York (Molleson 1993: 200, Table 147; Peck 2009: 145; Wells 1982: 163). Few cases of sharp force trauma are reported at most sites, Cirencester being a notable exception, with up to 11 individuals affected (Wells 1982: 169). Other sharp force cranial injuries are reported from York (Peck 2009: 145), Poundbury (Molleson 1993: 203), Baldock (Roberts 2007: 263) and Dorchester (Harman 1987). Fractures of the ribs are common at most sites, with Cirencester having the highest CPR (9.2%), followed by Godmanchester (8.5%). At most sites, spondylolysis is more common than are vertebral compression fractures. Fractures of the long bones comprise the majority of injuries at all sites. Less than 5% of individuals have fractures of the hand/foot elements.

Figure 57 compares long bone TPRs for small towns and public towns[38]. The pattern for all sites is similar in that the humerus and femur are the least fractured bones and, with the exception of Ancaster, the fibula is the single most commonly fractured element. The pattern of long bone trauma at other sites mirrors differences observed between Ancaster and Winchester, in that the upper limb is more affected at the small towns, while the lower limb is more affected at the public towns. In addition, the radius is more affected than the ulna at both Ancaster and the other small towns, while the opposite trend is seen at the public towns. Table 82 presents data for the prevalence of ulnar ‘parry’ fractures in Romano-British populations. No ulnar fractures are reported for the samples from Baldock, Dorchester and Ilchester sample. Only one of the five ulnar fractures observed in the Ancaster sample met the criteria for a parry fracture. Parry fractures appear to be more common at the public

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[38] TPRs for Poundbury are provided for a sample of 509 adults (Molleson 1993: Table 55), but no explanation is provided as to how this sample was selected.

towns, although it is possible that other researchers applied less stringent criteria in designating injuries as parry fractures (Judd 2008).

Table 81. Crude fracture prevalence by skeletal region in Romano-British populations. (N.B. CPRs are calculated from the total number of adult individuals present.)

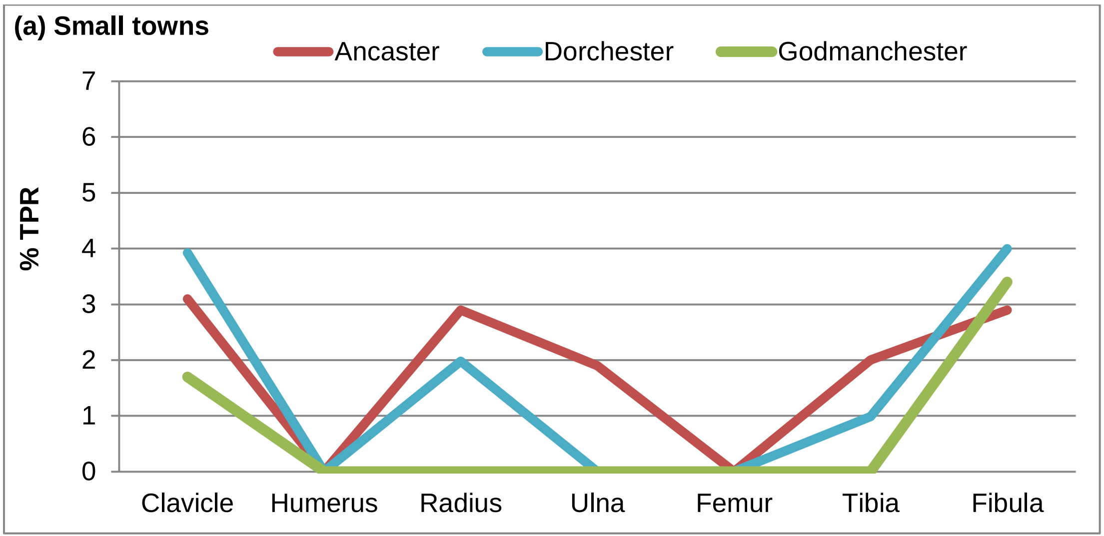
	Skull		**Vertebrae**[1]		**Ribs**		**Long bones**[2]		**Hands/Feet**	
	#	**CPR**	**#**	**CPR**	**#**	**CPR**	**#**	**CPR**	**#**	**CPR**
Ancaster (N=196)	6	3.1	C: 6 S: 2	3.1 1.0	15	7.7	25	12.8	2	1.0
Baldock (N=117)	1	0.9	C: 3 S: 2	2.6 1.7	8	6.8	8	6.8	5	4.3
Dorchester (N=107)	1	0.9	- S: 4	- 3.7	0	0.0	7	6.5	0	0.0
Godman (N=47)	0	0.0	C: 0 S: 1	0.0 2.1	4	8.5	3	6.4	0	0.0
Ilchester (N=50)	0	0.0	C: 0 S: 2	0.0 4.0	0	0.0	2	4.0	1	2.0
Cirencester (N=306)	11	3.6	C: 1 S: 8	0.3 2.6	28	9.2	31	10.1	12	3.9
Colchester (N=467)	4	0.9	C: 1 S: 1	0.2 0.2	2	0.4	22	4.7	0	0.0
Poundbury (N=706)	10	1.4	C: 4 S: 27	0.6 2.8	23	3.3	122	17.3	18	2.5
Gloucester (N=51)	1	2.0	C: 0 S: 1	0.0 2.0	2	3.9	4	7.8	2	3.9
Leicester (N=43)	2	4.7	C: 2 S: 0	4.7 0.0	1	2.3	2	4.7	1	2.3
London (N=105)	1	1.0	C: 2 S: 2	1.9 1.9	5	4.8	3	2.9	4	3.8
Winchester (N=200)	5	2.5	C: 4 S: 7	2.0 3.5	9	4.5	23	11.5	2	1.0

[1] C=compression fracture; S=spondylolysis or other fracture of the neural arch.

[2] Includes the clavicle.

Table 82. Prevalence of ulnar 'parry' fractures in Romano-British populations.

Site	**Total # Ulnar Fractures**	**# Parry Fractures**	**% Parry Fractures**
Ancaster	5	1	20.0
Baldock	0	-	-
Dorchester	0	-	-
Godmanchester	0	-	-
Ilchester	0	-	-
Cirencester	8	5	63.0
Colchester	5	3	60.0
Poundbury	9	7	77.8
Gloucester	0	-	-
Leicester	1	1	100.0
London	2	2	100.0
Winchester	4	2	50.0
York	- (No data)	-	-



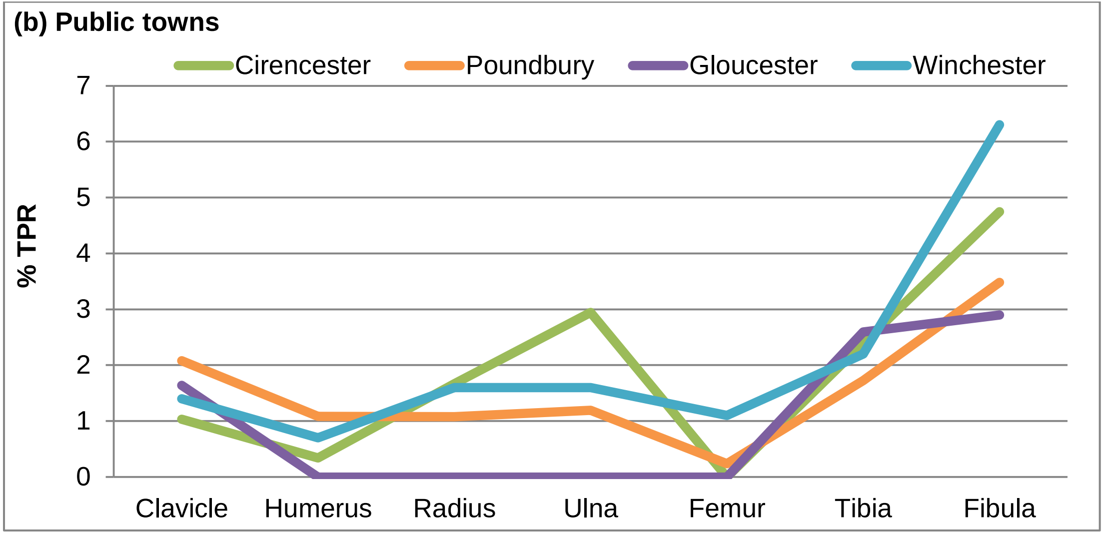


Figure 57. Graphs comparing long bone fracture prevalence rates between small towns and public towns.

6.4.2 *Discussion*

6.4.2.1 Interpersonal violence

Trauma to the skull was relatively uncommon in both samples. Only six individuals from each site (Ancaster CPR 3.1%; Winchester CPR 3.0%) exhibited cranio-facial fractures. Compared to crude prevalence rates reported for some other European populations, these figures are low (e.g. Brødholt and Holck 2012; Fibiger *et al*. 2003; Paine *et al*. 2007). The majority of skull fractures comprised healed depression ('pond') fractures of the vault elements. Injuries were typically small (*c*. 1 cm or less), and the inner table was unaffected, suggesting low energy trauma. Larger depression fractures were observed in one individual from Ancaster, ANC 273, and two from Winchester, VR 45 and HYS 17. The parietal fracture observed in VR 45 measured *c*. 31 by 26 mm (Figure 91), and in this case, the inner table was affected, indicating greater force. These healed injuries could represent intentional blows to the head with a blunt weapon of some kind, but they may also be consistent with injuries sustained during falls, when the head strikes a stationary object (Lovell 1997: 15). A bias toward the left side of the skull has been noted in cranial injuries in modern assault victims, reflecting the fact that most assailants are right handed (Brink *et al*. 1998: 706; Shepherd *et al*. 1990: 76). Similar patterning has been observed in some archaeological populations (e.g. Owens 2007). Neither study sample exhibited a predilection for trauma to the left side of the skull; in the Winchester sample, lesions were evenly distributed between right and left sides, and at Ancaster all parietal injuries occurred on the right side. This might counter against interpreting these injuries as evidence for violent assaults, although it has been noted that left-side preference is most commonly the result of formalised face-to-face combat, while less organised attacks produce a more random injury distribution (Boylston 2000: 361).

The presence of peri-mortem trauma is sometimes considered a stronger indicator of inter-personal violence. Only two cases of peri-mortem trauma were observed in the Winchester sample, and no individuals from Ancaster exhibited peri-mortem injuries. Two Winchester females, VR 66 and VR 67, had sustained blunt force traumas to the skull (Figure 91). While these injuries may be the product of violent assaults, they could equally represent serious accidents, such as falls from heights (Velmahos *et al*. 1997: 816).

Sharp-force trauma is more likely to reflect violent trauma, particularly in the case of unhealed blade wounds to the skull (Judd and Redfern 2012: 365), but no such injuries were observed in either study sample. Only one individual from Ancaster, ANC 209 (35-49, M) exhibited a healed sharp force injury to the cranium (Figure 90). This took the form of a linear blade wound, *c*. 3 cm long, located at the approximate mid-point of the right parietal, roughly parallel to the sagittal suture. The only other sharp force trauma observed was a healed blade wound at the anterior left patella of ANC 56 (Figure 104). It is tempting to interpret such injuries as examples of weapon trauma, but other scenarios could explain blade wounds, such as work-related accidents with tools.

Determining the aetiology of post-cranial fractures is complicated by the wider range of mechanisms of injury that may result in similar fractures. The distinction between transverse fractures and oblique/spiral fractures has often been emphasised in discussions of violent trauma. Some researchers consider transverse fractures (e.g. ulnar 'parry' fractures) more likely to represent intentional, direct blows (Judd and Roberts 1999: 240). Overall, only a minority of fractures in the study samples were transverse breaks (25.7% at Ancaster and 17.1% at Winchester)[39]. One individual from Ancaster (ANC 225) and two from Winchester (VR 54 and CHR 595) exhibited transverse ulna fractures that meet the criteria for 'parry' injuries. One of the affected individuals from Winchester, CHR 595 (35-49, F), also exhibited a transverse fracture of the proximal ulna shaft of the opposite arm (Figure 100 and Figure 101). Both fractures were well healed, and could thus have been sustained in the same or separate incidents. The second fracture could be an example of a Monteggia fracture, which can result from a direct blow to the forearm (Waldron 2009: 140). Two other individuals had sustained transverse breaks of the forearm bones. HYS 20 had fractured the left distal ulna and left radius mid-shaft. ANC 23 had sustained fractures of the right proximal ulna and radius shafts (Figure 100 and Figure 101). These injuries could have been the result of direct blows sustained while fending off an attack. However, the assumption that transverse breaks are more likely to reflect violent encounters should not be overstated, as both direct and indirect force can lead to such breaks (Ortner 2003: 143).

In addition to cranio-facial trauma and ulnar parry fractures, bioarchaeologists have also inferred inter-personal violence from high rates of fractures of the hands, which are commonly injured in both victims and perpetrators of assault (Brickley and Smith 2006). Only one individual from Ancaster, ANC 117, exhibited fractures of the hand bones. Three individuals from Winchester were affected (VR 48, HC 306 and RR F30; Figure 102). All four individuals were male. This may be significant as males are more likely to be victims and perpetrators of assaults, but men are also at greater risk of breaking hand bones in sports and occupationally related accidents (De Jonge *et al*. 1994; Packer and Shaheen 1993; van Onselen 2003).

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[39] It should be noted that, as fracture type was determined from visual analysis alone, well-healed fractures might have been misclassified (*cf*. Judd 2008; Jurmain *et al*. 2009).

The torso is another common target of violent assaults, and rib fractures have been used as indicators of inter-personal violence (Hershkovitz *et al*. 1996). The location of rib fractures (sternal *vs.* vertebral end) may be suggestive regarding causation. Fractures located near the vertebral extremity of the rib usually occur due to a force from the posterior, while fractures of the sternal ribs ends or angle are usually the result of force applied to the anterior body. Sternal rib fractures, when present in conjunction with a fracture of the sternum itself, can indicate high velocity direct trauma to the anterior chest (Lovell 1997: 159). Sternal rib fractures were slightly more prevalent in the Ancaster sample, but the difference between the sites was not statistically significant. One individual from Ancaster (ANC 5) exhibited a fracture of the sternum in addition to sternal rib fractures, which is suggestive of force having been applied to the anterior of the chest (Hamblen and Simpson 2007: 119). However, most fractures occurred at the vertebral/posterior portions of the ribs, and could represent falls. Additionally, the ribs are susceptible to stress fractures in individuals with persistent coughs, particularly older individuals with low bone mineral density (Brickley 2006: 70).

The co-occurrence of cranio-facial trauma, isolated ulnar fractures and/or rib fractures at different stages of healing has been considered suggestive of violent trauma (Judd 2002a). In the present study, none of the individuals in either sample with ‘parry’ fractures of the ulna exhibited fractures of the ribs or cranium, although it is arguable that ‘parry’ fractures resulting from an assault would not be expected to occur in conjunction with cranio-facial trauma, as the act of fending a blow is intended to protect the head and face. Two individuals (both from Winchester) had sustained fractures of the cranium and ribs. VR 45 exhibited a depression fracture of the right parietal and fractures of two unsided rib shaft fragments. A second individual, VR 73, had fractures of four right ribs (vertebral ends), two rib shaft fragments, and a depression fracture of the left parietal. These injuries could have been contemporaneous, but, as the interval between the time at which a fracture was sustained and death cannot be determined, it is equally possible that the fractures were sustained at different times.

Although no individuals had sustained fractures of the skull and forearm, a minority of individuals in both samples exhibited multiple traumas. Excluding individuals with multiple fractures of the ribs and fractures obviously sustained in the same incident (e.g. spiral tibia/fibula fractures), 11 individuals from Ancaster and 14 individuals from Winchester had multiple traumas. There is only one definite case of injury recidivism (VR 67, described above). A probable male of undetermined age from Winchester (CFX 351) had a well-healed fracture of the humerus, although the type of break could not be determined (Figure 98), and a compression fracture of a thoracic vertebra most likely sustained in later life. ANC 98 exhibited a healed compression fracture of the L1 and a fracture of a sternal rib end that was possibly still in the process of healing, although the fragment was incomplete. The remaining cases could represent injury recidivism, but this cannot be determined with any certainty, as all fractures were well healed. The majority of individuals with multiple fractures were mature or elderly. ANC 241 (≥50, F) exhibited compression fractures of the T12, L3, fractures of the vertebral ribs and a Colles' fracture of the radius. AR 312 (≥50, M) had a compression fracture of the T9 and Colles' fracture of the radius. In both these cases, the fractures could indicate osteoporosis. VR 26B (35-49, M) had fractures of the scapular body and a rib fragment, both probably sustained due to a direct blow to, or fall onto, the back. A number of other individuals exhibited combinations of injuries that might be expected to result from a fall forwards, e.g. clavicle and rib fractures in ANC 57, 230A and 244. An elderly male from Ancaster (204A) with fractures of the parietal, clavicle and fibula, and another elderly male from Winchester (VR 73) with fractures of the parietal, ribs and compression of the T9, are perhaps the most likely candidates for injury recidivism considering the diverse location of injuries.

The number of individuals with possible evidence for violent trauma is relatively small for both populations as a proportion of the total number of cases of trauma observed. More potential evidence for interpersonal aggression was observed in the Winchester sample in terms of cranial trauma, peri-mortem fractures and possible ulnar parry fractures. From the data collated for other populations, evidence for interpersonal violence was also generally less common relative to accidental trauma at the majority of sites, but cranio-facial injuries and ulnar parry fractures are generally more prevalent among the populations from the public towns.

Individual cases of violence-related trauma may represent isolated instances of aggression but, at the population level, skeletal evidence for inter-personal violence is potentially a barometer of general levels of social and political stress (Roberts 2000b: 338). A number of sociological theories have posited greater levels of social stress in urban communities, arising from the strains of living in larger, denser communities, poor social cohesion, marked disparities in socio-economic status and cultural heterogeneity (Fischer 1984: 24-32; Pollard 1999: 232). The evidence for somewhat greater levels of violent trauma at the public towns could be interpreted with reference to the increased stresses of life at larger urban centres. However, applying such theories to ancient urbanism may be inappropriate since they were developed with reference to the post-industrial towns and cities of nineteenth and early twentieth century.

Several other factors must be considered in interpreting the evidence for inter-personal violence in late Roman Britain. Although there is relatively little direct archaeological evidence for widespread military activity in the civilian zone of Britain in the late third and fourth century, there were intermittent periods of political instability (Casey 1994), and increasing threats from hostile tribes beyond the borders (Mattingly 2006: 231-2, 235). The construction of new fortifications at many of the small towns, modifications to existing defensive circuits at other sites (including the addition of bastions to the defences of Winchester in the fourth century; Biddle 1983: 112-3), and the construction of the Saxon Shore forts have sometimes been interpreted as a response to the barbarian threat (Casey 1983). The evidence for abandonment of extra-mural areas at many sites (including Ancaster) could reflect a concern with defence. However, the extent to which the barbarian incursions of the later fourth century, and the revolts of Carausius and Allectus, Magnentius and Magnus Maximus, and any associated violence, actually impacted directly on the civilian populace is difficult to determine.

One issue that is problematic in interpreting the evidence for inter-personal violence is our inability to determine what proportion of males interred in Romano-British cemeteries were soldiers, or had served in the army. Such individuals might be expected to exhibit more evidence of fracture trauma, reflecting injuries sustained during combat or training. Additionally, soldiers were often employed in construction work, which may have exposed them to accidental injuries due to falls (Huang and Hinze 2003). It might be assumed that retired veterans would have chosen to settle at the larger towns, especially those with an historical link to the military such as Colchester, Gloucester and Lincoln, although they might equally have decided to remain at the civilian settlements attached to military bases (Birley 1980: 97). With the exception of York, there is little definitive evidence for a significant military presence at most late Roman towns (Esmonde Cleary 1989: 54; see also section 2.2.1.5.3), although it has been suggested that most towns might have possessed a local militia (Johnson 1980: 31). Troops attached to the governor's retinue were stationed in the Cripplegate fort in London (Casey 1994: 32; Mattingly 2006: 265), and it is possible that the other late Roman provincial capitals also housed similar units. Wells (1982: 168) suggested that some of the cranio-facial fractures observed in the Cirencester population might represent injuries sustained by soldiers or gladiators, or during 'pub brawls', although if the latter explanation were accepted, it would not explain the large number of injuries at Cirencester compared to other sites. A high rate of cranial trauma has been documented among postulated male gladiator burials from Ephesus, Turkey (Kanz and Grossschmidt 2006), and comparisons with the injuries observed at Cirencester would be of interest. The possibility that the Cirencester sample includes a relatively greater number of soldiers has previously been suggested by other researchers (Pitts and Griffin 2012: 266), and would provide an explanation for the high rate of cranial trauma. Although the CPR for cranial trauma at York is unknown, injuries to the skull reportedly comprised almost a fifth of all fractures (Peck 2009: 145). It may also be significant that the nasal bones were among the most commonly fractured elements in the sample from Lankhills (Clough and Boyle 2010: 364), given the postulated military connection of some grave goods at this site.

In summary, there is some evidence for a greater level of inter-personal violence at the public towns. Whether this reflects greater social stress, the presence of military units, or a combination of factors, is difficult to determine. In addition, it should be borne in mind that many violent assaults result in soft tissue lacerations and bruising only (Shepherd *et al*. 1987), thus skeletal trauma can only ever provide a minimum estimate of levels of inter-personal aggression.

6.4.2.2 Trauma as an indicator of lifestyle and settlement environment

The majority of fractures in most skeletal samples will reflect accidental trauma due to trips and falls, and thus provide insights into aspects of lifestyle and activity patterns (Roberts 2000b: 338). Globally, falls are the second most common cause of accidental death and account for many more injuries (WHO 2012). Depending on an individual's age and sex, and factors such as the height from which a fall occurs, fractures sustained during falls may have several characteristic mechanisms of injury. In a fall from a standing position, the instinctive response to extend the arms to break the fall often results in fractures of the forearm and clavicle. Such injuries (especially radius fractures) are particularly common in the elderly (Hsiao and Robinovitch 1997; Palvanen *et al*. 2000). Many of the fractures observed in both study samples could have been the result of falls from standing height. The single most common type of forearm fracture in both samples were Colles' fractures (transverse fractures the distal radius shaft with dorsal displacement of the distal segment; Figure 99), indicating falls onto the wrist with the arm in pronation (Hamblen and Simpson 2007: 177). Of the eight radius fractures observed in the Ancaster sample, five (62.5%) were Colles' injuries, and three of four (75.0%) radius fractures in the Winchester sample were of this type (Table 42). In two Ancaster individuals (ANC 53 and ANC 191, both elderly females) Colles' fractures occurred in conjunction with un-united (abruption) fractures of the ulnar styloid process (Hamblen and Simpson 2007: 179). The fractures of the clavicle observed in eight individuals from Ancaster and two individuals from Winchester may be the result of falls from a standing position in which the individual landed on their arm or shoulder (Figure 97). Higher energy impacts, e.g. falls from heights, can result in injuries such as vertebral fractures, multiple rib fractures, femoral fractures and multiple traumas (Helling *et al*. 1999; Ragg 2000; Velmahos *et al*. 1997). Many of the rib fractures observed could have been sustained during falls from ladders, stairs and carts, or from horseback. Scapular fractures in ANC 45 and VR 26B (Figure 96) are suggestive of higher energy trauma, perhaps a fall in which the individual landed on their back, although they could also be due to direct blows to the back of the shoulder. Most of the vertebral compression fractures observed occurred in mature or elderly individuals, and are suggestive of underlying osteoporosis (see below, section 6.5.4.2). ANC 58 exhibited a clavicle fracture, compression fracture of a lumbar vertebra, and burst fracture of a thoracic vertebra (Figure 92), the last of which is suggestive of sudden compressive loading of the spine (Lovell 1997: 141) and may indicate a fall in which the individual landed on their feet or buttocks.

Similar percentages of individuals from both sites had sustained fractures of one or more long bone (Ancaster: 25/195 individuals, CPR 12.8%; Winchester: 23/200 individuals, CPR 11.5%). In both samples, and other Romano-British populations, the most fractured long bone was the fibula (Figure 57). However, the relative prevalence of upper *vs.* lower long bone trauma differed. Overall, the upper limb was more affected at Ancaster, while the Winchester population exhibited a greater proclivity for lower limb trauma. Comparison with other Romano-British populations revealed similarities in the pattern of long bone trauma at Ancaster and other small towns, while the majority of populations from other public towns exhibited a pattern similar to Winchester. A number of studies have found fractures of the upper limb to be more prevalent relative to leg fractures in agricultural communities, reflecting the increased risk of falls while traversing uneven ground (e.g. furrowed fields) and from incidents with livestock. In a medieval skeletal sample from the rural settlement of Raunds, Northants, the true prevalence of fractures of the upper limb bones combined was 4.1%, compared to 2.5% for the lower limb elements (Judd and Roberts 1999). The most affected elements at Raunds were the clavicle and fibula – the same pattern seen at Ancaster, Dorchester and Godmanchester. This pattern was also observed in the Romano-British population from Kempston, one of the few rural samples for which fracture TPRs are available (Boylston and Roberts 2004: 341). Peck (2009: 145) found the upper limb to be more affected in Iron Age populations from Yorkshire when compared to the Roman population from York. Similar findings were reported for rural medieval populations from Serbia (Djurić *et al.* 2006), and early medieval England and Germany (Jakob 2004). Modern clinical data also point to higher rates of upper limb trauma in modern rural populations (e.g. Saw *et al.* 2010). The patterning of fractures observed at Ancaster and other small towns thus appears to resemble that seen in early agricultural settings, providing further support for this community having engaged largely in agricultural activities.

Fractures of the clavicle in particular were more prevalent among the Ancaster sample, and all affected individuals were male. All injuries occurred at the mid or lateral shaft (Figure 97), and the left bone was more affected than the right. In modern populations, vehicular accidents are a common cause of clavicular fractures (Postacchini *et al*. 2002; Nordqvist and Petersson 1995), although falls also account for a significant proportion of breaks. A study of clavicle fractures in a modern Swedish population found that 85% of injuries were the result of a direct fall onto the shoulder, 13% were due to a direct blow, and 2% occurred in falls onto an outstretched arm (Nowak *et al*. 2000: 355). The high TPR for the clavicle among Ancaster males therefore suggests that they were engaging in activities more likely to result in falls onto the shoulder compared to both Ancaster females and individuals from Winchester. This could include falls in which the individual fell sideways rather than forwards, falls while carrying objects thus preventing the arm being extended to break the fall, or falls from heights, e.g. from a cart or ladder. Additionally, Ancaster males may have been at greater risk of direct blows to the pectoral girdle, perhaps caused by kicks from animals. This could provide further evidence for the more agrarian life-way of the Ancaster community, as clinical data indicate that such mechanisms of injury are common in agricultural workers, particularly dairy farmers (Busch *et al*. 1986). Such incidents could also account for the higher prevalence of rib fractures at Ancaster, and the sternum fractures observed in two Ancaster males.

Oblique and spiral fractures of the tibia and fibula were somewhat more common in the Winchester sample (Figure 106). Oblique fractures can occur due to falls in which the individual lands on the feet. Spiral fractures are usually caused by rotation of the leg while the foot is planted in position (Lovell 1997: 163). In modern populations, spiral fractures in particular commonly occur as sports injuries (Court-Brown and McBirnie 1995). Molleson (1993: 199) suggested that similar fractures observed in the Poundbury population could have been sustained in falls from horses in which the rider’s foot was caught in a stirrup, or falls from scaffolding during building works.

In addition to lifestyle and occupational risk factors, the living environment may also increase the risk of trips and falls. Several researchers have identified high prevalence rates of long bone trauma in skeletal populations living in regions of difficult terrain (Alvrus 1999; Kilgore *et al*. 1997; Lessa 2011a). Neither the Ancaster nor Winchester regions could be considered 'rough terrain', and the similarity in the crude prevalence of long bone fractures suggests there was little difference in the overall risk of injury. Nevertheless, differing factors may have contributed to falls. Three femoral fractures were observed in the Winchester sample, while no individuals from Ancaster had fractures of this element (Figure 103)[40]. The presence of these fractures in the Winchester sample, while not a large number, is notable given the general rarity with which the femur is fractured relative to the other long bones (excluding osteoporotic femoral fractures in the elderly). VR 30 (18-24, F) exhibited a well-healed fracture of the proximal left femur. An unsexed elderly adult, VR 58B, had sustained an oblique fracture of the distal left shaft that had resulted in marked anterior angulation of the distal segment at *c*. 30-40°. A mature female, CHR 580, had a fracture of the distal left femur shaft, although the precise nature of the injury could not be assessed as the bone was incomplete (Figure 103). Significant force is usually required to fracture the femoral shaft (Lovell 1997: 162). In clinical settings, such injuries are often the result of high-energy collisions, and are most common in young adult males (Hedlund and Lindgren 1986; Loder *et al*. 2006; Singer *et al*. 1998; Taylor *et al*. 1994). Femoral shaft fractures can also occur due to low-energy trauma, e.g. a fall, especially if the bone is already weakened by existing pathology such as osteomalacia or neoplastic disease (Papakostidis and Giannoudis 2012). It is possible that the femoral fractures observed in VR 30, VR 58B and CHR 580 developed due to some underlying pathology, although there was no macroscopic evidence for this in any of the affected individuals. These injuries could represent serious accidents precipitated by a busier urban environment, such as collisions with carts or falls from heights.

Some bioarchaeological studies have observed an increase in the prevalence of fractures with age, reflecting the cumulative risk of trauma over the life-course and age-related increase in fragility fractures (e.g. Jakob 2004; Lovejoy and Heiple 1981). In the Ancaster sample, the fracture CPR increased steadily from young to elderly adulthood. In contrast, the prevalence rate for the Winchester sample

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[40] Roberts (1988) identified a male with a subtrochanteric femoral fracture from Chester Road (CHR 552), but this individual was not included in the present study sample.

remained the same between young and prime adulthood, increased in mature adulthood and declined in elderly adulthood. When age-related CPRs were examined by sex, elderly Ancaster females were notably more affected than Winchester counterparts. It is possible that poorer preservation of elderly females at Winchester could account for the variation in the age-related fracture prevalence in women, although there was no significant difference in skeletal completeness between elderly females from the two sites. In both samples, the numbers of elderly females were relatively small (15 from Ancaster and 12 from Winchester), and the difference could be a product of sample size. If the difference in CPRs for elderly females is not due to sample bias, it could suggest that Ancaster females had a higher risk of sustaining injuries in later life. This could be interpreted in terms of a more agrarian lifestyle, with women at Ancaster undertaking more physically strenuous activities in later life, thus increasing their risk of injury.

High prevalences of spondylolysis have been widely used by bioarchaeologists as an indicator of activity levels (Arriaza 1997; Lessa 2011b; Merbs 1983, 1996a, 2002b). In the present study, only two cases of spondylolysis were observed in the Ancaster sample, giving an overall CPR of 1.5% (0.8% for the L4 and L5 each), but seven cases were observed at Winchester (Figure 93), giving an overall CPR of 6.4% (7.5% for the L5). Reported prevalence rates typically range from *c.* 3-7% (T. Waldron 1991a), thus the prevalence for Ancaster is low, while that for Winchester is relatively high, although it should be noted that methods of calculation have been shown to exert a significant influence on prevalences (Fibiger and Knüsel 2005). Spondylolysis is generally considered a type of stress fracture that develops due to excessive hyperflexion and extension of the spine (Merbs 1996b, 2002b; Mays 2007b; Standaert and Herring 2000). The higher prevalence of spondylolysis at Winchester would conventionally be interpreted as evidence for a more physically strenuous lifestyle. However, the exact aetiology of spondylolysis is disputed, and various intrinsic genetic and/or anatomical factors may predispose individuals to developing such fractures (Mays 2006c; Pilloud and Canzonieri 2012; Ward *et al*. 2010; Weiss 2009).

No subadults in either sample had sustained fractures, healed or unhealed, although a small number of adults exhibited injuries that probably occurred in childhood or adolescence. Trauma in subadults is observed infrequently in skeletal samples (Judd and Redfern 2012: 369). Few other researchers have reported fracture trauma in subadults from Romano-British sites, exceptions being an example of fracture trauma in an adolescent from Colchester (Pinter-Bellows 1993: 76), an adolescent from Poundbury (Molleson 1993: Table 47), two adolescents from Dorchester (Harman 1987) and one subadult from York (Peck 2009: 145). Additionally, Lewis (2010) identified several further individuals from Poundbury with rib fractures that were possibly linked to rickets. Since the number of cases reported is small, it is not possible to assess the levels of risk to which children and adolescents were exposed in Romano-British towns, and if this varied between the small and public towns. One possible reason why trauma is so rarely reported in subadults is that fractures often take the form of incomplete breaks that heal relatively quickly (Lewis 2007: 163, 167). Subadults in the study samples could have sustained breaks in earlier childhood that were fully remodelled at the time of death. Radiography might have helped identify such injuries, but even this will not necessarily reveal very well healed fractures (Mays 2008: 86-7). The crania and ribs of subadults from both samples were often extremely fragmentary, and trauma to these elements might not have been apparent. Peri-mortem fractures in particular can be difficult to detect in poorly preserved subadult remains (Roberts 2000: 346).

6.5 Metabolic disease

6.5.1 *Scurvy*

Two subadults from Winchester, VR 9 and VR 15, exhibited signs of scurvy (Figure 113 and Figure 114). No Ancaster subadults were affected. Brickley and Ives (2008: 73) identified only three cases of scurvy in Romano-British populations, but additional cases have since been published. Figure 58 illustrates the prevalence of (subadult) scurvy at Romano-British sites. As reported cases are relatively rare, all cases are included. This includes one case from the Eastern Cemetery of London (Conheeney 2000: 286) and five possible cases from the Lankhills cemetery of Winchester (Clough and Boyle 2010: 392). If the five cases from Lankhills are combined with the two cases identified in the Winchester study sample, the overall CPR for Winchester is 3.5%. The total number of cases of scurvy identified is 21, giving a prevalence of 2.6% for the public towns (see Appendix 6, Table 118 for data). To date, no cases from small towns have been published. No statistical comparisons can be made. An important point to consider is the possibility that scurvy has been under-diagnosed in many populations, as skeletal manifestations can be subtle and sometimes ambiguous. Under-diagnosis is particularly problematic in relation to older skeletal collections, as diagnostic criteria were poorly defined until recently (Melikian and Waldron 2003; Ortner and Ericksen 1997; Ortner *et al*. 1999).

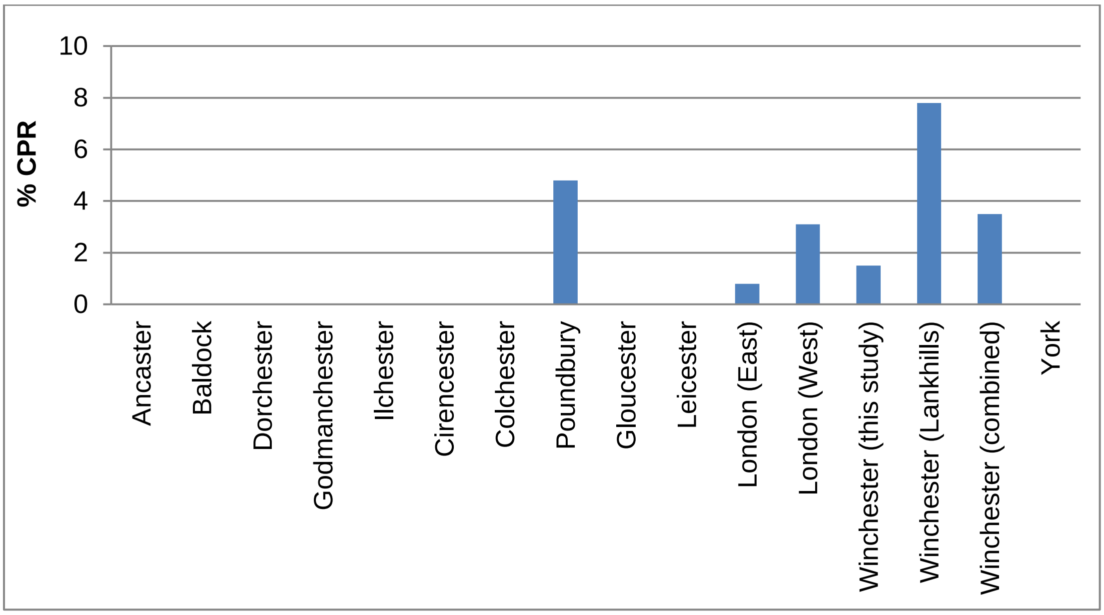

Figure 58. Graph comparing the crude prevalence of subadult scurvy in Romano-British populations.

6.5.2 *Rickets and osteomalacia*

No adults in either sample exhibited evidence for healed childhood rickets or osteomalacia. Only one subadult from Ancaster, ANC 208, exhibited probable signs of rickets (Figure 115). Twenty-one cases of subadult rickets are reported in the literature for Romano-British populations (Figure 59; see Appendix 6, Table 119 for data). This includes cases from the Southern Cemetery of London (MoL South) and the Lankhills cemetery of Winchester (Clough and Boyle 2010: 389-90). Healed rickets was observed in adults from Poundbury (Molleson 1993: 184) and Lankhills (Clough and Boyle 2010: 389-90). Possible osteomalacia was reported at Poundbury (Molleson 1993: 184), but no other urban sites (Table 120). The total number of cases of subadult rickets reported for the public towns is 18 (CPR 2.6%) and for the small towns it is 3 (CPR 1.7%). The numbers of individuals affected are too small for statistical comparison. Once again, the subtle nature of skeletal changes associated with rickets in subadults (excluding bowing of the long bones) and recent advances in diagnosis (Brickley *et al*. 2005, 2007; Mays *et al*. 2006) means that other cases of vitamin D deficiency may have been missed or misdiagnosed, as Lewis (2010: 411) noted that the friable appearance of poorly mineralised bone in subadults with rickets can be mistaken for poor preservation.

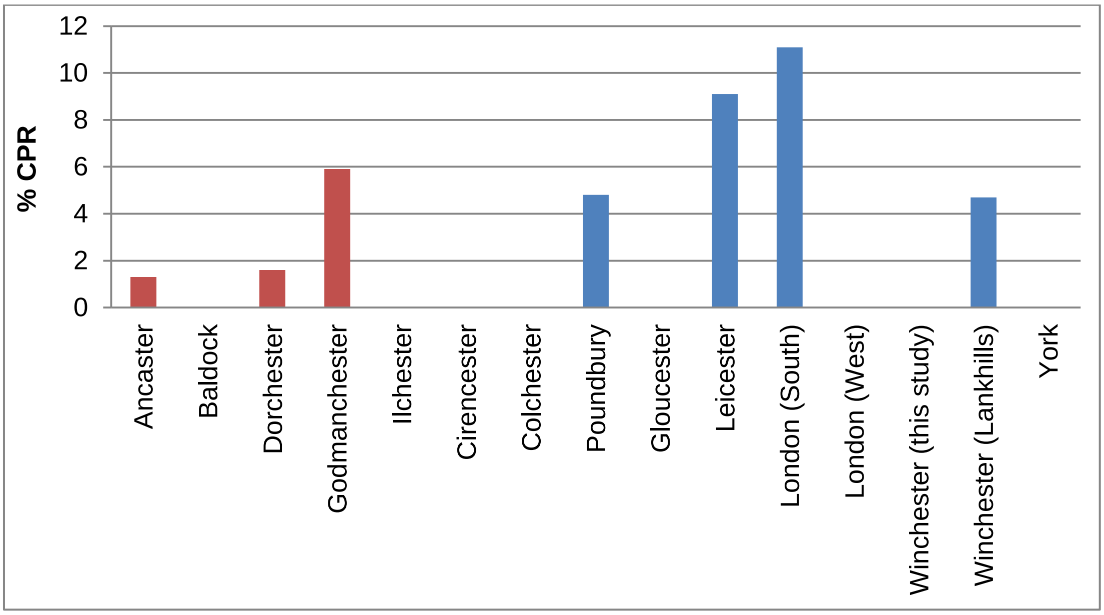

Figure 59. Graph comparing the crude prevalence of subadult rickets in Romano-British populations.

6.5.3 *Osteoporosis*

One definite case of osteoporosis was observed in a female from Ancaster (Figure 116). Other possible cases were identified in five individuals from Ancaster and two individuals from Winchester, based on the presence of vertebral compression and/or radial Colles' fractures in elderly individuals. The lack of evidence for osteoporosis in Winchester females is notable. No vertebral or Colles' fractures were observed in women in this sample, while four of the five radial fractures at Ancaster occurred in females, and two females from this site exhibited compression fractures of one or more vertebrae. Mays (2006a) recorded a healed fracture of the femoral neck in an elderly Ancaster female who was not included in the present study.

Differences in the criteria used to diagnose osteoporosis mean it is impossible to compare reliably prevalence rates between populations (Appendix 6, Table 121 for data). Molleson (1993) identified as many as 36 individuals (4.5% of adults) with osteoporosis among the Poundbury sample, although many individuals were diagnosed because they had ‘light’ bones, rather than from the presence of classic osteoporotic fractures. The only other cases of osteoporosis reported are in a female and a male from Baldock, and a male from Dorchester. Due to the problems in diagnosis, no statistical comparisons between settlements have been carried out.

6.5.4 *Discussion*

6.5.4.1 Vitamin deficiency diseases

The skeletal evidence for scurvy and rickets/osteomalacia in Roman Britain is limited, and the possibility that both conditions have been under-diagnosed in many Romano-British samples has already been discussed. In the case of scurvy, the tendency for infants to be under-represented in many Romano-British populations may also have contributed to the low reported prevalence rates, since infants aged 6-18 months are the most at-risk age group (Brickley and Ives 2006: 163; Kozlowski and Witas 2012). Indeed, most of the cases identified in Romano-British populations occurred in subadults of this age range – both affected individuals from Winchester were aged *c.* 6 months to 1 year; the majority of affected individuals at Poundbury were aged less than 2.5 years.

A number of scholars have proposed that chronic malnutrition was endemic in the ancient world because of the reliance on cereals to provide the majority of calories (Garnsey 1998, 1999; Laes 2011: 42-3). Garnsey (1998: 232) in particular has questioned the presumed healthfulness of the ‘Mediterranean diet’, noting references in ancient medical texts to illnesses that can probably be identified as scurvy and rickets, and other conditions resulting from malnutrition. However, determining the extent to which poor diet was responsible for deficiency diseases, as opposed to factors such as unsanitary living conditions leading to infections and gastrointestinal problems, which may cause and/or exacerbate nutritional deficiencies (*cf*. Scrimshaw and SanGiovanni 1997), is problematic.

In the case of scurvy, it could be argued that the Romano-British diet is unlikely to have been deficient in vitamin C, despite the predominance of grains. Many indigenous plants, including various berries and leafy green vegetables, are good sources of vitamin C (Geissler and Powers 2011). Furthermore, a number of new plant species with high vitamin C content, such as cherries, were introduced to Britain in the Roman period (Pliny the Elder, *Natural History* 15.102). The identification of kitchen gardens at many towns suggests that some fruits and vegetables were produced at the household level (e.g. Perring 2002: 179). Providing some of these foods were consumed raw (as cooking destroys vitamin C; Geissler and Powers 2011), most people may have had adequate vitamin C levels. Nevertheless, Pliny the Elder (*Natural History* 25.6.20-1) described probable scurvy among Roman troops encamped over the winter in Germany, and noted the use of a plant referred to as *radix Britannica* (believed to be a type of dock or sorrel) as treatment. Although there is some debate regarding the accuracy of this ascription (Dixon and Southern 1997: 101; Fitzpatrick 1991), it may suggest that the condition was well known in the Northwest provinces. The situation described by Pliny was an extreme one, but Maat (2004) has argued that North European populations in earlier periods would frequently have experienced short-term deficiencies of vitamin C in the winter months, when fruits and vegetables are less readily available. The recommended daily intake of vitamin C is *c.* 45 mg/day, although an intake of *c.* 10 mg/day is sufficient to prevent clinical symptoms from developing (WHO 2004: 133). Like Maat (2004), Brickley and Ives (2008): 53-4) propose that many people in the past probably experienced temporary seasonal shortages, but suggest that the condition may have been subclinical (i.e. without apparent symptoms) in many individuals.

The general absence of scurvy in Romano-British adults could indicate that any short-term deficiencies in vitamin C were not significant enough to produce scorbutic lesions in the skeleton, although the fact that lesions can remodel over time should be borne in mind when assessing the prevalence of scurvy in skeletal samples. Additionally, ante-mortem tooth loss in adults with scurvy caused by recession of the gingiva and loosening of the periodontal ligament is not easily distinguished from tooth loss linked to age and/or the presence of other dental pathology (caries, abscesses and attrition). The fact that the majority of Romano-British cases occur in infants and children could suggest that younger individuals were more susceptible to shortages of fresh fruits and vegetables. However, Brickley and Ives (2008: 54-5) also note that many subadults with symptoms of scurvy probably died of acute infections; had they lived, the lesions may have remodelled over time.

The absence of reported cases of scurvy at the small towns could be a factor of the generally smaller sample sizes of populations from this category of site, rather than indicating the absence of the condition. Additionally, with the exception of the 17 subadults from Godmanchester recently examined by Brickley (2003), the other small town skeletal samples included for comparison in the present study were all examined prior to the publications of Ortner and others in the 1990s and 2000s. On the other hand, no definitive evidence for scurvy was identified in the relatively large sample of subadults from Ancaster, despite careful examination. If the higher prevalence of scurvy at the public towns is evidence that the condition was genuinely more common in these populations, it could point to restricted access to fresh produce. In contrast to the public towns, the more agrarian orientation of economic activity at the small towns may have ensured greater access to fresh foods produced locally. However, on the other hand, it is arguable that the greater pull of the major towns as markets would, have ensured that their inhabitants had access to a wide range of plant foods, and this is supported by environmental evidence. For example, at various sites including Winchester, Silchester, London, Colchester and York, the remains of many different fruits and vegetables such as pears, apples, peaches, berries, figs, grapes and celery, have been recovered (Dobney *et al*. 1999; Robinson 2012: 221-2; Wilcox 1977). As noted above, some of these were probably grown locally, while others would have been imported from surrounding areas or further afield.

Other factors could also account for higher rates of scurvy at the public towns. Lewis (2010: 413) suggested that the adoption of Romanised infant feeding practices and weaning foods recommended by Roman medical writers could explain the relatively high rates of metabolic disease at Poundbury. Soranus erroneously believed that infants should not be breast-fed in the first three weeks of life, and advised the use of goat’s milk instead (Fildes 1986: 34). Although Soranus stated that infants should subsequently be exclusively breast-fed for *c.* 6 months, he noted that this was not always possible. The continued use of goat's milk as supplementary to or as a substitute for breast milk, and the introduction of other vitamin C-deficient foods during weaning, which largely comprised bread or other flour-based foods, (Fildes 1986: 27, 34), could have contributed to the development of scurvy. It has been pointed out that Soranus provided recommendations for infant feeding and weaning, rather than descriptions of actual practices (Prowse *et al*. 2008: 297), and other Roman medical writers provided different advice (Fildes 1986: 27). Nevertheless, it is possible that members of the upper classes and migrants from other regions of the Empire were more likely to follow such practices, and this could account for the presence of scurvy at the more cosmopolitan large urban centres. It has also been noted that exclusive breastfeeding of infants is often abandoned at an earlier age in migrant communities (Lewis 2007: 100), and the presence of scurvy at the public towns could reflect earlier weaning of infants among migrant families. The identification of five possible cases of scurvy in the Lankhills sample may be significant in this light, given stable isotope evidence for a significant minority of non-local individuals in this area of Winchester's cemeteries (Evans *et al*. 2006).

The relatively small number of cases of rickets reported from Roman Britain could indicate that most people were not substantially deficient in vitamin D. Once again the fact that lesions can remodel over time may mean that reported prevalences under-estimate the true frequency of the condition, and the difficulties in diagnosing rickets in infants have also probably led to under-diagnosis. Garnsey (1998: 232) notes that there are relatively few ancient references to symptoms of rickets in Roman medical texts, which may further suggest the condition was not particularly widespread. However, as in the case of scurvy, infants aged between three and eighteen months are one of the most at-risk age groups (Brickley and Ives 2008: 91-2), and cases of rickets in children not old enough to crawl/walk may not have been recognised in the absence of bowing deformities arising from weight-bearing.

In recent historical periods, rickets has generally been linked to inadequate UVB exposure, exacerbated by industrial pollution and poor working conditions (Holick 2006). Although the construction of tenement buildings at Rome itself and other sites such as Ostia may have created darker living environments for some people (Ward-Perkins 1994: 192), light levels in Mediterranean regions were presumably sufficiently high to prevent vitamin D deficiency in most people. Nevertheless, rickets can occur in regions with high UVB levels. Littleton (1998) observed rickets in skeletal material from Jordan, and proposed that cultural practices such as veiling could explain its occurrence. In contemporary populations, women and young children from cultures that practise purdah are at increased risk of vitamin D deficiency (Pettifor 2005: 1006). It is unlikely that most middle and lower status Roman women regularly wore full veils or head coverings (Olson 2008: 35), though Iconographic evidence from Roman Britain indicates that both sexes typically wore long sleeved garments, and sometimes scarves and/or capes with hoods (Allason-Jones 2005: 104-6). Given Britain's latitude, this may not have exposed sufficient skin to ensure vitamin D levels were maintained, particularly in the winter (Rhodes *et al.* 2010), although studies suggest that exposing the face and neck and/or lower arms for five to fifteen minutes per day between Spring and Autumn is adequate to prevent deficiency (Brickley and Ives 2008: 77). The duration of UVB exposure required to maintain vitamin D levels varies between individuals according to factors such as age, health status, activity-levels, and skin pigmentation. In relation to the last variable, the possibility that migrants from more southerly regions of the Empire, and potentially their descendants (e.g. Leach *et al.* 2010), were at risk of vitamin D deficiency should be considered.

As in the case of scurvy, the slightly higher prevalence of vitamin D deficiency at the public towns may be a result of the generally larger samples, and the recent (re-)examination of material from several sites (i.e. Poundbury, Winchester). However, if the larger number of cases of rickets reported at the public towns is not simply due to sample size, or under-diagnosis in populations from small towns, it could be explained by one or more factors. Lower rates of rickets at the small towns could be interpreted in terms of a more agrarian lifestyle, with people spending more time outside. Although dietary factors are usually less significant in the development of rickets/osteomalacia, food sources are important for maintaining vitamin D levels in the winter months in higher latitudes. Good sources of vitamin D include eggs, dairy and, in particular, oily fish (Brickley and Ives 2008: 83). The archaeological, faunal and isotopic evidence for diet in Roman Britain would seem to suggest that the populations of the public towns probably consumed more vitamin D-rich foods compared to other communities. For example, stable isotope analysis of individuals from Poundbury indicated greater consumption of marine foods among individuals from higher status mausoleum burials (Richards *et al*. 1998). The results of stable isotope analysis of individuals from Gloucester and surrounding rural settlements also suggest that the population of the *colonia* consumed more marine and/or freshwater foods (Cheung *et al*. 2012). Remains of domestic fowl occur in significantly greater quantities at public towns, which might indicate that these communities consumed eggs regularly. However, it is possible that consumption of such foods was restricted to the upper classes (*cf*. Richards *et al*. 1998).

Deficiencies in dietary constituents other than vitamin D can lead to rickets, most notably calcium, the main sources of which are dairy products (Aggarwal *et al*. 2012). Cool (2006: 93) has argued against significant dairy consumption in Roman Britain more generally, although this view is not shared by some other researchers (Dobney 2001: 37). The populations of smaller, more agrarian communities may have had better access to dairy products. However, whether there was any difference in access to dairy products between public and small towns is extremely difficult to determine archaeologically, as direct evidence for dairy consumption is limited (Cool 2006: 93).

6.5.4.2 Osteoporosis

Osteoporosis is a significant and growing burden on health services in Western countries due, in part, to increases in life expectancy (Atik *et al*. 2006). Other factors have also contributed to rising rates of osteoporosis, such as tobacco and caffeine consumption (Lane 2006). Despite the influence of modern lifestyle factors on osteoporosis, several bioarchaeological studies have identified similar age-related decline in bone mineral density in past populations, particularly in females (Mays 1996, 2000; Mays *et al*. 2006; Zaki *et al*. 2009). Mays (2006a) measured cortical bone thickness in a sample of 39 females from Ancaster, and identified a significant decline in bone quantity between the 20-49 and 50+ year age groups. Although it is not possible to determine the age at which healed fractures were sustained, the evidence provided by Mays' study for age-related bone loss in Ancaster females provides support for interpreting the vertebral compression and radial fractures observed at Ancaster as osteoporotic. No similar study has been conducted for Winchester (nor any other Romano-British population), thus it is not known whether rates of age-related bone loss differed between sites.

The absence of osteoporotic fractures at Winchester could reflect a difference in the age structures of the samples. Although elderly females comprise similar proportions of the total female samples at both sites (19.2% at Ancaster and 17.9% at Winchester), it is possible that elderly females at Winchester had a lower mean age-at-death. Post-menopausal women generally have an increased risk of developing osteoporosis, but this increases in magnitude from *c.* 70 years (Resnick and Greenspan 1989). The presence of more very elderly women at Ancaster could account for the greater number of probable osteoporotic fractures but, as age estimates cannot be refined, there is no way to determine whether this is the case (Weaver 1998: 37).

If the difference is not due to age, it could suggest that individuals at Winchester experienced less marked bone loss and/or a lower risk of sustaining fractures (Brickley 2002). Various factors could have contributed to differing rates of bone loss between the samples, including differences in activity, diet, and, in the case of women, fertility (Weaver 1998). Physical activity is thought to militate against bone loss due to its effect on muscle mass and bone remodelling (Borer 2005). It might be assumed that women at the public towns would have led relatively less active lifestyles, in which case one would expect Winchester females to have experienced greater levels of bone loss. Either there was no marked difference in overall activity levels between Ancaster and Winchester females (which may be indicated by the lack of a statistically significant difference in CPRs for joint disease), or other factors contributed to higher rates of osteoporosis at Ancaster.

Parity and lactation are related to the risk of osteoporosis in later life in females. Women can experience depleted calcium levels during pregnancy and breastfeeding, and repeated pregnancies might thus be expected to increase the risk of osteoporosis in later life. Paradoxically, several studies have recorded lower rates of osteoporosis in multiparous women (e.g. Cure *et al.* 1998; Hoffman *et al.* 1993; Michaëlsson *et al.* 2001; Sadat-Ali *et al.* 2005), the reasons for which are not entirely clear. Explanations include the possibility that pregnancy and prolonged lactation result in enhanced calcium storage, or that repeated pregnancies protect against bone loss due to increased body mass and weight bearing during pregnancy (Hoffman *et al*. 1993: 175; Streeten *et al*. 2005). The possibility that fertility rates were higher at the small towns has already been discussed (section 6.1.3.1), though, if this were the case, it does not appear to have benefited Ancaster women in terms of conferring any protective effect on age-related bone loss.

The higher rate of osteoporotic fractures among Ancaster females may indicate that women in this community achieved lower peak bone mass relative to Winchester females (Brickley and Ives 2008: 155). Each individual has the genetic potential to achieve a certain peak bone mass (which is usually achieved in early adulthood; Matkovic *et al*. 1994), but dietary and lifestyle factors determine the extent to which that potential is fulfilled (Bachrach 2001; Eisman 1999; Heaney *et al*. 2000). Vitamin D and calcium have a major influence on bone mass, although the lack of definitive evidence for rickets/osteomalacia in the Ancaster population suggests deficiency in either of these was not widespread. Other dietary factors that have been linked to low peak bone mass attainment include protein deficiency (Bonjour *et al*. 2001; Reid and New 1997). Stable carbon and nitrogen isotope analysis of individuals from Gloucester, Winchester (Lankhills) and York, and the small towns of Catterick and Dorchester (Chenery *et al*. 2010, 2011; Fuller *et al*. 2006; Müldner *et al*. 2011) suggests that the majority of individuals at both settlement categories consumed similar quantities of animal protein (*cf*. Chenery *et al*. 2011: 1531). This is also supported by faunal evidence (Maltby 2007, 2010). It is possible, however, that access to animal protein could have varied within some communities. In their analysis of individuals from Dorchester, Oxon, Fuller *et al*. (2006) found significantly lower nitrogen values in females, and suggested that this could reflect preferential allocation of animal proteins in favour of males. Differential access to resources between the sexes has been observed in some traditional agricultural societies where men and boys make a greater contribution to production (Wheeler 1991; Worthman 1996: 60), and Fuller *et al*. (2006) proposed that restricted access to animal proteins among females at Dorchester could reflect the agrarian nature of the community. If Ancaster females consumed less animal protein relative to males and Winchester females, this could have contributed to higher rates of osteoporosis in later life. In the absence of stable isotope evidence for diet at Ancaster, it is not possible to assess whether this was the case. In any event, while the evidence from Dorchester, Oxon, may point to differences in animal protein consumption at one small town, lower nitrogen values have also been reported in females from Poundbury (Richards *et al*. 1998) and Winchester (Lankhills; Cummings and Hedges 2010: 415), suggesting that, if there was gender bias in diet, it was not restricted to the small towns.

A more prosaic explanation for the difference in osteoporotic fractures between the samples may relate to the risk of falls. Females from Ancaster were perhaps more likely to suffer falls (and thus sustain fractures) in later life. Mays *et al*. (2006) recorded similar levels of age-related bone loss in medieval populations from England and Norway, yet osteoporotic fractures were more prevalent in the latter group, and it was suggested that this pointed to an increased risk of falls among the Norwegian females, in this case due to the harsher climate. It is possible that Winchester females experienced similar levels of bone loss, but simply had a lower risk of sustaining injuries because they had a less active lifestyle.

6.6 Specific infections

6.6.1 *Tuberculosis*

The prevalence of tuberculosis was higher for the Ancaster sample, although the difference was not statistically significant[41]. There were three definite cases from Ancaster (ANC 1, ANC 11 and ANC 218), and one from Winchester (VR 129). In addition, six individuals from Ancaster (ANC 47, ANC 48B, ANC 55, ANC 62, ANC 143 and ANC 240) and three from Winchester (VR 96, CHR 512A and CHR 636) had rib lesions, but did not exhibit any other diagnostic features of tuberculosis. Four individuals from Ancaster exhibited widespread, symmetric periostitis that may be indicative of tuberculous hypertrophic pulmonary osteopathy (ANC 48B, ANC 55, ANC 225 and ANC 240), but these lesions could also represent some other systemic condition. Three further individuals from Ancaster (ANC 46, ANC 82 and

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[41] Clough and Boyle (2010) identified several individuals in the Lankhills sample with rib periostitis that could represent TB, but none exhibited diagnostic features of tuberculosis, corroborating the relatively low prevalence in the Winchester study sample.

ANC 210) had possible tuberculous lesions. If definite and possible cases are combined, the overall number of individuals affected at Ancaster is 13 (4.8% of the total sample, 1.3% of subadults, 6.1% of adults); and four at Winchester (1.2% of the total sample, 0.8% of subadults, 1.5% of adults). The majority of individuals exhibiting definite or possible evidence for TB in the study samples were subadults or young/prime adults. This relatively young age distribution resembles the pattern seen in modern TB patients (Roberts and Buikstra 2003: 48), and may lend some support to interpreting rib lesions/HPO as possible signs of TB. The overall figures of 4.8% and 1.2% for Ancaster and Winchester respectively are broadly in line with estimates for the proportion of individuals infected with TB that go on to develop skeletal involvement (*c.* 3-5%; Roberts and Buikstra 2003: 89), suggesting many more individuals may have been infected.

Reported cases of tuberculosis in Romano-British skeletons have previously been collated and summarised by Roberts and Buikstra (2003: 119) and Roberts and Cox (2003). Roberts and Cox (2003) reported only 12 definite cases in skeletal remains of Roman date. Since these publications, a number of additional cases of tuberculosis have been reported. Several researchers reported instances of rib periostitis and/or widespread woven bone deposits in other skeletal samples that may represent pulmonary tuberculosis, as suggested in relation to similar lesions observed in individuals from Ancaster and Winchester. Roberts and Buikstra (2003: 132) identified 35 Romano-British individuals with rib periostitis (although this did not include the cases from Ancaster, which were not noted by Cox). Lewis (2011) recorded seven subadults with probable TB among 165 from Poundbury, in addition to several further cases of pulmonary infection; in several cases, diagnosis was based on the presence of widespread periostitis, including rib lesions. Similarly, Clough and Boyle (2010: 386-8) identified several possible cases of pulmonary TB at Lankhills on the basis of rib lesions and widespread periosteal new bone deposits, but no diagnostic changes (i.e. Pott’s disease or involvement of the major joint surfaces) were observed. Other cases are reported from the peripheral cemeteries of Dorchester (Dorset) and the small towns of Ashton and Towcester, Northants

(Anderson 2001b; McKinley 1999; Stirland and Waldron 1990; Waldron 2002). A male skeleton with TB was recently excavated at York[42].

Table 122 (Appendix 6) provides summary details for the number of cases so far reported (this includes individuals with diagnostic changes only, i.e. spinal or extra-spinal joint involvement)[43]. In some cases, diagnosis was tentative, but if all proposed diagnoses are accepted, the total number of reported instances rises to 23 – 16 for the public towns (nine adults and seven subadults) and seven for the small towns. The crude prevalence rates are unknown for Ashton, Towcester and the peripheral cemeteries of Dorchester; hence, CPRs including all cases of TB cannot be calculated. When only adult cases from those sites for which the total sample size (i.e. the denominator) is known are included, the CPR for the public towns is 0.2% (5/2093 adults) and for the small towns it is 0.8% (4/517 adults). The numbers of individuals affected are too small for statistical comparison.

The absence of reported cases of tuberculosis in subadults prior to Lewis' recent study is unsurprising, as the skeletal changes associated with the condition can be difficult to recognise in children (Dawson and Robson Brown 2012). Many children with TB probably died before diagnostic skeletal lesions could develop, but it should also be borne in mind that cases of tuberculosis identified in adult individuals, especially young adults, could represent the re-activation of infection contracted in childhood (Roberts and Buikstra 2003: 17-18). Rib periostitis and HPO observed in two older children in the study samples (CHR 636 and ANC 55), and in one child from Lankhills (Clough and Boyle 2010: 388) are possible examples of childhood tuberculosis.

A number of potentially confounding factors should be considered in interpreting the skeletal evidence for TB in Romano-British populations. The likelihood that an infected individual will develop skeletal involvement, and the form that osseous changes take in terms of the balance of bone formation (e.g. rib periostitis) *vs.* destruction, vary according to a range of factors, such as age and immune status (Roberts and Buikstra 2003: 88). Therefore, differences in the age structures of populations and the age at which individuals were first exposed to the

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[42] See: http://www.york.ac.uk/news-and-events/news/2008/roman-skeleton/

[43] A case reported by Eickelmann (2011) has not been included owing to the doubtful provenance of the skeleton.

bacillus may have contributed to variations in the skeletal manifestations of TB at different sites. Additionally, in populations that experienced greater levels of dietary and physiological stress (see below, section 6.7) and/or had limited previous exposure, infected individuals may have been more likely to die before the development of skeletal lesions (Wilbur *et al*. 2008).

6.6.2 *Other specific infections*

Evidence for other specific infectious diseases was limited for both populations. One individual from Winchester (VR 95) exhibited probable evidence of poliomyelitis (Figure 126). Cases of possible poliomyelitis have also been reported from Cirencester (Wells 1982: 181) and one of the cemeteries of Baldock (McKinley 2007: 312). The poliovirus is an enterovirus, acquired via the faecal-oral route, therefore the presence of poliomyelitis points to unsanitary conditions including contamination of food/water with human faecal matter (Smallman-Raynor *et al*. 2006: 4). The small number of cases reported and tentative nature of diagnoses preclude any further interpretations regarding variations in the prevalence of poliomyelitis in Romano-British populations.

Three individuals from Ancaster (ANC 1, ANC 179 and ANC 201) exhibited lesions that may represent brucellosis, but are more likely to be traumatic in aetiology (Figure 144 to Figure 146; see Appendix 4, Table 99). The lesion present in the fifth lumbar vertebrae of ANC 179 may be an avulsion injury of the endplate, and resembles a similar lesion observed by Redfern (2006: Fig. 72c) in an Iron Age male. To the author’s knowledge, no examples of brucellosis are reported in skeletal material from other Romano-British sites or earlier British populations, although Lewis (2011: 16-7) suggested brucellosis as a possible differential diagnosis for some suspected cases of TB at Poundbury, and noted the similar modes of disease transmission. Anderson (2003) reported a possible case of medieval date in an individual from Northamptonshire. A possible case of brucellosis has been identified in a horse skeleton of late Iron Age/early Roman date (Bendrey 2008). If this diagnosis is correct, it would indicate either that the condition was present in Britain in the pre-Roman period, or that it was introduced around the time of the Roman conquest perhaps due to the movement of horses or other livestock. Capasso (1999) claimed to have identified brucellosis in *c.* 17% of individuals from Herculaneum based on the presence of vertebral lesions, and suggested the disease was endemic in urban communities in Roman Italy due to consumption of infected dairy products. In light of the lack of consensus regarding the skeletal features of brucellosis, it is not possible to draw any conclusions regarding the presence and prevalence of brucellosis in the Romano-British period, and molecular analysis would be necessary to confirm its presence.

6.6.3 *Discussion*

Ancient medical texts suggest that tuberculosis ('phthisis'; Celsus, *On Medicine* 3.22) was endemic in the Mediterranean region (Sallares 1991: 237). Until relatively recently, the earliest reported cases of tuberculosis in British skeletal material dated to the Roman period, leading to the suggestion that the appearance of TB in the archaeological record at this time reflected population mobility and increased population size and density following the Roman conquest (Roberts and Cox 2003: 119). However, tuberculosis has since been confirmed in a male skeleton from Tarrant Hinton, Dorset, dated to the Middle Iron Age (Mays and Taylor 2003; Taylor *et al*. 2005), indicating that the disease was already present in Britain at the time of the Roman invasion.

Today, tuberculosis is a re-emerging disease that is intimately linked with overcrowding, poor sanitation, malnutrition and poverty (Sohail 2006). While consumption of, and contact with, contaminated meat and dairy is a significant route of transmission of *M. Bovis* among certain high-risk groups (de Kantor *et al*. 2010; de la Rua-Domenech 2006), the majority of carriers are infected by the human form of the disease (Roberts and Buikstra 2003). Bioarchaeologists have often linked the presence of TB in ancient populations with high population densities, since *M. tuberculosis* spreads via droplet infection (e.g. Dabernat and Crubézy 2010). However, the extent to which the prevalence of TB in earlier populations can be used as a proxy for population density is questionable. Lewis (2011: 20) interpreted the presence of tuberculosis in Poundbury subadults as possible evidence for crowded living conditions, but it seems unlikely that overcrowding was a significant problem for this community in the later Roman period, given the evidence for population decline and partial abandonment of intramural areas (section 2.2.1.5.2). Additionally, several recent studies have demonstrated the presence of *M. tuberculosis* in low population density settings. Analysis of pathogenic DNA from the infected Iron Age male from Tarrant Hinton identified *M. tuberculosis* as the causative agent (Taylor *et al*. 2005), and molecular analysis has also shown that *M. tuberculosis* was present at the medieval farming village of Wharram Percy, N Yorks (Mays *et al*. 2001).

Other factors that contribute to the spread of TB include domestic environments. The spread of *M. tuberculosis* via droplet inhalation is more likely to occur in poorly ventilated properties, and indoor pollution caused by the burning of biomass fuels has been found to increase the risk of transmission (Sumpter and Chandramohan 2013). The reasons for the association between TB and air pollution are not entirely understood, but could relate to the fact that inhalation of particulates causes irritation and inflammation of the upper and/or lower respiratory tract, and the persistent coughing experienced by affected individuals may increase the risk of TB transmission. Indoor air pollution has also been shown to affect general health status and immunity, and may thus increase an individual's susceptibility to TB (Bruce *et al*. 2000: 1084). It is difficult to assess how well ventilated Romano-British houses were, as there is a near-complete lack of surviving superstructures (Perring 2002: 111). Many people at both public and small towns would have occupied relatively small buildings such as strip houses, with domestic and craft activities taking place in a restricted space (Burnham and Wacher 1990: 46; Perring 2002: 58-9). It is possible that the larger, courtyard-style properties at the public towns were better ventilated. Lower rates of TB among the elite residents of the public towns due to better living conditions could thus account for the slightly lower rate of TB at Winchester. However, levels of air pollution are also influenced by factors other than property size, such as the type of fuel being burnt. It is probable that the occupants of larger properties relied to a greater extent on the burning of animal and vegetable oils in lamps and braziers, as suggested by the strong bias towards the major towns in the distribution of heating and lighting equipment (Eckardt 2011: 192). The burning of oils can be particularly harmful as it produces very fine particulates that penetrate the lower respiratory tract (Smith *et al*. 2004: 1437). It may be unlikely, therefore, that the wealthier residents of courtyard houses experienced significantly better respiratory health. Maxillary sinusitis (inflammation of the paranasal sinuses) and rib periostitis can represent irritation of the upper and lower respiratory tracts respectively, and have been used by some bioarchaeologists as a proxy for air quality in the past (e.g. Capasso 2000). Bernofsky (2010) examined the evidence for secular changes in air quality in Britain by analysing the prevalence of maxillary and rib periostitis in skeletal samples from the Iron Age to post-medieval periods. She found an increase in the prevalence of lesions between the Iron Age and Roman periods, but there was no obvious relationship between upper/lower respiratory disease and settlement type in the Roman period (Bernofsky 2010: Fig. 6.2 and 6.3).

The role of population mobility in the spread of TB is an interesting issue. It is possible that the migration of individuals from highly urbanised, densely settled regions of the Empire to Britain could have increased the rate of infection at the major population centres. However, if this were the case one might expect to see more cases of TB in skeletal samples from London in particular, and the other public towns where high levels of mobility are attested from stable isotope studies, including Winchester (Evans *et al*. 2006). The importance of many small towns as staging posts on the *cursus publicus* is potentially significant in this respect. It is possible that the populations of those small towns located on major routes – such as Ancaster – were exposed to TB by passing travellers and the army. Like Ancaster, both Towcester and Ashton were located on important roads (Burnham and Wacher 1990: 152, 279). Thus, a high degree of connectivity of many small towns could account for the slightly higher rate of infection at Ancaster. Roberts and Cox (2003: 119) noted that the majority of cases of TB so far reported come from sites in the South, Southeast and Southwest of England, where the majority of large towns were located. This could provide some support for the influence of connectivity on the spread of tuberculosis, although whether the distribution of cases reflects a genuine geographic patterning, as opposed to the greater number of excavations and larger sample sizes excavated in these regions is difficult to determine.

The relative contribution of *M. bovis* and *M. tuberculosis* to rates of tuberculosis in Roman Britain is unknown. If bovine tuberculosis was endemic among Romano-British cattle populations, then consumption of infected meat and dairy might have been a common route of infection at both the public and small towns. Additionally, the evidence for specialist carcass processing for both meat and secondary products at many public towns, including Winchester (Maltby 2010: 105-6) would have increased people's risk of contracting bovine TB (De Kantor *et al*. 2010). Nevertheless, the more agrarian character of the small towns may have led to greater rates of infection with bovine tuberculosis arising from closer contact with infected livestock. The presence of aisled buildings at small towns, including Ancaster (Burnham and Wacher 1990: 237), suggests some living spaces were shared with livestock. Molecular analysis would be required to determine whether there was any variation in rates of infection with *M. tuberculosis* and *M. bovis* between settlements[44], although rural-urban migration might obscure differences, since infections contracted in childhood can be (re-)activated in later life (Flynn and Chan 2001).

6.7 Non-specific indicators of health

6.7.1 *Periostitis*

The prevalence of periostitis was slightly higher for Winchester, although the difference was not statistically significant. When rib and bilateral tibia periostitis were considered, the Ancaster sample was more affected in both cases. Young Ancaster males exhibited a particularly high CPR (50%), and young Ancaster males also exhibited notably more tibial lesions compared to their Winchester counterparts. The samples differed in that males were more affected than females in the Ancaster sample, while Winchester females were more affected than males, although males at both sites had a higher prevalence of tibia periostitis. Lower prevalence rates of periostitis in females have often been noted in other skeletal samples (e.g. Ortner 1998), and may be explained by enhanced female buffering (Nunn *et al*. 2009).

Figure 60 compares the crude prevalence of periostitis in the study samples with other Romano-British populations (see Appendix 6, Table 123 for data). The prevalence of non-specific periostitis varies considerably between sites. The highest

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[44] Testing of tuberculous individuals from various Romano-British sites (including some of the individuals from Winchester included in the study sample) is currently on-going, but none of the samples from Winchester has produced pathogenic DNA (R. Müller, personal communications).

prevalence is reported for Gloucester (46.7%), followed by London (25.5%) and York (24.7%). The prevalence rates for Ancaster, Baldock, Godmanchester, Cirencester and Winchester are broadly similar, while the lowest prevalences occur in the populations from Colchester and Leicester. When the overall CPRs (adults and subadults combined) are compared, the prevalence is slightly higher for the public towns (10.1% *vs.* 9.1%). The difference in overall CPRs between the public and small towns is not statistically significant, although there are some significant differences when sites are compared individually, e.g. the CPR for Gloucester is significantly higher than other sites (Test 88). TPRs for the tibia are unavailable for most sites, although some reports provide data (see Table 123). The highest tibia TPR reported is for Gloucester (28.9%), followed by London (13.8%), York (13.4%), Cirencester (10.8%), Ancaster (6.5%) and Winchester (3.4%).

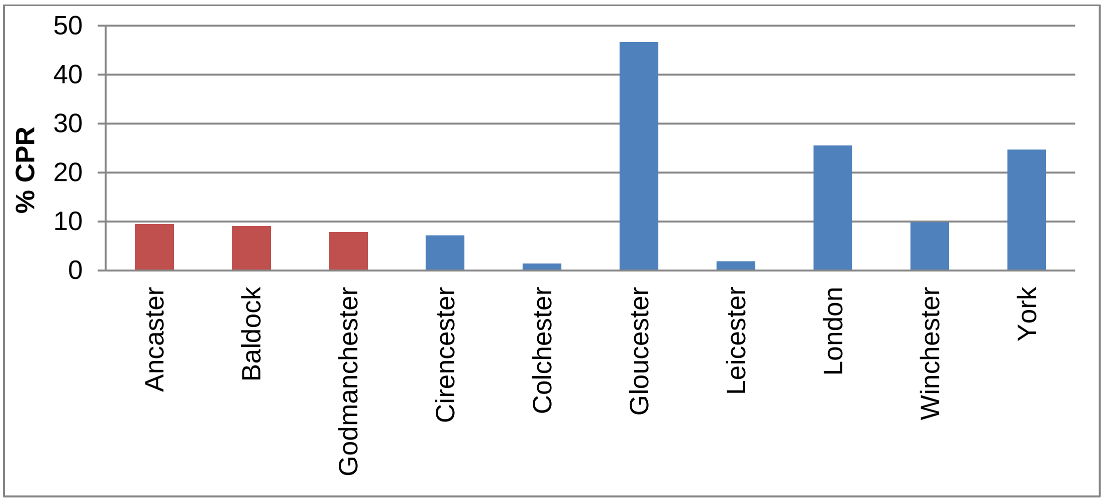

Figure 60. Graph comparing the crude prevalence of non-specific periostitis in Romano-British populations.

6.7.2 *Cribra orbitalia*

The overall crude prevalence of cribra orbitalia was higher for Winchester, although the difference in CPRs between the samples was not statistically significant either for the total samples, or by age/sex. In both populations, the prevalence rate was lower in adults than subadults, which is explained by remodelling of lesions in adulthood. In light of this, it is unusual that, among Winchester adults, the CPR was greatest for the elderly age group. A higher prevalence of cribra orbitalia among older adults was also observed in medieval English populations (Jakob 2004: 332). Assuming the elderly individuals were among the most resilient members of the community, high

CPRs could be an example of the 'osteological paradox' at work, i.e. individuals capable of surviving ill health in childhood were more likely to survive to old age. It is also notable that there was little difference between the study samples in the prevalence of cribra orbitalia among subadults, with the CPR actually being slightly higher for Ancaster. To some extent, this may be due to sample bias due to the relatively small numbers of subadults with preserved orbits. However, the fact that the adult CPR was higher for Winchester could indicate that episodes of stress experienced by Winchester subadults were more severe, and that more individuals died before lesions could develop.

In both populations, the crude prevalence of cribra orbitalia was greater for males than females across all age groups (with the exception of unaged Ancaster adults). Either males experienced greater levels of stress in childhood, or stressed females were less likely to survive to adulthood. As in the case of non-specific periostitis, a tendency for males to exhibit higher prevalence rates could reflect differences in immune status between the sexes (Ortner 1998). The fact that men from both samples also exhibited higher prevalence rates of non-specific tibia periostitis further supports an interpretation of greater levels of systemic stress in males due to differences in immune response.

The prevalence of active *vs.* healed lesions and the severity of lesions were similar between the samples. As expected of a childhood condition, active lesions were only observed in subadults. The majority of individuals had only slight (grade 1) porosity and no grade 5 lesions were present in either sample. Young adults tended to have more severe lesions than did older adults, which is again explained by progressive remodelling of lesions in adulthood.

Prevalence data for cribra orbitalia are available for most sites (Figure 61; see Appendix 6, Table 124 for data). The site with the highest CPR is London, followed by Poundbury, Winchester, Ancaster and Gloucester. The highest subadult CPRs are for Ancaster, Poundbury, London and Winchester, while prevalences at Cirencester and Colchester are low, and no subadults from Godmanchester were affected. Adults from London, Gloucester and Winchester have the highest prevalences and Godmanchester and Colchester again have the lowest CPRs (Table 124)[45]. When the

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[45] Harman (1987) does not provide a breakdown by age for the Dorchester population.

data are combined (subadults and adults), the CPR for the small towns is 15.3%, for the public towns it is 20.9%, and the difference is not significant (Test 89).

It is possible that some of the variation between sites is the result of inter-observer error. High rates of cribra orbitalia at London are corroborated by different researchers (e.g. Gowland and Redfern 2010; Jenny 2011). Gowland and Redfern (2010) found that the rate for London was markedly higher than that for any other Romano-British population, but the subadult CPR reported by Lewis (2010) for Poundbury is, in fact higher than that for London, as is the Winchester CPR. The probability that cribra orbitalia is under-reported in earlier studies is suggested by the fact that Conheeney (2000: 285), drawing on bone reports produced by several researchers, reported an improbably low prevalence of *c.* 5.0% for the Eastern Cemetery of London. The cemetery at Dunstable (Matthews *et al.* 1981) has not been included among comparative samples due to the lack of pathology data, but it is notable that only one individual (out of 112) was identified as exhibiting ‘orbital osteoporosis’, which may suggest that cribrotic lesions were not routinely recorded.

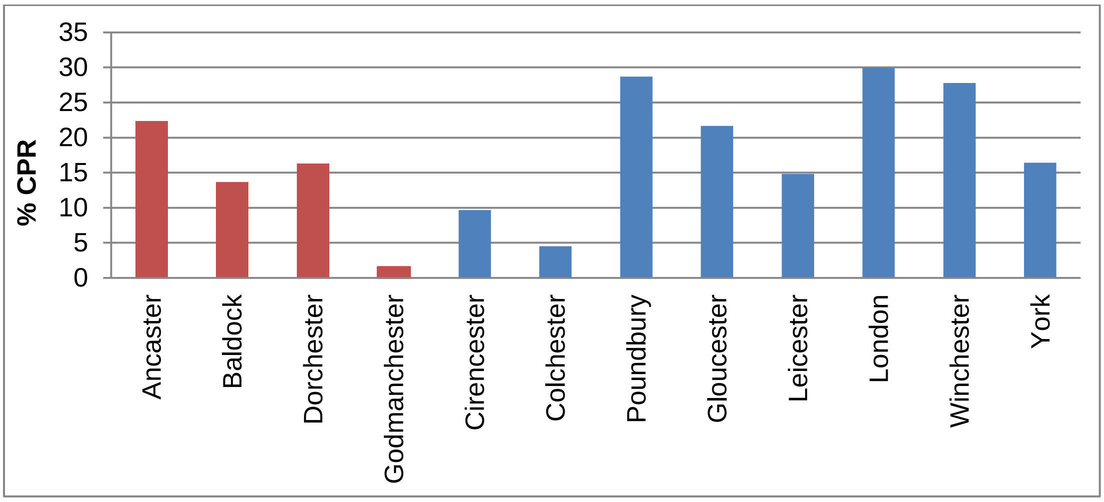

Figure 61. Graph comparing the crude prevalence of cribra orbitalia in Romano-British populations.

6.7.3 *Porotic hyperostosis*

The prevalence of porotic hyperostosis was very low for both samples, although the Winchester sample was slightly more affected. Only one Ancaster adult and three Winchester subadults exhibited porosity with expansion of the diploë (ANC 204A; VR 38, VR 44, VR 121). An extreme case was observed in a young child from

Winchester, VR 121, who exhibited large areas of porosity at the posterior parietals (Figure 129). There also appeared to be slight deposits of sub-periosteal new bone present. Both orbits were affected by severe cribra orbitalia, and deep endocranial lesions with branching vessel impressions were present at the parietals. The possibility that this child suffered from scurvy or rickets (instead of/in addition to anaemia) was considered, but no other diagnostic features of either condition were present. Both maxillae showed marked porosity, although this took the form of an arc of porous new bone on the hard palate, which is common in developing subadults (Ortner *et al*. 1999: 327), and there was only slight porosity of the alveolar processes.

It is not possible to compare prevalence rates with other populations due to inconsistencies in reporting and diagnosis. The only detailed studies of porotic hyperostosis for the period are those conducted on the material from Poundbury by Stuart-Macadam (1985: 393), who reported CPRs of 17.2% for subadults and 5.7% for adults. Lewis (2010: 410, Table 2) gives a lower figure for Poundbury of 7.0% that excludes individuals with other skeletal manifestations of scurvy and/or rickets.

6.7.4 *Dental enamel hypoplasia*

Overall, hypoplasia was more prevalent in the Winchester sample (Figure 149). When considered by age group, the CPR was slightly higher for Ancaster subadults. The subadult prevalences may be inaccurate because of ante-mortem loss of deciduous teeth and the inability to observe unerupted adult teeth. The adult CPR was higher for Winchester, and the difference was statistically significant. In particular, young and mature Winchester males had significantly more hypoplasia than Ancaster counterparts.

Figure 62 compares the crude prevalence of hypoplasia between Romano-British populations (see Appendix 6, Table 125 for data). There is considerable variation in CPRs between sites, ranging from a low of 12.2% at Cirencester, to 76.0% at London. When the data are combined, the CPR for the small towns is 19.0%, for the public towns it is 25.4%, and the difference is statistically significant (Test 90). A number of potential methodological problems should be borne in mind when comparing prevalences for DEH. Attrition, caries and calculus can obliterate defects, and this probably explains the age-related decline in prevalence observed in the study samples. Inter-observer error may arise from differences in the identification of defects. Particularly wide perikymata (incremental growth lines) in teeth can be mistaken for hypoplasia. Conversely, faint defects can be difficult to identify without magnification (Hindle 1998: 32-4).

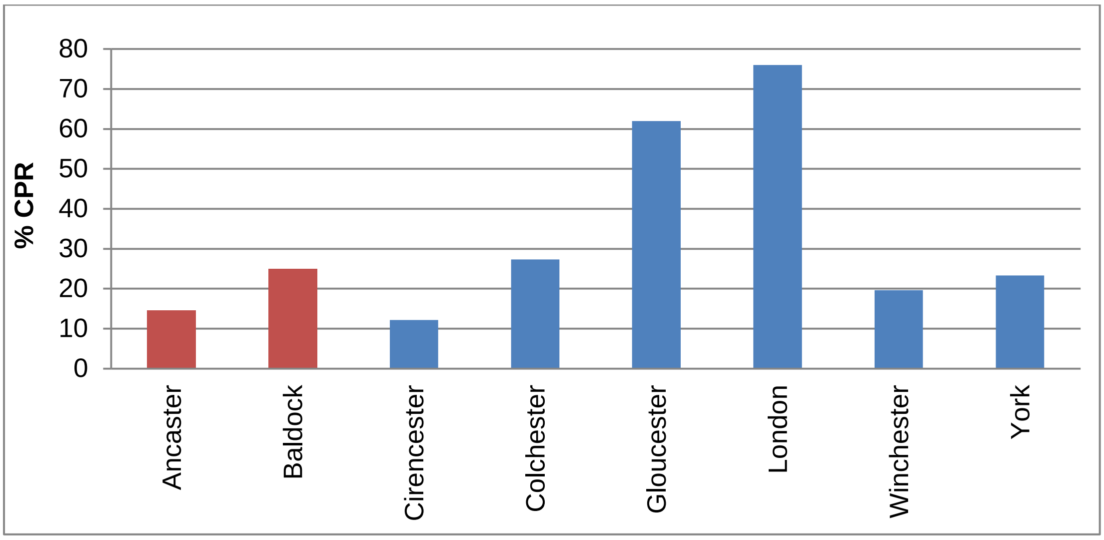

Figure 62. Graph comparing the crude prevalence of dental enamel hypoplasia in Romano-British populations.

6.7.5 *Discussion*

6.7.5.1 Periostitis

Non-specific periostitis has become synonymous with infection in the palaeopathological literature, though it is known that many conditions may cause the formation of periosteal new bone (Weston 2012: 503). Periostitis arising from infection, trauma, venous conditions and ulcers can be indistinguishable from one another by macroscopic analysis alone. Well-remodelled ossified haematomas can appear similar to remodelled periostitis and only histological analysis can differentiate between the two (Van der Merwe *et al*. 2010). Furthermore, in infants and young children, the presence of woven bone is a normal manifestation of growth (Lewis and Roberts 2002: 584; Weston 2012: 496-9). Healed periosteal lesions will remodel over time, thus differences in the age structures of samples may affect the comparability of prevalence rates.

In the study samples, several individuals exhibited unilateral periostitis that could represent ulcers, localised infection, trauma, or infection secondary to trauma (e.g. Figure 128), and seven Winchester individuals with fractures had evidence of associated healed periostitis. When only bilateral tibia periostitis was considered, the Ancaster sample was more affected. Since bilateral lesions are more likely to indicate a systemic condition (Roberts 2000a: 148), this finding could point to greater levels of non-specific stress in the Ancaster population, but it is also possible that the higher prevalence of tibial lesions may be related to the slightly higher rate of tuberculosis at Ancaster. TB has already been suggested as a likely cause of the visceral rib lesions observed in both samples, although other pulmonary conditions such as pneumonia, lung cancer, and atmospheric pollution cannot be ruled out (Matos and Santos 2006; Mays *et al*. 2002; Santos and Roberts 2006). Two individuals from Ancaster with rib lesions (ANC 55 and ANC 240) also exhibited bilateral periostitis of the long bones, and this may represent tuberculosis-related hypertrophic pulmonary osteopathy (Assis *et al*. 2011).

The heterogeneous aetiology of periostitis also complicates comparisons with other Romano-British populations, as the relative contribution of non-specific infection, specific infection (e.g. tuberculosis), trauma, and other causes might have varied between sites (*cf*. Mays 2010b: 214). In the absence of more detailed data on the nature of non-specific periosteal changes at other sites (such as the number of unilateral *vs*. bilateral lesions, number of lesions secondary to fractures, associations between rib and tibia periostitis, occurrence of hypertrophic pulmonary osteopathy etc.), it is impossible to determine if, and to what extent, the causes of non-specific periostitis differed between populations (*cf*. Ortner 2003: 209). Additionally, methodological issues arise in using data compiled by different researchers. It has been suggested that neonates and infants should be excluded from the calculation of prevalence rates, as widespread porous new bone can be growth related (Ribot and Roberts 2006: 71). However, some researchers may have recorded normal, growth related woven bone as pathological. For example, Molleson (1993: 190) diagnosed an unusually large number of neonates and infants (N=57) as having infantile cortical hyperostosis (Caffey’s disease), a condition of uncertain aetiology that involves the widespread formation of new bone (Ortner 2003: 416-8). However, Lewis (2007: 145-6; 2010) suggests that many of these cases are more likely explained by normal bone growth, with some others representing infantile scurvy and/or rickets. Further problems with the interpretation of periostitis prevalence rates include the fact that un-remodelled periostitis is fragile and may be dislodged, and weathering can destroy woven bone deposits, a problem noted by Roberts (2007: 264) in relation to the skeletal material from Baldock.

If it is assumed that the CPRs for different populations are broadly representative of the same contributing factors, then the lack of any marked differences between the majority of sites (Ancaster, Baldock, Godmanchester, Cirencester and Winchester), would imply generally similar levels of non-specific infection in most Romano-British populations. The rate of transmission of infectious diseases increases where people live in close proximity to one another (Manchester 1992), thus bioarchaeologists sometimes use the prevalence of non-specific periostitis as a proxy for population size and density (Larsen 1999: 85). The prevalence rates for the majority of Romano-British sites are relatively low, and are similar to that reported for the medieval rural population from Wharram Percy, where only *c.* 8% of individuals were affected (Mays 2010: 214). In contrast, Grauer (1993) reported a CPR of 22.2% for an urban medieval sample from St. Helen-on-the-Walls, York. A superficial comparison might therefore suggest that the density of Romano-British populations was not as high as in later periods. Such an interpretation would be consistent with a picture of comparatively low building densities and the presence of open spaces in towns (Dobney *et al*. 1999: 18), particularly in the later Roman period (Esmonde Cleary 1989: 145). However, it should also be noted that higher prevalence rates for later medieval populations may well reflect higher rates of tuberculosis and syphilis, as periostitis occurs as part of the disease process of both (Ortner 2003: 88).

The prevalence rates for Gloucester, London and York are remarkable, and the exceptionally high CPR for Gloucester is particularly notable, given the reportedly poor condition of the remains (Márquez-Grant and Loe 2008: 32). It is possible that the CPR for Gloucester is an anomaly produced by the relatively small sample size, but this seems unlikely, as another sample from a different site in Gloucester (Kingsholm) produced a similarly high TPR (24.2%) for tibia periostitis (Roberts and Cox 2003: 126). The fact that the samples from Gloucester, London and York also exhibit some of the highest rates of cribra orbitalia and DEH suggests that the greater prevalence of non-specific periostitis does reflect greater levels of non-specific infection. This could be interpreted in terms of relatively larger, denser populations at these sites compared to other towns which, in the case of London and York, might reflect their position as provincial capitals. Additionally, the presence of the legionary fortress at York and its role as the base of the *dux Britanniarum* in the fourth century (Ottaway 1999: 149; Wacher 1995: 172) could have contributed to higher population densities. The exceptionally high prevalence for Gloucester is more difficult to explain, although the fact that Gloucester has similar prevalences to London and York is potentially of interest in the light of suggestions that Gloucester, rather than Cirencester, may have been one of the four late Roman provincial capitals (Reece 1999). The evidence for the partial abandonment of intramural areas at most public towns, with particularly early decline at London (Marsden and West 1992; Perring 2011b) might seem to count against significantly higher population densities at these sites relative to other public towns, but some other aspect of the nature of the communities at Gloucester, London and York, may have influenced levels of non-specific stress. Stable isotope evidence suggests that a significant minority of individuals at York and Gloucester were non-local (Eckardt 2010: 122). While no similar analysis has yet been conducted for London, levels of mobility were also presumably high, given its status and importance. High levels of mobility may have meant that the populations of Gloucester, London and York were more frequently exposed to new pathogens (*cf*. Scheidel 2009: 8). However, a significant minority of migrants were present at Winchester Lankhills, yet rates of non-specific periostitis were relatively low. It may be that other factors particular to the local environment or nature of the communities at Gloucester, York and London, relating to topography and environment, increased levels of non-specific infection.

The possibility that the use of communal facilities such as bathhouses and latrines contributed to the spread of non-specific infections and parasites at public towns has been raised by some researchers (Allason-Jones 1999: 139; Fagan 2006: 194; Redfern and Roberts 2005: 115). Although some private houses and *mansiones* at small towns possessed private bath suites, it is unlikely that the majority of the community had regular access to such facilities, in contrast to the populations of the public towns. In the absence of chlorination, public bathhouses could have increased the spread of infection and water-borne pathogens, depending upon the frequency with which the water was replaced, number of users and temperature (Pond 2005). A culture of public bathing may have been better established at sites like London and York, reflecting their more cosmopolitan populations and closer links with the military community. No public bathhouse has yet been identified at Gloucester, although the town almost certainly possessed one (Rogers 2011: 84). However, considering the fact that many bathhouses went out of use at a relatively early date (Rogers 2011: 83-9), in part owing to the costs and difficulties in maintaining their aqueducts (Burgers 2001: 4), it is unclear to what extent bathing would have contributed to the spread of non-specific infections. At London, the Huggin Hill baths were no longer functioning by the later second century (Perring 2011b: 271), although how many other public bath complexes existed, and whether they remained operational, is unknown (Rogers 2011: 85).

One important factor that should be considered in interpreting the high prevalence rates of non-specific periostitis (and cribra orbitalia and DEH) at Gloucester, London and York is chronology. As noted in Chapter 4 (section 4.2.9), these samples include a relatively greater proportion of earlier (i.e. second and early third century) inhumation burials. However, determining whether earlier burials outnumber later (i.e. *c.* AD 270 onwards) burials is extremely difficult because of the general lack of grave goods. The sample from Gloucester includes burials dating from the Flavian (mid/late first century) period, although the majority of dated inhumations belonged to the third and fourth centuries (Simmonds *et al*. 2008: 9-13). Of the 132 burials from the Western Cemetery of London, date ranges are available for 125. Twelve (9.6% of dated burials) were considered to date to AD 250 or earlier. A further three burials (2.4%) were dated between *c.* AD 120 and 410. Fifteen (12%) were late Roman (*c.* AD 200-410). The vast majority of graves (95 or 76% of dated burials) were assigned a date range of AD 43-410 only. If a significant proportion of burials at London *are* earlier in date, then it could be argued that the high prevalence rates of periostitis and other stress indicators reflect a higher population density in earlier periods, before decline set in following a major fire in the Hadrianic period (Perring 2011b). Unless the dating of burials can be refined, secular trends in the prevalence of stress indicators cannot be assessed.

6.7.5.2 Cribra orbitalia and porotic hyperostosis

The interpretation of cribra orbitalia and porotic hyperostosis is complicated by the heterogeneous aetiology of orbit and vault lesions (see section 4.2.6.5.2.1). There are also several methodological issues that make interpretations of the data problematic. A study by Wapler *et al*. (2004) found that histological signs of anaemia (principally marrow hyperplasia) were present in less than 50% of individuals with orbital lesions in a sample of Sudanese Nubians, and the majority of 'cribrotic' lesions were instead found to represent haematomas, were of unknown cause, or were pseudo-pathological. It could be argued that the varied aetiology of cribrotic lesions and presence of pseudo-lesions should not be problematic, provided that the relative contributions of differing factors is similar in all skeletal populations being compared (*cf*. Mays 2012b: 296). Without the widespread application of histological analysis to skeletal collections, this cannot necessarily be taken for granted. Another potential problem with the study and interpretation of cribra orbitalia concerns inter-observer error. Jacobi and Danforth (2002) found that researchers disagreed relatively frequently in their assessment of the severity and activity of lesions. The study of porotic hyperostosis is affected by similar problems. Vault lesions may have different causes, including rickets and scurvy. In addition to the problem of differentiating between porotic hyperostosis and other metabolic conditions, the presence of generalised porosity at the parietals, frontal bregma and occipitals, unaccompanied by hyperostosis of the vault bones, is relatively common in skeletal samples and is of unknown aetiology (Mann and Hunt 1995: 22).

In relation to the study samples, inter-observer error can obviously be ruled out as a complicating factor, and in the absence of any evidence to the contrary, it must be assumed that the lesions recorded are broadly representative of the same pathological process. If so, the higher prevalence of cribra orbitalia and porotic hyperostosis in the Winchester sample (and public towns in general) would point to greater levels of physiological stress in larger urban communities, which may have arisen due to dietary factors, aspects of the living environment such as levels of sanitation, or a combination of the two. As discussed in Chapter 4 (section 4.2.6.5.2.1), the role of diet in the development of cribra orbitalia and porotic hyperostosis is disputed. Most researchers now reject a simplistic relationship between these lesions and iron deficiency anaemia, with megaloblastic anaemia arising from vitamin B12/folic acid deficiency now considered a more likely cause (Walker *et al*. 2009), although there remains some disagreement. If iron deficiency was a factor in the development of orbital and vault lesions, it seems improbable that a dietary insufficiency was the cause, given the faunal and isotopic evidence for relatively significant levels of meat consumption at the public towns (Cummings 2009; Maltby 2010). Leafy green vegetables, and meat, dairy and eggs are good sources of folic acid and vitamin B12 respectively. Unless consuming a very restricted diet, it is unlikely that most people were substantially deficient in either, though pregnant women and infants are susceptible to folate/B12 deficiency (WHO 2004: 294-5). Fairgrieve and Molto (2000) identified an increase in rates of cribra orbitalia in Egyptian subadults following the Roman conquest, and suggested that this could reflect the adoption of Romanised infant feeding practices. Both Soranus and Galen recommended the substitution of human milk and cow’s milk with goat’s milk, which the infant gut is better able to tolerate (Fildes 1986). Goat’s milk is deficient in vitamin B12, folic acid and iron, and megaloblastic anaemia has been observed in modern infants fed on unfortified goat’s milk (O’Connor 1994). It has previously been suggested (section 6.5.4.1) that the adoption of new feeding practices among the upper classes at the public towns, and the importation of such practices by migrants from other regions of the Empire, might account for the presence of infantile scurvy in these communities, and it could also have contributed to higher rates of cribra orbitalia. Fairgrieve and Molto (2000: 328) also noted the inter-relationship between vitamin C, folic acid and vitamin B12, in the metabolising of protein, as vitamin C influences the uptake of folic acid; hence, the prevalence of these conditions may have been linked. The evidence for the exploitation of goats at Romano-British public towns is, in fact, rather limited. Goat remains comprised only a small minority of ovicaprid remains in faunal deposits from Winchester (Maltby 2010: 158), and there was little evidence in terms of mortality curves for the management of sheep/goat for their milk (Maltby 2010: 251). However, it remains possible that other changes in infant feeding practices, as discussed in relation to vitamin C deficiency, contributed to elevated prevalences of cribra orbitalia at the public towns.

While differences in infant feeding practices may have contributed to the higher rates of cribra orbitalia and porotic hyperostosis at Winchester and other public towns, other factors may also be responsible. Higher rates of cribra orbitalia at the public towns could point to less sanitary living conditions. Dobney *et al*. (1999: 20) reviewed the evidence for living conditions in the *coloniae*, and concluded that Romano-British towns were probably more sanitary than later medieval towns, based on evidence for the careful disposal and subsequent avoidance of refuse deposits at many sites. Nevertheless, despite clear evidence for the management of waste and advances in water technology and sewage in the Roman period, literary sources suggest that sanitation in towns was poor, with cesspits for domestic waste situated in and around properties, and latrines located next to kitchens (Scobie 1986: 412). In the absence of any real understanding of how diseases spread, cross-contamination of food and water must have been common (Jackson 1988: 53). In poorer regions of the world, gastro-enteritis and dysentery arising from the contamination of water and food by bacteria such as members of the *Campylobacter* and *Helicobacter* genera, *E. coli* and salmonella, are major causes of morbidity and mortality, especially among children (WHO 2008: Ch.11). Intestinal parasites, such as cryptosporidium, roundworm and tapeworm, are also common causes of diarrhoeal disease, and are spread via the contamination of water and food with human and animal waste (Motarjemi *et al*. 1993). Jackson (1988: 53) notes that ancient Roman medical texts make frequent reference to diarrhoeal disease. Remains of roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichuria*) and the dog tape worm (*Echinococcus granulosis*) have been identified in burials, pits and well deposits from both public towns and small towns (Jones 1993; Murphy 2007: 401), but they have also been found at rural sites (Wells and Dallas 1976), indicating that poor sanitation was not just a problem for urban communities. At rural sites, people may have been exposed to parasites through the use of human and animal waste (‘night soil’) to fertilise crops (e.g. Needham *et al*. 1998), a practice recommended in ancient texts on agriculture (Scobie 1986: 408). However, the impact of parasitic gut infestation on an individual’s health depends on the level of pathogen-load, and individuals harbouring small numbers of parasites may experience few symptoms. Factors that influence pathogen-load include the frequency of exposure and an individual's immune status (Wilson *et al*. 2002). A greater proportion of the populations of public towns may have experienced higher pathogen-loads due to more frequent exposure to contaminated food and water arising from greater pressure on water supplies, and greater levels of nutritional stress (Scrimshaw and SanGiovanni 1997), which could explain the generally higher prevalence rates at the larger towns. Alternatively, it is possible that sanitation in the major towns worsened in the later Roman period, despite lower population densities, due to the deterioration of the urban fabric. It has been suggested that the evidence for the accumulation of refuse deposits within the intra-mural areas of some towns, including Winchester (Frere *et al*. 1985: 311), points to a growing lack of concern for hygiene and sanitation (Faulkner 2000: 124), although, as discussed in Chapter 2 (section 2.2.1.5.1) the interpretation of such deposits is disputed. If household and industrial waste was being increasingly dumped close to areas of habitation, this may have contributed to the contamination of wells and streams. Depending on where material was discarded, and local topography, problems with contamination may have been greater at some sites than others. Failure to maintain drains and sewers could have resulted in contamination of wells and cisterns due to seepage (Burgers 2001: 87).

Another factor that, it has been suggested, could have contributed to anaemia in Roman populations is lead poisoning (Stuart-Macadam 1991: 103). Lead can contribute to the development or exacerbate anaemia as it inhibits haem synthesis (Jain *et al*. 2005; Spriewald *et al*. 1999). Lead was widely used by the Romans in aqueduct channels, water pipes, crockery, industry, the containers used to produce wine, pottery glazes, cosmetic products, and as an artificial sweetener (Boulakia 1972; Retief and Cilliers 2005). In Britain, lead-lined aqueduct channels supplied water to York and some of the other public towns, although other aqueduct channels were constructed of stone, wood or ceramic (Burgers 2001: 26). Scholars are divided on the issue of the scale and impact of lead poisoning in the Roman Empire (Gilfillan 1965; Needleman and Needleman 1985; Nriagu 1983; Retief and Cilliers 2005; Scarborough 1984). The degree to which lead poisoning was an issue for individuals and communities would depend to a great extent on a range of factors, such as whether households primarily drew water from wells and rivers as opposed to piped supplies, use of lead table wares, and exposure to lead in industrial processes. It is possible that the populations of the public towns were exposed to greater levels of lead. Several studies of lead levels in teeth and bone samples from Romano-British skeletons have been conducted (Mackie *et al*. 1975; Molleson *et al*. 1986; Montgomery *et al*. 2010; Waldron 1981, 1982, 1983; Waldron and Wells 1979; Waldron *et al*. 1976, 1979). The most recent study (Montgomery *et al*. 2010) compared lead levels in British skeletal material from the prehistoric to late medieval periods, in addition to individuals from the vicinity of Rome itself. The results indicate a peak in lead levels in British skeletal material in the Roman period, although levels were very low compared to contemporaneous burials from Rome, and later post-medieval burials (*cf*. Aufderheide *et al*. 1992). Additionally, lead levels varied markedly in individuals from the same period. The possibility that some Romano-British individuals with high lead levels grew up in areas of the Empire where exposure to lead was greater should be considered (Montgomery *et al*. 2010). No similar studies of lead levels in individuals from small towns have been conducted, therefore it is not possible to assess the extent to which lead poisoning was a greater health concern at the public towns, if at all.

A final issue that should be considered in interpreting indicators of childhood stress is population mobility. Gowland and Redfern (2010: 33) proposed that the high rates of cribra orbitalia (and dental enamel hypoplasia) in skeletal samples from London (Eastern, Southern and Western cemeteries combined) could reflect high levels of migration into London. If a significant proportion of the residents of London originated from more highly urbanised regions of the Empire where levels of infectious and metabolic stress experienced in childhood were perhaps greater due to higher population densities and endemic malaria (Gowland and Garnsey 2010; Scheidel 2010), their presence in London’s cemeteries would have the effect of increasing prevalence rates. Gowland and Redfern (2010: 34) noted that the combined subadult and adult cribra orbitalia prevalence rate for London was greater than the subadult prevalence alone. This is contrary to what is usually expected, given the remodelling of cribrotic lesions throughout adulthood, and Gowland and Redfern suggested that this provided further support for their argument that a significant number of adults were non-local. When CPRs for other sites are examined (Table 124), subadult prevalence rates are higher than adult prevalences in all cases, suggesting London may be anomalous in this respect. The adult and subadult CPRs for Gloucester are very similar (21.6% and 22.2% respectively), but other populations which might be expected to include a greater proportion of non-local migrants, e.g. York, have relatively low adult CPRs. Nevertheless, if Gowland and Redfern's argument is correct, it is possible that generally higher CPRs for the other public towns could partly reflect greater levels of mobility.

6.7.5.3 Dental enamel hypoplasia

In contrast to cribra orbitalia, porotic hyperostosis, and periosteal new bone, dental enamel defects are not remodelled over the life-course. Like periostitis and cribra orbitalia, hypoplastic defects may have multiple causes. Numerous factors have been shown to result in defect formation, ranging from serious bouts of infectious disease and malnutrition (e.g. Zhou and Corruccini), to short-term episodes of stress (Goodman and Rose 1990: 65; Lewis 2007: 104-5). Given that hypoplasia can reflect relatively minor stress episodes, it may be a more sensitive indicator of general population health status, with high prevalences pointing to frequent non-lethal stress. On the other hand, it could be argued that low rates of DEH might arise in populations with high levels of frailty, such that minor assaults on health were fatal (Wood *et al*. 1992). Several studies have found DEH to be more common in populations that historical and archaeological evidence would suggest were likely to have experienced high levels of nutritional and disease stress (e.g. Bennike *et al*. 2005; Palubeckaité *et al*. 2002). Other studies have demonstrated a correlation between DEH, other stress indicators, and lower mean age-at-death (e.g. Goodman *et al*. 1988: 181; Obertová and Thurzo 2008), suggesting that hypoplasia is, in general, a useful indicator of health status.

The higher prevalence of dental enamel hypoplasia at Winchester is consistent with the evidence of cribra orbitalia and porotic hyperostosis in pointing to greater levels of systemic stress in this population. In the Ancaster population, prevalence rates were slightly higher for females than males, although the difference was not significant. In contrast, in the Winchester population, males were more affected than females. Guatelli-Steinberg and Lukacs (1999) reported a tendency for males to be more affected than females in archaeological populations, and suggested that this reflected preferential biological buffering of females. The similarity in prevalence rates for females and males at Ancaster could be interpreted in terms of preferential cultural buffering of males in Romano-British society, while the higher rate for males at Winchester might suggest that the negative impact of diet and/or environment on health at public towns was significant enough to over-ride preferential treatment of boys.

In both samples, the most affected tooth was the canine, mirroring the general trend in tooth involvement observed in other skeletal populations (Goodman and Rose 1990: 88). The age-distribution of defect formation was similar for both samples in that defect formation peaked at 2.0-4.0 years. As the canines are particularly susceptible to defect formation at this time, it is not possible to assess the extent to which this may also relate to weaning stress, if at all (Lewis 2007: 106-7). Of greater interest is the presence of an additional peak in formation at a later age in the Winchester population at *c.* 4.0-4.4 years that, in Winchester males, was greater than the earlier peak. There is no peak in subadult mortality among this age group at Winchester, suggesting that whatever stressors were responsible were generally non-lethal. This could include more frequent and/or more severe bouts of diarrhoeal disease and infection due to less hygienic living conditions, as previously discussed. Additionally, as enamel defects may also reflect traumatic incidents or periods of psychological stress, the secondary peak in early childhood at Winchester could also be explained in terms of the increased risks of living in a larger, busier town, as children become increasingly independent around this age (Halcrow and Tayles: 208). In the case of males, the larger peak in childhood could indicate that boys began to be introduced to craft activities at this age, potentially exposing them to trauma and waste products (Halcrow and Tayles 2008: 201-2). A final possibility is that the higher rate of DEH at Winchester could reflect greater exposure to lead and/or other waste from production activities, as environmental toxins have been linked to defect formations in contemporary populations (Lawson *et al*. 1971). In the absence of comparable data on age of defect formation at other sites, it is not possible to determine to what extent the difference between Ancaster and Winchester is replicated at other small and public towns.

Crude prevalence rates for the majority of sites (including York[46]) are broadly similar to Ancaster and Winchester, but London and Gloucester once again have exceptionally high CPRs. It seems improbable that methodological differences account for the remarkably high prevalences of enamel defects at these two sites. This could reflect some particular aspect of the social and/or settlement environment at these sites. Once again, the notably high CPR for London could reflect high levels of population mobility and the presence of a significant number of migrants from other regions of the Empire (Gowland and Redfern 2010: 33). However, it has been noted that reported prevalences of dental enamel hypoplasia in Roman-period skeletal samples from in and around the City of Rome itself vary markedly, with rates of up to *c.* 80% reported in some samples, while much lower prevalences are recorded in others (Killgrove 2011). This variation may reflect differences in social status, although some skeletal samples believed to represent lower class communities have been found to have very low prevalences of DEH and other stress lesions. Killgrove (2011) has suggested that markedly different prevalences could point to localised differences in disease ecology across the City, and such variation may have existed between Romano-British communities.

As discussed in relation to periostitis, the possibility that the skeletal samples from London and Gloucester reflect living conditions and population health in earlier periods must again be considered. Some of the enamel defects observed in Romano-British individuals could reflect the survival of episodes of ill-health linked to epidemics, such as the Antonine Plague of AD 165-180, thought to have been an outbreak of smallpox and/or measles (Littman and Littman 1973), and another major epidemic that broke out in *c.* AD 250 (Jackson 1988: 175). In this context, the suggestion that a mass grave at Gloucester may represent a ‘plague pit’ linked to the Antonine Plague may be significant (Simmonds *et al*. 2008: 140-1), although the dating has been questioned (Hurst 2010). Jackson (1988: 174) notes that mortality linked to the Antonine Plague was highest in urban areas, and port cities such as London may have suffered the most (Mattingly 2006: 334). While skeletal lesions cannot, of course, be linked to specific events, and there is no direct evidence that the Antonine Plague itself reached Britain (Mattingly 2006: 334), localised outbreaks of

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[46] The lower prevalence for York may be due to the fact that only incisors and canines were scored for the presence of DEH (Peck 2009: 86).

infectious diseases not documented in the historical sources must occasionally have occurred in towns throughout the Empire (Jackson 1988: 179; Scheidel 2009: 7). In Britain, these may have been more frequent in earlier periods, when the size and density of urban populations was higher. In addition to more frequent outbreaks of infectious disease, urban provincial populations in the later second and third centuries might also have experienced greater levels of psycho-social stress due to the political and economic instability of the period (Bowman 2005), which may have contributed to higher CPRs for stress indicators at London, Gloucester and York.

6.8 Dental disease

6.8.1 *Caries*

The overall crude prevalence of caries was slightly higher for Ancaster, although this is largely due to the smaller number of subadults in the total sample, among whom only one individual exhibited caries. When considered individually, both the subadult and adult CPRs were greater for Winchester, though the difference was not statistically significant. In contrast to the CPR, the TPR was slightly greater for Ancaster than Winchester. The slightly greater TPR for Ancaster adults could indicate that proportionally fewer individuals were affected, but that they tended to have slightly more teeth affected on average. In both study samples, the crude prevalence was higher for females. Several other studies have noted a tendency for females to be more affected by caries (Hillson 2002: 253; Larsen *et al*. 1991: 194-5). This has sometimes been interpreted in terms of gender-based dietary differences, but there are many other factors that could account for higher female prevalences, including differences in tooth enamel composition, earlier age of eruption, pregnancy and breastfeeding, and physiological factors influencing the oral environment (Ferraro and Vieira 2010; Lukacs 2008; Lukacs and Largaespada 2006).

Caries is one category of pathology for which most reports provide data, although it is more typical for caries prevalences to be provided as TPRs, rather than CPRs. Figure 63 compares CPRs and TPRs between populations (see Appendix 6, Table 126 for data). The site with the highest crude prevalence is Dorchester, while Gloucester has the lowest CPR. The highest TPR is reported for Poundbury (15.8%), while Colchester has the lowest TPR (3.9%). No TPR is available for the Western

Cemetery of London, but Conheeney (2000: 283) reported a rate of 7.3% for the Eastern Cemetery. When crude prevalence data are combined, the CPR for the small towns is 60.3% and for the public towns it is 44.8%, and the difference in CPRs is statistically significant (Test 91). The overall TPR for the small towns is 9.1% and for the public towns it is 6.2%. The prevalence rate for the public towns may be an underestimate, as it does not include the Poundbury sample due to the lack of raw data. The age structures of the various populations must be taken into consideration when comparing prevalence data for dental disease. CPRs may decline with age reflecting the impact of AMTL (e.g. Wasterlain *et al.* 2009: 69), and this was observed in both study samples. Unfortunately, as CPRs are unavailable for some sites, it is difficult to assess the potential impact of age structure on prevalences.

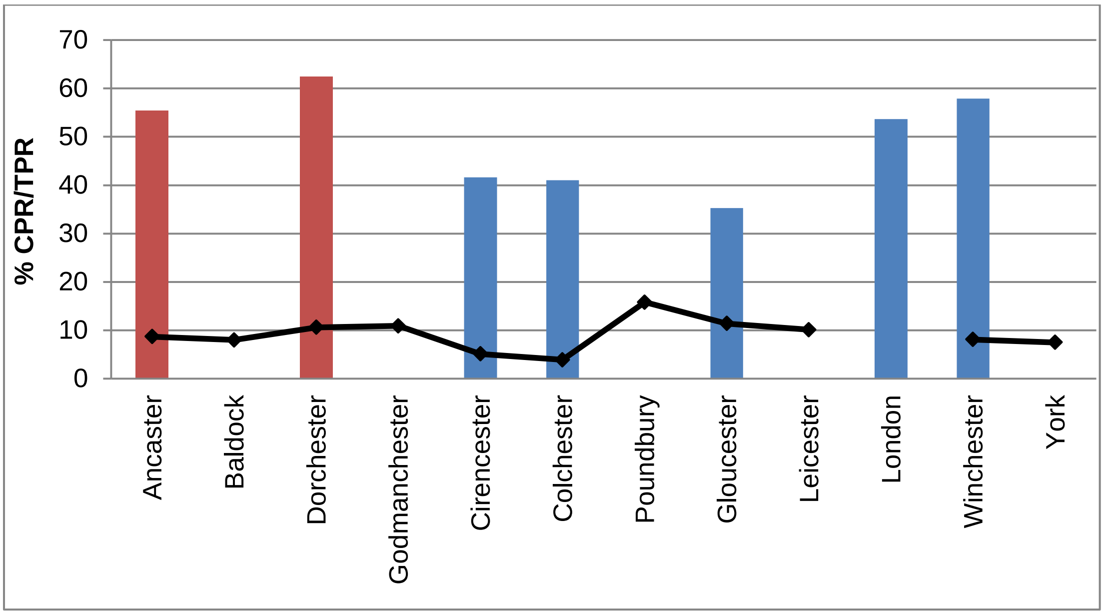

Figure 63. Graph comparing the crude (bar) and true (line) prevalence of caries in Romano-British populations.
(N.B. CPRs/TPRs were not available for all sites.)

6.8.2 *Calculus*

Calculus was more common in the Ancaster sample in terms of both crude and true prevalence rates, although none of the differences were statistically significant. The age-related prevalence of calculus differed slightly between the samples, in that the Ancaster CPR peaked in prime adulthood, declining thereafter, while it peaked in mature adulthood in the Winchester sample. In both samples, the TPR increased between young and mature adulthood, and declined in elderly adulthood. The lower prevalence rates for elderly adulthoods are almost certainly the product of age-related attrition and ante-mortem tooth loss. The pattern of calculus broadly resembles that seen in other ancient and modern populations, corresponding to the location of the salivary glands (Lieverse 1999: 220).

Crude prevalence data are available for few other sites (Figure 64; see Appendix 6, Table 127 for data). The CPRs for Ancaster, Baldock, Cirencester, Gloucester and Winchester are similar, ranging between *c.* 49% and 57%, but the rates for Godmanchester and London are much higher, at 87.1% and 94.4% respectively. Overall, the combined crude prevalence for the small towns is 56.6%, for the public towns it is 57.3%, and the difference is not statistically significant (Test 92). However, comparing rates of calculus between sites is potentially problematic, as preservation of calculus deposits can depend to a great extent on if and how remains are cleaned following excavation. Additionally, repeated handling of remains can dislodge deposits. The higher CPRs for Godmanchester and London may be due to better curation and less handling and/or less vigorous cleaning of the material. Differences in age structure may also account for some of the variation between populations, as the crude prevalence would be expected to increase with age initially.

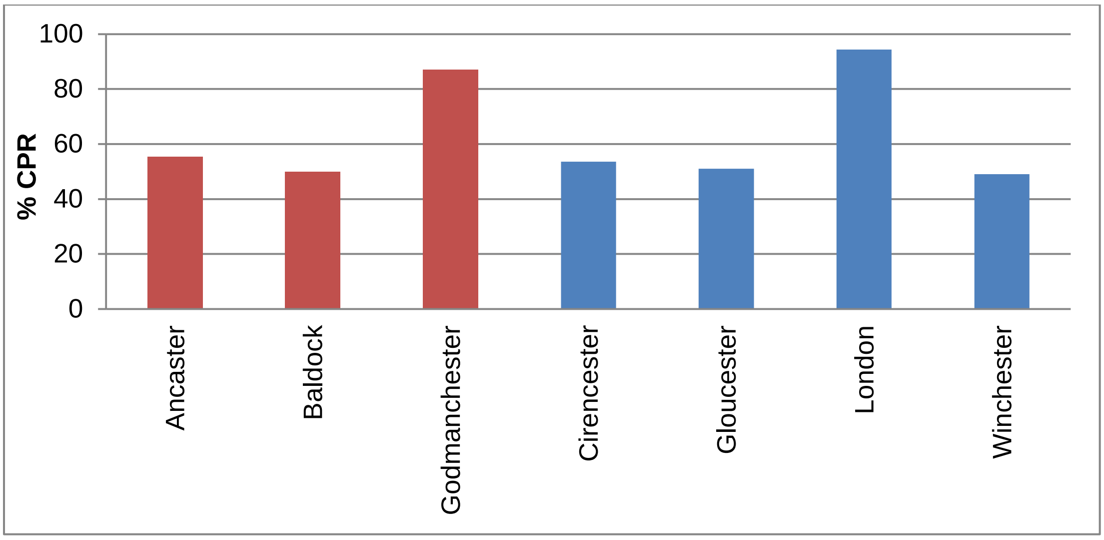

Figure 64. Graph comparing the crude prevalence of calculus in Romano-British populations.

6.8.3 *Periodontal disease*

The prevalence of periodontal disease was significantly higher for the Ancaster sample in terms of both crude and true prevalence, with the Ancaster TPR exceeding the Winchester CPR.

Prevalence data are available for relatively few other sites (Figure 65; see Appendix 6, Table 128 for data). The highest CPR is reported for Baldock, with all surviving maxillae/mandibles exhibiting some level of periodontal disease, the majority of which were said to be affected to a, 'medium or considerable degree' (Roberts 2007: 246). The CPR for Godmanchester is also high, at *c*. 90%. The prevalence for Colchester seems improbably low, and may reflect some difference in diagnosis and/or poor preservation. When data are combined, the overall CPR for the small towns is 67.9% and for the public towns it is 27.9%, and the difference is statistically significant (Test 93). Factors that may have contributed to variations in prevalence between sites include differences in rates of attrition and associated continuous eruption (Whittaker *et al*. 1982), and age-at-death.

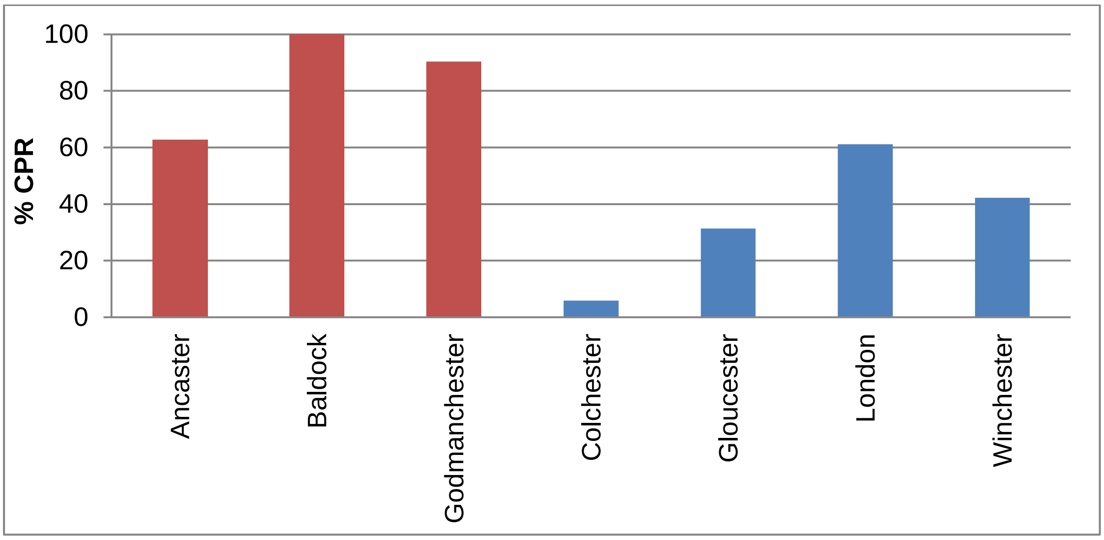

Figure 65. Graph comparing the crude prevalence of periodontal disease in Romano-British populations.

6.8.4 *Peri-apical lesions*

The crude prevalence of peri-apical lesions was greater for the Ancaster sample. The difference between the samples was statistically significant overall, although when CPRs were compared by age group the difference was significant for the unaged category only. The TPR was also slightly higher for Ancaster, although broadly speaking there was little difference between the samples in the proportions of sockets affected. This might indicate that more individuals at Ancaster were affected by peri-apical lesions, but that Winchester adults tended to have more lesions per person. The higher crude prevalence of lesions in the Ancaster sample could also be the result of better preservation, as CPRs were calculated as the percentage of individuals affected with preserved maxillae/mandibles.

Figure 66 compares the prevalences of peri-apical lesions in the study samples with other Romano-British populations (see Appendix 6, Table 129 for data). The highest CPR is reported for Dorchester at 59.0%, followed by Ancaster. The sites with the lowest prevalences are Baldock and Gloucester. Dorchester again exhibits an unusually high TPR of 8.5%, while at all other sites the TPR is equal to or less than 2.5%. The combined CPR for the small towns is 33.9%, for the public towns it is 20.6%, and the difference between settlement categories is statistically significant (Test 94). In comparing prevalence rates, it should be noted that, in the absence of radiography, the presence of lesions can only be determined from the existence of a sinus or fistula (Waldron 2009: 242-3). Where the cranium is intact, lesions draining into the maxillary sinuses may not be visible, therefore the condition of skeletal material may influence prevalences. Once again, differences in the age-structures of samples may account for some of the variation between settlements.

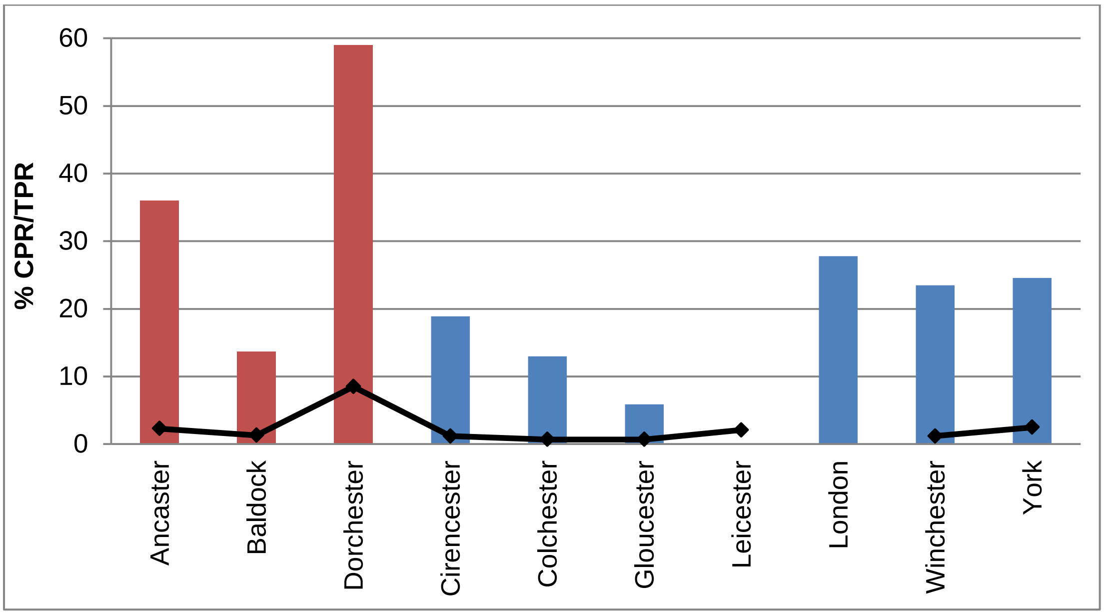

Figure 66. Graph comparing the crude (bar) and true (line) prevalence of peri-apical lesions in Romano-British populations.
(N.B. CPRs/TPRs were not available for all sites.)

6.8.5 *Ante-mortem tooth loss*

Ante-mortem tooth loss was more prevalent in the Ancaster sample in terms of crude prevalence, although the difference between the samples was not statistically significant. The difference was most marked for the mature adult age group, which could indicate that poorer preservation of maxillae/mandibles in the Winchester sample has led to the CPR being under-estimated for this sample, as is probable also the case for peri-apical lesions. The TPR was slightly higher for Winchester. In both samples, the prevalence of ante-mortem tooth loss increased with age, with 96.3% and 100.0% of elderly Ancaster and Winchester adults respectively exhibiting loss of one or more teeth. This is to be expected, given the cumulative effects of attrition, peri-apical lesions, periodontal disease and caries on tooth loss. A number of edentulous or near-edentulous individuals were present in both samples (ANC 54A, ANC 58, ANC 98, ANC 135, ANC 273; VR 36, VR 73, VR 92, NR F393, NR F397, NR F405, CHR 613; see Figure 149).

Figure 67 compares the prevalence of ante-mortem tooth loss between populations (see Appendix 6, Table 130 for data). Ancaster and Dorchester have the highest CPRs at 62.6% and 62.3% respectively. The lowest CPR is reported for Baldock (42.7%), but this was calculated from the total number of individuals present rather than the number with preserved maxillae/mandibles. The highest TPRs are reported for Poundbury and Baldock (22.0% and 19.8% respectively). The combined CPR for the small towns is 55.7%, for the public towns it is 55.3%, and there is no significant difference (Test 95). As AMTL is strongly correlated with increasing age, higher prevalences would be expected for populations with relatively older age profiles. The high CPR for Dorchester seems unlikely to be explained by the age structure of the sample, as this population included relatively more young adults compared to the majority of sites. Conversely, the relatively high TPR for Poundbury could be due, in part, to the presence of more elderly adults (Table 80). The lack of CPR data for some other sites means it is difficult to assess the contribution of age to variations in prevalence in detail.

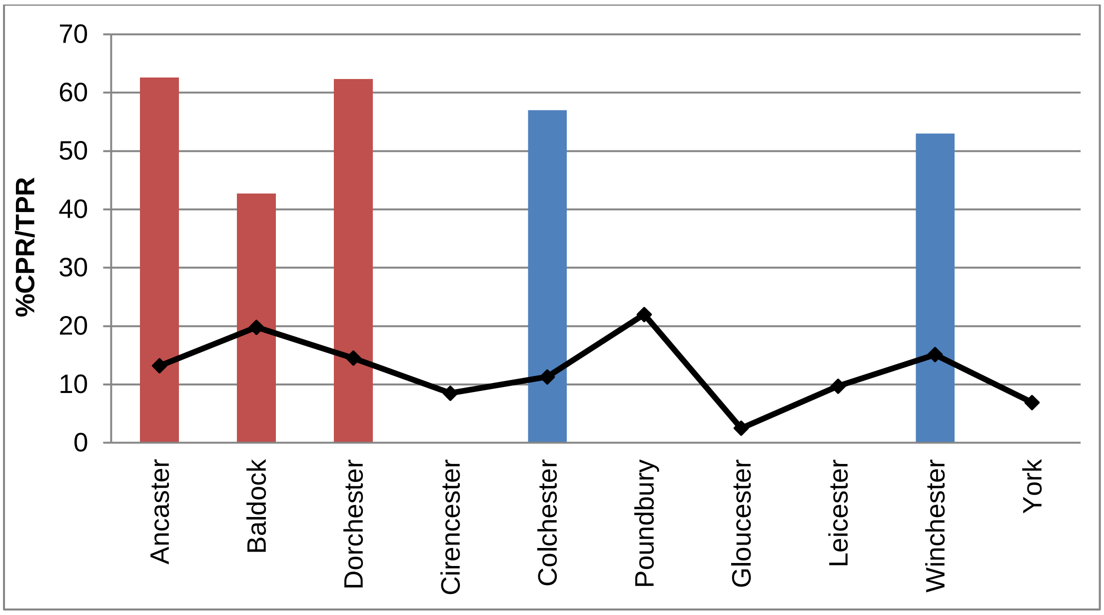

Figure 67. Graph comparing the crude (bar) and true (line) prevalence of ante-mortem tooth loss in Romano-British populations.
(N.B. CPRs/TPRs were not available for all sites.)

6.8.6 *Discussion*

6.8.6.1 Dental disease and diet

Archaeological, historical and isotopic evidence suggest that the Romano-British diet, with its reliance on cereal foods, would have been quite cariogenic, and this is evident in the relatively high crude prevalences for both study samples. Over half of all adults from both sites exhibited at least one carious lesion. A number of researchers have highlighted a peak in caries prevalence in British skeletal populations in the Roman period. Moore and Corbett (1971, 1973) compared caries rates in skeletal material of Iron Age, Roman, Anglo-Saxon and medieval date, and noted a peak in prevalences in the Roman period. A similar study of subadult caries found that rates were higher in Romano-British populations relative to prehistoric and early medieval populations (O'Sullivan *et al*. 1993). Brothwell (1959, 1961) also reported high caries prevalence in Romano-British populations, not surpassed until the seventeenth century. Peck (2009: 166-7) observed an increase in caries between the Iron Age and Roman period in N Yorkshire, and suggested that this pointed to a greater reliance on cereals and decline in meat consumption, although isotopic analysis of Iron Age and Roman individuals from Dorset does not support this argument (Redfern *et al*. 2010). If the increase in caries does not reflect a greater dependency on cereal grains, it may reflect other changes in diet, specifically new cultural trends and greater access to highly-cariogenic foodstuffs. This could include wine, which has high sugar content and is very acidic. Although wine was imported to Britain during the Iron Age as a luxury product (Arnold 2001), consumption expanded in the Roman period, with vines being grown in some regions such as the Nene Valley (Brown *et al*. 2001). The addition of honey and other sweeteners to wine and other foods would have increased the cariogenicity of the diet (Cool 2006: 67-8). Other cariogenic foodstuffs introduced in the Roman period include dates and figs (Cool 2006: 119-24). The fact that dental attrition appears to under-age Roman populations in both Britain (see sections 4.2.3.2.3.2 and 6.1.3.1) and abroad (e.g. Killgrove 2010: 71), could indicate a reduction in the quantities of tough, fibrous foods being consumed, relative to softer, stickier foods, which would also have increased rates of caries (*cf*. Prowse 2011: 416).

If the consumption of wine and stickier food-stuffs, reflecting the Mediterranean influence on diet, largely accounts for the rise in caries in the Roman period, it might be expected that caries rates would be highest at those sites that presumably enjoyed greater access to imported foods, i.e. the public towns (Jones 2004: 185). Comparison of CPRs at public and small towns does not reveal any obvious tendency for the public towns to be more affected, with the highest reported CPR occurring at the small town of Baldock. True prevalence rates also do not differ markedly between sites, with the exception of the unusually high TPR for Poundbury. This could indicate little difference in the composition and cariogenicity of diet at the small towns and public towns. It may also be that higher consumption of cariogenic foods such as wine at the public towns was balanced by a somewhat greater reliance on cereals at small towns. However, it could also be the case that prevalence rates for other sites are not strictly comparable because of variations in methodology. For example, some researchers included subadults in their calculations of TPRs, and the calculation of CPRs varied in terms of whether the total sample size, or number of individuals with surviving dentitions was used as the divisor. Additional problems encountered in comparing caries prevalence rates include the differing age profiles of populations (previously noted, section 6.8.1), and differences in the prevalences of other dental pathology, as caries prevalence may be inter-related with AMTL and attrition (Lukacs 1995; Maat and Van der Velde 1987). Finally, inter-observer error should not be ignored. While developed carious lesions are easily identified, researchers may vary in recognising incipient caries (Liebe-Harkort *et al*. 2010, 2011).

Although there is no overall difference in caries prevalence between site categories, detailed comparison of the Winchester and Ancaster samples does reveal some variations in the pattern and prevalence of caries that could point to subtle differences in the cariogenicity of diet at the two sites. The subadult CPR was higher for Winchester with four subadults exhibiting caries, three of whom were older children with caries at the deciduous molars (VR 39, HYS 8 and AR 304). In the fourth subadult, VR 86 (an adolescent) the permanent first and third molars were affected. The greater prevalence of caries among older children at Winchester relative to other age groups is to be expected, reflecting the longer period over which the deciduous dentition were exposed to the oral environment. Despite the small numbers of individuals affected, the slightly higher prevalence of caries among Winchester subadults could point to a more cariogenic weaning diet. Additionally, if the caries observed developed in the post-weaning period, they might point to a somewhat stickier diet at Winchester. Prowse *et al*. (2008: 305-6) observed caries in Roman children as young as *c.* 2.5 years, and suggested that this could reflect the introduction of cariogenic complementary foods during weaning. The only subadult from Ancaster affected by caries was a young child (ANC 233), who exhibited caries in the majority of the surviving anterior deciduous maxillary dentition. This individual also had unusually severe hypoplastic defects, and the caries were associated with these defects (Figure 148). There is a well-established correlation between caries and hypoplasia, reflecting the increased susceptibility of hypoplastic enamel to carious destruction (e.g. Pascoe and Seow 1994).

Differences in the age-related prevalence of caries may also point to earlier caries development at Winchester. In both samples, there is an overall decline in crude prevalence in mature and elderly adulthood, presumably due to the impact of age-related AMTL (see above, section 6.8.1), but at Winchester, prevalence peaks in prime adulthood, compared to mature adulthood at Ancaster, suggesting an earlier average age of caries formation. The prevalence of peri-apical lesions and AMTL (of which caries are one of the main causes) are also higher among young and prime adults at Winchester. Another possible indicator of earlier caries formation is the greater prevalence of gross destruction of the crown at Winchester, where over a quarter of carious lesions (26.2%) had resulted in complete destruction of the crown, compared to 17.2% at Ancaster.

Some differences between the samples in the patterning of caries were noted. In both samples, the posterior teeth were more affected than the anterior dentition, a trend widely observed due to the fact that food readily accumulates in the occlusal fissures of the premolars and molars (Hillson 2001: 252). Inter-proximal caries were more prevalent at Winchester (18.9% of lesions *vs.* 9.4% at Ancaster), possibly suggesting a greater propensity for foodstuffs to become trapped in the interstitial spaces, and this could reflect more consumption of stickier foods such as honey and fruit syrups. Additionally, the crude prevalences of coronal and CEJ/root caries were relatively similar at Ancaster, while the CPR for coronal caries was twice that of CEJ/root caries at Winchester (e.g. Figure 149). In the case of Ancaster, the higher rate of CEJ/root caries is almost certainly related to the higher rate of periodontal disease, as recession of the gingiva and alveolar margins results in exposure of the CEJ and root to the oral environment (Hillson 2001: 250). The greater predilection for caries to affect the coronal surfaces of teeth at Winchester could again be explained by a stickier diet.

While caries prevalence primarily relates to the carbohydrate content of a diet, calculus is often said to be linked to protein content, due to the influence of protein consumption on oral pH (Lieverse 1999: 224). Some earlier bioarchaeological studies of dental pathology noted a tendency for the prevalence of caries and calculus to be inversely related (Hillson 1979: 150). A number of modern studies have also documented an inverse relationship between caries and calculus (e.g. Duckworth and Huntington 2005), though a review of the bioarchaeological literature found no clear pattern (Lieverse 1999). In the present study, calculus was slightly more prevalent in the Ancaster population, although the difference between the samples was not statistically significant, and many individuals exhibited both caries and calculus (45 individuals from Ancaster and 32 from Winchester). This could point to a lack of dietary differences, but equally it may simply reflect the fact that the relationship between diet and calculus is not straightforward (Lieverse 1999: 224-5). With the exceptions of Godmanchester and London, the crude prevalence of calculus was generally similar for all sites. It seems improbable that the exceptionally high rates of calculus at Godmanchester and London reflect dietary factors; hence, non-dietary factors may have influenced the unusually high prevalences of calculus at these sites (see below, section 6.8.6.2). The possibility that the high CPRs for these sites may also (at least in part) simply represent better preservation of calculus has already been noted.

Although the Romano-British diet may have been somewhat less abrasive relative to earlier periods, in comparison to a modern diet, attrition rates would still have been high owing to the consumption of tough fibrous plants and the presence of inclusions in foodstuffs introduced during food processing. In addition to caries, one of the main causes of peri-apical lesions is exposure of the pulp cavity due to attrition. Peri-apical lesions were more prevalent at Ancaster and other small towns. This could point to a slightly more abrasive diet, although this difference was primarily due to the exceptionally high prevalence of lesions at Dorchester. Peri-apical lesions were significantly more prevalent at Ancaster (particularly in the first molar) despite there being relatively little difference in the crude or true prevalence of caries, which may also suggest that greater rates of attrition at Ancaster are responsible. However, other aspects of the data suggest attrition rates did not differ between the samples, including the fact that both the crude and true prevalence of ante-mortem tooth loss were not significantly different. Rather than being linked to attrition, the higher rate of peri-apical lesions at Ancaster could be due to the greater prevalence of periodontal disease, since peri-apical lesions can also arise directly from infection of the alveolar bone (Dahlén 2002). A relationship between periodontal disease and peri-apical lesions at Ancaster is also suggested by the fact that there is a correlation in the prevalence of these two conditions by tooth position, while at Winchester, they exhibit an inverse relationship. The unusually high prevalence of peri-apical lesions at Dorchester may also be due to high rates of periodontal disease, but no data on this condition were available for the Dorchester population.

6.8.6.2 Non-dietary influences on dental disease

Many factors other than diet influence dental health. This includes other extrinsic variables, such as the composition of drinking water, as well as intrinsic variables relating to age, sex and genetics. One variable known to influence the frequency of caries is fluoride consumption. Fluoride, which is naturally present in certain foodstuffs and water, helps protect against the development of caries through its role in mineralising the hydroxyapatite present in tooth enamel (Simmer and Fincham 1995: 90). Populations living in areas with naturally high fluoride concentrations in ground water (*c.* 1 ppm) have been shown to experience lower caries rates (Edmunds and Smedley 2005: 301-2), and differences in fluoride intake have been suggested as a possible explanation for variations in caries rates between past populations with similar subsistence regimes and diets (e.g. Jakob 2004: 264). Most regions of Britain have sub-optimal fluoride levels (Pye 2004: 230), but this varies greatly within relatively small regions. Fluoride levels also vary between ground water, surface water and rainwater, and change over time (Edmunds and Smedley 2005: 307). For these reasons, it is very difficult to determine whether the populations of Ancaster and Winchester consumed water with optimal fluoride levels. Naturally high fluoride levels occur in a small region of Northern Hampshire, but this does not include the Winchester area. Similarly, some areas in the South Kesteven district of Lincolnshire (where Ancaster is located) have naturally occurring optimal fluoridation (Clarke and Mann 1960), but it is not known if this includes Ancaster itself. In the absence of site-specific data, it is impossible to assess the impact of fluoride intake on dental health in the study samples.

The mineral composition of drinking water can also influence the development of calculus. Calculus forms due to the precipitation of crystals of calcium phosphate and other minerals, thus consumption of water with a high mineral content can increases its formation (Lieverse 1999: 225). Both Winchester and Ancaster are located in ‘hard water’ regions (Drinking Water Inspectorate 2011), but it is possible that some difference in the mineral composition of water at the two sites contributed to the higher CPR for the Ancaster population. Variations in the composition of local drinking water could also account for the unusually high CPRs for calculus at Godmanchester and London. Once again, in the absence of chemical analysis of water samples from the study sites themselves, it is not possible to assess the extent to which water composition influenced calculus rates.

Like calculus, periodontal disease was more prevalent in the Ancaster sample (e.g. Figure 149), and the difference in the overall crude prevalence rates was statistically significant. It is logical to view the higher prevalences of calculus and periodontal disease at Ancaster as linked, since gross supra-gingival calculus deposits can contribute to periodontal disease by causing irritation of the gingiva (Lieverse 1999: 220). Additionally, in both samples, periodontal disease and calculus exhibit a similar age-related prevalence. Despite a similar pattern of tooth involvement in the distribution of calculus in both samples, the pattern of socket involvement in periodontal disease exhibits an almost inverse relationship at the two sites. Additionally, CPRs for periodontal disease were markedly higher at other small towns compared to public towns, yet there was little difference in calculus prevalences between settlement categories. This suggests some other factor is responsible for the higher rates of periodontal disease at Ancaster and other small towns. Although calculus can exacerbate periodontal disease, the condition is ultimately bacterial in aetiology. Factors that influence the development of periodontal disease include immune status (Garcia *et al*. 2000), and several bioarchaeological studies have demonstrated a link between periodontal disease, mortality risk, and stress indicators (DeWitte 2012; DeWitte and Bekvalac 2010, 2011). The high prevalence of periodontal disease at Ancaster and other small towns is thus interesting in light of the fact that CPRs for stress indicators suggest that physiological stress was more prevalent at the public towns. Recent research suggests that psychological stress can also contribute to the development of periodontal disease due to its effect on cortisol levels in saliva (Genco *et al*. 1998). While it might be imagined that the inhabitants of larger urban centres would experience greater social stress (as discussed in relation to violent trauma), it could also be argued that a more agrarian lifestyle would engender greater levels of psychological stress related to pressures associated with meeting requirements for productivity (*cf*. Pitts and Griffin 2012: 272-3).

A final factor that may have influenced differences in dental disease between the study samples is oral hygiene. It is clear from Roman medical texts that poor dental health was a significant problem. Celsus (*On Medicine* 7.12) describes caries, abscesses, calculus and ante-mortem tooth loss, and methods for their management. The extent to which most ordinary people were aware of, or heeded such advice, and the efficacy of any preventative and curative treatments, is difficult to determine. In relation to calculus, the vast majority of calculus deposits observed in both samples were slight. Moderate deposits were relatively more common at Winchester, but gross calculus deposits were rare in both samples. Inter-proximal deposits were only present in the Ancaster sample, which could point to slightly poorer oral hygiene at Ancaster, although the number of individuals affected was very small. In any case, given that calculus can develop in individuals with access to dentistry and practicing good oral hygiene (White 1997), it seems improbable that any attempts to prevent the build-up of plaque (and subsequent mineralisation) would have been particularly effective.

The impact of the intentional extraction of diseased teeth on the prevalence and patterning of caries, abscesses and AMTL in particular should be considered. Celsus (*On Medicine* 6.9 and 6.12) identified caries and abscesses as causes of tooth ache, and described methods for extraction (7.12.1). Excavations in a *taberna* near the Temple of Castor and Pollux in the Forum Romanum at Rome uncovered dozens of carious teeth that had been extracted (Fejerskov *et al*. 2012). It is arguable that the populations of larger towns, such as Winchester, would have had greater access to dental treatments. The extent to which people would have been willing to undergo the extractions and other treatments described is debatable, as Celsus identifies several potential complications, but the evidence for tooth extraction at Rome itself suggests that the pain associated with caries and abscesses was great enough to over-ride any concerns, at least for some people. In the absence of unusual patterns of ante-mortem tooth loss, identifying evidence for tooth extraction in the past is extremely difficult.

7 Conclusions

7.1 Research aim and objectives

The purpose of this study was to provide a bioarchaeological perspective on variations in the health status of populations at major and minor urban centres in Roman Britain through an examination of osteological data. The objectives of the study were four-fold:

1. To generate detailed data on skeletal and dental indicators of health (demography, subadult growth and adult stature, and skeletal and dental pathology) in skeletal populations derived from a public town (Winchester, Hants) and a small town (Ancaster, Lincs) using a standardised recording protocol.
2. To compare and contrast indicators of health between the study samples and utilise statistical tests to identify any significant differences.
3. To collate and compare published data for other public town and small town populations.
4. To apply a biocultural approach in interpreting the results with reference to contextual archaeological and historical evidence for Romano-British settlement and society.

The first objective of the study was achieved by systematically recording detailed data on skeletal and dental pathology at the level of individual elements, joints and teeth, and permitted in-depth analysis of the prevalence and patterning of disease in the study samples. The application of a standardised methodology for determining age-at-death, sex and stature also ensured that the results for each study sample were comparable. This study arguably provides the most detailed analysis of one of the largest excavated skeletal samples from a Romano-British small town yet conducted. Although both samples had previously been analysed to differing degrees by other researchers, re-analysis allowed previously undocumented pathologies to be identified and recorded (e.g. scurvy and possible poliomyelitis at Winchester, and additional possible cases of tuberculosis and rickets at Ancaster).

The second and third objectives addressed the dearth of comparative studies of health in Romano-British populations. To date, no study has compared skeletal samples from major and minor urban centres in detail and this study presents the first detailed comparison of cemetery populations from a public town and small town carried out by a single researcher. Several problems were encountered in collating and comparing published data for contemporaneous populations, such as small sample sizes and incompatible data. Despite these difficulties, comparisons with other sites broadly corroborated the findings of the original analysis.

The fourth and final study objective – the application of a biocultural approach – allowed the osteological evidence to be situated within its cultural and historical context. Taken in isolation, skeletal and dental indicators of health are potentially open to paradoxical interpretations, but careful consideration of the archaeological setting of the study samples aided interpretations of the data. The chronological distribution of inhumation burials in Roman Britain is such that the study samples and comparative populations are primarily of late date, which could be seen as a limitation. However, in another sense, this also provided a greater degree of chronological resolution and permitted more meaningful interpretations of the data as they relate to lifestyle and settlement environment.

7.2 Summary of key findings

The osteological analysis generated a substantial quantity of data. Due to the sometimes ambiguous nature of osteological evidence, some of the findings remain open to interpretation. However, the key findings and conclusions of the study can be summarised as follows:

Lifestyle and activity:

- Higher prevalences of osteoarthritis and intervertebral disc disease at Ancaster (and other small towns) and differences in the patterning of joint involvement can be interpreted as pointing to the Ancaster population having engaged in more frequent and/or extended periods of heavy labour. This is consistent with the communities in small towns having followed a more agrarian way of life.

- The pattern of long bone trauma observed in the Ancaster sample resembles that seen in other skeletal populations from later rural contexts, providing further support for a more agrarian life-way at this site. Other small towns and public towns also exhibit differing patterns of long bone trauma

Diet and nutrition:

- Scurvy was observed in the Winchester sample only. All other reported cases derive from public towns, possibly pointing to dietary stress, higher-pathogen load and/or the adoption of 'Romanised' infant feeding practices at the public towns.
- Slight differences in the patterning and age-related prevalence of caries between the samples could point to a marginally more cariogenic diet at Winchester, although the differences were not pronounced.

Settlement environment:

- More potential evidence for violent trauma was observed in the Winchester sample, as were fractures indicative of high-energy trauma. This could be explained with references to greater levels of social stress and inequality among the civilian populations of the public towns, although some injuries could reflect more widespread political instability and, in the case of males, injuries sustained by soldiers.
- Prevalence rates for tuberculosis were broadly similar, suggesting there was little difference between the sites in factors known to influence the transmission of TB, such as population density, housing, contact with infected livestock, and connectivity and population mobility.
- Higher prevalences of three general stress indicators at Winchester (cribra orbitalia, porotic hyperostosis and dental enamel hypoplasia) point to greater levels of physiological stress at public towns, possibly reflecting less sanitary living conditions and/or higher levels of nutritional stress.

In certain respects, the results of the original analysis and review of published data suggest that differences in health status between the populations of small towns and public towns were relatively minor. Nevertheless, some significant differences were observed, pointing to broad variations in lifestyle, diet and settlement environment. The findings are consistent with existing perspectives on public and small towns in Roman Britain regarding their socio-economic characters and functions within the settlement hierarchy. The results of the study are of broader relevance to the topic of urbanism in Roman Britain in two respects. Firstly, the findings provide a more nuanced view of the negative impact of urbanism on population health, and the view that habitation in large towns was inversely correlated with health status (*cf.* Redfern and Roberts 2005) is only partially substantiated. Secondly, the evidence for the existence of differences in lifestyle, diet and settlement environment between the public towns and small towns in the later third and fourth centuries is of interest regarding the issue of urban decline in the later Roman period, in that it points to the public towns having retained a distinct socio-economic character down to a relatively late date.

7.3 Limitations of the study

All bioarchaeological studies are affected by a number of generic limitations arising from intrinsic sample biases, incomplete preservation of skeletal remains, the osteological invisibility of many diseases (especially infectious diseases), limits on diagnosis, and the problems of the ‘osteological paradox’ (Ortner 2012; Wood *et al*. 1992). Molecular analysis and radiography may aid in the identification and diagnosis of pathology, but can rarely be applied to large skeletal samples as they are time consuming and (in the case of the former) destructive.

In addition to generic problems encountered in the study of human remains, there are a number of limitations specific to the study of Romano-British inhumation populations. Throughout this study, it has been assumed that the majority of individuals interred in the cemeteries at Ancaster and Winchester lived and worked in the settlements, but some individuals may have been migrants from the countryside. Additionally, it is possible that people living in surrounding rural communities were interred in the cemeteries of nearby towns. In the case of the *civitas* capitals in particular, it has been suggested that public towns provided a focus for burial among the wider community (Millett 1990: 142). There is no reliable way to differentiate the burials of people who actually lived in or around a town, from those of individuals inhabiting surrounding rural communities whose relatives chose to inter them in the cemetery of the nearest town (Esmonde Cleary 1992b; Pearce 1999a: 169). The extent to which populations from different towns are comparable in terms of socio-economic composition is uncertain, and it is possible that some cemetery assemblages include relative more lower or high status individuals than others. Finally, the chronological bias of Romano-British inhumation cemeteries to the later third and fourth centuries means the results of the present study may not reflect patterns of health in earlier periods. The possibility that high prevalence rates of stress indicators at some sites (London, Gloucester and York) could reflect population dynamics and settlement environments in earlier periods was raised. Unfortunately, the absence of substantial numbers of inhumation burials pre-dating the later third century at the great majority of sites makes assessment of secular trends very difficult.

7.4 Recommendations for future research

Much of our current knowledge of Romano-British populations is based on a relatively small number of sites, in particular Poundbury, while other large assemblages (e.g. Cirencester and Colchester) have not been subject to the same degree of re-examination. Given that it is unlikely that further, large skeletal samples will be excavated in the near future, it is important that greater use be made of existing skeletal collections (Roberts and Mays 2011).

Incompatibilities in the work of different researchers hinder broader syntheses of health status in Romano-British populations. Despite recent progress in developing basic guidelines for osteological analysis and reporting (e.g. Brickley and McKinley 2004), greater standardisation in methods of ageing, diagnosis and data presentation is necessary (Falys and Lewis 2011; Stodder 2012; Waldron 2009). This will not, however, address existing limitations. Ideally, future studies of population health status in Roman Britain would include re-examination of older collections in accordance with modern standards, though this may be impractical from a time/cost perspective. A more realistic approach would be to adopt one of the following strategies: (1) examine a restricted number of indicators of health that can be recorded in large skeletal samples relatively rapidly (e.g. cribra orbitalia, hypoplasia; *cf*. Steckel *et al*. 2002); (2) conduct detailed re-examination of sub-samples of the larger skeletal samples.

The present study has provided an insight into variations in the health status of urban populations in Roman Britain according to broad differences in political status and socio-economic character. However, other variables remain to be explored. For example, archaeological evidence points to broad geographic differences in settlement and society in Roman Britain (*cf*. Reece 1992; Sargent 2002), and the possibility of north-south or east-west divides in urban (and general) population health status, reflecting differing regional histories and landscapes, should be examined. In the future, further integration of osteological, archaeological and historical evidence will contribute new insights into the varied experiences of the people of Roman Britain.

Variations in the Health Status of Urban Populations in Roman Britain: A Comparison of Skeletal Samples from Major and Minor Towns

Volume 2 of 2

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Journal title abbreviations follow the National Library of Medicine (http://www.ncbi.nlm.nih.gov/nlmcatalog/), with the exception of some archaeology, Classics and ancient history journals, which are abbreviated according to L'Année Philologique (http://www.annee-philologique.com//files/sigles_fr.pdf) as follows:

AJ	Archaeological Journal
AJA	American Journal of Archaeology
AJPh	American Journal of Philology
ANRW	Aufstieg und Niedergang der römischen Welt: Geschichte und Kultur
Ant J	Antiquaries Journal
AR	Archaeological Reports
BASO	Bulletin of the American Schools of Oriental Research
C Arch J	Cambridge Archaeological Journal
CJ	Classical Journal
CQ	Classical Quarterly
G&R	Greece and Rome
Historia	Historia: Zeitschrift für Alte Geschicht
JFA	Journal of Field Archaeology
JRA	Journal of Roman Archaeology
JRS	Journal of Roman Studies
MEFRA	Mélanges de l'École Française de Rome: Antiquité
OJA	Oxford Journal of Archaeology
PBSR	Papers of the British School at Rome

Other abbreviations used are as follows:

AE	Archaeologia Aeliana
BAR	British Archaeological Reports
CAH	The Cambridge Ancient History
CBA	Council for British Archaeology
DAJ	Derbyshire Archaeological Journal
EMAB	East Midlands Archaeological Bulletin
MoL	Museum of London
PHFCAS	Proceedings of the Hampshire Field Club and Archaeological Society
RIB	Roman Inscriptions of Britain (Collingwood and Wright 1965)
SxAC	Sussex Archaeological Collections
TLMAS	Transactions of the London and Middlesex Archaeological Society
WANHM	Wiltshire Archaeological and Natural History Magazine

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Appendices

Appendix 1. Cemetery Plans

Figure 68. Plan of burials in the Roman cemetery at Ancaster.
(From excavation archive; provided by A. Doherty.)

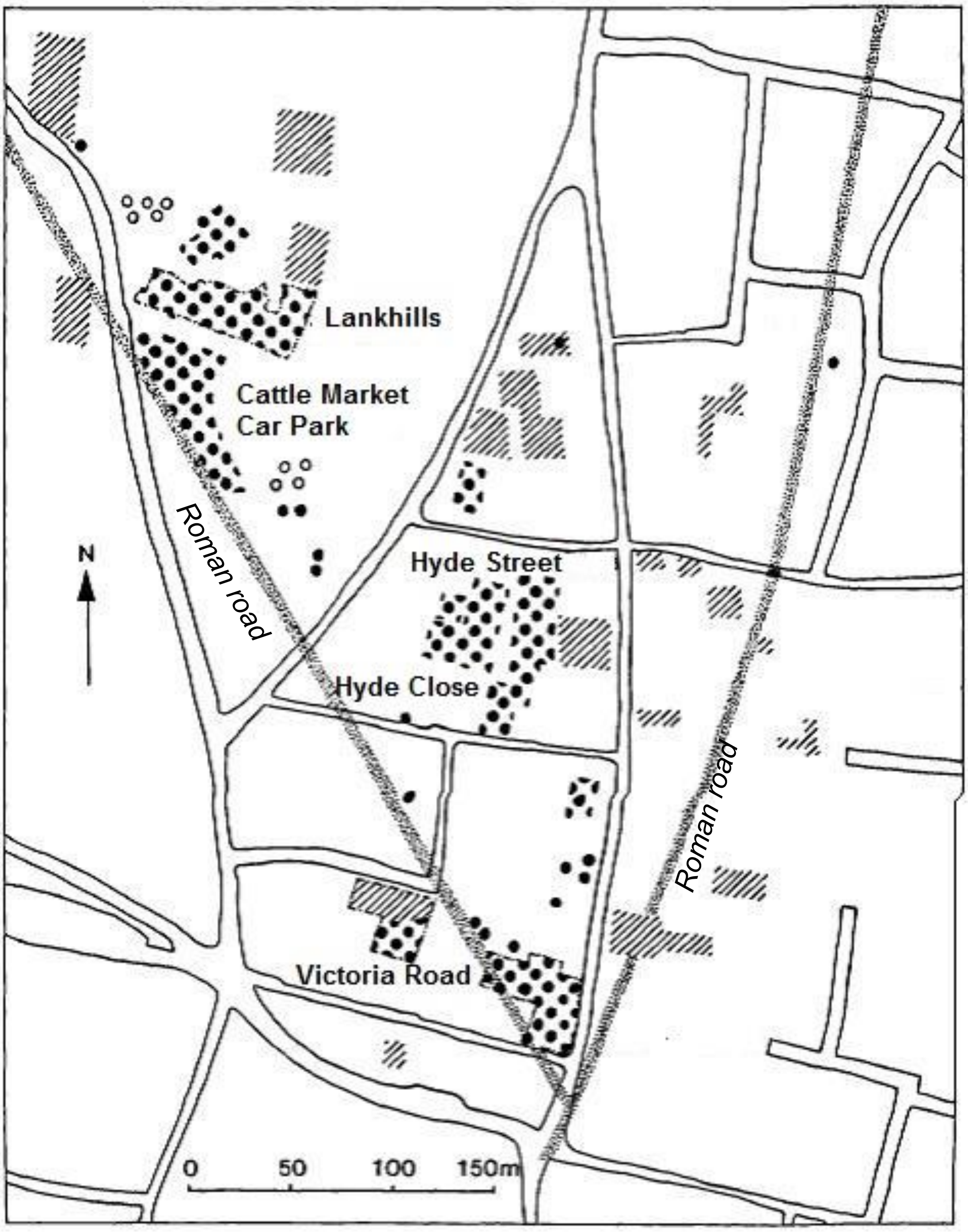

Figure 69. Plan showing the location of excavations in the Northern Cemetery of Winchester (adapted from Pearce 1999a).

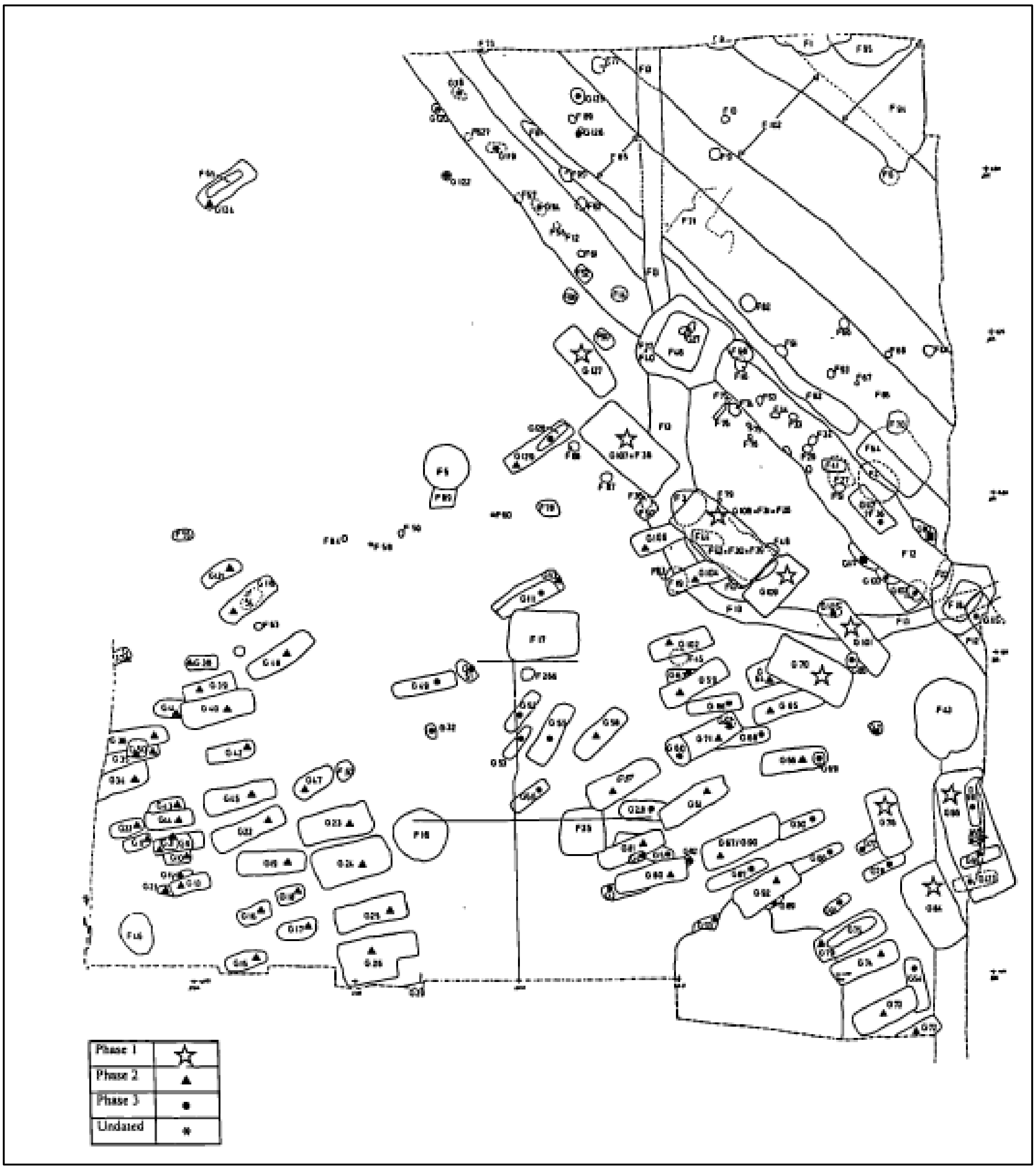

Figure 70. Plan showing the layout and phasing of burials at Victoria Road, Winchester (adapted from Pearce 1999a).

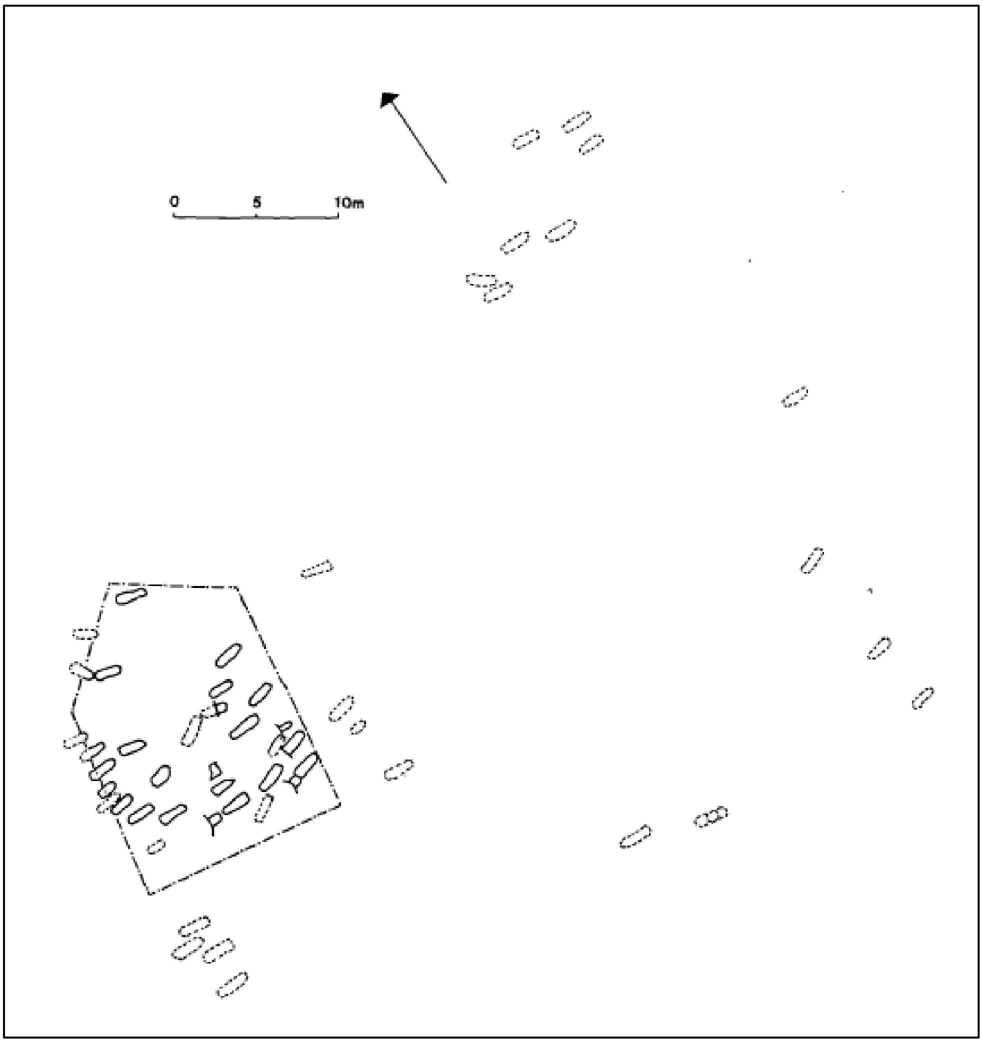

Figure 71. Plan showing the locations of late Roman burials at Hyde Street, Winchester (adapted from Pearce 1999a).

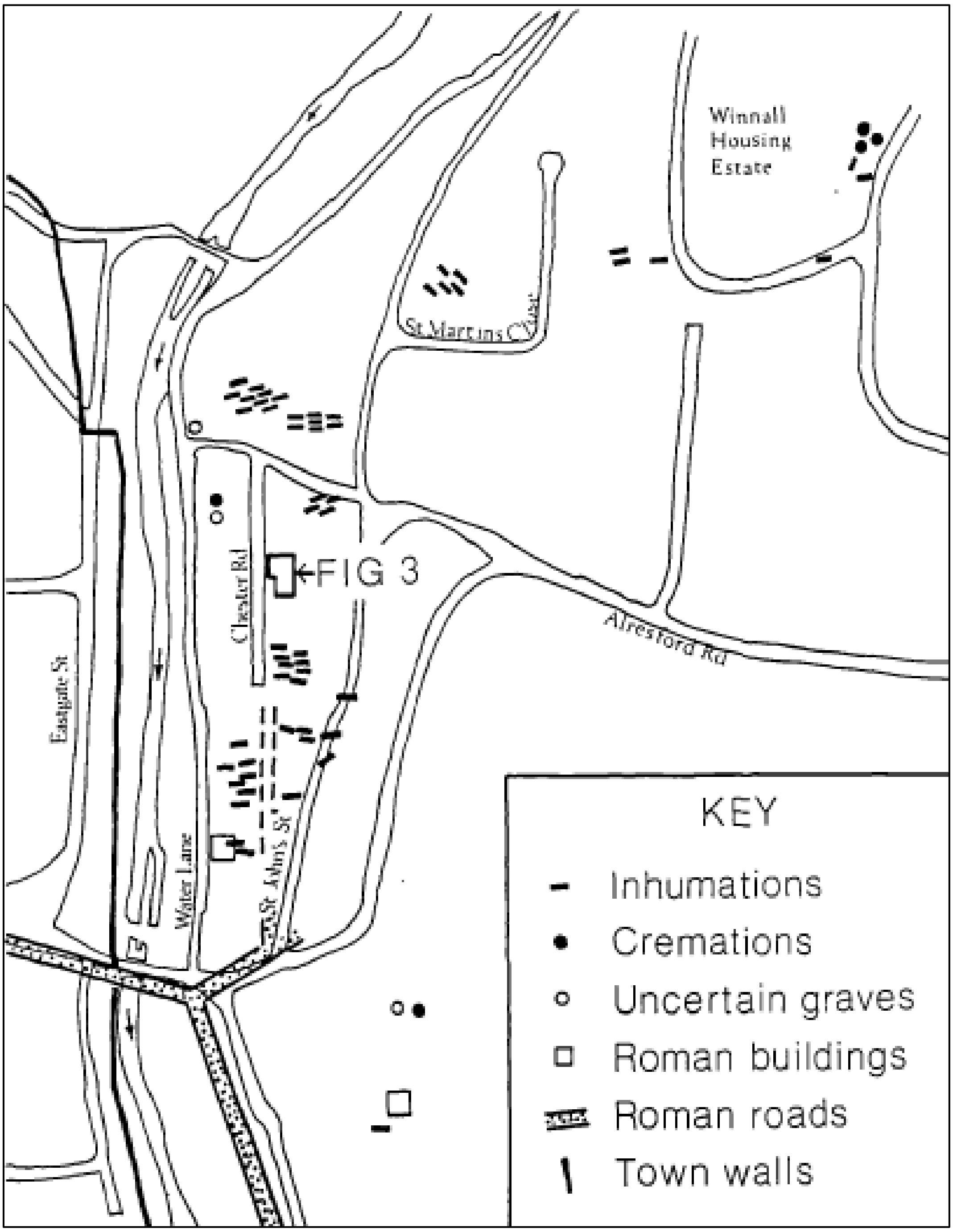

Figure 72. Plan showing the locations of excavations in the Eastern Cemetery of Winchester (adapted from Pearce 1999a).

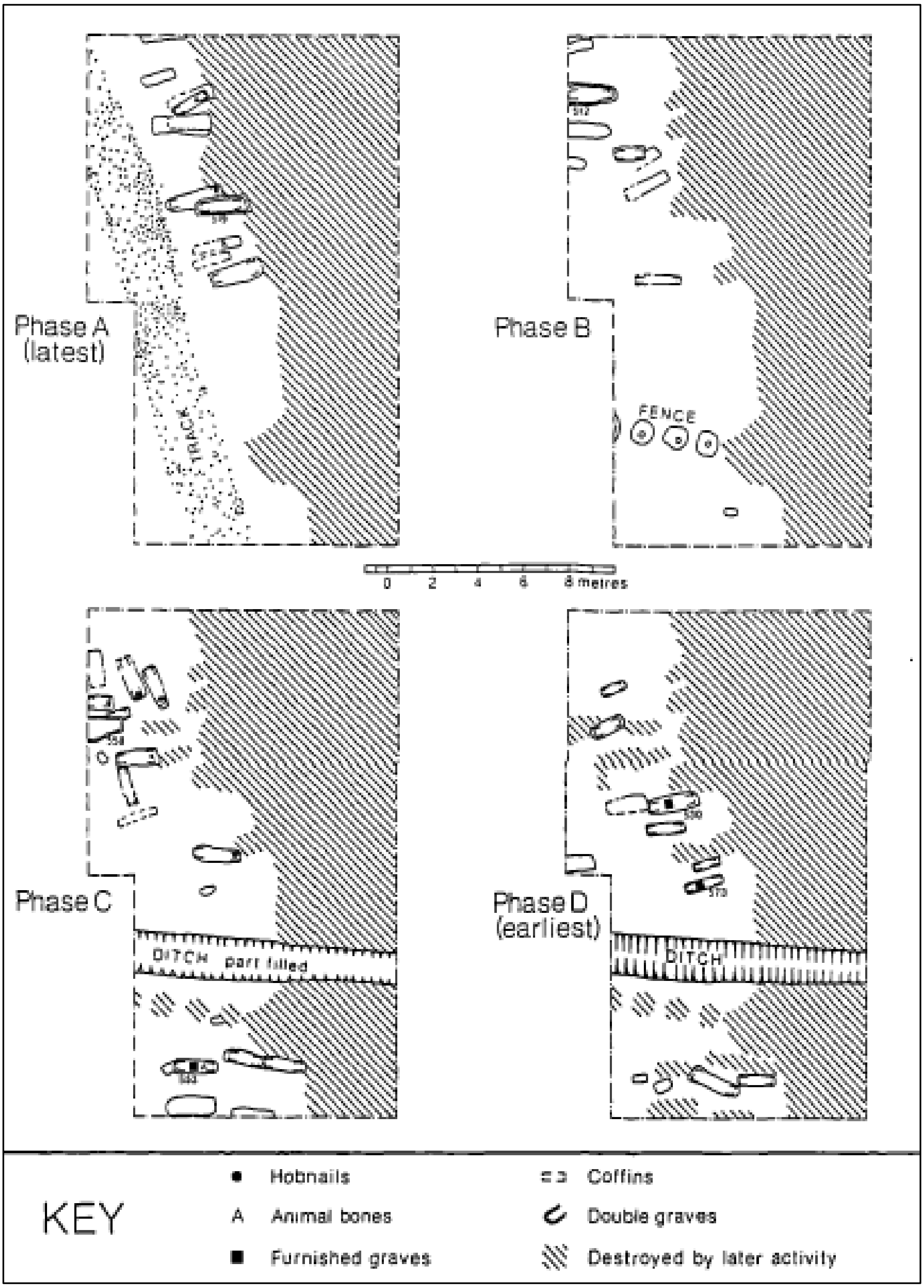

Figure 73. Plan showing the layout and phasing of burials at Chester Road, Winchester (adapted from Pearce 1999a).

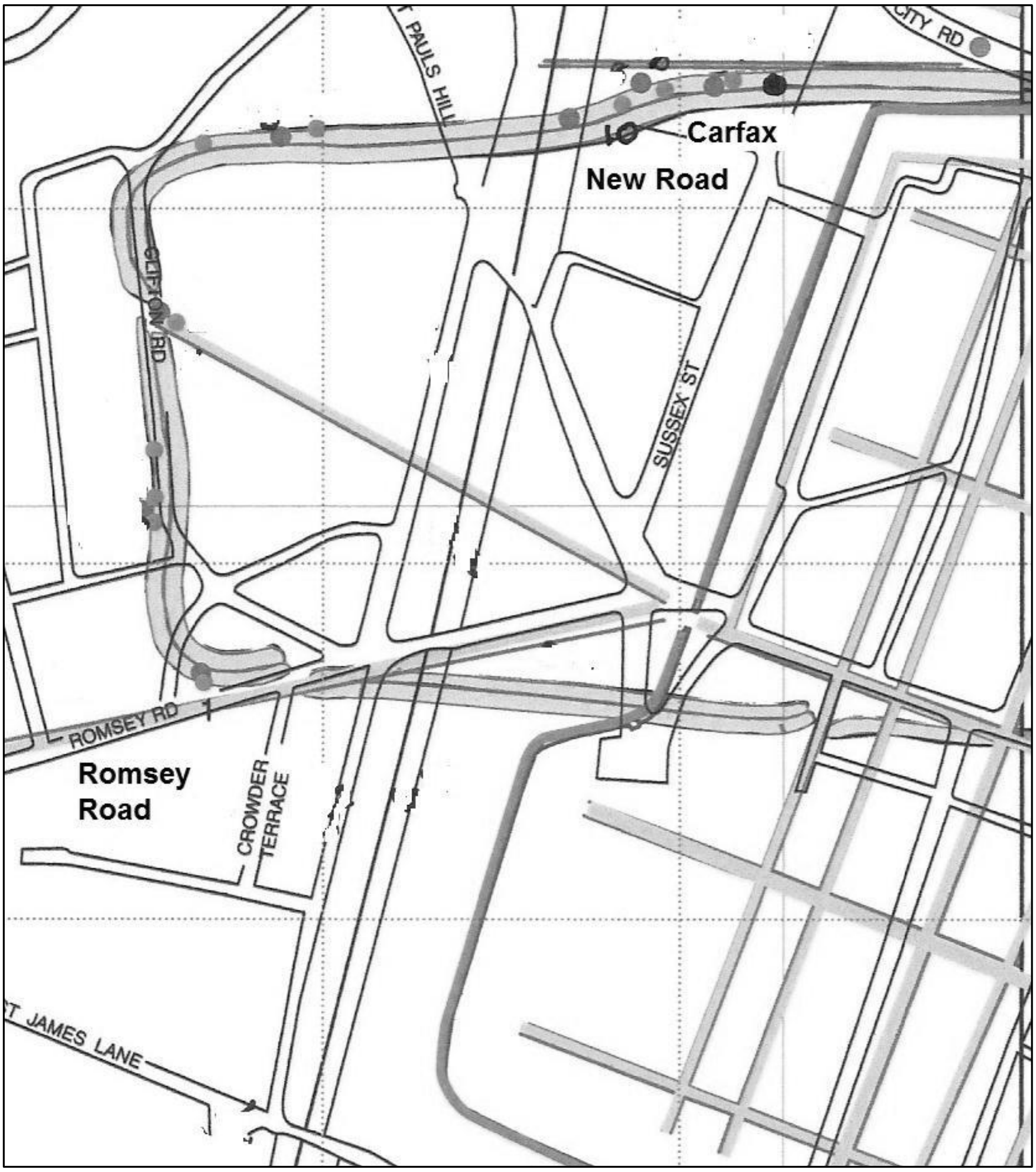

Figure 74. Plan showing the locations of sites in the Western Cemetery of Winchester (provided by H. Rees, Winchester Museums Service).

Appendix 2. Supporting Information for Methodology

Table 83. Skeletal inventory system.
(N.B. Text in brackets [ ] indicates modifications for the recording of subadult skeletons.)

Skull	**Recording Protocol**	**Element 'Present'**
Frontal	Squamous portion; R and L orbits	Squamous ≥50%
Parietals	Recorded as single elements	≥50%
Occipital	Supraocciput; R and L exocciput; basiocciput	Supraocciput ≥50%
Sphenoid	Recorded as a single element	≥50%
Ethmoid	Not recorded	-
Lacrimal	Not recorded	-
Vomer	Not recorded	-
Hyoid	Not recorded	-
Zygomatic	Recorded as single elements	≥50%
Nasals	Recorded as single elements	≥50%
Auditory ossicles	Not recorded	-
Maxillae	Recorded as single elements	≥50%
Mandible	R and L body; R and L condyles [R and L body]	≥50%
Post-cranium	**Recording Protocol**	**Element 'Present'**
Vertebrae	Complete; isolated centra; isolated neural arches, identified to position, otherwise, number present noted [Number complete, isolated centra, isolated neural arches]	≥50%
Sacrum	First to fifth sacral bodies; R and L auricular surfaces [First to fifth sacral segments]	≥50%
Coccyx	Not recorded	-
Sternum	Manubrium; corpus; xiphoid process [Manubrium, sternebrae 1 to 4]	Corpus ≥50%
Ribs	Number of R and L vertebral ends, sternal ends and shaft fragments [Number complete ribs/rib heads]	-
Clavicles	Medial 1/3, mid 1/3 and lateral 1/3 [Recorded as single elements]	At least two segments ≥50%
Scapulae	Glenoid cavity; coracoid process; acromion; superior border; medial border; lateral border [Recorded as single elements]	At least three segments ≥50% including one infraspinous
Pelves	Ilium; ischium; pubis; auricular surface; acetabulum [Ilium, ischium, pubis]	At least three segments ≥50%
Long bones	Proximal joint surface; distal joint surface; proximal 1/3 shaft, middle 1/3 shaft; distal 1/3 shaft [Proximal epiphysis, diaphysis, distal epiphysis]	At least three segments ≥50%
Carpals/ metacarpals	Each recorded as a single element [Number present]	≥50%
Patellae	Recorded as single elements	≥50%
Tarsals/ metatarsals	Each tarsal recorded as a single element [Number present]	≥50%
Phalanges	Identified as hand or foot phalanges, and proximal, intermediate or distal, unsided [Number present]	≥50%

Table 84. Dental notation system for identifying tooth/socket position.
(NB. L/l=left; R/r=right; After Schaefer *et al*. 2009: 68.)

Permanent (Adult) Dentition				**Deciduous (Subadult) Dentition**			
Upper	**Code**	**Lower**	**Code**	**Upper**	**Code**	**Lower**	**Code**
R M^3	1	L M$_3$	17	r m^2	A	l m$_2$	K
R M^2	2	L M$_2$	18	r m^1	B	l m$_1$	L
R M^1	3	L M$_1$	19	r c	C	l c	M
R PM^2	4	L PM$_2$	20	r i^2	D	l i$_2$	N
R PM^1	5	L PM$_1$	21	r i^1	E	l i$_1$	O
R C	6	L C	22	l i^1	F	r i1	P
R I^2	7	L I$_2$	23	l i^2	G	r i$_2$	Q
R I^1	8	L I$_1$	24	l c	H	r c	R
L I^1	9	R I$_1$	25	l m^1	I	r m$_1$	S
L I^2	10	R I$_2$	26	l m^2	J	r m$_2$	T
L C	11	R C	27				
L PM^1	12	R PM$_1$	28				
L PM^2	13	R PM$_2$	29				
L M^1	14	R M$_1$	30				
L M^2	15	R M$_2$	31				
L M^3	16	R M$_3$	32				

Table 85. Dental notation system for recording presence/absence.

Presence/Absence	**Notation**
Tooth and socket present	TS
Socket present, tooth lost post-mortem	PM
Socket present, tooth lost ante-mortem	AM
Socket present, tooth congenitally absent	CA
Tooth present, socket absent	T
Socket present, tooth unerupted/partially erupted (deciduous dentition)	NE
Tooth and socket absent	X

Table 86. Sectioning points for the determination of sex from post-cranial metrics.
(N.B. F?/M?=probable female or male.)

Measur-ement*	**Mean**		**Sectioning Point**					
	F	**M**	**SP**	**Overlap**	**F**	**F?**	**M?**	**M**
Glenoid length	34.8	39.6	37.2	33.1-42.0	<33.1	33.1 - 37.2	>37.2 - 42.0	>42.0
HuHD	40.5	46.4	43.5	41.1-47.4	<41.1	41.1 - 43.5	>43.5 - 47.4	>47.4
HuE1	55.4	64.1	59.8	53.3-65.1	<53.3	53.3 - 59.8	>59.8 - 65.1	>65.1
FeHD	41.6	47.9	44.8	41.9-47.5	<41.9	41.9 - 44.8	>44.8 - 47.5	>47.5
FeE	72	81	76.5	71.3-78.9	<71.3	71.3 - 76.5	>76.5 - 78.9	>78.9
FeC	80.2	91	85.6	75.0-92.0	<75.0	75.0 - 85.6	>85.6 - 92.0	>92.0
TiE	67.2	75.4	71.3	64.6-77.4	<64.6	64.6 - 71.3	>71.3 - 77.4	>77.4
TiDist	44.5	49	46.8	42.7-50.9	<42.7	42.7 - 46.8	>46.8 - 50.9	>50.9
TiCirc	84	97.3	90.7	81.0-103.0	<81.0	81.0 - 90.7	>90.7 - 103.0	>103.0

*HuHD=vertical diameter of humeral head; HuE1=distal humerus epicondylar breadth; FeHD=maximum diameter of femoral head; FeE=distal femur condylar breadth; FeC=maximum circumference of femur at mid-shaft; TiE=maximum proximal breadth of tibia; TiDist=maximum distal breadth of tibia; TiCirc=maximum tibia circumference at nutrient foramen.

Table 87. Regression equations for estimating perinatal age-at-death (Scheuer *et al.* 1980).

Element	**Regression Equation**
Humerus	Age = (0.4585 x humerus length) + 8.6563 ±2.33
Radius	Age = (0.5850 x radius length) + 7.7100 ± 2.29
Ulna	Age = (0.5072 x ulna length) + 7.8208 ± 2.20
Femur	Age = (0.3303 x femur length) + 13.5583 ±2.08
Tibia	Age = (0.4207 x tibia length) + 11.4724 ± 2.12

Table 88. Subadult age estimates based on dental development and eruption (after Gustafson and Koch 1974, reproduced in White and Folkens 2005).
(N.B. m=months; all other ages are in years.)

	Age (Months/Years)							
	Mineralisation		**Crown Complete**		**Eruption**		**Completion of Root**	
	Mean	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
i^1	Foetal	-	3m	2-4m	8.75m	6-11m	1.5	1.5-2
i^2	Foetal	-	4m	2-4.5m	11.5m	6-12m	1.75	1.5-2
c	Foetal	-	9m	8.5-9.5m	1.5	1-1.75	3	2.75-3
m^1	Foetal	-	6m	5.5-7m	1.25	1-1.5	2.5	2-2.5
m^2	Foetal	-	10.5m	10-12m	2	1.75-2.5	3	2.75-3
i_1	Foetal	-	3.5m	2-4m	7m	4-10m	1.75	1.5-2
i_2	Foetal	-	4.2m	2.5-4.5m	11.5	5.5m-1	1.75	1.5-2
c	Foetal	-	8.75m	7.5-9.25m	1.5	1-1.75	3.25	2.5-3.5
m_1	Foetal	-	6m	5.25-7m	1.25	1-1.25	2.25	1.75-2.5
m_2	Foetal	-	10.5m	10-12m	2.25	1.5-2-5	3	2.75-3
I^1	3.5m	3-4m	4.5	4-5.25	7.75	5.5-8.5	10	9-11
I^2	11m	10-12m	5	4-5.5	8	6.5-10	11	10-12
C	4.5	4-5	6.25	5.5-7	11.5	8-12	14	12-14
PM^1	1.75	1.25-1	6	5-7.5	10.5	8-12	13	12-14.25
PM^2	2	2-3	7	6-8.5	12.5	9-14	14	12-15.5
M^1	0	0	3	2.5-4.5	6.5	5-7	10	9-11.5
M^2	2.75	3-4	7.75	7-8	12.5	10-14	15	14-16
M^3	9.5	8-11	13	11.75-14.75	18	17.25+	-	-
I_1	3.75m	3-4m	4	3.5-5	6.75	5-7.5	9	8.5-10
I_2	3.5m	3-4m	4.5	4-5	7.75	6-9	10	9.75-11
C	4.75m	4-5m	6.25	4.25-7	10.5	7.5-12	14	12-15
PM_1	1.75	1.5-2	6	4.5-7	10.5	8-13	13	12-14
PM_2	2.25	2-2.5	7	6-8	11.5	9-12.25	13.5	12-15
M_1	0m	0	3	2.5-4	6.25	5-7	10	9-11.5
M_2	2.25	2.5-3	7.5	6.25-8	12	10-13.5	15	13.5-16.25
M_3	9.5	9-10.75	13.25	12-13.75	18.5	17.5+	-	-

Table 89. Subadult age estimates based on epiphyseal fusion (after Schaefer *et al.* 2009).

Element	**Location**	**Age of Fusion (Range/Minimum)**
Frontal	Metopic suture	2-4 yrs
Occipital	Fusion of supraocciput and exoccipitals	1-3 yrs
Sphenoid	Greater wings and body	1 yr
Mandible	Mandibular symphysis	1 yr
Cervicals	Neural arch	2 yrs
	Neurocentrum	4 yrs
Thoracics	Neural arch	2 yrs
	Neurocentrum	6 yrs
Lumbars	Neural arch	5 yrs
	Neurocentrum	5 yrs
Sacrum	All elements	14 yrs
Scapula	Coracoid process	16 yrs
	Glenoid	18 yrs
Pelvis	Tripartite fusion	11 yrs
Humerus	Proximal epiphysis	14-21 yrs
	Distal epiphysis: medial epicondyle	13-18 yrs
	Distal epiphysis: trochlea	11-18 yrs
Radius	Proximal epiphysis	12-18 yrs
	Distal epiphysis	14-20 yrs
Ulna	Proximal epiphysis	12-18 yrs
	Distal epiphysis	15-20 yrs
Femur	Proximal epiphyses	14-19 yrs
	Distal epiphysis	14-20 yrs
Tibia	Proximal epiphysis	14-18 yrs
	Distal epiphysis	14-20 yrs
Fibula	Proximal epiphysis	14-20 yrs
	Distal epiphysis	14-20 yrs
Hands	Fusion of MCs	16.5 yrs
Feet	Fusion of MTs	16 yrs

Table 90. Subadult metrics (after Schaefer *et al.* 2009).

Element	**Sub-Element**	**Measurement**	**Description**	**Schaefer *et al.* code**
Occipital	Pars basilaris	Maximum width	Greatest distance measured in the line of the lateral angles	p. 9, no. 1
		Sagittal length	Midline distance between the foramen magnum and synchondrosis spheno-occipitalis	p. 9, no. 2
		Maximum length	Maximum distance between the posterior edge of the lateral condyle and synchondrosis spheno-occipitalis	p. 9, no. 3
	Pars lateralis	Maximum length	Greatest distance between the anterior and posterior inter-occipital synchondroses	p. 9, no. 4
		Maximum width	Greatest distance between the medial and lateral margins of the posterior inter-occipital synchondroses	p. 9, no. 5
Temporal	Pars petrosa	Length	Maximum anterior-posterior distance across bone	p. 21, no. 4
		Width	Maximum distance at right angles to length across arcuate eminence	p. 21, no. 5
Clavicle	Diaphysis	Diaphysis length	Maximum length	N/A
Scapula	N/A	Glenoid length	Maximum distance between the superior and inferior borders of the glenoid articular surface	p. 155, no. 1
		Scapula width	Maximum distance between the glenoid fossa and the medial end of the spine	p. 155, no. 5
		Scapula length	Distance between the superior and inferior angles of the scapula	p. 155, no. 6
Pelvis	Ilium	Length	Greatest distance between the anterior and posterior superior iliac spines	p. 240, no. 1
		Width	Greatest distance between the mid-point of the iliac crest and the convexity of the acetabular extremity	p. 240, no. 2
	Ischium	Length	Greatest distance between the convexity of the acetabular extremity and the tip of the ischial ramus	p. 240, no. 3
Humerus	N/A	Diaphysis length	Maximum length	N/A
Radius	N/A	Diaphysis length	Maximum length	N/A
Ulna	N/A	Diaphysis length	Maximum length	N/A
Femur	N/A	Diaphysis length	Maximum length	N/A
Tibia	N/A	Diaphysis length	Maximum length	N/A

Table 91. Adult cranial and mandibular metrics (after Buikstra and Ubelaker 1994: 74-8).

Element	**Measurement**	**Buikstra and Ubelaker Code**
Cranium	Maximum length	1
	Maximum breadth	2
	Bizygomatic diameter	3
	Basion-bregma height	4
	Cranial base length	5
	Basion-prosthion length	6
	Maxillo-alveolar breadth	7
	Maxillo-alveolar length	8
	Biauricular breadth	9
	Upper facial height	10
	Minimum frontal breadth	11
	Upper facial breadth	12
	Nasal height	13
	Nasal breadth	14
	Orbital breadth	15
	Orbital height	16
	Biorbital breadth	17
	Inter-orbital breadth	18
	Frontal chord	19
	Parietal chord	20
	Occipital chord	21
	Foramen magnum length	22
	Foramen magnum breadth	23
Mandible	Symphysis height	25
	Height of body	26
	Breadth of body	27
	Bigonial breadth	28
	Bicondylar breadth	29
	Minimum ramus breadth	30
	Maximum ramus breadth	31
	Maximum ramus height	32

Table 92. Adult post-cranial metrics (after Buikstra and Ubelaker 1994: 79-84).

Element	**Measurement**	**Buikstra and Ubelaker Code**
Clavicle	Maximum length	35
	Anterior-posterior diameter	36
	Superior-inferior diameter	37
Scapula	Height of body	38
	Breadth of body	39
	Glenoid length	-
Humerus	Maximum length	40
	Epicondylar breadth	41
	Vertical diameter of head	42
	Maximum diameter at midshaft	43
	Minimum diameter at midshaft	44
	Least circumference	-
Radius	Maximum length	45
	Anterior-posterior diameter	46
	Medial-lateral diameter	47
Ulna	Maximum length	48
	Anterior-posterior diameter	49
	Medial-lateral diameter	50
	Minimum circumference	52
Sacrum	Anterior length	53
	Anterior-superior breadth	54
	Maximum transverse diameter at base	55
Pelvis	Height	56
	Iliac breadth	57
	Pubis length	58
	Ischium length	59
Femur	Maximum length	60
	Epicondylar breadth	62
	Maximum diameter of head	63
	Anterior-posterior subtrochanteric diameter	64
	Medial-lateral subtrochanteric diameter	65
	Anterior-posterior diameter at midshaft	66
	Medial-lateral diameter at midshaft	67
	Circumference at midshaft	68
Tibia	Complete length	-
	Maximum length	69
	Maximum proximal breadth	70
	Maximum distal breadth	71
	Maximum diameter at nutrient foramen	72
	Minimum diameter at nutrient foramen	73
	Circumference at nutrient foramen	74
Fibula	Maximum length	75
	Maximum diameter at midshaft	76
Calcaneus	Maximum length	77
	Middle breadth	78
	Height	-
Talus	Maximum length	-
	Width	-
	Height	-

Table 93. Adult stature estimation formulae (after Brothwell and Zakrzewski 2004).
(N.B. Formulae are listed in order from most to least accurate.)

Females	**Formula**	**Error ±**
Humerus, femur and tibia	0.68 humerus length + 1.17 femur length + 1.15 complete tibia length + 50.12	3.51
Femur and tibia	1.48 femur length + 1.28 complete tibia length + 53.07	3.55
Femur and tibia	1.39 (femur length + complete tibia length) + 53.20	3.55
Fibula	2.93 fibula length + 59.61	3.57
Tibia	2.90 complete tibia length + 61.53	3.66
Humerus and tibia	1.35 humerus length + 1.95 complete tibia length + 52.77	3.67
Femur	2.47 femur length + 54.10	3.72
Radius	4.74 radius length + 54.93	4.24
Ulna	4.27 ulna length + 57.76	4.30
Humerus	3.36 humerus length + 57.97	4.45
Males	**Formula**	**Error ±**
Femur and tibia	1.30 (femur length + complete tibia length) + 63.29	2.99
Femur	2.38 femur length + 61.42	3.27
Fibula	2.68 fibula length + 71.78	3.29
Tibia	2.52 complete tibia length + 78.62	3.37
Femur and fibula	1.31 (femur length + fibula length) + 63.05	3.62
Humerus	3.08 humerus length + 70.05	4.32
Humerus and radius	1.82 (humerus length + radius length) + 67.97	4.31
Ulna	370 ulna length + 74.05	4.32
Radius	3.78 radius length + 79.01	4.32

Table 94. Description and classification of fractures (after Lovell 1997: 141-4, Table 2).

Type	**Description**	**Complete/ Incomplete**	**Type of Force**
Avulsion	Segment of bone detached owing to tension on ligament or tendon	Complete	Indirect, tension
Burst	Result from compression of vertebrae	Incomplete	Indirect, compression
Comminuted	Bone broken into two or more fragments, often forming a T or Y shape; common in long bone shafts	Complete	Direct OR indirect
Compression or crush	Caused by crushing forces on both sides of bone	Incomplete, compression	Direct, compression
Depression	Caused by crushing force on one side of bone	Incomplete	Direct, compression
Impacted	Two ends of break driven into one another	Complete	Indirect, compression
Oblique	Results from rotational and angular stress on the long axis	Complete	Indirect, rotation/ angulation
Penetrating	Partial or complete penetration of bone cortex	Complete OR incomplete	Direct, sharp force
Spiral	Results from rotational and longitudinal stresses on the long axis	Complete	Indirect, rotation/ angulation
Spondylolysis	Partial (unilateral) or complete (bilateral) separation of the neural arch	Complete	Indirect/repeated stress
Torus/ Greenstick	Common in children; caused by longitudinal bending of bone shaft	Incomplete	Indirect, angulation
Transverse	Results from force applied perpendicular to the long axis (includes Colles' and parry fractures)	Complete	Direct, angulation

Appendix 3. Life Table Data

Since the majority of adult individuals were aged using broader age categories, ages were distributed equally across age brackets where necessary, i.e. in the case of an individual with an estimated age of 25-34 years, the value (1.0) was distributed across the 25-29 (0.5) and 30-34 (0.5) year age brackets.

Table 95. Life table: Ancaster (total sample).

Age (Yrs) (x)	**Number of Deaths (D_x)**	**Proportion of Deaths (d_x)**	**Survivorship (l_x)**	**Probability of Death (q_x)**	**Average Years Lived (L_x)**	**Sum of Average Years Lived (T_x)**	**Life Expectancy (e_x)**
0	49.5	18.3	100.0	0.2	454.3	2933.5	29.3
5	16.0	5.9	81.7	0.1	393.9	2479.2	30.3
10	6.5	2.4	75.8	0.0	373.2	2085.3	27.5
15	12.9	4.8	73.4	0.1	355.3	1712.1	23.3
20	11.3	4.2	68.7	0.1	332.9	1356.9	19.8
25	33.3	12.3	64.5	0.2	291.7	1024.0	15.9
30	32.5	12.0	52.2	0.2	230.9	732.4	14.0
35	29.8	11.0	40.2	0.3	173.5	501.4	12.5
40	24.7	9.1	29.2	0.3	123.2	328.0	11.2
45	8.7	3.2	20.1	0.2	92.3	204.8	10.2
50	17.7	6.5	16.9	0.4	67.9	112.5	6.7
55	17.7	6.5	10.3	0.6	35.2	44.6	4.3
60	10.2	3.8	3.8	1.0	9.4	9.4	2.5

Table 96. Life table: Winchester (total sample).

Age (Yrs) (x)	**Number of Deaths (D_x)**	**Proportion of Deaths (d_x)**	**Survivorship (l_x)**	**Probability of Death (q_x)**	**Average Years Lived (L_x)**	**Sum of Average Years Lived (T_x)**	**Life Expectancy (e_x)**
0	91.8	27.7	100.0	0.3	430.5	2544.6	25.4
5	15.3	4.6	72.2	0.1	349.5	2114.1	29.3
10	12.3	3.7	67.6	0.1	328.6	1764.1	26.1
15	27.3	8.3	63.9	0.1	298.7	1435.5	22.5
20	24.0	7.3	55.6	0.1	259.8	1136.9	20.4
25	10.7	6.3	48.3	0.1	226.0	877.0	18.1
30	27.4	8.3	42.1	0.2	189.5	651.1	15.5
35	25.1	7.6	33.7	0.2	149.6	461.6	13.7
40	22.3	6.8	26.1	0.3	113.7	312.0	11.9
45	10.6	3.2	19.4	0.2	88.8	198.3	10.2
50	20.4	6.2	16.2	0.4	65.4	109.5	6.8
55	20.2	6.1	10.0	0.6	34.6	44.2	4.4
60	12.7	3.9	3.8	1.0	9.6	9.6	2.5

Table 97. Life table: Ancaster (sexed adults).
(x=age in years; D_x=number of deaths; d_x=proportion of deaths; l_x=survivorship; L_x=average years lived; Tx=sum of average years lived; e_x=life expectancy.)

ANCASTER Females							
x	**D_x**	**d_x**	**l_x**	**q_x**	**L_x**	**T_x**	**e_x**
15	4.9	6.3	100.0	0.1	484.3	2326.9	23.3
20	5.1	6.6	93.7	0.1	452.2	1842.6	19.7
25	12.9	16.5	87.2	0.2	394.5	1390.4	16.0
30	14.9	19.1	70.7	0.3	305.6	995.9	14.1
35	8.5	11.0	51.6	0.2	230.5	690.3	13.4
40	9.4	12.1	40.6	0.3	172.9	459.8	11.3
45	3.4	4.4	28.5	0.2	131.6	286.9	10.1
50	7.6	9.8	24.1	0.4	96.2	155.3	6.4
55	7.6	9.8	14.4	0.7	47.5	59.0	4.1
60	3.6	4.6	4.6	1.0	11.6	11.6	2.5
ANCASTER Males							
x	**D_x**	**d_x**	**l_x**	**q_x**	**L_x**	**T_x**	**e_x**
15	4.0	3.8	100.0	0.0	490.5	2340.7	23.4
20	5.2	5.0	96.2	0.1	468.5	1850.2	19.2
25	19.5	18.5	91.2	0.2	409.8	1381.7	15.1
30	16.6	15.8	72.7	0.2	323.9	972.0	13.4
35	19.8	18.8	56.9	0.3	237.2	648.1	11.4
40	13.8	13.1	38.0	0.3	157.3	410.9	10.8
45	4.3	4.1	24.9	0.2	114.3	253.6	10.2
50	8.5	8.1	20.8	0.4	83.9	139.4	6.7
55	8.5	8.1	12.8	0.6	43.7	55.5	4.3
60	5.0	4.7	4.7	1.0	11.8	11.8	2.5

Table 98. Life table: Winchester (sexed adults).
(x=age in years; D_x=number of deaths; d_x=proportion of deaths; l_x=survivorship; L_x=average years lived; Tx=sum of average years lived; e_x=life expectancy.)

WINCHESTER Females							
x	**D_x**	**d_x**	**l_x**	**q_x**	**L_x**	**T_x**	**e_x**
15	7.3	10.9	100.0	0.1	472.8	2179.3	21.8
20	8.4	12.6	89.1	0.1	414.0	1706.5	19.2
25	6.9	10.4	76.5	0.1	356.6	1292.5	16.9
30	13.2	19.7	66.1	0.3	281.4	935.9	14.2
35	8.2	12.3	46.4	0.3	201.3	654.6	14.1
40	4.2	6.3	34.1	0.2	154.8	453.3	13.3
45	2.0	3.0	27.8	0.1	131.7	298.4	10.7
50	6.5	9.7	24.9	0.4	100.1	166.8	6.7
55	6.3	9.5	15.2	0.6	52.3	66.6	4.4
60	3.8	5.7	5.7	1.0	14.3	14.3	2.5
WINCHESTER Males							
x	**D_x**	**d_x**	**l_x**	**q_x**	**L_x**	**T_x**	**e_x**
15	5.3	5.7	100.0	0.1	485.8	2432.9	24.3
20	11.6	12.5	94.3	0.1	440.2	1947.2	20.6
25	8.4	9.0	81.8	0.1	386.4	1506.9	18.4
30	10.8	11.6	72.8	0.2	334.8	785.7	10.8
35	13.3	14.3	61.2	0.2	270.0	785.7	12.8
40	14.5	15.6	46.8	0.3	195.2	515.7	11.0
45	4.0	4.3	31.2	0.1	145.4	320.5	10.3
50	10.0	10.8	26.9	0.4	107.7	175.1	6.5
55	10.0	10.8	16.2	0.7	53.9	67.3	4.2
60	5.0	5.4	5.4	1.0	13.5	13.5	2.5

Appendix 4. Differential Diagnoses

Table 99 provides descriptions and differential diagnoses of selected pathologies observed in the study samples and referred to in the main text. It does not include common joint diseases (osteoarthritis, disc disease, Schmorl's nodes and rotator cuff disease), fractures, general stress indicators (cribra orbitalia, porotic hyperostosis and hypoplasia), neoplasms, congenital anomalies (e.g. spina bifida occulta), and dental diseases (caries, calculus, periodontal disease, peri-apical lesions and ante-mortem tooth loss), and pathology of uncertain aetiology, details of which are provided in the relevant tables contained in the Access database.

Table 99. Differential diagnoses.
(N.B. Preferred diagnosis is presented first; brackets indicate differential diagnoses.)

Skeleton ID (Age, Sex)	**Elements Affected**	**Description of Lesions**	**Differential Diagnosis**
ANC 1 (18-24, F)	Both pelves; sacrum; R femur; tibiae; R MT3	Right acetabulum exhibits lytic lesions with sclerotic margins; right femoral head exhibits extreme lytic destruction and sclerosis; lytic lesions and sclerosis present at the auricular surfaces of the pelves and sacrum; right tibia and right MT3 exhibit para-articular sinuses at the distal ends; both tibiae exhibit remodelled striated periostitis at the proximal/medial aspects of the shafts	Tuberculosis
ANC 1 (18-24, F)	T9 and T10	T9 and T10 exhibit lesions at the anterior-inferior and anterior-superior margins respectively; the lesions affect the epiphyseal rings and endplates; there is minimal new bone formation	Trauma/avulsion fracture (Maat and Mastwijk 2000; Mays 2007a) (TB – unlikely, as this does not generally preferentially target the anterior margin; Roberts and Buikstra 2003) (Brucellosis? The lesions could represent vertebral epiphysitis; Aufderheide and Rodríguez-Martín 1998: 192-3; Özaksoy *et al*. 2010; Samra *et al*. 1982; Solera *et al*. 1999)

Skeleton ID (Age, Sex)	**Elements Affected**	**Description of Lesions**	**Differential Diagnosis**
ANC 11 (35-49, M)	T8-T11, R tibia, R fibula	Collapse of the T9 and T10 due to lytic destruction of the bodies, resulting in marked anterior kyphosis; fusion of T8-11 by large ossifications at the body and also at the posterior facets (secondary OA?); right tibia and fibula are 'swollen' at the distal shafts; radiograph did not reveal cause (Cox 1989); remodelled periostitis present at distal tibia shaft	Tuberculosis – Pott's disease of the spine
ANC 11 (35-49, M)	T3 to L5, ribs, sternum, pelves majority of joint surfaces, calcanei	Large osteophytic growths at the margins of the majority of thoracic and lumbar vertebrae; T8-T11 fused at right side by osteophytic growths; ossification of costal cartilage of ribs and sternum; widespread marginal lipping of most joint elements; enthesophytes at iliac crests, insertions for Achilles tendons	Sub-clinical DISH? (Ankylosis of vertebrae may be secondary to tuberculous destruction; bone formation may be age-related)
ANC 12B (35-49, M)	C3 to L5, majority of extra-spinal joints, ribs, sacrum, pelves, long bones, R patella. calcanei	Large DISH-like osteophytic growths affecting majority of vertebral bodies (but no ankylosis); lipping of most extra-spinal joint margins; lipping of rib heads and tubercles; ankylosis of both SIJs; enthesophytes at the iliac crests of the pelves, insertions for deltoids, biceps, triceps, quadriceps femoris and Achilles tendons	Sub-clinical DISH (Age-related; natural bone former)
ANC 24 (35-49, M?)	R humerus	Head of right humerus affected by severe OA, exhibits extreme flattening (glenoid absent)	Congenital dysplasia; (Or simply extreme osteoarthritic change)
ANC 45 (≥50, F)	C4 to L5, scapulae, clavicles, ribs, sternum, long bones, L patella, L calcaneus	DISH-like growths affecting majority of vertebrae; ankylosis of the T6 to T12; widespread marginal osteophytosis of all major and minor joints; widespread enthesophytes affecting almost all elements (majority of sacrum and pelvis absent, thus not known whether there was fusion of the SIJs)	DISH
ANC 46 (25-34, M?)	L tibia	Distal joint surface exhibits possible lytic lesions; porous new bone also present (talus absent)	Tuberculosis? (Septic arthritis; osteomyelitis)
ANC 47 (35-49, M)	Ribs	Active periostitis at visceral aspects of three ribs	Possible pulmonary TB or other pulmonary infection; (Neoplastic)
ANC 48B (18-24, M)	Ribs, L tibia, L fibula	Partially remodelled periostitis at visceral aspects of seven ribs; active periostitis at anterior aspects of tibia and fibula	Possible pulmonary TB or other systemic infection

Skeleton ID (Age, Sex)	**Elements Affected**	**Description of Lesions**	**Differential Diagnosis**
ANC 55 (6-11)	Ribs, L ulna, femora, tibiae, fibulae	Active woven bone at visceral aspects of eight ribs, symmetrical plaques of active periostitis at the shafts of the long bones	Hypertrophic pulmonary osteopathy=pulmonary TB or other pulmonary infection/disease
ANC 62 (UA, F)	Ribs, R tibia	Active periostitis at visceral aspect of a rib fragment; healed periostitis at the tibia shaft	Possible pulmonary TB or other pulmonary infection
ANC 82 (18-24, M)	Frontal, occipital	Plaques of porous new bone present at endocranial surfaces of both bones; partially remodelled with vascular impressions	Tuberculous meningitis? (Haemorrhage due to other infection, trauma or scurvy)
ANC 143 (25-34, M?)	Ribs, L MC5	Active periostitis at visceral aspect of a rib fragment; active periostitis at the palmar aspect of the MC5	Possible pulmonary TB or other pulmonary infection
ANC 156 (≥50, M?)	T3 to L5, scapulae, clavicles, ribs, pelves, sacrum, radii, tibiae, patellae, L calcaneus	DISH-like growths at the margins of most vertebrae; fusion of the T10-T12 by large 'candle-wax' growths at the right side; the facets of T10/11 are not fused, but the facets and spines of the T11/12 are fused (possible case of congenital fusion/block vertebrae?); marginal lipping of most joints; lipping of rib heads and tubercles; ossification of the costal cartilage; widespread enthesophytes; ossification of the sacroiliac ligaments.	Sub-clinical DISH? (Age-related/bone former; Cox suggests that the ossification at the anterior margins is the result of disc disease causing kyphosis and consequent fusion).
ANC 179 (25-34, M)	L4, L5	Oblique lesion at the anterior-superior margin of the L5; possible lesion at the anterior-superior margin of the L4 with osteophytic growth and bony proliferation at the anterior body	Trauma/avulsion fracture (Maat and Mastwijk 2000; Mays 2007a) (TB – unlikely, as this does not generally preferentially target the anterior margin; Roberts and Buikstra 2003) (Brucellosis? The lesions could represent vertebral epiphysitis; Aufderheide and Rodríguez-Martín 1998: 192-3; Özaksoy *et al*. 2010; Samra *et al*. 1982; Solera *et al*. 1999) Cox (1989) suggested infection as the cause of the bony exostoses at the anterior wall of the L4; S. Mays (personal communication) suggests traction on the periosteum
ANC 188 (25-34, M)	L pelvis, L femur	Severe OA of hip joint, marked shortening of femoral neck, extreme flattening of proximal femur	Congenital hip dysplasia; (Slipped femoral epiphysis; Legg-Calvé-Perthes disease)

Skeleton ID (Age, Sex)	**Elements Affected**	**Description of Lesions**	**Differential Diagnosis**
ANC 201 (≥50, M)	T10, L4	Lesion at anterior superior margin of the T10; lesion at anterior inferior margin of L4; minimal new bone formation	Trauma/avulsion fracture (Maat and Mastwijk 2000; Mays 2007a) (TB – unlikely, as this does not generally preferentially target the anterior margin; Roberts and Buikstra 2003) (Brucellosis? The lesions could represent vertebral epiphysitis; Aufderheide and Rodríguez-Martín 1998: 192-3; Özaksoy *et al*. 2010; Samra *et al*. 1982; Solera *et al*. 1999)
ANC 208 (<1)	Frontal, occipital, mandible, humeri, ulnae, radii, femora, tibiae, ribs	Porous deposits of woven bone at orbital roofs (also cribra orbitalia); porosity of the external aspect of the mandibular body; porosity and slight flaring at the metaphyses of the long bones; both femora exhibit slight *coxa vara* deformity of the proximal ends; tibiae exhibit slight medial angulation; slight flaring at sternal rib ends	Rickets; (and/or Scurvy)
ANC 210 (25-34, M?)	L talus, calcaneus, navicular, cuboid	Navicular exhibits a large 'cleft' running dorsal/plantar through the centre of the joint surface; slight proliferative, sclerotic bone; calcaneus, talus and cuboid also exhibit combination of possible lytic lesions and sclerotic new bone	Possible tuberculosis? (Fracture of navicular with secondary infection; Septic arthritis?)
ANC 218 (25-34, F)	L5, sacrum, both pelves, humeri, femora	L5 and S1 exhibit lytic and sclerotic lesions at inferior and superior surfaces respectively; auricular facets of both pelves and sacrum also exhibit lytic and sclerotic lesions; lytic lesions at margins of proximal humeri joint surfaces and proximal and distal margins of the femoral joints surfaces	Tuberculosis

Skeleton ID (Age, Sex)	**Elements Affected**	**Description of Lesions**	**Differential Diagnosis**
ANC 230A (≥50, M)	T4 to L5, ribs, sternum, sacrum, pelves, majority of extra-spinal joints, long bones, patellae, calcanei	Ankylosis of the T4-T9, T10-T12 by large 'candle-wax' osteophytic growths, confined to right side in thoracic region (T9-T10 probably fused but broken apart p/m); posterior facet joints not fused, but exhibit lipping; L1-L5 exhibit large osteophytes but no fusion; marginal lipping of most extra-spinal joints; ossification of the sacroiliac ligaments, incipient ankylosis of the SIJs; ossification of costal cartilage of ribs and sternum; extreme enthesophytes at the iliac crests of the ilia and insertions for the deltoids, biceps, triceps, quadriceps femoris and Achilles tendons	DISH
ANC 238 (UA, M)	L femur, L patella, L tibia, L fibula	Extreme proliferative bone formation at all joint surfaces of left knee; incipient ankylosis at *c.* 45° angle; no lytic lesions; sclerosis	Septic arthritis (TB and osteomyelitis unlikely due to absence of lytic lesions)
ANC 240 (35-49, M?)	Ribs, ulnae, femora, tibiae, fibulae	Healed periostitis at visceral aspect of a rib; symmetrical deposits of active periostitis at the long bone shafts	Hypertrophic pulmonary osteopathy=pulmonary TB or other pulmonary infection/disease
ANC 252 (25-34, M)	T2 to L5, ribs, pelves, majority of extra-spinal joints, long bones, patellae, calcanei	Majority of vertebrae exhibit DISH-like ossifications at the margins, confined to right side in thoracic region; fusion of the T10-T11; widespread enthesophytes affecting majority of elements, marginal lipping of most joint elements, lipping of rib heads and tubercles, ossification of costal cartilage	Sub-clinical DISH; (Age-related/bone former)
VR 9 (<1)	Frontal, temporals, occipital, sphenoid, mandible	Deposits of woven bone at both orbits; woven bone at endocranial aspect of frontal; porosity at spheno-frontal articulation; porosity at ectocranial surfaces of temporals, occipital, greater wings of sphenoid; porosity at medial aspects of coronoid processes of mandible	Infantile scurvy
VR 15 (1-5)	Frontal, temporals, sphenoid, mandible	Porosity at ectocranial surface of frontal and orbital roofs; porosity at ectocranial surfaces of temporals, greater wings of sphenoid, and medial aspects of coronoid processes of mandible	Infantile scurvy
VR 35 (18-24, F)	L pelvis	Absence of clearly defined auricular surface; healed and active periostitis at pubic rami and external ilium (sacrum absent)	Dislocation of the SIJ? (Trauma; Congenital anomaly)

Skeleton ID (Age, Sex)	**Elements Affected**	**Description of Lesions**	**Differential Diagnosis**
VR 54 (UA, M?)	L pelvis, L femur	Extreme OA of the hip; flattening of femoral head and shortening of the neck	Congenital hip dysplasia with secondary OA; (Legg-Calvé-Perthes; Slipped femoral epiphysis)
VR 88 (35-49, M)	T1 to L5, sacrum, pelves, ribs, sternum, scapulae, majority of extra-spinal joints, long bones, patellae, calcanei	Large osteophytic growths affecting most vertebrae, T11-T12 look as though they would have fused; marginal lipping of most extra-spinal joints, lipping of rib heads and tubercles, ossification of costal cartilage, widespread enthesophytes affecting most elements	Sub-clinical DISH (Age-related/bone former)
VR 95 (18-24, M)	Humeri, femora	Marked atrophy and shortening of the right humerus and left femur relative to the opposite bones; right humerus shorter than left by *c.* 4 cm (R=317mm, L=354 mm); left femur shorter than right by *c.* 2 cm (R=474 cm, L=455 cm); left femur also exhibits increased angle at femoral neck (*coxa valga*); proximal epiphyses of both humeri unfused; distal epiphysis of unaffected bones are unfused, but the epiphyses of the affected bones are fused prematurely; porosity and trabecular thickening present at anterior aspects of both femoral necks; porosity also present at proximal metaphyses of humeri	Poliomyelitis (Waldron 2009: 109); (Birth trauma causing damage to nerves; Other neurological condition causing paralysis; *cf.* Thompson 2012) The differences between right and left bones are almost certainly too pronounced to be explained by activity-related asymmetry (Auerbach and Ruff 2006), and the near-complete absence of muscle markings on the abnormal bones and evidence for osteoporosis strongly indicates partial or complete paralysis of the affected limbs.
VR 96 (25-34, F)	Ribs	Active periostitis at the visceral aspects of three ribs	Possible pulmonary TB or other pulmonary infection
VR 129 (25-34, F)	Ribs, R femur	Active periostitis at visceral aspects of ribs; femur exhibits destruction of the lateral portion of the greater trochanter and active periostitis at the shaft	Tuberculosis
AR 318 (25-34, M)	T2 to T12, L2 to L1, majority of extra-spinal joints, ribs, sacrum, pelves, long bones, patellae, calcanei	Ankylosis of T2 to T12 at the anterior bodies by large ‘candle wax’ growths, confined to right side in thoracic region; L2 and L3 also fused; large osteophytic growths at remaining lumbars; incipient ankylosis of both SIJs, widespread marginal lipping of most extra-spinal joints, widespread enthesophytes	DISH
CHR 512A (25-34, M?)	Ribs	Partially remodelled periostitis at visceral aspects of two rib fragments	Possible pulmonary TB or other pulmonary infection

Skeleton ID (Age, Sex)	**Elements Affected**	**Description of Lesions**	**Differential Diagnosis**
CHR 527 (UA, U)	L1 to L5, long bones, calcanei	Large osteophytic growths affecting the lumbars (majority of cervicals and thoracics absent); appears as though T12 and L1 were fused at the right side; widespread enthesophytes	Sub-clinical DISH (Age-related/bone former)
CHR 562 (UA, F)	Spine (cervical and thoracic vertebrae), ribs, both pelves, sacrum	Fusion of spine at vertebral bodies of C6-T1, T2-T12; growths arise from vertebral margin and are smooth (syndesmophytes?); possible 'skip' lesions at T1-T2 but may have broken apart p/m; posterior facet joints also fused at C4-5, C6-T1 and T2-T12; ribs fused to thoracics; complete fusion of both SIJs	Ankylosing spondylitis; (Other spondylo-arthropathy, e.g. psoriatic arthritis)
CHR 607 (≥50, M)	Both pelves, femora	Both hip joints exhibit severe OA; femoral heads extremely flattened; shallow acetabula	Congenital hip dysplasia
CHR 636 (6-11)	Ribs	Active periostitis at the visceral aspect of a rib	Possible pulmonary TB or other pulmonary infection

Appendix 5: Results of Statistical Tests

Test 1. Skeletal completeness: intra-sample comparison by age/sex.

	ANCASTER				**WINCHESTER**			
	1-4 (d.f.=3)		**1/2 *vs.* 3/4**		**1-4 (d.f.=3)**		**1/2 *vs.* 3/4**	
	χ^2	***p***	**χ^2**	***p***	**χ^2**	***p***	**χ^2**	***p***
Subadult *vs.* adult	3.020	0.389	1.090	0.296	7.533	0.057	0.633	0.426
Adults <35 *vs.* ≥35	1.656	0.647	0.560	0.454	0.470	0.925	0.252	0.616
F *vs.* M	6.592	0.086	3.803	0.051	0.609	0.894	0.000	1.000
F <35 *vs.* ≥35	3.473	0.324	0.237	0.626	-	-	0.065	0.799
M <35 *vs.* ≥35	-	-	0.182	0.670	-	-	0.093	0.760
F <35 *vs.* M <35	-	-	1.881	0.170	-	-	0.040	0.841
F ≥35 *vs.* M ≥35	-	-	1.445	0.229	-	-	0.079	0.779

Test 2. Skeletal completeness: Ancaster *vs.* Winchester.

	All Grades		**Grades 1/2 *vs.* 3/4**	
	χ^2 (d.f.=3)	***p***	**χ^2**	***p***
Perinate	-	-	0.303	0.582
<1	-	-	-	-
1-5	-	-	0.084	0.772
6-11	-	-	0.524	0.469
12-17	-	-	-	-
UA	-	-	-	-
Total subadults	3.574	0.311	0.001	0.975
18-24	-	-	0.020	0.888
25-34	-	-	1.168	0.280
35-49	8.678	0.034	2.892	0.090
≥50	-	-	0.007	0.833
UA	-	-	0.087	0.768
Total adults	7.836	0.050	5.041	0.025
Females <35	-	-	0.339	0.560
Females ≥35	-	-	0.070	0.791
Total females	0.923	0.820	0.357	0.550
Males <35	-	-	0.006	0.938
Males ≥35	-	-	2.283	0.131
Total males	3.543	0.315	1.848	0.174
Total samples	5.709	0.127	3.106	0.078

Test 3. Bone surface preservation: intra-sample comparison by age/sex.
(N.B. The moderate and poor categories have been combined due to the small number of individuals with poor bone surface preservation.)

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	**χ^2**	***p***
Subadult *vs.* adult	0.008	0.928	0.024	0.878
Adults <35 *vs.* ≥35	0.282	0.596	0.097	0.755
F *vs.* M	6.608	0.010	0.959	0.328
F <35 *vs.* ≥35	0.648	0.421	-	-
M <35 *vs.* ≥35	0.039	0.844	-	-
F <35 *vs.* M <35	4.542	0.033	-	-
F ≥35 *vs.* M ≥35	0.311	0.577	-	-

Test 4. Bone surface preservation: Ancaster *vs.* Winchester.

(N.B. The moderate and poor categories have been combined due to the small number of individuals with poor bone surface preservation.)

	χ^2	p		χ^2	p		χ^2	p
Perinates	-	-	18-24	1.030	0.310	Females <35	5.987	0.014
<1	-	-	25-34	1.569	0.210	Females ≥35	-	-
1-5	-	-	35-49	0.251	0.616	Total females	18.234	0.000
6-11	-	-	≥50	2.807	0.094	Males <35	-	-
12-17	-	-	UA	7.609	0.006	Males ≥35	0.901	0.343
US	-	-	Total	11.561	0.001	Total males	1.438	0.230
Total	6.061	0.014				Total samples	18.511	0.000

Test 5. Element survival rates: intra-sample comparison by age/sex.

(N.B. *Individuals with at least one vertebral/sacral segment; **Number of elements; ***Individuals with at least one rib/rib fragments.)

	ANCASTER				**WINCHESTER**			
	Subs *vs.* Adults		**F *vs.* M**		**Subs *vs.* Adults**		**F *vs.* M**	
	χ^2	p	χ^2	p	χ^2	p	χ^2	p
Frontal	0.002	0.964	0.363	0.547	9.916	0.002	0.210	0.647
Parietal	0.798	0.372	3.099	0.078	31.521	0.000	0.246	0.620
Temporal	0.000	1.000	1.560	0.212	1.582	0.208	0.483	0.487
Occipital	0.576	0.448	3.157	0.076	14.638	0.000	0.001	0.975
Sphenoid	9.849	0.002	0.314	0.575	0.063	0.802	0.348	0.555
Zygomatic	3.222	0.073	5.902	0.015	11.638	0.001	0.012	0.913
Nasal	N/A	N/A	0.007	0.933	N/A	N/A	0.101	0.751
Maxilla	4.595	0.032	0.539	0.463	46.125	0.000	0.514	0.473
Mandible	2.211	0.137	1.631	0.202	3.013	0.083	1.536	0.215
Spine*	0.970	0.325	0.073	0.787	0.009	0.924	0.073	0.787
Cervicals**	N/A	N/A	23.699	0.000	N/A	N/A	0.086	0.769
Thoracics**	N/A	N/A	66.224	0.000	N/A	N/A	0.363	0.547
Lumbars**	N/A	N/A	8.879	0.003	N/A	N/A	14.198	0.000
Sacrum**	N/A	N/A	0.114	0.736	N/A	N/A	12.485	0.000
Sternum	N/A	N/A	11.309	0.001	N/A	N/A	0.015	0.902
Ribs**	7.409	0.006	37.525	0.000	47.107	0.000	0.446	0.504
Ribs***	0.034	0.854	0.275	0.600	0.378	0.539	0.016	0.899
Clavicle	14.332	0.000	0.984	0.321	10.702	0.001	3.427	0.064
Scapula	0.689	0.407	7.368	0.007	34.192	0.000	0.529	0.467
Pelvis	2.572	0.109	0.108	0.742	1.135	0.287	0.858	0.354
Ilium	6.659	0.010	0.014	0.906	17.312	0.000	1.348	0.246
Ischium	10.150	0.001	0.033	0.856	3.732	0.053	7.609	0.006
Pubis	12.869	0.000	0.301	0.583	3.188	0.074	0.176	0.675
Humerus	3.574	0.059	0.129	0.719	21.165	0.000	0.049	0.825
Radius	2.836	0.092	0.784	0.005	3.142	0.076	2.750	0.097
Ulna	2.454	0.117	2.581	0.108	N/A	N/A	17.676	0.000
Carpals	N/A	N/A	0.004	0.950	N/A	N/A	3.854	0.049
Metacarpals	N/A	N/A	1.450	0.229	0.612	0.434	2.866	0.090
Femur	4.398	0.036	1.145	0.285	N/A	N/A	2.235	0.135
Patella	N/A	N/A	1.345	0.246	4.319	0.038	7.186	0.007
Tibia	13.500	0.000	0.000	1.000	26.741	0.000	9.885	0.002
Fibula	9.975	0.002	0.043	0.836	27.377	0.000	11.795	0.001
Tarsals	N/A	N/A	0.000	1.000	N/A	N/A	37.707	0.000
Metatarsals	N/A	N/A	0.415	0.519	N/A	N/A	13.821	0.000
Phalanges	N/A	N/A	3.218	0.073	N/A	N/A	53.629	0.000

Test 6. Element survival rates: Ancaster *vs.* Winchester (subadults).

(N.B. *Individuals with at least one vertebral/sacral segment; **Number of elements; ***Individuals with at least one rib/rib fragments.)

	All Subadults		**<1**		**1-5**		**6-17**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***	χ^2	***p***
Frontal	9.990	0.002	8.258	0.004	0.089	0.765	1.410	0.235
Parietal	41.592	0.000	44.719	0.000	1.139	0.286	1.472	0.225
Temporal	0.000	1.000	0.231	0.631	0.056	0.813	0.018	0.893
Occipital	9.800	0.002	-	-	0.364	0.546	0.018	0.893
Sphenoid	7.430	0.006	2.155	0.142	0.000	1.000	4.062	0.044
Zygomatic	2.072	0.150	0.006	0.938	0.771	0.380	1.569	0.210
Maxilla	16.724	0.000	6.644	0.010	0.376	0.540	3.196	0.074
Mandible	2.668	0.102	0.600	0.439	0.047	0.828	0.551	0.458
Spine*	0.060	0.806	1.879	0.170	-	-	0.020	0.888
Ribs**	103.220	0.000	8.350	0.004	64.952	0.000	20.893	0.000
Ribs***	1.210	0.271	2.601	0.107	0.126	0.723	0.044	0.834
Clavicle	1.238	0.266	0.361	0.548	0.167	0.683	3.263	0.071
Scapula	11.157	0.001	0.006	0.938	7.091	0.008	14.970	0.000
Humerus	0.791	0.374	0.030	0.862	0.719	0.396	0.053	0.818
Radius	9.511	0.002	7.861	0.005	5.077	0.024	0.000	1.000
Ulna	0.990	0.320	0.512	0.474	5.077	0.024	0.554	0.457
Ilium	0.111	0.739	2.845	0.092	2.725	0.099	0.003	0.956
Ischium	0.447	0.504	2.298	0.130	5.378	0.020	0.077	0.781
Pubis	0.106	0.745	4.020	0.044	0.229	0.632	0.077	0.781
Femur	0.006	0.938	1.040	0.308	3.040	0.081	0.416	0.519
Tibia	0.005	0.944	0.016	0.899	1.058	0.304	0.708	0.400
Fibula	12.272	0.000	2.506	0.113	10.784	0.001	0.011	0.916

Test 7. Element survival rates: Ancaster *vs.* Winchester (adults).

(N.B. *Individuals with at least one vertebral/sacral segment; **Number of elements; ***Individuals with at least one rib/rib fragments.)

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Frontal	1.570	0.210	0.474	0.491	0.117	0.732
Parietal	2.962	0.085	2.592	0.107	0.262	0.609
Temporal	2.920	0.087	2.249	0.134	0.110	0.740
Occipital	1.879	0.170	0.661	0.416	0.325	0.569
Sphenoid	2.415	0.120	0.024	0.877	0.111	0.739
Zygomatic	0.581	0.446	2.633	0.105	0.604	0.437
Nasal	20.468	0.000	0.675	0.411	3.011	0.083
Maxilla	1.016	0.313	4.129	0.042	0.000	1.000
Mandible	5.135	0.023	2.175	0.140	1.017	0.313
Cervicals**	82.872	0.000	2.000	0.157	111.573	0.000
Thoracics**	78.942	0.000	3.327	0.068	50.054	0.000
Lumbars**	43.070	0.000	7.054	0.008	4.005	0.045
Sacrum	4.001	0.045	0.591	0.442	0.002	0.964
Sternum	8.153	0.004	0.000	1.000	9.328	0.002
Ribs**	0.196	0.659	0.943	0.332	0.004	0.950
Ribs***	110.434	0.000	0.374	0.541	40.944	0.000
Clavicle	9.635	0.002	1.082	0.298	3.685	0.055
Scapula	99.452	0.000	20.766	0.000	53.129	0.000
Ilium	2.568	0.109	0.009	0.924	1.807	0.179
Ischium	0.546	0.460	0.156	0.693	2.640	0.104
Pubis	11.816	0.001	6.638	0.010	0.241	0.623
Humerus	3.706	0.054	0.879	0.348	0.000	1.000
Radius	2.819	0.093	2.492	0.114	0.275	0.600
Ulna	2.788	0.095	0.089	0.765	0.330	0.566
Carpals**	12.604	0.000	5.931	0.015	3.930	0.047
Metacarpals**	0.342	0.559	1.073	0.300	22.954	0.000
Femur	4.546	0.033	0.000	1.000	0.636	0.425
Patella	4.842	0.028	0.214	0.644	0.291	0.590
Tibia	7.415	0.006	5.673	0.017	0.048	0.827
Fibula	27.380	0.000	18.521	0.000	2.105	0.147
Tarsals	42.563	0.000	22.954	0.000	1.722	0.189
Metatarsals	0.129	0.719	3.513	0.061	7.055	0.008
Phalanges	35.616	0.000	33.807	0.000	19.383	0.000

Test 8. Spinal OA, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-
25-34	-	-	-	-
35-49	0.022	0.882	-	-
≥50	-	-	-	-
UA	-	-	-	-
Total	4.986	0.026	1.264	0.261

Test 9. Spinal OA, overall CPR: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-	-	-
25-34	-	-	-	-	-	-
35-49	6.984	0.008	-	-	3.934	0.047
≥50	0.638	0.424	-	-	-	-
UA	0.010	0.920	-	-	-	-
Total	5.269	0.022	0.635	0.426	4.012	0.045

Test 10. Spinal OA, CPR by spinal region: intra-sample comparison.

	All Adults			**Females**			**Males**		
ANCASTER	χ^2	**d.f.**	***p***	χ^2	**d.f.**	***P***	χ^2	**d.f.**	***p***
C *vs.* T *vs.* L	6.463	2	0.049	0.753	2	0.686	12.744	2	0.002
C *vs.* T	0.248	1	0.618	0.045	1	0.832	0.427	1	0.513
C *vs.* L	5.512	1	0.019	0.268	1	0.605	11.128	1	0.001
T *vs.* L	2.963	1	0.085	0.216	1	0.642	6.609	1	0.010
WINCHESTER	χ^2	**d.f.**	***p***	χ^2	**d.f.**	***P***	χ^2	**d.f.**	***p***
C *vs.* T *vs.* L	5.482	2	0.065	0.926	2	0.629	6.254	2	0.044
C *vs.* T	0.274	1	0.601	0.271	1	0.603	0.027	1	0.868
C *vs.* L	4.599	1	0.032	0.259	1	0.611	4.759	1	0.029
T *vs.* L	2.311	1	0.128	0.082	1	0.755	3.404	1	0.065

Test 11. Spinal OA, CPR by spinal region: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Cervical region	5.587	0.017	0.704	0.401
Thoracic region	2.709	0.100	1.953	0.162
Lumbar region	1.348	0.246	-	-

Test 12. Spinal OA, CPR by spinal region: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Cervical region	1.370	0.242	0.020	0.888	1.437	0.231
Thoracic region	1.732	0.188	0.225	0.635	0.721	0.396
Lumbar region	1.553	0.213	1.311	0.252	0.112	0.738

Test 13. Spinal OA, CPR by side: intra-sample comparison.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	0.962	0.327	0.478	0.489	0.005	0.944
Winchester	0.169	0.681	0.016	0.899	0.189	0.664

Test 14. Spinal OA, CPR by side: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Right	9.171	0.002	1.566	0.211	4.783	0.029
Left	2.087	0.149	0.072	0.788	2.442	0.118

Test 15. Disc disease, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-
25-34	2.033	0.154	-	1.000
35-49	-	-	-	-
≥50	-	-	-	-
UA	-	-	-	-
Total	3.640	0.056	0.266	0.606

Test 16. Disc disease, overall CPR: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-	-	-
25-34	1.321	0.250	-	-	1.366	0.243
35-49	-	-	-	-	-	-
≥50	-	-	-	-	-	-
UA	-	-	-	-	-	-
Total	7.262	0.005	1.037	0.309	11.764	0.001

Test 17. Disc disease, CPR by spinal region: intra-sample comparison.

	All Adults			**Females**			**Males**		
ANCASTER	χ^2	**d.f.**	***p***	χ^2	**d.f.**	***p***	χ^2	**d.f.**	***p***
C *vs.* T *vs.* L	20.107	2	0.000	5.274	2	0.072	15.791	2	0.000
C *vs.* T	16.956	1	0.000	3.963	1	0.047	12.438	1	0.002
C *vs.* L	10.671	1	0.001	2.347	1	0.126	8.658	1	0.003
T *vs.* L	0.509	1	0.476	0.103	1	0.748	0.117	1	0.732
WINCHESTER	χ^2	**d.f.**	***p***	χ^2	**d.f.**	***p***	χ^2	**d.f.**	***p***
C *vs.* T *vs.* L	5.845	2	0.054	2.162	2	0.339	5.402	2	0.056
C *vs.* T	5.091	1	0.024	1.077	1	0.299	4.168	1	0.041
C *vs.* L	2.118	1	0.146	0.038	1	0.845	2.552	1	0.110
T *vs.* L	0.394	1	0.530	0.938	1	0.033	0.038	1	0.845

Test 18. Disc disease, CPR by spinal region: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Cervical region	0.002	0.964	0.700	0.403
Thoracic region	0.572	0.449	2.552	0.110
Lumbar region	0.780	0.377	5.488	0.019

Test 19. Disc disease, CPR by spinal region: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Cervical region	0.804	0.370	0.717	0.397	0.002	0.964
Thoracic region	6.514	0.011	3.038	0.081	1.463	0.226
Lumbar region	5.894	0.010	5.780	0.016	1.265	0.261

Test 20. Schmorl's nodes, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-
25-34	8.751	0.003	0.051	0.821
35-49	0.136	0.712	-	-
≥50	3.472	0.062	-	-
UA	-	-	-	-
Total	12.416	0.000	9.909	0.002

Test 21. Schmorl's nodes, overall CPR: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-	-	-
25-34	0.646	0.422	-	-	1.613	0.204
35-49	0.024	0.877	-	-	0.004	0.956
≥50	1.097	0.295	-	-	0.194	0.659
UA	-	-	-	-	-	-
Total	2.544	0.111	0.823	0.364	1.007	0.299

Test 22. Schmorl's nodes, CPR by spinal region: intra-sample comparison.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	8.243	0.004	0.545	0.460	7.525	0.006
Winchester	3.271	0.071	0.887	0.346	1.760	0.185

Test 23. Schmorl's nodes, CPR by spinal region: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Thoracic region	13.947	0.000	12.936	0.000
Lumbar region	4.069	0.044	10.604	0.001

Test 24. Schmorl's nodes, CPR by spinal region: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Thoracic region	1.442	0.230	0.452	0.501	0.328	0.567
Lumbar region	0.077	0.781	0.897	0.344	0.104	0.747

Test 25. Extra-spinal OA, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-
25-34	-	-	-	-
35-49	0.010	0.920	-	-
≥50	-	-	-	-
UA	-	-	-	-
Total	2.396	0.122	0.960	0.327

Test 26. Extra-spinal OA, overall CPR: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-	-	-
25-34	-	-	-	-	-	-
35-49	3.732	0.053	-	-	4.711	-
≥50	0.601	0.438	0.313	0.576	-	-
UA	0.008	0.929	-	-	-	-
Total	4.014	0.045	0.088	0.766	0.844	0.358

Test 27. Extra-spinal OA, CPR by region: intra-sample comparison, upper *vs.* lower body.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	17.042	0.000	6.543	0.011	6.083	0.004
Winchester	10.343	0.001	2.333	0.127	4.029	0.045

Test 28. Extra-spinal OA, CPR by region: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Upper	0.878	0.349	0.706	0.401
Lower	1.353	0.245	0.438	0.508

Test 29. Extra-spinal OA, CPR by region: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Upper	2.540	0.111	0.433	0.511	0.949	0.323
Lower	0.207	0.649	-	-	0.020	0.888

Test 30. Extra-spinal OA, CPR by side: intra-sample comparison.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	0.122	0.727	0.000	1.000	0.091	0.763
Winchester	0.320	0.572	0.059	0.808	1.126	0.289

Test 31. Extra-spinal OA, CPR by side: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Right	1.632	0.201	0.793	0.373
Left	1.668	0.197	0.363	0.547

Test 32. Extra-spinal OA, CPR by side: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Right	1.728	0.189	0.050	0.823	0.076	0.783
Left	7.403	0.007	0.819	0.365	3.848	0.050

Test 33. Extra-spinal OA, CPR by joint: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Acromioclavicular	0.201	0.654	0.064	0.800
Hand	0.094	0.759	0.004	0.950

Test 34. Extra-spinal OA, CPR by joint: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Sternoclavicular	0.003	0.956	-	-	0.034	0.854
Acromioclavicular	0.673	0.412	0.055	0.815	0.218	0.641
Wrist	0.010	0.920	-	-	0.065	0.799
Hand	0.475	0.491	0.067	0.796	0.001	0.975
Hip	0.031	0.860	-	-	-	-
Foot	0.024	0.877	-	-	0.006	0.938

Test 35. Extra-spinal OA, TPR by joint: intra-sample comparison, right *vs.* left.

	All Adults		**All Adults**	
	χ^2	***p***	χ^2	***p***
Sternoclavicular	0.220	0.882	0.568	0.451
Acromioclavicular	0.160	0.689	0.869	0.351
Hand	1.469	0.226	0.377	0.539
Hip	0.061	0.805	-	-
Foot	0.000	0.990	0.392	0.531

Test 36. Extra-spinal OA, TPR by joint: Ancaster *vs.* Winchester.

	Right		**Left**	
	χ^2	***p***	χ^2	***p***
Sternoclavicular	0.009	0.924	1.180	0.278
Acromioclavicular	0.155	0.694	2.118	0.146
Hand	0.209	0.648	2.147	0.143
Foot	0.006	0.939	-	-

Test 37. Fractures, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-
25-34	-	-	-	-
35-49	0.100	0.752	-	-
≥50	0.025	0.874	-	-
UA	-	-	-	-
Total	2.214	0.137	4.915	0.027

Test 38. Fractures, overall CPR: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-	-	-
25-34	0.508	0.476	-	-	-	-
35-49	0.029	0.865	-	-	0.007	0.933
≥50	0.045	0.832	-	-	1.516	0.218
UA	-	0.187	-	-	-	0.025
Total	0.012	0.913	0.000	0.995	0.325	0.569

Test 39. Fractures, CPR by element: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ribs	1.062	0.303	-	-	0.098	0.754
Tibia	0.017	0.895	-	-	-	0.739
Fibula	-	-	-	-	2.088	0.148

Test 40. Fractures, CPR by region: intra-site comparisons, upper *vs.* lower limb.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	1.538	0.215	-	-	0.892	0.345
Winchester	0.161	0.688	-	-	0.261	0.609

Test 41. Fractures, CPR by region: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Upper	2.540	0.111	0.433	0.511	0.949	0.323
Lower	0.522	0.470	-	-	0.020	0.888

Test 42. Periostitis, overall CPR: Ancaster *vs.* Winchester.

	Subadults			**All Adults**		**Females**		**Males**	
	χ^2	***p***		χ^2	***p***	χ^2	***p***	χ^2	***p***
<1	-	-	18-24	-	-	-	-	-	-
1-5	-	-	25-34	-	-	-	-	-	-
6-11	-	-	35-49	-	-	-	-	-	-
12-17	-	-	≥50	-	-	-	-	-	-
US	-	-	UA	-	-	-	-	-	-
Total	-	-	Total	0.011	0.915	0.736	0.391	0.598	0.439
Total samples (subadults+adults): χ^2=0.180, d.f.=1, p=0.670									

Test 43. Periostitis, tibia CPR: Ancaster *vs.* Winchester.

	Subadults			**All Adults**		**Females**		**Males**	
	χ^2	***p***		χ^2	***p***	χ^2	***p***	χ^2	***p***
<1	-	-	18-24	-	-	-	-	-	-
1-5	-	-	25-34	-	-	-	-	-	-
6-11	-	-	35-49	-	-	-	-	-	-
12-17	-	-	≥50	-	-	-	-	-	-
US	-	-	UA	-	-	-	-	-	-
Total	-	-	Total	0.217	0.642	-	0.730	0.018	0.893
Total samples (subadults+adults): χ^2=0.731, d.f.=1, p=0.393									

Test 44. Cribra orbitalia, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-
25-34	-	-	-	-
35-49	-	-	-	-
≥50	-	-	-	-
UA	-	-	-	-
Total	1.121	0.290	0.228	0.633

Test 45. Cribra orbitalia, overall CPR: Ancaster *vs.* Winchester.

	Subadults			**All Adults**		**Females**		**Males**	
	χ^2	***p***		χ^2	***p***	χ^2	***p***	χ^2	***p***
<1	-	-	18-24	-	-	-	-	-	-
1-5	0.956	0.328	25-34	0.003	0.956	-	-	-	-
6-11	-	-	35-49	-	-	-	-	-	-
12-17	-	-	≥50	-	-	-	-	-	-
UA	-	-	UA	-	-	-	-	-	-
Total	0.057	0.812	Total	1.587	0.208	1.361	0.243	0.641	0.423
Total samples (subadults+adults): χ^2=0.932, d.f.=1, p=0.334									

Test 46. Hypoplasia, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24				
25-34	0.000	1.000	-	
35-49	-	0.591	-	
≥50	-	1.000	-	
UA	-	1.000	-	
Total	0.284	0.594	1.459	0.227

Test 47. Hypoplasia, overall CPR: Ancaster *vs.* Winchester.

	Subadults			**All Adults**		**Females**		**Males**	
	χ^2	***p***		χ^2	***p***	χ^2	***p***	χ^2	***p***
<1	-	-	18-24	-	-	-	-	-	-
1-5	-	-	25-34	2.272	0.132	0.206	0.650	-	0.247
6-11	-	-	35-49	-	-	-	-	-	-
12-17	-	-	≥50	-	-	-	-	-	-
US	-	-	UA	-	-	-	-	-	-
Total	-	-	Total	4.886	0.027	0.002	0.964	6.556	0.010
Total samples (subadults+adults): χ^2=1.899, d.f.=1, p=0.168									

Test 48. Caries, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24	-		0.080	0.778
25-34	1.589	0.207	-	-
35-49	-	-	-	-
≥50	-	-	-	-
UA	-	-	-	-
Total	0.001	0.975	0.249	0.618

Test 49. Caries, overall CPR: Ancaster *vs.* Winchester.

	Subadults			**All Adults**		**Females**		**Males**	
	χ^2	***p***		χ^2	***p***	χ^2	***p***	χ^2	***p***
<1	-	-	18-24	0.050	0.824	-	-	-	-
1-5	-	-	25-34	0.662	0.416	-	-	1.275	0.259
6-11	-	-	35-49	0.006	0.938	-	-	0.027	0.869
12-17	-	-	≥50	0.021	0.884	-	-	-	-
US	-	-	UA	0.576	0.448	-	-	-	-
Total	-	-	Total	0.074	0.786	0.527	0.468	0.059	0.808
Total samples (subadults+adults): χ^2=0.088, d.f.=1, p=0.767									

Test 50. Caries, CPR by arch: intra-sample comparison, maxilla *vs.* mandible.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	5.214	0.022	2.530	0.112	2.450	0.118
Winchester	0.130	0.718	0.046	0.830	1.337	0.248

Test 51. Caries, CPR by arch: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Maxilla	0.102	0.749	0.371	0.542
Mandible	0.614	0.433	0.504	0.478

Test 52. Caries, CPR by arch: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Maxilla	1.794	0.180	1.035	0.309	3.464	0.063
Mandible	1.727	0.189	0.400	0.527	0.679	0.410

Test 53. Caries, CPR by tooth aspect: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Coronal	0.033	0.856	0.583	0.445
CEJ/Root	0.644	0.422	0.032	0.858

Test 54. Caries, CPR by tooth aspect: intra-sample comparison, coronal *vs.* CEJ/root caries.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	0.788	0.375	0.040	0.841	0.016	0.899
Winchester	11.086	0.001	6.649	0.020	5.257	0.022

Test 55. Caries, CPR by tooth aspect: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Coronal	0.217	0.64	0.516	0.473	0.024	0.877
CEJ/Root	3.684	0.050	1.915	0.166	1.239	0.266

Test 56. Calculus, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24	-	-	0.003	0.956
25-34	1.781	0.182	-	-
35-49	-	-	-	-
≥50	-	-	-	-
UA	-	-	-	-
Total	7.501	0.006	2.134	0.144

Test 57. Calculus, overall CPR: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-	-	-
25-34	1.033	0.309	0.015	0.903	-	-
35-49	0.690	0.406	-	-	-	-
≥50	0.009	0.924	-	-	0.031	0.860
UA	0.142	0.706	-	-	-	-
Total	0.753	0.386	0.011	0.916	1.049	0.306

Test 58. Calculus, CPR by arch: intra-sample comparison, maxilla *vs.* mandible.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	6.458	0.001	0.006	0.938	9.213	0.002
Winchester	2.105	0.146	0.199	0.656	2.340	0.126

Test 59. Calculus, CPR by arch: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Maxilla	0.012	0.913	1.480	0.224
Mandible	8.315	0.004	1.884	0.170

Test 60. Calculus, CPR by arch: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Maxilla	0.005	0.944	0.022	0.882	0.437	0.509
Mandible	0.864	0.353	0.003	0.956	1.218	0.270

Test 61. Calculus, CPR by location (supra/sub): intra-sample comparison.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	79.424	0.000	20.819	0.000	59.327	0.000
Winchester	30.965	0.000	11.207	0.001	15.130	0.000

Test 62. Calculus, CPR by location (supra/sub): intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Supra-gingival	5.972	0.015	0.364	0.546
Sub-gingival	-	-	-	-

Test 63. Calculus, CPR by location (supra/sub): Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Supra-gingival	2.975	0.085	0.011	0.916	3.770	0.052
Sub-gingival	-	-	-	-	-	-

Test 64. Calculus, CPR by severity: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Slight	5.933	0.015	0.411	0.521
Moderate	0.722	0.340	0.471	0.493
Severe	-	1.000	-	0.372

Test 65. Calculus, CPR by severity: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Slight	0.336	0.562	0.1	0.667	0.696	0.404
Moderate	0.000	1.000	0.002	0.964	0.006	0.938
Severe	0.008	0.777	-	-	-	-

Test 66. Calculus, CPR by location (buccal/lingual/inter-proximal): intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Buccal	5.281	0.022	1.833	0.176
Lingual	2.090	0.148	0.922	0.337
Inter-proximal	-	1.000	-	1.000

Test 67. Calculus, CPR by location (buccal/lingual/inter-proximal): Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Buccal	0.000	1.000	0.185	0.667	0.001	0.975
Lingual	0.123	0.726	0.005	0.944	0.089	0.765
Inter-proximal	-	-	-	-	-	-

Test 68. Periodontal disease, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24	-	0.546	-	0.600
25-34	0.009	0.924	-	0.428
35-49	-	0.176	-	1.000
≥50	0.183	0.669	-	1.000
UA	-	0.592	-	0.524
Total	0.425	0.514	0.696	0.404

Test 69. Periodontal disease, overall CPR: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-	-	-
25-34	9.842	0.002	2.150	0.143	5.371	0.020
35-49	0.081	0.776	-	-	-	-
≥50	2.625	0.105	-	-	-	-
UA	-	0.428	-	-	-	-
Total	9.332	0.002	2.183	0.140	6.061	0.014

Test 70. Periodontal disease, CPR by arch: intra-sample comparison, maxilla *vs.* mandible.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	2.584	0.108	0.000	1.000	3.214	0.073
Winchester	0.201	0.654	0.056	0.813	0.005	0.944

Test 71. Periodontal disease, CPR by arch: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Maxilla	0.016	0.899	0.040	0.841
Mandible	1.062	0.303	0.002	0.964

Test 72. Periodontal disease, CPR by arch: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Maxilla	9.037	0.003	5.004	0.025	3.490	0.062
Mandible	16.917	0.000	3.941	0.047	12.435	0.000

Test 73. Peri-apical lesions, overall CPR: intra-sample comparison, females *vs.* males.

	Ancaster		**Winchester**	
	χ^2	***p***	χ^2	***p***
18-24	-	1.000	-	0.326
25-34	0.820	0.365	-	1.000
35-49	-	0.131	-	0.266
≥50	-	0.397	-	0.197
UA	-	1.000	-	0.524
Total	0.242	0.623	0.436	0.509

Test 74. Peri-apical lesions, overall CPR: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-	-	-
25-34	0.029	0.865	0.079	0.779	-	-
35-49	0.823	0.364	-	-	0.653	0.419
≥50	0.089	0.765	-	-	-	-
UA	-	-	-	-	-	-
Total	4.459	0.035	2.806	0.094	0.093	0.760

Test 75. Peri-apical lesions, CPR by arch: intra-sample comparison, maxilla *vs.* mandible.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	0.067	0.796	0.016	0.899	0.075	0.784
Winchester	0.925	0.336	0.096	0.757	0.043	0.836

Test 76. Peri-apical lesions, CPR by arch: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Maxilla	0.066	0.797	1.225	0.268
Mandible	0.000	1.000	0.018	0.893

Test 77. Peri-apical lesions, CPR by arch: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Maxilla	1.411	0.235	1.378	0.240	0.207	0.649
Mandible	3.850	0.050	1.149	0.284	1.870	0.171

Test 78. Ante-mortem tooth loss, overall CPR: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-
25-34	0.048	0.827	0.025	0.874
35-49	-	-	-	-
≥50	-	-	-	-
UA	-	-	-	-
Total	0.000	1.000	0.532	0.466

Test 79. Ante-mortem tooth loss, overall CPR: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
18-24	-	-	-	-	-	-
25-34	0.044	0.834	0.035	0.852	0.009	0.924
35-49	1.788	0.181	-	-	0.916	0.339
≥50	-	-	-	-	-	-
UA	0.597	0.440	-	-	-	-
Total	2.162	0.141	1.612	0.204	0.034	0.854

Test 80. Ante-mortem tooth loss, CPR by arch: intra-sample comparison, maxilla *vs.* mandible.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Ancaster	0.685	0.408	2.119	0.145	5.158	0.023
Winchester	1.653	0.199	0.387	0.534	2.345	0.265

Test 81. Ante-mortem tooth loss, CPR by arch: intra-sample comparison, females *vs.* males.

	ANCASTER		**WINCHESTER**	
	χ^2	***p***	χ^2	***p***
Maxilla	1.779	0.182	0.022	0.882
Mandible	5.405	0.020	0.630	0.427

Test 82. Ante-mortem tooth loss, CPR by arch: Ancaster *vs.* Winchester.

	All Adults		**Females**		**Males**	
	χ^2	***p***	χ^2	***p***	χ^2	***p***
Maxilla	1.037	0.309	0.001	0.975	0.968	0.325
Mandible	1.220	0.269	0.686	0.408	5.675	0.017

Test 83. Spinal OA, CPR: comparisons between Romano-British populations.

	Ancaster	**Godmanchester**	**Ilchester**	**Cirencester**	**Gloucester**	**London**	**Winchester**
Ancaster	-	0.411	0.816	0.198	0.030	0.349	0.022
Godmanchester	0.411	-	0.738	0.976	0.016	0.148	0.018
Ilchester	0.816	0.738	-	0.716	0.039	0.314	0.049
Cirencester	0.198	0.976	0.716	-	0.002	0.056	0.000
Gloucester	0.030	0.016	0.039	0.002	-	0.340	0.619
London	0.349	0.148	0.314	0.056	0.340	-	0.585
Winchester	0.022	0.018	0.049	0.000	0.619	0.585	-
Small towns *vs.* public towns: χ^2=2.167, d.f.=1, *p*=0.141							

Test 84. Disc disease, CPR: comparison between Romano-British populations.

	Ancaster	**Baldock**	**Cirencester**	**Colchester**	**Gloucester**	**Leicester**	**London**	**Winchester**	**York**
Ancaster	-	0.062	0.930	0.000	0.000	0.000	0.899	0.005	0.223
Baldock	0.062	-	0.062	0.000	0.000	0.000	0.101	0.000	0.005
Cirencester	0.930	0.062	-	0.000	0.000	0.000	0.969	0.002	0.168
Colchester	0.000	0.000	0.000	-	0.000	0.000	0.000	0.002	0.000
Gloucester	0.000	0.000	0.000	0.000	-	-	0.000	0.000	0.000
Leicester	0.000	0.000	0.000	0.000	-	-	0.000	0.000	0.000
London	0.899	0.101	0.969	0.000	0.000	0.000	-	0.039	0.420
Winchester	0.005	0.000	0.002	0.002	0.000	0.000	0.039	-	0.159
York	0.223	0.005	0.168	0.000	0.000	0.000	0.420	0.159	-
Small towns *vs.* public towns: χ^2=39.718, d.f.=1, *p*=0.000									

Test 85. Schmorl’s nodes, CPR: comparison between Romano-British populations.

	Ancaster	**Baldock**	**Cirencester**	**Gloucester**	**Leicester**	**London**	**Winchester**
Ancaster	-	0.321	0.468	0.000	0.003	0.696	0.111
Baldock	0.321	-	0.130	0.000	0.069	0.759	0.002
Cirencester	0.468	0.130	-	0.000	0.010	0.920	0.002
Gloucester	0.000	0.000	0.000	-	0.126	0.000	0.000
Leicester	0.003	0.069	0.010	0.126	-	0.026	0.000
London	0.696	0.759	0.920	0.000	0.026	-	0.744
Winchester	0.111	0.002	0.002	0.000	0.744	0.744	-
Small towns *vs.* public towns: χ^2=4.437, d.f.=1, *p*=0.035							

Test 86. Extra-spinal OA, CPR: comparison between Romano-British populations.

	Ancaster	**Dorchester**	**Godmanchester**	**Ilchester**	**Cirencester**	**Gloucester**	**Winchester**
Ancaster	-	0.000	0.041	0.005	0.471	0.007	0.045
Dorchester	0.000	-	0.354	0.980	0.000	0.629	0.005
Godmanchester	0.041	0.354	-	0.672	0.000	0.893	0.003
Ilchester	0.005	0.980	0.672	-	0.011	0.001	0.094
Cirencester	0.471	0.000	0.011	0.000	-	0.975	0.399
Gloucester	0.007	0.629	0.893	0.001	0.975	-	0.149
Winchester	0.045	0.005	0.399	0.094	0.003	0.149	-
Small towns *vs.* public towns: χ^2=7.526, d.f.=1, *p*=0.006							

Test 87. Fractures, CPR: comparison between Romano-British populations.

	Ancaster	**Baldock**	**Dorchester**	**Godmanchester**	**Ilchester**	**Cirencester**	**Colchester**	**Poundbury**	**Gloucester**	**Leicester**	**London**	**Winchester**	**York**
Anc	-	.408	.026	.448	.057	.921	.000	.423	.483	.244	.018	.912	.003
Bald	.408	-	.236	.964	.236	.325	.000	.092	.975	.631	.181	.461	.093
Dorch	.026	.236	-	.578	.901	.015	.011	.002	.492	.977	.956	.032	.919
Godm	.448	.964	.578	-	.474	.395	.003	.200	.935	.912	.494	.486	.390
Ilchest	.057	.236	.901	.474	-	.044	.239	.015	.410	.790	1.00	.065	.950
Ciren	.921	.325	.015	.395	.044	-	.000	.396	.426	.208	.010	.909	.001
Colch	.000	.000	.011	.003	.239	.000	-	.000	.000	.036	.022	.000	.012
P'bury	.423	.092	.002	.200	.015	.396	.000	-	.213	.096	.001	.345	.000
Gloucs	.483	.975	.492	.935	.410	.426	.000	.213	-	.838	.414	.525	.311
Leics	.244	.631	.977	.912	.790	.208	.036	.096	.838	-	.882	.268	.783
Lond	.018	.181	.956	.494	1.00	.010	.022	.001	.414	.882	-	.022	.933
Win	.912	.461	.032	.486	.065	.090	.000	.345	.525	.268	.022	-	.004
York	.003	.093	.919	.390	.950	.001	.012	.000	.311	.783	.933	.004	-
Small towns *vs.* public towns: χ^2=0.001, d.f.=1, *p*=0.975													

Test 88. Periostitis, CPR: comparison between Romano-British populations.

	Ancaster	**Baldock**	**Godmanchester**	**Cirencester**	**Colchester**	**Gloucester**	**Leicester**	**London**	**Winchester**	**York**
Ancaster	-	.956	.862	.380	.000	.000	-	.000	1.000	.000
Baldock	.956	-	.975	.607	.000	.000	-	.001	.950	.001
Godmanchester	.862	.975	-	-	-	.000	-	.006	.791	.008
Cirencester	.380	.607	-	-	.000	.000	-	.000	.288	.000
Colchester	.000	.000	-	.000	-	.000	-	.000	.000	.000
Gloucester	.000	.000	.000	.000	.000	-	.000	.006	.000	.003
Leicester	-	-	-	-	-	.000	-	.000	-	.000
London	.000	.001	.006	.000	.000	.006	.000	-	.000	.975
Winchester	1.000	.950	.791	.288	.000	.000	-	.000	-	.000
York	.000	.001	.008	.000	.000	.003	.000	.975	.000	-
Small towns *vs.* public towns: χ^2=0.257, d.f.=1, *p*=0.612										

Test 89. Cribra orbitalia, CPR: comparison between Romano-British populations.

	Ancaster	**Baldock**	**Godmanchester**	**Cirencester**	**Colchester**	**Poundbury**	**Gloucester**	**Leicester**	**London**	**Winchester**	**York**
Ancaster	-	.082	.000	.002	.000	.117	.933	.327	.174	.178	.254
Baldock	.082	-	.015	.273	.000	.000	.234	.975	.002	.578	.629
Godmanchester	.000	.015	-	.057	-	.000	.001	-	.000	.004	.005
Cirencester	.002	.273	.057	-	.003	.000	.013	.358	.000	.019	.045
Colchester	.000	.000	-	.003	-	.000	.000	.004	.000	.000	.000
Poundbury	.117	.000	.000	.000	.000	-	.299	.877	.039	.000	.003
Gloucester	.933	.234	.001	.013	.000	.299	-	.484	.306	.439	.491
Leicester	.327	.975	-	.358	.004	.877	.484	-	.049	.933	.950
London	.174	.002	.000	.000	.000	.039	.306	.049	-	.003	.012
Winchester	.178	.578	.004	.019	.000	.000	.439	.933	.003	-	.896
York	.254	.629	.005	.045	.000	.003	.491	.950	.012	.896	-
Small towns *vs.* public towns: χ^2=0.748, d.f.=1, *p*=0.387											

Test 90. Hypoplasia, CPR: comparisons between Romano-British populations.

	Ancaster	**Baldock**	**Cirencester**	**Colchester**	**Gloucester**	**London**	**Winchester**	**York**
Ancaster	-	0.031	0.509	0.003	0.000	0.000	0.168	0.074
Baldock	0.031	-	0.001	0.714	0.001	0.000	0.473	0.854
Cirencester	0.509	0.001	-	0.000	0.000	0.000	0.013	0.004
Colchester	0.003	0.714	0.000	-	0.001	0.000	0.168	0.467
Gloucester	0.000	0.001	0.000	0.001	-	0.006	0.000	0.000
London	0.000	0.000	0.000	0.000	0.006	-	0.000	0.000
Winchester	0.168	0.473	0.013	0.168	0.000	0.000	-	0.719
York	0.074	0.854	0.004	0.467	0.000	0.000	0.719	-
Small towns *vs.* public towns: χ^2=4.946, d.f.=1, *p*=0.026								

Test 91. Caries, CPR: comparison between Romano-British populations.

	Ancaster	**Dorchester**	**Cirencester**	**Colchester**	**Gloucester**	**London**	**Winchester**
Ancaster	-	0.072	0.009	0.017	0.022	0.956	0.786
Dorchester	0.072	-	0.000	0.000	0.000	0.113	0.166
Cirencester	0.009	0.000	-	1.000	0.623	0.109	0.004
Colchester	0.017	0.000	1.000	-	0.585	0.139	0.008
Gloucester	0.022	0.000	0.623	0.585	-	0.089	0.012
London	0.956	0.113	0.109	0.139	0.089	-	0.730
Winchester	0.786	0.166	0.004	0.008	0.012	0.730	-
Small towns *vs.* public towns: χ^2=14.626, d.f.=1, *p*=0.000							

Test 92. Calculus, CPR: comparison between Romano-British populations.

	Ancaster	**Baldock**	**Godmanchester**	**Cirencester**	**Gloucester**	**London**	**Winchester**
Ancaster	-	0.458	0.002	0.827	0.706	0.000	0.386
Baldock	0.458	-	0.000	0.616	0.964	0.000	1.000
Godmanchester	0.002	0.000	-	0.001	0.002	0.437	0.000
Cirencester	0.827	0.616	0.001	-	0.862	0.000	0.956
Gloucester	0.706	0.964	0.002	0.862	-	0.000	0.000
London	0.000	0.000	0.437	0.000	0.000	-	0.000
Winchester	0.386	1.000	0.000	0.956	0.956	0.000	-
Small towns *vs.* public towns: χ^2=0.018, d.f.=1, *p*=0.894							

Test 93. Periodontal disease, CPR: comparison between Romano-British populations.

	Ancaster	**Godmanchester**	**Cirencester**	**Gloucester**	**London**	**Winchester**
Ancaster	-	0.006	0.000	0.000	0.975	0.002
Godmanchester	0.006	-	0.000	0.000	0.009	0.000
Cirencester	0.000	0.000	-	0.000	0.000	0.000
Gloucester	0.000	0.000	0.000	-	0.004	0.256
London	0.975	0.009	0.000	0.004	-	0.035
Winchester	0.002	0.000	0.000	0.256	0.035	-
Small towns *vs.* public towns: χ^2=74.502, d.f.=1, *p*=0.000						

Test 94. Peri-apical lesions, CPR: comparison between Romano-British populations.

	Ancaster	**Baldock**	**Dorchester**	**Cirencester**	**Colchester**	**Gloucester**	**London**	**Winchester**	**York**
Ancaster	-	0.000	0.001	0.001	0.002	0.000	0.001	0.035	0.066
Baldock	0.000	-	0.000	0.302	0.267	0.229	0.044	0.070	0.050
Dorchester	0.001	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000
Cirencester	0.001	0.302	0.000	-	1.000	0.042	0.000	0.384	0.290
Colchester	0.002	0.267	0.000	1.000	-	0.038	0.277	0.494	0.386
Gloucester	0.000	0.229	0.000	0.042	0.038	-	0.007	0.011	0.008
London	0.001	0.044	0.000	0.000	0.277	0.007	-	0.000	0.000
Winchester	0.035	0.070	0.000	0.384	0.494	0.011	0.000	-	0.957
York	0.066	0.050	0.000	0.290	0.386	0.008	0.000	0.957	-
Small towns *vs.* public towns: χ^2=21.203, d.f.=1, *p*=0.000									

Test 95. Ante-mortem tooth loss, CPR: comparison between Romano-British populations.

	Ancaster	**Baldock**	**Dorchester**	**Colchester**	**Winchester**
Ancaster	-	0.002	0.916	0.411	0.141
Baldock	0.002	-	0.009	0.024	0.135
Dorchester	0.916	0.009	-	0.523	0.225
Colchester	0.411	0.024	0.523	-	0.549
Winchester	0.141	0.135	0.225	0.549	-
Small towns *vs.* public towns: χ^2=0.000, d.f.=1, *p*=1.000					

Appendix 6. Comparative Data

The following tables collate demography and pathology prevalence data for other Romano-British sites. Unless otherwise stated, all data are derived from the relevant human bone report listed in the bibliography (Table 100). Footnotes provide additional information where relevant. In the pathology tables, cells left blank indicate that no data were provided in the bone report.

Table 100. References to human bone reports for comparative populations.

Site	**Site**	**Human Bone Report**
Baldock (Herts)	California Cemetery (BAL-1)	Roberts 2007
Dorchester-on-Thames (Oxon)	Queenford Farm and Queensford Mill	Harman 1987; Harman *et al*. 1979
Godmanchester (Cambs)	The Parks	Brickley 2003
Ilchester (Somer)	Little Spittle and Townsend Close	Everton and Rogers 1982
Cirencester (Gloucs)	South of the Fosse Way	Wells 1982
Colchester (Essex)	Butt Road	Pinter-Bellows 1993
Poundbury (Dorchester, Dorset)	Late Roman	Molleson 1993
Gloucester (Gloucs)	London Road	Márquez-Grant and Loe 2008
Leicester (Leics)	Newarke Street	Wakely and Carter 1996
London	Western Cemetery	MoL West
York (N Yorks)	Trentholme Drive	Peck 2009

Table 101. Demography of the Baldock population (after Roberts 2007).

Age (Years)	Number of Individuals*	Percentage of Sample
Neonate	5	3.9
Child	9	7.0
Young adult	9	7.0
Young/middle adult	32	25.0
Middle adult	7	5.5
Elderly adult	9	7.0
Unaged subadult	1	0.8
Unaged adult	56	43.8
Total	128	100.0

*Figures given in table do not match the total figure (132) given in the main text of the report.

Table 102. Demography of the Dorchester population (after Harman 1987).
(N.B. Based on burial catalogue.)

Age (Years)	Number of Individuals	Percentage of Sample
Perinate	1	0.6
<1	1	0.6
1-5	32	18.9
6-11	17	10.1
12-17	11	6.5
18-24	24	14.2
25-34	22	13.0
35-49	9	5.3
≥50	23	13.6
Unaged subadult	0	0.0
Unaged adult	29	17.2
Total	59	100.0

Table 103. Demography of the Godmanchester population (after Brickley 2003).

Age (Years)	Number of Individuals	Percentage of Sample
0-2	3	4.7
3-5	9	14.1
6-10	5	7.8
11-15	0	0.0
16-25	6	9.4
26-45	15	23.4
≥45	16	25.0
Adult	10	15.6
Total	64	100.0

Table 104. Demography of the Ilchester population (after Everton and Rogers 1982).

Age (Years)	Number of Individuals	Percentage of Sample
Neonate	3	5.1
Infant	1	1.7
1-5	1	1.7
6-11	2	3.4
12-17	1	1.7
18-24	8	13.6
25-34	13	22.0
35-44	6	10.2
≥45	3	5.1
Unaged adult	20	33.9
Unknown age	1	1.7
Total	59	100.0

Table 105. Demography of the Cirencester population (after Wells 1982).
(N.B. Wells used narrower five-year age brackets, which have been subsumed into the broader age-categories used in the present study.)

Age (Years)	Number of Individuals	Percentage of Sample
Perinate	0	0.0
<1	19	5.2
1-5	15	4.1
6-11	15	4.1
12-17	14	3.9
18-24	24	6.6
25-34	41	11.3
35-49	110	30.4
≥50	65	18.0
Unaged subadult	0	0.0
Unaged adult	59	16.3
Unknown age	0	0.0
Total	362	100.0

Table 106. Demography of the Colchester population (after Pinter-Bellows 1993).
(N.B. Subadult=<20 years.)

Age (Years)	Number of Individuals	Percentage of Sample
0-0.9	6	1.0
1-1.9	13	2.3
2.4.9	27	4.7
5-8.9	33	5.7
10-14.9	27	4.7
15-19.9	15	2.6
20-29.9	76	13.2
30-49.9	153	26.6
≥50	43	7.5
Unaged adult	152	26.4
Unknown age	30	5.2
Total	575	100.0

Table 107. Demography of the Gloucester population (after Márquez-Grant and Loe 2008).

Age (Years)	Number of Individuals	Percentage of Sample
Perinate	1	1.6
0-2	0	0.0
2-5	2	3.2
5-12	2	3.2
13-17	3	4.8
18-25	12	19.0
26-35	11	17.5
36-45	3	4.8
≥45	7	11.1
Unaged subadult	1	1.6
Unaged adult	18	28.6
Unknown age	3	4.8
Total	63	100.0

Table 108. Demography of the Leicester population (after Wakely and Carter 1996).

Age (Years)	Number of Individuals	Percentage of Sample
0-2	2	3.7
3-5	1	1.9
6-10	3	5.6
11-17	3	5.6
18-25	4	7.4
26-35	10	18.5
36-45	1	1.9
≥46	4	7.4
Unknown age	26	48.1
Total	54	100.0

Table 109. Demography of the London (Western Cemetery) population (MoL West).

Age (Years)	Number of Individuals	Percentage of Sample
Perinate and <1	0	0.0
1-5	8	5.8
6-11	7	5.1
12-17	12	8.8
18-25	5	3.6
26-35	7	5.1
36-45	16	11.7
≥46	3	2.2
Unaged subadult	5	3.6
Unaged adult	74	54.0
Total	137	100.0

Table 110. Demography of the Poundbury (late Roman) population (after Molleson 1993).

Age (Years)	Number of Individuals	Percentage of Sample
Perinate	65	6.1
1-3	160	14.9
4-7	54	5.0
8-12	43	4.0
13-17	46	4.3
18-24	94	8.8
25-34	174	16.2
35-44	165	15.4
≥45	229	21.3
Unaged subadult	0	0.0
Unaged adult	44	4.1
Unknown age	0	0.0
Total	1074	100.0

Table 111. Demography of the York (Trentholme Drive) population (after Peck 2009).

Age (Years)	Number of Individuals	Percentage of Sample
Perinate	1	0.4
0-4	0	0.0
5-9	13	5.0
10-14	10	3.8
15-19	11	4.2
20-24	105	40.1
34-49	83	31.7
≥50	16	6.1
Unknown age	23	8.8
Total	262	100.0

Table 112. Stature: Romano-British populations.
(Statures rounded to nearest centimetre; M/F=stature sexual dimorphism, calculated as mean male stature divided by mean female stature.)

	Females				**Males**				**M/F**
Public Towns	**N**	**Mean**	**Range**	**SD**	**N**	**Mean**	**Range**	**SD**	
Cirencester	44	158	148-170	-	107	169	160-182	-	1.07
Colchester	59	156	142-171	-	85	168	155-190	-	1.07
Poundbury	360	161	151-171	4.2	341	166	148-185	5.9	1.04
Gloucester	-	160	-	-	-	169	-	-	1.07
Leicester	9	159	151-170	-	7	171	161-177	-	1.07
London[1]	65	158	145-172	-	104	169	158-180	-	1.07
Winchester	38	156	144-166	4.8	60	168	153-177	4.9	1.08
York[2]	28	160	143-173	5.4	52	170	159-181	8.3	1.11
Small Towns	**N**	**Mean**	**Range**		**N**	**Mean**	**Range**		
Ancaster	56	155	144-169	5.7	73	169	158-180	5.7	1.09
Baldock	14	159	151-172	-	22	167	160-175	-	1.05
Dorchester[3]	33	157	148-170	6.5	40	168	156-182	5.5	1.06
Godmanchester	5	155	151-162	-	14	168	159-176	-	1.08
Ilchester[4]	13	158	151-165	4.7	25	170	157-179	5.9	1.08

[1] The mean statures given for the Western Cemetery are 165.8 cm for females and 168.9 cm for males. The figure for females is clearly atypical, therefore the data included above are for the Eastern Cemetery (Conheeney 2000: 280).

[2] Calculated from femoral lengths provided in burial catalogue (Peck 2009).

[3] Calculated from stature estimates provided in burial catalogue (Harman 1987).

[4] Samples from Little Spittle and Townsend Close combined; stature estimates extracted from burial catalogue (Everton and Rogers 1982).

Table 113. Prevalence of spinal osteoarthritis in Romano-British populations. (N^1=number of individuals/joints/vertebrae affected; N^2=number of individuals/joints/vertebrae affected; %=CPR/TPR.)

		CPR			**TPR***		
Public Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Cirencester[1]	N^1/N^2	80/190	22/63	58/127	419/6126	132/1889	287/4237
	%	42.1	34.9	45.6	6.8	70.9	6.8
Colchester[2]	N^1/N^2	-	-	-	-	-	-
	%	-	-	-	-	-	-
Poundbury	N^1/N^2	-	-	-	-	-	-
	%	-	-	-	-	-	-
Gloucester[3]	N^1/N^2	9/51	2/10	5/24	-	-	-
	%	17.6	20.0	20.1	-	-	-
Leicester	N^1/N^2	-	-	-	-	-	-
	%	-	-	-	-	-	-
London	N^1/N^2	16/59	3/20	10/27	-	-	-
	%	27.1	15.0	37.0	-	-	-
Winchester (this study)	N^1/N^2	31/139	10/58	21/78	171/3514	34/1400	137/2106
	%	22.3	17.2	26.9	4.9	2.4	6.5
York[4]	N^1/N^2	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Public	N^1/N^2	136/439	10/58	94/256	-	-	-
	%	31.0	17.2	36.7	-	-	-
		CPR			**TPR**		
Small Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Ancaster (this study)	N^1/N^2	59/169	17/69	41/96	323/5693	71/2064	148/3592
	%	34.9	24.6	42.7	5.7	3.4	6.9
Baldock[5]	N^1/N^2	-	-	-	-	-	-
	%	-	-	-	-	-	-
Dorchester[6]	N^1/N^2	-	-	-	-	-	-
	%	-	-	-	-	-	-
Godman-chester[7]	N^1/N^2	15/34	-	-	-	-	-
	%	44.0	-	-	-	-	-
Ilchester[8]	N^1/N^2	19/50	-	-	-	-	-
	%	38.0	-	-	-	-	-
TOTAL Small	N^1/N^2	93/253	17/69	41/96	323/5693	71/2064	148/3592
	%	36.8	24.6	42.7	5.7	3.4	6.9

[1] Data available for sexed adults only; CPR calculated from the number of individuals with partial/complete spines; TPR calculated as the number of 'hemi-vertebrae' (upper/lower facet pairs) affected.

[2] Data for sexed adults are presented in graph form only.

[3] No overall CPR provided, but data are provided by spinal region: all adults, C=17.1%, T=3.3%, L=3.6%; females, C=10.0%; T, L=0.0%; males, C=22.2%, T=5.9%, L=6.3%.

[4] The term 'osteoarthritis' is used, but appears to refer to disc disease.

[5] Separate data are given for osteophytosis, eburnation, and porosity; hence, the data are not comparable; 15 individuals had eburnation (23.8% of adults with preserved spines), but this will be a minimum estimate; Roberts (2008: 271) noted that eburnation was relatively rare, and considered most changes at the facet joints to be age-related.

[6] No distinction made between true osteoarthritis of the posterior facets and disc disease.

[7] CPR calculated as the proportion of individuals affected of those with at least one surviving vertebra.

[8] Unclear what diagnostic criteria were employed; total of 19/50 adults (38.0%) are recorded as having 'spinal osteoarthrosis'.

*No overall TPRs calculated as data are incompatible.

Table 114. Prevalence of degenerative disc disease in Romano-British populations. (N^1=number of individuals/joints/vertebrae affected; N^2=number of individuals/joints/ vertebrae affected; %=CPR/TPR.)

		CPR			**TPR***		
Public Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Cirencester[1]	**N^1/N^2**	125/190	36/63	89/127	1296/ 5577	262/ 1720	1034/ 3857
	%	65.8	57.1	70.1	23.2	15.2	26.8
Colchester[2]	**N^1/N^2**	73/238	20/101	53/137	-	-	-
	%	30.7	19.8	38.7	-	-	-
Poundbury	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Gloucester	**N^1/N^2**	4/51	1/10	2/23	-	-	-
	%	7.8	10.0	8.3	-	-	-
Leicester	**N^1/N^2**	3/43	0/12	3/11	-	-	-
	%	6.7	0.0	27.3	-	-	-
London	**N^1/N^2**	38/59	13/20	18/27	-	-	-
	%	64.4	65/0	66.7	-	-	-
Winchester (this study)	**N^1/N^2**	58/122	22/49	37/72	428/1572	94/626	334/945
	%	48.4	44.9	51.4	27.2	15.0	35.3
York[3]	**N^1/N^2**	70/122	17/32	42/65	-	-	-
	%	57.4	53.1	64.6	-	-	-
TOTAL Public	**N^1/N^2**	371/825	109/287	244/463	-	-	-
	%	45.0	38.0	52.7	-	-	-
		CPR			**TPR**		
Small Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Ancaster (this study)	**N^1/N^2**	98/150	35/62	62/85	872/2544	244/901	622/1628
	%	65.3	56.5	72.9	34.3	27.1	38.2
Baldock[4]	**N^1/N^2**	50/63	-	-	343/761	-	-
	%	79.4	-	-	45.0	-	-
Dorchester[5]	**N^1/N^2**	-	-	-		-	-
	%	-	-	-		-	-
Godmanchester[6]	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Ilchester[7]	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Small	**N^1/N^2**	148/213	35/62	62/85	-	-	-
	%	69.5	56.5	72.9	-	-	-

[1] Data provided for sexed adults only; CPR calculated from the number of individuals with partial/complete spines; TPR calculated as the number of 'hemivertebrae' (superior/inferior vertebral bodies) affected.

[2] Data provided for aged and sexed adults only.

[3] Referred to as 'osteoarthritis'.

[4] CPR calculated from the number of individuals with preserved/partially preserved spines; TPR calculated as the number of vertebrae affected.

[5] No distinction between true osteoarthritis of the posterior facet joints and disc disease.

[6] No overall CPR or TPR data provided (only TPR by vertebral level).

[7] One individual is described as having vertebral osteophytosis, although the term spinal osteoarthrosis is generally used, and it is unclear whether this refers to true spinal osteoarthritis and/or disc disease.

*No overall TPRs calculated as data are incompatible.

Table 115. Prevalence of Schmorl's nodes in Romano-British populations.
(N^1=number of individuals/joints/vertebrae affected; N^2=number of individuals/joints/ vertebrae affected; %=CPR/TPR.)

		CPR			**TPR***		
Public Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Cirencester[1]	**N^1/N^2**	83/190	24/63	59/127	419/5930	101/1804	318/4126
	%	43.7	38.1	46.5	7.1	5.6	7.7
Colchester[2]	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Poundbury	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Gloucester	**N^1/N^2**	4/51	1/10	3/24	-	-	-
	%	7.8	10.0	12.5	-	-	-
Leicester	**N^1/N^2**	9/43	3/12	6/11	-	-	-
	%	20.9	25.0	54.5	-	-	-
London	**N^1/N^2**	26/59	7/20	13/27	-	-	-
	%	44.1	35.0	48.1	-	-	-
Winchester (this study)	**N^1/N^2**	45/112	9/43	36/68	199/1153	37/445	162/707
	%	40.2	20.9	52.9	17.3	8.3	22.9
York	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Public	**N^1/N^2**	167/455	44/148	117/257	-	-	-
	%	36.7	29.7	45.5	-	-	-
		CPR			**TPR**		
Small Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Ancaster (this study)	**N^1/N^2**	70/145	18/58	52/83	308/1884	68/668	140/1207
	%	48.3	31.0	61.9	16.3	10.2	19.9
Baldock	**N^1/N^2**	25/63	-	-	111/499	-	-
	%	39.7	-	-	22.2	-	-
Dorchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Godmanchester[3]	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	14.9	20.5
Ilchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Small	**N^1/N^2**	95/208	18/58	52/83	-	-	-
	%	45.7	31.0	61.9	-	-	-

[1] Data provided for sexed adults only; CPR calculated from the number of individuals with partial/complete spines; TPR was calculated as the number of 'hemivertebrae' (upper/lower facet pairs) affected.

[2] Pinter-Bellows (1993: 75) considered Schmorl's nodes as trauma; she reported only two females with Schmorl's nodes, which seems improbably low, and also recorded an example in the cervical spine.

[3] Percentage TPRs for females and males provided, but no overall figures or raw data are given.

*No overall TPRs calculated as data are incompatible.

Table 116. Prevalence of extra-spinal osteoarthritis in Romano-British populations. (N^1=number of individuals/joints affected; N^2=number of individuals/joints affected; %=CPR/TPR.)

		CPR			**TPR***		
Public Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Cirencester[1]	**N^1/N^2**	104/300	25/93	79/207	-	-	-
	%	34.7	26.9	38.2	-	-	-
Colchester[2]	**N^1/N^2**	-	-	-	-	-	-
	%	-	0-14.0	6-23.0	-	-	-
Poundbury[3]	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Gloucester[4]	**N^1/N^2**	7/51	0/10	5/24	-	-	-
	%	13.7	0.0	20.1	-	-	-
Leicester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
London	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Winchester (this study)	**N^1/N^2**	43/198	14/67	27/93	108/2773	29/1076	77/1510
	%	21.7	20.9	29.0	3.9	2.7	5.1
York[5]	**N^1/N^2**	121/151	34/43	65/81	-	-	-
	%	80.0	79.1	80.2	-	-	-
TOTAL Public	**N^1/N^2**	275/700	73/213	176/405	108/2773	29/1076	77/1510
	%	39.3	34.3	43.5	3.9	2.7	5.1
		CPR			**TPR**		
Small Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Ancaster (this study)	**N^1/N^2**	61/196	19/78	38/105	161/3113	50/1241	106/1780
	%	31.1	24.4	36.2	5.2	4.0	6.0
Baldock[6]	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Dorchester	**N^1/N^2**	9/107	3/51	5/46	-	-	-
	%	8.4	5.9	10.9	-	-	-
Godmanchester[7]	**N^1/N^2**	7/47	3/17	4/19	-	-	-
	%	14.9	17.6	21.1	-	-	-
Ilchester	**N^1/N^2**	5/50	2/18	3/29	-	-	-
	%	10.0	11.1	10.3	-	-	-
TOTAL Small	**N^1/N^2**	82/400	27/164	50/199	161/3113	50/1241	106/1780
	%	20.5	16.5	25.1	5.2	4.0	6.0

[1] Data provided for sexed adults only (excludes rib heads); 16 females and 52 males exhibited multiple joint involvement; prevalences possibly inflated due to diagnosing OA from the presence of a single feature only.

[2] Diagnostic criteria unclear; CPR data provided for most joints, separated by sex (F/M), as follows: TMJ=4%/6%; shoulder: 5%/12%; elbow: 5%/10%; wrist: 8%/23%; hands: 4%/6%; hip: 9%/17%; knee: 10%/11%; ankle: 7%/20%; foot: 0%/6%.

[3] Data provided for 'severe' OA but unclear how this was defined; most affected joints (from most to least): knee, hand, foot, shoulder and wrist.

[4] No overall TPR given in text; order of joint involvement (from most to least): hip, elbow, hand and knee.

[5] Improbably high prevalence as it includes all joints with marginal osteophytosis.

[6] Forty-six individuals are listed as having extra-spinal joint disease, but this includes joints with osteophytosis only.

[7] Two individuals had OA of the knee; one had OA of the foot; two had OA of the hand; one had OA of the hip. TPRs: left knee=6.7%; right hand=3.1%; left hip=2.9%; right hip=3.1%.

*No overall TPRs calculated as data are incompatible.

Table 117. Prevalence of fracture trauma in Romano-British populations.

	Subadults		**Adults**					
			All		**Females**		**Males**	
Public Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cirencester[1]	0/56	0.0	73/306	23.9	8/93	8.6	64/207	30.9
Colchester[2]	1/108	0.9	23/467	4.9	7/140	5.0	16/170	9.4
Poundbury[3]	2/368	0.6	188/706	26.6	64/346	18.5	122/326	37.4
Gloucester[4]	0/9	0.0	9/51	17.6	0/10	0.0	7/24	29.2
Leicester	0/11	0.0	6/43	14.0	4/12	33.3	2/11	18.2
London	0/32	0.0	12/105	11.4	0/27	0.0	8/30	26.7
Winchester (this study)	0/130	0.0	46/200	23.0	12/67	17.9	31/93	33.3
York[5]	1/24	4.2	18/163	11.3	6/59	10.2	12/104	11.4
TOTAL Public	4/738	0.5	375/2061	18.2	101/754	13.4	262/965	27.2
	Subadults		**Adults**					
			All		**Females**		**Males**	
Small Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Ancaster (this study)	0/75	0.0	46/196	23.5	14/78	17.9	30/105	28.6
Baldock	0/15	0.0	22/117	18.8	6/55	10.9	12/44	27.3
Dorchester	2/62	3.2	13/107	12.1	3/51	5.9	10/46	21.7
Godmanchester[6]	0/17	0.0	8/47	17.0	3/17	17.6	4/19	21.1
Ilchester	0/8	0.0	5/50	10.0	3/18	16.7	2/29	6.9
TOTAL Small	2/177	1.1	94/517	18.2	29/219	13.2	58/243	23.9

[1] Data include blunt and sharp force trauma, healed and peri-mortem injuries; unclear if spondylolysis (seven cases) included.

[3] Data provided by Molleson (1993, p. 200, Table 47); unclear whether this includes earlier burials; also unclear whether spondylolysis is included.

[4] Total of 14 elements affected; two individuals had multiple fractures.

[5] Adult data are for sexed individuals only.

[6] One male had spondylolysis; 4 individuals (2M, 2F) with rib fractures; 1F with clavicle fracture (TPR 1/59, 1.7%); 2M with fibula fractures (TPR 2/58, 3.4%).

Table 118. Prevalence of scurvy in Romano-British populations.
(N^1=number of individuals affected; N^2=number of individuals present; %=CPR.)

	Subadults		**Adults**					
			All		**Females**		**Males**	
Public Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cirencester	0/56	0.0	0/306	0.0	0/93	0.0	0/207	0.0
Colchester	0/108	0.0	0/467	0.0	0/140	0.0	0/170	0.0
Poundbury[1]	12/248	4.8	-	-	-	-	-	-
Gloucester	0/9	0.0	0/51	0.0	0/10	0.0	0/24	0.0
Leicester	0/11	0.0	0/43	0.0	0/12	0.0	0/11	0.0
London (East)[2]	1/129	0.8	0/386	0.0	0/109	0.0	0/186	0.0
London (West)	1/32	3.1	0/150	0.0	0/27	0.0	0/30	0.0
Winchester (this study)	2/130	1.5	0/200	0.0	0/67	0.0	0/93	0.0
Winchester (Lankhills)[3]	5/64	7.8	0/220	0.0	0/94	0.0	0/94	0.0
York	0/24	0.0	0/215	0.0%	0/59	0.0%	0/104	0.0
TOTAL Public	21/812	2.6	0/2038	0.0	0/611	0.0	0/919	0.0
	Subadults		**Adults**					
			All		**Females**		**Males**	
Small Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Ancaster (this study)	0/75	0.0	0/196	0.0	0/78	0.0	0/105	0.0
Baldock	0/15	0.0	0/117	0.0	0/55	0.0	0/44	0.0
Dorchester	0/62	0.0	0/107	0.0	0/51	0.0	0/46	0.0
Godmanchester	0/17	0.0	0/47	0.0	0/17	0.0	0/19	0.0
Ilchester	0/8	0.0	0/50	0.0	0/18	0.0	0/29	0.0
TOTAL Small	0/177	0.0	0/517	0.0	0/219	0.0	0/243	0.0

[1] No data given in the original report (Molleson 1993); Melikian and Waldron (2003) identified two cases in 52 subadult crania; figure given in the table is from Lewis (2010).

[2] One case is reported from Eastern Cemetery by Conheeney (2000: 286).

[3] Diagnoses are tentative (Clough and Boyle 2010).

Table 119. Prevalence of rickets in Romano-British populations.
(N^1=number of individuals affected; N^2=number of individuals present; %=CPR.)*

	Subadults		**Adults**					
			All		**Females**		**Males**	
Public Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cirencester	0/56	0.0	0/306	0.0	0/93	0.0	0/207	0.0
Colchester	0/108	0.0	0/467	0.0	0/140	0.0	0/170	0.0
Poundbury[1]	12/248	4.8	1/706	0.0	1/346	0.3	0/326	0.0
Gloucester	0/9	0.0	0/51	0.0	0/10	0.0	0/24	0.0
Leicester[2]	1/11	9.1	0/43	0.0	0/12	0.0	0/11	0.0
London (West)	0/32	0.0	0/105	0.0	0/27	0.0	0/30	0.0
London (South)[3]	2/18	11.1	0/28	0.0	0/10	0.0	0/11	0.0
Winchester (this study)	0/130	0.0	0/200	0.0	0/67	0.0	0/93	0.0
Winchester (Lankhills)[4]	3/64	4.7	2/220	0.9	1/94	1.1	1/94	1.1
York	0/24	0.0	0/215	0.0%	0/59	0.0%	0/104	0.0
TOTAL Public	18/676	2.7	3/2341	0.1	2/858	0.2	1/1070	0.1
	Subadults		**Adults**					
			All		**Females**		**Males**	
Small Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Ancaster (this study)	1/75	1.3	0/196	0.0	0/78	0.0	0/105	0.0
Baldock	0/15	0.0	0/117	0.0	0/55	0.0	0/44	0.0
Dorchester[5]	1/62	1.6	0/107	0.0	0/51	0.0	0/46	0.0
Godmanchester[6]	1/17	5.9	0/47	0.0	0/17	0.0	0/19	0.0
Ilchester	0/8	0.0	0/50	0.0	0/18	0.0	0/29	0.0
TOTAL Small	3/177	1.7	0/517	0.0	0/219	0.0	0/243	0.0

[1] Original report (Molleson 1993) lists two cases in infants, and one young adult female with bowing of the femora and tibiae; subadult figures given above are from Lewis (2010).

[2] One subadult exhibited slight bowing of the long bones, diagnosis tentative.

[3] Two cases from the Southern Cemetery (MoL website); Conheeney (2000: 286-7) refers to a ‘few’ possible cases from the Eastern cemetery, but no details provided.

[4] Clough and Boyle (2010).

[5] Older child with bowing of the femora.

[6] Older child.

*A small number of cases have also been reported in skeletal remains from rural sites, including Kempston, Beds (Boylston and Roberts 2004: 345) and from Radley, Oxon (Harman *et al*. 1979: 159).

Table 120. Prevalence of osteomalacia in Romano-British populations.
(N^1=number of individuals affected; N^2=number of individuals present; %=CPR.)*

	All Adults		**Females**		**Males**	
Public Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cirencester	0/306	0.0	0/93	0.0	0/207	0.0
Colchester	0/467	0.0	0/140	0.0	0/170	0.0
Poundbury[1]	2/706	0.3	2/346	0.6	0/326	0.0
Gloucester	0/51	0.0	0/10	0.0	0/24	0.0
Leicester	0/43	0.0	0/12	0.0	0/11	0.0
London	0/105	0.0	0/27	0.0	0/30	0.0
Winchester (this study)	0/200	0.0	0/67	0.0	0/93	0.0
York	0/215	0.0	0/59	0.0	0/104	0.0
TOTAL Public	2/2093	0.1	2/754	0.3	0/965	0.0
	All Adults		**Females**		**Males**	
Small Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Ancaster (this study)	0/196	0.0	0/78	0.0	0/105	0.0
Baldock	0/117	0.0	0/55	0.0	0/44	0.0
Dorchester	0/107	0.0	0/51	0.0	0/46	0.0
Godmanchester	0/47	0.0	0/17	0.0	0/19	0.0
Ilchester	0/50	0.0	0/18	0.0	0/29	0.0
TOTAL Small	0/517	0.0	0/219	0.0	0/243	0.0

[1] Two females exhibited deformation of the pelves.

*One case is reported from Kempston, Beds (Boylston and Roberts 2004: 345).

Table 121. Prevalence of osteoporosis in Romano-British populations.
(N^1=number of individuals affected; N^2=number of individuals present; %=CPR.)

	All Adults		**Females**		**Males**	
Public Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cirencester	0/306	0.0	0/93	0.0	0/207	0.0
Colchester	0/467	0.0	0/140	0.0	0/170	0.0
Poundbury[1]	32/706	4.5	28/346	8.1	8/326	2.5
Gloucester	0/51	0.0	0/10	0.0	0/24	0.0
Leicester	0/43	0.0	0/12	0.0	0/11	0.0
London	0/105	0.0	0/27	0.0	0/30	0.0
Winchester (this study)	2/200	1.0	0/67	0.0	2/93	2.2
York	0/215	0.0	0/59	0.0	0/104	0.0
TOTAL Public	34/2093	1.6	28/754	3.7	10/965	1.0
	All Adults		**Females**		**Males**	
Small Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Ancaster (this study)	6/196	3.1	4/78	5.1	2/105	1.9
Baldock[3]	2/117	1.7	1/55	1.8	1/44	2.3
Dorchester[4]	1/107	0.9	0/51	0.0	1/46	2.2
Godmanchester	0/47	0.0	0/17	0.0	0/19	0.0
Ilchester	0/50	0.0	0/18	0.0	0/29	0.0
TOTAL Small	9/517	1.7	5/219	2.3	4/243	1.6

[1] Majority of cases diagnosed from ‘light bones’.

[2] Conheeney (2000: 287) reported that approximately ‘5.0%’ of adults in the sample from the Eastern Cemetery were affected, but it is unclear how this was diagnosed.

[3] Two adults had compression fractures of one or more vertebrae.

[4] One elderly male had a vertebral compression fracture.

Table 122. Prevalence of tuberculosis in Romano-British populations.
(N^1=number of individuals affected; N^2=number of individuals present; %=CPR.)

	Subadults		Adults					
			All		Females		Males	
Public Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cirencester[1]	0/56	0.0	1/306	0.3	0/93	0.0	1/207	0.5
Colchester[2]	0/108	0.0	0/467	0.3	0/140	0.0	0/170	0.0
Poundbury[3]	7/165	4.2	2/706	0.3	2/346	0.6	0/326	0.0
Other Dorchester[4]	-	-	3/?	?	1/?	?	2/?	?
Gloucester	0/9	0.0	0/51	0.0	0/10	0.0	0/24	0.0
Leicester[5]	0/11	0.0	1/43	2.3	1/12	8.3	0/11	0.0
London[6]	0/32	0.0	0/105	0.0	0/27	0.0	0/30	0.0
Winchester (this study)	0/130	0.0	1/200	0.5	1/67	1.5	0/93	0.0
York	0/24	0.0	0/215	0.0	0/59	0.0	0/104	0.0
Other York[7]			1/?	?			1/?	?
TOTAL Public	7/535	1.3	5/2192 (9/?)	0.2 (?)	4/754 (5/?)	0.5 (?)	1/965 (4/?)	0.1 (?)
	Subadults		**Adults**					
			All		**Females**		**Males**	
Small Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Ancaster (this study)	0/75	0.0	3/196	1.5	2/78	2.6	1/105	1.0
Ashton[8]	0/33	0.0	2/137	1.5	1/36	2.8	1/81	1.2
Baldock	0/15	0.0	0/117	0.0	0/55	0.0	0/44	0.0
Dorchester[9]	0/62	0.0	1/107	0.9	1/51	2.0	0/46	0.0
Godmanchester	0/17	0.0	0/47	0.0	0/17	0.0	0/19	0.0
Ilchester	0/8	0.0	0/50	0.0	0/18	0.0	0/29	0.0
Towcester[10]	-	-	1/?	?	-	-	1/?	?
TOTAL Small	0/210	0.0	6/654 (7/?)	0.9 (?)	4/255	1.6	2/324 (3/?)	0.6 ?

[1] Spinal TB in a male.

[2] Pinter-Bellows (1993: 91) refers to the 'rarity' of TB, but it is unclear whether this indicates the condition was entirely absent.

[3] Data for subadults are from Lewis (2011); original report (Molleson 1993) lists two cases of spinal TB in mature females.

[4] A mature/elderly male skeleton of late (possibly sub-) Roman date from Tolpuddle Ball, within Dorchester's Roman cemeteries, also exhibited spinal TB (McKinley 1999). Stirland and Waldron (1990) report a case of spinal TB in a young male from Alington Avenue, and Waldron (2002: 152) reports a case in a female from the same site.

[5] Possible spinal TB in a female, diagnosis tentative.

[6] No cases in the Western Cemetery, although one individual exhibited possible HPO; Conheeney (2000) reports two possible cases from the Eastern Cemetery, but no details of age/sex are given and there is no reference to TB at London in either Roberts and Cox (2003) or Roberts and Buikstra (2003).

[7] Male skeleton of Roman date exhibiting TB recently excavated (http://www.york.ac.uk/news-and-events/news/2008/roman-skeleton/).

[8] Stirland and Waldron (1990) report two cases of spinal TB in a young female and young male.

[9] Harman (1987): One case of probable spinal TB in a female aged at least 25 years.

[10] Anderson (2001b) reports a case of spinal TB in a mature male, total sample size unknown.

Table 123. Prevalence of periostitis in Romano-British populations.
(N^1=number of individuals affected; N^2=number of individuals present; %=CPR.)

	Subadults		**Adults**					
			All		**Females**		**Males**	
Public Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Cirencester[1]	0/56	0.0	26/306	8.5	7/93	7.5	18/207	8.7
Colchester[2]	0/108	0.0	8/467	1.7	1/140	0.7	7/170	4.1
Poundbury[3]	-	-	28/706	4.0	16/346	4.6	12/326	3.7
Gloucester[4]	3/9	33.3	25/51	49.0	7/10	70.0	12/24	50.0
Leicester[5]	0/11	0.0	1/43	2.3	1/12	8.3	0/11	0.0
London[6]	8/32	25.0	27/105	20.0	3/27	11.0	7/30	23.0
Winchester (this study)	3/74	4.1	24/200	12.0	9/67	13.4	9/93	9.7
York[7]	5/32	15.6	33/122	17.2	6/43	14.0	15/79	19.0
TOTAL Public	19/322	5.9	172/2000	8.6	50/738	6.8	80/940	8.5
	Subadults		**Adults**					
			All		**Females**		**Males**	
Small Towns	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**	**N^1/N^2**	**%**
Ancaster[8] (this study)	3/57	5.3	21/196	10.7	6/78	7.7	15/105	14.3
Baldock	0/15	0.0	12/117	10.3	3/55	5.5	7/44	1.59
Dorchester[9]	0/62	0.0	0/107	0.0	0/51	0.0	0/46	0.0
Godmanchester[10]	1/17	5.9	4/47	8.5	0/17	0.0	2/29	10.5
Ilchester	-	-	-	-	-	-	-	-
TOTAL Small	4/151	2.6	37/467	7.9	9/201	4.5	24/224	10.7

[1] Data refers to the number of individuals with periostitis of the tibiae and/or fibulae; three individuals had periostitis of the hand bones, but it is unclear if these individuals also had tibia/fibula periostitis; TPR for tibiae of 10-12%.

[2] Three individuals had circumscribed areas of periostitis on the tibia, possibly associated with ulcers or soft tissue trauma; three individuals had widespread periostitis of the lower limbs; one adult had an area of periostitis on the radius; a young male exhibited widespread symmetrical woven bone affecting almost the entire skeleton (=HPO?).

[3] Refers to ‘florid’ periostitis of the lower leg bones only (Molleson 1993: Table 41); Molleson also refers to a large number of cases of infantile cortical hyperostosis, some of which actually appear to be rickets; she provides no data for subadult periostitis.

[4] TPR of 28.9% for the tibiae.

[5] One female exhibited rib periostitis.

[6] TPR of 13.8% for the tibiae; CPR of 10% reported for the Eastern Cemetery (Conheeney 2000: 286).

[7] TPR of 3.4% for the tibiae; CPR calculated as the percentage of individuals with at least one long bone present; adult data are for sexed adults only; TPRs for tibia: overall=13.4%; subadults=15.6%, adults=11.6%, females=11.5%, males=14.0%.

[8] TPR of 6.5% for the tibiae.

[9] Harman (1987) does not refer to periostitis, but it unclear whether this means the condition was completely absent.

[10] Three individuals (2M, 1U) had periostitis of one or more leg bones; in one case the aetiology was probably traumatic; in another case, periostitis was present at the anterior tibia; a third individual had periostitis of a tibia and fibula; a fourth individual had widespread periostitis of the long bones (=possible HPO?); one subadult exhibited periostitis at the femur.

Table 124. Prevalence of cribra orbitalia in Romano-British populations.
(N^1=number of individuals/orbits affected; N^2=number of individuals/orbits present; %=CPR/TPR.)

		CPR				TPR			
		Subs	Adults			Subs	Adults		
Public Towns			**All**	**F**	**M**		**All**	**F**	**M**
Cirencester[1]	**N^1/N^2**	8/56	27/306	7/93	20/207	13/37	40/226	10/75	30/151
	%	14.3	8.8	7.5	9.7	35.1	17.7	13.3	19.9
Colchester	**N^1/N^2**	11/108	15/467	6/140	6/170	-	-	-	-
	%	10.2	3.2	4.3	3.5	-	-	-	-
Poundbury[2]	**N^1/N^2**	77/200	-	-	-	-	-	-	-
	%	38.5	-	-	-	-	-	-	-
Gloucester	**N^1/N^2**	2/9	11/51	5/10	3/24	3/6	15/41	4/16	5/28
	%	22.2	21.6	50.0	12.5	50.0	36.6	25.0	27.8
Leicester	**N^1/N^2**	2/11	6/43	3/12	2/11	-	-	-	-
	%	18.2	14.0	25.0	18.2	-	-	-	-
London[3]	**N^1/N^2**	11/32	30/105	7/27	8/30	-	-	-	-
	%	34.4	28.6	25.9	26.7	-	-	-	-
Winchester (this study)	**N^1/N^2**	15/36	25/108	10/48	15/56	23/62	69/265	19/86	29/110
	%	41.7	23.1	20.8	26.8	37.1	26.0	22.1	26.4
York	**N^1/N^2**	7/14	17/132	8/40	5/63	-	-	-	-
	%	50.0	12.9	20.0	7.9	-	-	-	-
TOTAL Public	**N^1/N^2**	133/466	131/1212	46/370	59/561	39/105	124/532	33/177	64/298
	%	28.5	10.8	12.4	10.4	37.1	23.3	18.6	21.5
		CPR				**TPR**			
		Subs	**Adults**			**Subs**	**Adults**		
Small Towns			**All**	**F**	**M**		**All**	**F**	**M**
Ancaster (this study)	**N^1/N^2**	16/36	19/121	5/49	13/68	38/70	34/224	9/91	23/127
	%	44.4	15.7	10.2	19.1	54.3	15.2	9.9	18.1
Baldock[4]	**N^1/N^2**	4/15	14/117	6/55	6/44	-	-	-	-
	%	26.7	12.0	10.9	13.6	-	-	-	-
Dorchester[5]	**N^1/N^2**	-	-	-	-	-	-	-	-
	%	-	-	-	-	-	-	-	-
Godmanchester[6]	**N^1/N^2**	0/17	1/47	0/17	0/19	-	-	-	-
	%	0.0	2.1	0.0	0.0	-	-	-	-
Ilchester	**N^1/N^2**	-	-	-	-	-	-	-	-
	%	-	-	-	-	-	-	-	-
TOTAL Small	**N^1/N^2**	20/68	34/285	11/121	19/131	38/70	34/224	9/91	23/127
	%	29.4	11.9	9.1	14.5	54.3	15.2	9.9	18.1

[1] Adult data include unsexed adults.

[2] Molleson (1993) does not provide overall prevalence date; Lewis (2010) gives a subadult CPR of 38.5% (77/200 individuals); Stuart-Macadam (1991) gives an overall CPR of 28.7% for a sample of 752 adult and subadult crania.

[3] Unclear how many individuals actually had preserved orbits; overall TPR (20.8%) given, but no breakdown by age/sex; Conheeney (2000: 285) reports that 'less than 5%' of individuals from the Eastern Cemetery were affected, but this seems improbably low.

[4] 16/77 left (20.8%) and 10/76 right (13.2%) orbits affected; 18 individuals were affected (no breakdown by age/sex).

[5] Data provided for total 1972 sample only: 8/49 (16.3%) individuals affected (no breakdown by age/sex).

[6] One young adult of unknown sex affected; no TPR data provided.

Table 125. Prevalence of dental enamel hypoplasia in Romano-British populations. (N^1=number of individuals/teeth affected; N^2=number of individuals/teeth present; %=CPR/TPR.)

		CPR				**TPR**			
		Subs	**Adults**			**Subs**	**Adults**		
Public Towns			**All**	**F**	**M**		**All**	**F**	**M**
Cirencester[1]	**N^1/N^2**	-	44/362	-	-	-	-	-	-
	%	-	12.2	-	-	-	-	-	-
Colchester[2]	**N^1/N^2**	13/75	51/159	24/74	25/85	-	-	-	-
	%	17.3	32.1	32.0	29.0	-	-	-	-
Poundbury[3]	**N^1/N^2**	-	-	-	-	-	-	-	-
	%	-	-	-	-	-	-	-	-
Gloucester	**N^1/N^2**	5/9	26/52	8/10	14/24	-	98/279	39/125	40/99
	%	55.6	51.0	80.0	58.3	-	35.1	31.2	40.4
Leicester[4]	**N^1/N^2**	-	-	-	-	-	-	-	-
	%	-	-	-	-	-	-	-	-
London	**N^1/N^2**	17/21	40/54	12/15	23/28	-	-	-	-
	%	81.0	74.1	80.0	82.1	-	-	-	-
Winchester (this study)	**N^1/N^2**	4/54	31/114	10/48	19/57	-	110/1983	29/802	74/1095
	%	7.4	27.2	20.8	33.3	-	5.5	3.6	6.8
York[5]	**N^1/N^2**	4/13	25/112	3/32	13/54	-	48/355	5/82	20/142
	%	30.8	22.2	9.4	24.1	-	13.4	6.1	14.1
TOTAL Public	**N^1/N^2**	43/172	217/853	57/179	94/248	-	256/2617	73/1009	134/1336
	%	25.0	25.4	31.8	37.9	-	9.8	7.2	10.0
		CPR				**TPR**			
		Subs	**Adults**			**Subs**	**Adults**		
Small Towns			**All**	**F**	**M**		**All**	**F**	**M**
Ancaster (this study)	**N^1/N^2**	5/39	21/139	10/54	11/81	-	139/2098	52/717	87/1342
	%	12.8	15.1	18.5	13.6	-	6.6	7.3	6.5
Baldock	**N^1/N^2**	1/15	32/117	-	-	-	-	-	-
	%	6.7	27.4	-	-	-	-	-	-
Dorchester	**N^1/N^2**	-	-	-	-	-	-	-	-
	%	-	-	-	-	-	-	-	-
Godmanchester	**N^1/N^2**	-	-	-	-	-	-	-	-
	%	-	-	-	-	-	-	-	-
Ilchester	**N^1/N^2**	-	-	-	-	-	-	-	-
	%	-	-	-	-	-	-	-	-
TOTAL Small	**N^1/N^2**	6.54	53/256	10/54	11/81	-	139/2098	52/717	87/1342
	%	11.1	20.7	18.5	13.6	-	6.6	7.3	6.5

[1] Data are provided for sexed adults only.

[2] CPR calculated from the number of individuals with preserved maxillae/mandibles.

[3] Molleson (1993) does not provide data.

[4] Reference is made to DEH, but no data are provided.

[5] Presence recorded for the incisors and canines only.

Table 126. Prevalence of caries in Romano-British populations.
(N^1=number of individuals/teeth affected; N^2=number of individuals/teeth present; %=CPR/TPR.)

		CPR			**TPR**		
Public Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Cirencester[1]	**N^1/N^2**	79/196	24/56	55/140	167/3251	47/869	120/2382
	%	41.6	42.9	39.2	5.1	5.4	5.0
Colchester[2]	**N^1/N^2**	65/159	-	-	127/3257	60/1509	67/1748
	%	41.0	-	-	3.9	4.0	3.8
Poundbury[3]	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	15.8	-	-
Gloucester[4]	**N^1/N^2**	18/51	5/10	9/24	62/546	18/205	34/254
	%	35.3	50.0	37.5	11.4	8.8	13.4
Leicester	**N^1/N^2**	-	-	-	59/590	-	-
	%	-	-	-	10.0	-	-
London[5]	**N^1/N^2**	29/54	7/15	18/28	-	-	-
	%	53.7	46.7	64.3	-	-	-
Winchester (this study)	**N^1/N^2**	66/114	31/48	33/57	164/2037	65/816	95/1135
	%	57.9	64.5	57.9	8.1	8.0	8.4
York[6]	**N^1/N^2**	-	-	-	121/1605	44/574	77/1031
	%	-	-	-	7.5	7.7	7.5
TOTAL Public	**N^1/N^2**	257/574	67/229	115/249	700/11,286	234/3973	393/6550
	%	44.8	29.3	46/2	6.2	5.9	6.0
		CPR			**TPR**		
Small Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Ancaster (this study)	**N^1/N^2**	77/139	30/54	44/81	186/2149	73/734	109/1376
	%	55.4	55.6	54.3	8.7	9.9	7.9
Baldock[7]	**N^1/N^2**	-	-	-	102/1275	-	-
	%	-	-	-	8.0	8.5	7.8
Dorchester[8]	**N^1/N^2**	55/80	26/40	28/37	155/1456	70/706	82/737
	%	62.5	65.0	75.7	10.6	9.9	11.1
Godmanchester[9]	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	10.9	-	-
Ilchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Small	**N^1/N^2**	132/219	56/94	72/118	443/4880	143/1440	191/2113
	%	60.3	59.6	61.0	9.1	9.9	9.0

[1] Data are for sexed adults only; no subadults were affected; CPR calculated as the percentage of skulls with affected dentitions; maxillary TPR=7.4%, mandibular TPR=3.3%.

[2] There are several inconsistencies in the report data; the CPR is given as 41.0%, but numbers are not provided; hence, the number of affected individuals has been calculated as 41.0% of the number of individuals with preserved maxillae/mandibles.

[3] Molleson (1993: 183) gives an overall TPR of 15.8%, but does not provide raw data.

[4] CPRs calculated from the number of individuals present.

[5] No TPR data are available for the Western Cemetery; Conheeney (2000) gives an overall TPR of 7.3% for the Eastern Cemetery (includes subadults).

[6] Total is for sexed adults.

[7] TPR appears to include subadult dentitions.

[8] The figures provided are for the combined 1972 and 1981 sample, obtained from the burial catalogue (Harman 1987); CPR calculated as the percentage of individuals affected as a proportion of those with surviving dentition.

[9] No CPR data available.

Table 127. Prevalence of calculus in Romano-British populations.
(N^1=number of individuals/teeth affected; N^2=number of individuals/teeth present; %=CPR/TPR.)

		CPR			**TPR**		
Public Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Cirencester[1]	**N^1/N^2**	105/196	-	-	-	-	-
	%	53.6	-	-	-	-	-
Colchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Poundbury[2]	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	31-75.0	-	-
Gloucester[3]	**N^1/N^2**	26/51	8/10	12/24	343/515	139/202	165/226
	%	51.0	80.0	50.0	66.7	68.8	73.0
Leicester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
London[4]	**N^1/N^2**	51/54	15/15	27/28	-	-	-
	%	94.4	100.0	96.4	-	-	-
Winchester (this study)	**N^1/N^2**	56/114	20/48	33/57	519/2037	205/816	305/1135
	%	49.1	41.7	57.9	25.5	25.1	26.9
York[6]	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Public	**N^1/N^2**	238/415	43/83	72/109	862/2552	344/1018	470/1361
	%	57.3	51.8	66.1	33.8	33.8	34.5
		CPR			**TPR**		
Small Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Ancaster (this study)	**N^1/N^2**	77/139	23/54	55/81	702/2149	169/734	533/1376
	%	55.4	42.6	67.9	32.7	23.0	38.7
Baldock[5]	**N^1/N^2**	45/78	16/40	26/48	581/1190	-	-
	%	57.7	40.5	68.0	48.8	-	-
Dorchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Godmanchester	**N^1/N^2**	27/31	-	-	-	-	-
	%	87.1	-	-	-	-	-
Ilchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Small	**N^1/N^2**	149/248	39/94	81/129	1283/3339	169/734	533/1376
	%	60.1	41.5	62.8	38.4	23.0	38.7

[1] Minimum of 105 individuals affected.

[2] No data provided in original report. Whittaker *et al.* (1998) provides data for a subsample of 20 females and 20 males from Poundbury: maxillary TPR=31.0%, mandibular TPR=75.0%

[3] No CPR data provided.

[4] No TPR data provided.

[5] CPR is for sexed adults only, and appears to have been calculated from the total number of individuals with *in situ* teeth; TPR data include *in situ* teeth only.

Table 128. Prevalence of periodontal disease in Romano-British populations.
(N^1=number of individuals/sockets affected; N^2=number of individuals/sockets present; %=CPR/TPR.)

		CPR			**TPR**		
Public Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Cirencester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Colchester	**N^1/N^2**	9/159	5/74	4/85	-	-	-
	%	5.7	6.8	4.7	-	-	-
Poundbury	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Gloucester[1]	**N^1/N^2**	16/51	6/10	8/24	-	-	-
	%	31.4	60.0	33.3	-	-	-
Leicester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
London	**N^1/N^2**	33/54	10/15	20/28	-	-	-
	%	61.1	66.7	71.4	-	-	-
Winchester (this study)	**N^1/N^2**	46/109	20/46	25/46	467/1903	183/750	282/1091
	%	42.2	43.5	44.6	24.5	24.4	25.8
York	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Public	**N^1/N^2**	104/373	41/145	57/183	467/1903	183/750	282/1091
	%	27.9	28.3	31.1	24.5	24.4	25.8
		CPR			**TPR**		
Small Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Ancaster (this study)	**N^1/N^2**	84/134	32/53	52/77	1073/ 2065	360/706	713/1322
	%	62.7	60.4	67.5	52.0	51.0	53.9
Baldock[2]	**N^1/N^2**	-	-	-	-	-	-
	%	100.0	100.0	100.0	-	-	-
Dorchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Godmanchester[3]	**N^1/N^2**	28/31	-	-	-	-	-
	%	90.3	-	-	-	-	-
Ilchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Small	**N^1/N^2**	112/165	32/53	52/77	1073/ 2065	360/706	713/1322
	%	67.9	60.4	67.5	52.0	51.0	53.9

[1] Calculated from the total number of adults present; may thus be an underestimate, as relatively few individuals had well preserved maxillae/mandibles (Márquez-Grant and Loe 2008: 45).

[2] Stated that all maxillae/mandibles were affected, but no data are provided for the numbers of individuals with preserved maxillae/mandibles.

[3] Calculated from the number of individuals with preserved maxillae/mandibles.

Table 129. Prevalence of peri-apical lesions in Romano-British populations.
(N^1=number of individuals/teeth affected; N^2=number of individuals/teeth present; %=CPR/TPR.)

		CPR			**TPR**		
Public Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Cirencester[1]	**N^1/N^2**	37/196	12/56	25/140	59/4710	-	-
	%	18.9	21.4	17.9	1.2	-	-
Colchester[2]	**N^1/N^2**	31/159	-	-	25/3665	9/1645	16/2021
	%	13.0	-	-	0.7	0.5	1.4
Poundbury	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Gloucester[3]	**N^1/N^2**	3/51	1/10	2/24	3/423	1/77	2/139
	%	5.9	10.0	8.3	0.7	0.5	1.4
Leicester	**N^1/N^2**	-	-	-	12/585	-	-
	%	-	-	-	2.1	-	-
London	**N^1/N^2**	15/54	4/15	10/28	-	-	-
	%	27.8	26.7	35.7	-	-	-
Winchester (this study)	**N^1/N^2**	31/132	12/51	18/58	48/2934	15/1202	31/1613
	%	23.5	23.5	31.0	1.6	1.2	1.9
York[4]	**N^1/N^2**	29/118	13/34	14/55	57/2281	13/633	25/1065
	%	24.6	38.2	25.5	2.5	2.1	2.3
TOTAL Public	**N^1/N^2**	146/710	42/166	69/305	204/ 14,598	38/3557	74/4838
	%	20.6	25.3	22.6	1.4	1.1	1.5
		CPR			**TPR**		
Small Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Ancaster (this study)	**N^1/N^2**	50/139	22/54	28/80	78/3293	29/1249	49/1954
	%	36.0	40.7	35.0	2.3	2.3	2.5
Baldock[5]	**N^1/N^2**	16/117	-	-	24/1903	-	-
	%	13.7	-	-	1.3	-	-
Dorchester[6]	**N^1/N^2**	49/83	20/41	27/39	155/1829	108/983	98/944
	%	59.0	48.8	69.2	8.5	11.0	10.4
Godman-chester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Ilchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Small	**N^1/N^2**	115/339	42/95	55/119	257/7025	137/2232	147/2898
	%	33.9	44.2	46.2	3.7	6.1	5.1

[1] CPR calculated as the percentage of skulls with affected dentitions; no breakdown of TPR data by sex.

[2] The actual number of individuals affected is not provided, but is calculated from the figure given for the CPR (13.0%) and the number of individuals with preserved maxillae/mandibles.

[3] CPR calculated from the total number of individuals present.

[4] Prevalence rates calculated from the data contained in the skeleton catalogue; excludes subadults and individuals of unknown age/sex; data are for adults aged ≥20 yrs only; CPR calculated as the percentage of individuals with at least one tooth socket preserved; TPR calculated as the percentage of tooth positions affected.

[5] CPR calculated from total number of adults present (therefore the figures are almost certainly an under-estimate; TPR calculated as the number of abscesses observed (24) as a proportion of the total number of sockets present (determined by adding the total number of adult teeth *in situ*, to the numbers of sockets with ante- and post-mortem tooth loss (Roberts 2007: Tables 100 and 101).

[6] Combined data for 1972 and 1981 samples.

Table 130. Prevalence of ante-mortem tooth loss in Romano-British populations.

		CPR			**TPR**		
Public Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Cirencester[1]	**N^1/N^2**	-	-	-	399/4710	155/1361	244/3349
	%	-	-	-	8.5	11.4	7.3
Colchester[2]	**N^1/N^2**	91/159			415/3666	142/1645	273/2021
	%	57.0			11.3	8.6	13.5
Poundbury	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	22.0	-	-
Gloucester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	2.5	-	-
Leicester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	9.7	-	-
London	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Winchester (this study)	**N^1/N^2**	70/132	29/51	38/58	441/2924	199/1202	225/1613
	%	53.0	56.9	65.5	15.1	16.6	13.9
York[3]	**N^1/N^2**	-	-	-	127/1832	61/694	66/1138
	%	-	-	-	6.9	8.8	5.8
TOTAL Public	**N^1/N^2**	161/291	29/51	38/58	1382/ 13,132	557/4902	808/8121
	%	55.3	56.9	65.5	10.5	11.4	9.9
		CPR			**TPR**		
Small Towns		**All**	**Females**	**Males**	**All**	**Females**	**Males**
Ancaster (this study)	**N^1/N^2**	87/139	33/54	50/80	435/3293	177/1249	231/1954
	%	62.6	61.1	62.5	13.2	14.2	11.8
Baldock[4]	**N^1/N^2**	50/117	-	-	398/2008	190/438	171/580
	%	42.7	-	-	19.8	43.4	29.5
Dorchester[5]	**N^1/N^2**	53/85	23/42	27/40	313/2164	54/857	187/1134
	%	62.3	54.8	67.5	14.5	6.3	16.5
Godmanchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
Ilchester	**N^1/N^2**	-	-	-	-	-	-
	%	-	-	-	-	-	-
TOTAL Small	**N^1/N^2**	190/341	56/96	77/120	1146/ 7465	421/2544	589/3668
	%	55.7	58.3	64.2	15.4	16.5	16.1

[1] No CPR data are provided.

[2] The number of individuals affected is not provided, but is calculated from the CPR (57%) and number of individuals with preserved maxillae/mandibles.

[3] Total is for sexed adults only.

[4] CPR calculated from the total number of individuals present (therefore probably an under-estimate).

[5] Combined data for 1972 and 1981 samples.

Appendix 7. Instructions for the Access Database

The Access database comprises 8 forms and 21 tables containing detailed information on age, sex, metrics, stature, skeletal and dental inventories and pathology. **Form A** is the Main Catalogue, from which other forms containing information on age-at-death, sex, metrics, stature and a dental inventory can be accessed (e.g. clicking on the 'Age' tab in Form A opens Form B at the relevant record for that individual). In addition to being identified by skeleton ID (e.g. VR 1), each skeleton was also assigned a skeleton number from 1 to 601 according to the order in which the remains were examined to aid sorting, e.g. VR 1=skeleton 1.

Forms	
A	Main Catalogue
B	Age-at-Death
C	Sex
D	Dental Inventory
E1	Cranial Metrics
E2	Postcranial Metrics
E3	Stature

Tables	
B2i	Subadult Dental Ages
B2ii	Subadult Maturation Ages
B2iii	Subadult Metric Ages
D1	Adult Skeletal Inventory
D2	Subadult Skeletal Inventory
D3	Adult Joint Inventory
D4	Dental Inventory (Individuals)
D5	Dental Inventory (Teeth/Sockets)
F1	Dental Pathology
F2i	Osteoarthritis
F2ii	Disc Disease
F2iii	Schmorl's nodes
F2iv	Other Joint Disease
F3i	Fractures
F3ii	Other Trauma
F4	Metabolic Disease
F5	Specific Infection
F6i	Periostitis
F6ii	Cribra orbitalia and Porotic Hyperostosis
F7	Neoplastic Disease
F8	Congenital Anomalies

Tables D1 and **D2** contain inventories of all adult and subadult skeletal elements present. **Table D3** is an inventory of all adult joint units present. Each joint was recorded as a binary array of 1s (indicating presence) and 0s (indicating absence; see Table 131, below). For example, the right hip joint (acetabulum and proximal femur) was recorded as 11 if both surfaces were at least 50% in intact; 10 if only the right acetabulum was present; and 01 if only the right femoral head was present. To aid sorting, each element and sub-element was given a code (see Table 132, below). Joints were also coded (see Table 133, below). These codes are used in all pathology data tables to aid sorting and cross-referencing. **Table D5** contains an inventory of all teeth/sockets observed, ordered by individual and tooth number.

Table F1 contains data on dental pathology organised by individual and tooth/socket. Skeletal pathology data are contained in **Tables F2-8**. In Table F1 (Dental Pathology), several expansion columns provide detailed information on the size/severity/location of dental disease. Tables F2i (Osteoarthritis) and F2ii (Disc Disease) indicate which diagnostic features were present for each affected joint. Table F3i (Fractures) lists all fractures observed and contains information on fracture type, healing, secondary pathology, underlying pathology and (for long bones) apposition, angulation, rotation and shortening. Table F6ii (Cribra Orbitalia and Porotic Hyperostosis) lists all orbits and cranial elements with lesions; for cribra orbitalia, the severity (grade 1-5) and activity of lesions is recorded.

Table 131. Notation system for recording joints.

Joint	**Binary Array**	**Joint Surfaces**
Atlanto-occipital	11	Occipital condyle | superior atlas facet
Median atlanto-axial (C1-C2 atlanto-odontoid)[1]	11	Anterior atlas arch | odontoid process of axis
Lateral atlanto-axial (C1-C2 facets)	11	Inferior atlas facet | superior axis facet
C3-C4 facets, etc.[2]	11	Inferior zygoapophyseal facet of C3 [most cranial vertebra] | superior zygoapophyseal facet of C4 [most caudal vertebra]
C3-C4 centra, etc.	11	Inferior endplate of C3 [most cranial vertebra] | superior endplate of C4 [most caudal vertebra]
Sacroiliac	11	Auricular surface of ilium | auricular facet of sacrum
Temporomandibular	11	Temporal mandibular fossa | mandibular condyle
Sternoclavicular	11	Manubrium clavicular notch | medial clavicle
Acromioclavicular	11	Lateral clavicle | acromion of scapula
Glenohumeral	11	Glenoid fossa | proximal humerus
Elbow	111	Distal humerus | proximal radius | proximal ulna
Wrist	1111	Distal radius | distal ulna | scaphoid | lunate
Hand[3]	11111	Carpals | metacarpals | proximal phals | middle phals | distal phals
Hip	11	Acetabulum | proximal femur
Knee	111	Distal femur | patella | proximal tibia
Ankle	111	Distal tibia | distal fibula | talus
Foot[4]	11111	Tarsals | metatarsals | proximal phals | middle phals | distal phals

[1] The medial atlanto-axial joint is referred to as the atlanto-odontoid joint to avoid confusion with the lateral atlanto-axial joints.

[2] For the posterior facet and intervertebral joints of the spine, the first number always refers to the most superior/cranial vertebra (e.g. the inferior facet/endplate of the C3) and the second number always refers to the most inferior/caudal vertebra (e.g. the superior facet/endplate of the C4, etc.).

[3,4] Carpals/tarsals, metacarpals/metatarsals, proximal phalanges, middle phalanges and distal phalanges were considered ‘present’ if at least one element from the group was present.

Table 132. Coding system for skeletal elements.

Code	**(Sub-)Element**
1.011; 1.012, 1.013	Frontal squama; R, L orbit
1.02, 1.03	R, L Parietal
1.04, 1.05	R, L Temporal
1.061; 1.062, 1.063; 1.064	Occipital supraocciput; R, L exocciput; basiocciput
1.08, 1.09	R, L Zygomatic
1.10, 1.11	R, L Nasal
1.12, 1.13	R, L Maxilla
1.14, 1.15	R, L Palatine
1.161, 1.162 1.171, 1.172	R Mandible body; R condyle L Mandible body; L condyle
2.101-107	C1-C7
2.201-212	T1-T12
2.301-305	L1-L5
2.401-405 2.406, 2.407	Sacral body segments 1-5 R, L Auricular facets
3.11, 3.12, 3.13	Sternum manubrium; corpus; xiphoid
3.2, 3.3; 3.4; 3.5	R, L vertebral ribs; sternal rib ends; rib shaft fragments
4.11, 4.12, 4.13 4.21, 4.22, 4.23	R clavicle medial end; shaft; lateral end L clavicle medial end; shaft; lateral end
4.31, 4.32, 4.33, 4.34, 4.35, 4.36 4.41, 4.42, 4.43, 4.44, 4.45, 4.46	R scapula glenoid; coracoid; acromion; superior border; medial border; lateral border L scapula glenoid; coracoid; acromion; superior border; medial border; lateral border
5.11, 5.12, 5.13, 5.14, 5.15 5.21, 5.22, 5.23, 5.24, 5.25	R pelvis ilium, auricular surface, ischium, acetabulum, pubis L pelvis ilium, auricular surface, ischium, acetabulum, pubis
6.11, 6.12, 6.13, 6.14, 6.15 6.21, 6.22, 6.23, 6.24, 6.25	R humerus prox end, prox 1/3, mid 1/3, dist 1/3, dist end L humerus prox end, prox 1/3, mid 1/3, dist 1/3, dist end
6.31, 6.32, 6.33, 6.34, 6.35 6.41, 6.42, 6.43, 6.44, 6.45	R radius prox end, prox 1/3, mid 1/3, dist 1/3, dist end L radius prox end, prox 1/3, mid 1/3, dist 1/3, dist end
6.51, 6.52, 6.53, 6.54, 6.55 6.61, 6.62, 6.63, 6.64, 6.65	R ulna prox end, prox 1/3, mid 1/3, dist 1/3, dist end L ulna prox end, prox 1/3, mid 1/3, dist 1/3, dist end
7.101, 102, 103, 104, 105, 106, 107, 108 7.109, 110, 111, 112, 113, 114, 115, 116	R scaphoid, capitate, hamate, lunate, triquetral, trapezium, trapezoid, pisiform L scaphoid, capitate, hamate, lunate, triquetral, trapezium, trapezoid, pisiform,
7.201, 202, 203, 204, 205 7.206, 207, 208, 209, 210	R metacarpals 1 to 5 L metacarpals 1 to 5
7.31, 7.32, 7.33	Proximal hand phalanges, intermediate hand phalanges, distal hand phalanges
8.11, 8.12, 8.13, 8.14, 8.15 8.21, 8.22, 8.23, 8.24, 8.25	R femur prox end, prox 1/3, mid 1/3, dist 1/3, dist end L femur prox end, prox 1/3, mid 1/3, dist 1/3, dist end
8.3, 8.4	R, L patella
8.51, 8.52, 8.53, 8.54, 8.55 8.61, 8.62, 8.63, 8.64, 8.65	R tibia prox end, prox 1/3, mid 1/3, dist 1/3, dist end L tibia prox end, prox 1/3, mid 1/3, dist 1/3, dist end
8.71, 8.72, 8.73, 8.74, 8.75 8.81, 8.82, 8.83, 8.84, 8.85	R fibula prox end, prox 1/3, mid 1/3, dist 1/3, dist end L fibula prox end, prox 1/3, mid 1/3, dist 1/3, dist end
9.101, 102, 103, 104, 105, 106, 107 9.108, 109, 110, 111, 112, 113, 114	R talus, calcaneus, cuboid, navicular, first cuneiform, second cuneiform, third cuneiform L talus, calcaneus, cuboid, navicular, first cuneiform, second cuneiform, third cuneiform
9.201, 202, 203, 204, 205 9.206, 207, 208, 209, 210	R metatarsals 1 to 5 L metatarsals 1 to 5
9.31, 9.32, 9.33	Proximal foot phalanges, intermediate foot phalanges, distal foot phalanges

Table 133. Coding system for joints.

Code	Joint	Code	Joint
1.01, 1.02	R, L temporomandibular	4.01, 4.02	R, L sternoclavicular
2.01, 2.02	R, L atlanto-occipital	4.03, 4.04	R, L acromioclavicular
2.03 2.04, 2.05	Medial atlanto-axial (atlanto-odontoid) Lateral atlanto-axial (C1-C2 facets)	4.05, 4.06	R, L glenohumeral
2.06, 2.07 2.08	R, L C2-C3 facet joints C2-C3 intervertebral (centra)	4.07, 4.08	R, L elbow
2.09, 2.10 2.11	R, L C3-C4 facet joints C3-C4 intervertebral (centra)	4.09. 4.10	R, L wrist
2.12, 2.13 2.14	R, L C4-C5 facet joints C4-C5 intervertebral (centra)	4.11, 4.12	R, L hand
2.15, 2.16 2.17	R, L C5-C6 facet joints C5-C6 intervertebral (centra)	5.01, 5.02	R, L sacroiliac
2.18, 2.19 2.20	R, L C6-C7 facet joints C6-C7 intervertebral (centra)	5.03, 5.04	R, L hip
2.21, 2.22 2.23	R, L C7-T1 facet joints C7-T1 intervertebral (centra)	5.05, 5.06	R, L knee
2.24, 2.25 2.26	R, L T1-T2 facet joints T1-T2 intervertebral (centra)	5.07, 5.08	R, L ankle
2.27, 2.28 2.29	R, L T2-T3 facet joints T2-T3 intervertebral (centra)	5.09, 5.10	R, L foot
2.30, 2.31 2.32	R, L T3-T4 facet joints T3-T4 intervertebral (centra)		
2.33, 2.34 2.35	R, L T4-T5 facet joints T4-T5 intervertebral (centra)		
2.36, 2.37 2.38	R, L T5-T6 facet joints T5-T6 intervertebral (centra)		
2.39, 2.40 2.41	R, L T6-T7 facet joints T6-T7 intervertebral (centra)		
2.42, 2.43 2.44	R, L T7-T8 facet joints T7-T8 intervertebral (centra)		
2.45, 2.46 2.47	R, L T8-T9 facet joints T8-T9 intervertebral (centra)		
2.48, 2.49 2.50	R, L T9-T10 facet joints T9-T10 intervertebral (centra)		
2.51, 2.52 2.53	R, L T10-T11 facet joints T10-T11 intervertebral (centra)		
2.54, 2.55 2.56	R, L T11-T12 facet joints T11-T12 intervertebral (centra)		
2.57, 2.58 2.59	R, L T12-L1 facet joints T12-L1 intervertebral (centra)		
2.60, 2.61 2.62	R, L L1-L2 facet joints L1-L2 intervertebral (centra)		
2.63, 2.64 2.65	R, L L2-L3 facet joints L2-L3 intervertebral (centra)		
2.66, 2.67 2.68	R, L L3-L4 facet joints L3-L4 intervertebral (centra)		
2.69, 2.70 2.71	R, L L4-L5 facet joints L4-L5 intervertebral (centra)		
2.72, 2.73 2.74	R, L L5-S1 facet joints L5-S1 intervertebral (centra)		

Appendix 8. Photographs of Selected Pathology

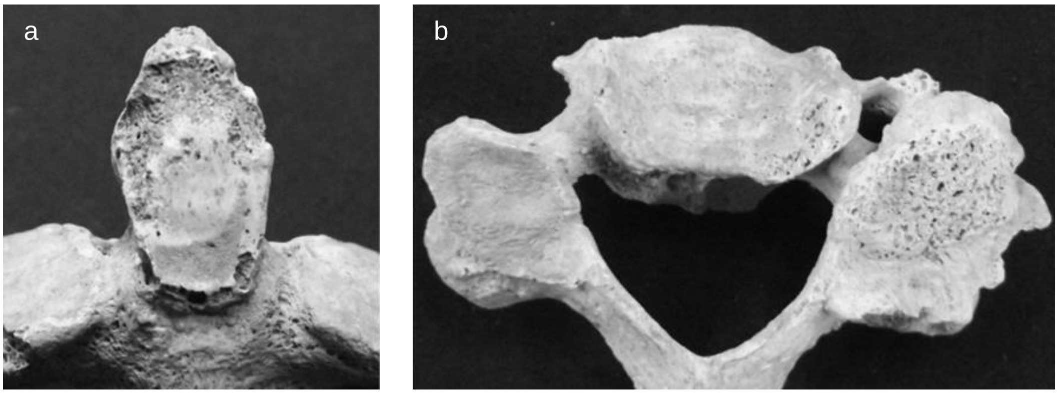

Figure 75. Spinal osteoarthritis: (a) odontoid process of second cervical (axis) vertebra, ANC 74; (b) posterior view of a cervical vertebra, ANC 325.

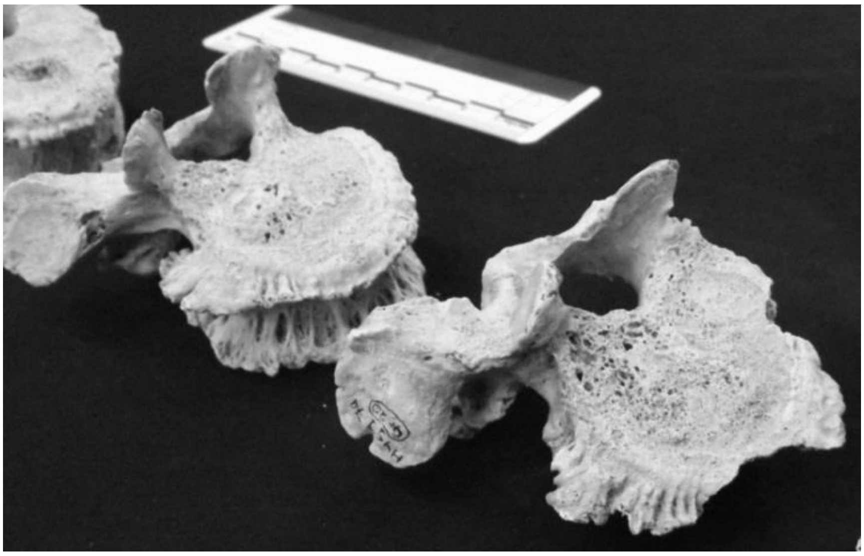

Figure 76. Disc disease, HYS 20.

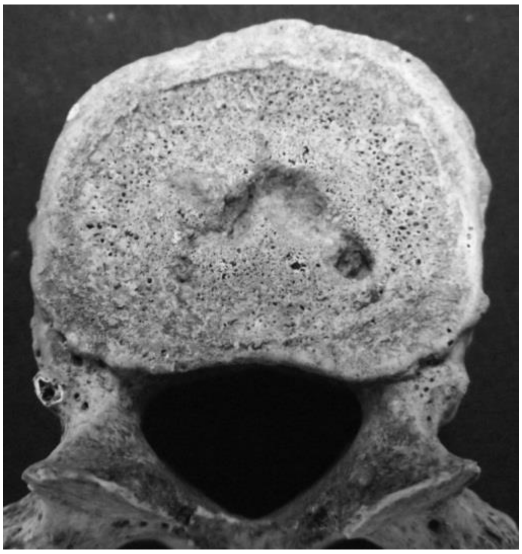

Figure 77. Schmorl’s node, ANC 56.

Figure 78. Osteoarthritis of the temporomandibular joint, VR 36: posterior view of right mandibular condyle.

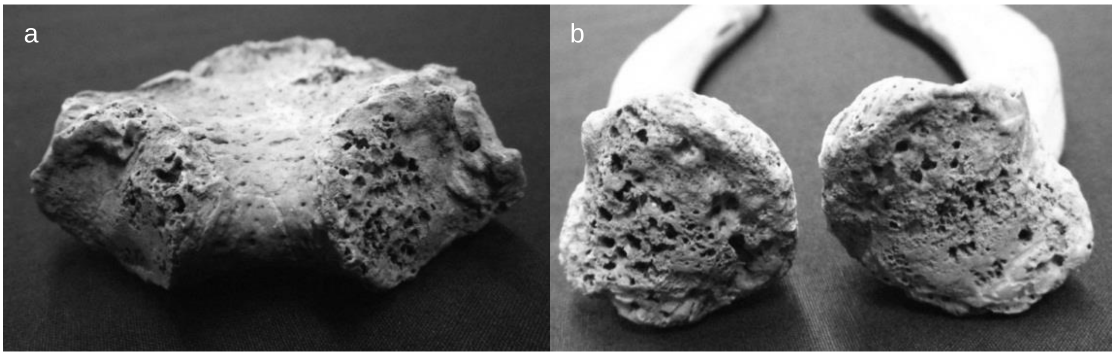

Figure 79. Osteoarthritis of the sternoclavicular joints, ANC 170: (a) superior view of manubrium; (b) medial joint surfaces of clavicles.

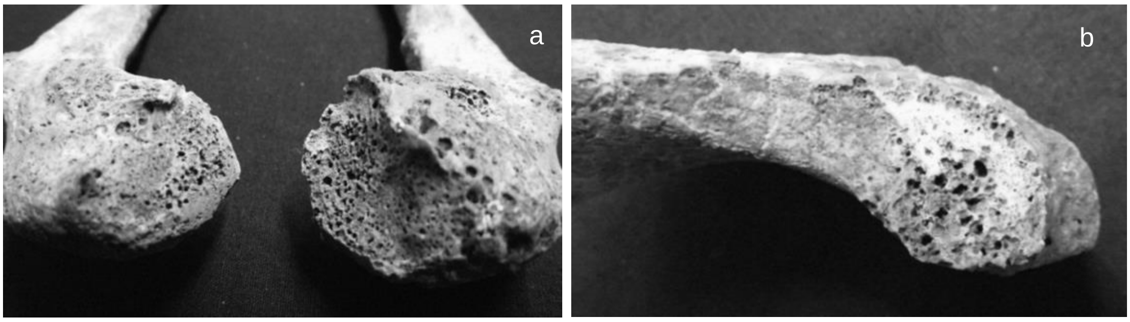

Figure 80. Osteoarthritis of the acromioclavicular joints, ANC 34: (a) lateral joint surfaces of the clavicles; (b) inferior view of left acromial process.

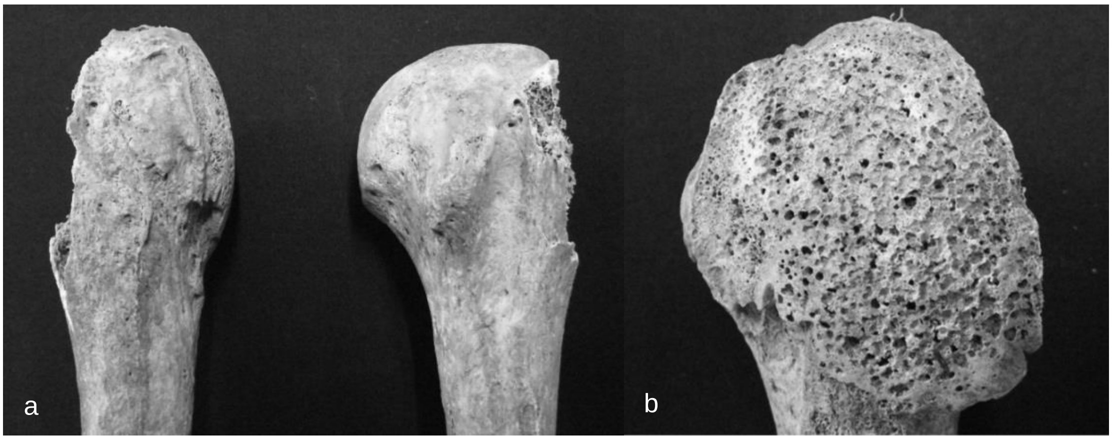

Figure 81. Osteoarthritis of the right glenohumeral joint, ANC 24: (a) anterior view of proximal humeri showing marked flattening of pathological (right) bone compared to the normal left bone; (b) medial view of right proximal humerus.

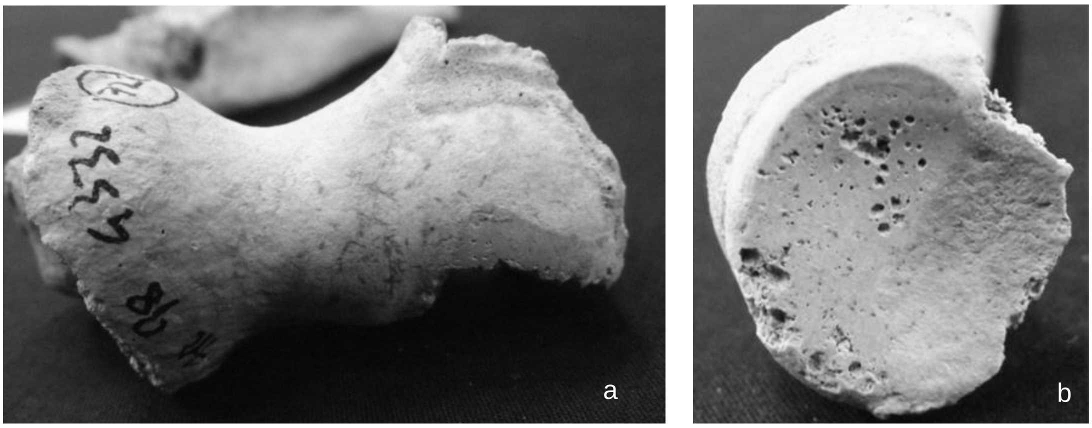

Figure 82. Osteoarthritis of the right elbow, AR 332: (a) distal humerus; (b) proximal radius.

Figure 83. Bilateral osteoarthritis of the wrists, CFX 351: (a) distal radii; (b) detailed view of right lunate.

Figure 84. Osteoarthritis of the hand, ANC 10: palmar view of proximal hand phalanges.

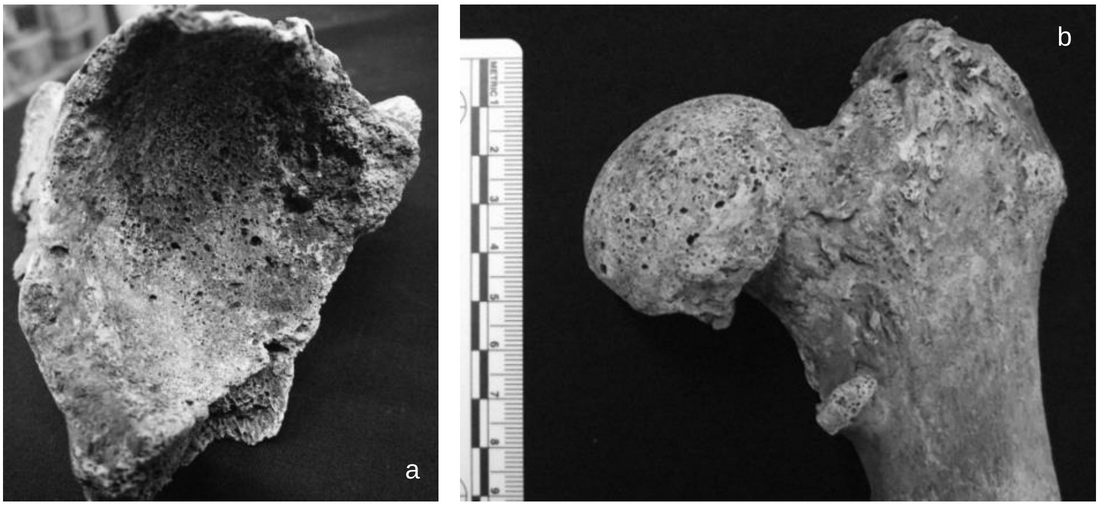

Figure 85. Osteoarthritis of the left hip, ANC 188: (a) acetabulum; (b) posterior view of left proximal femur.

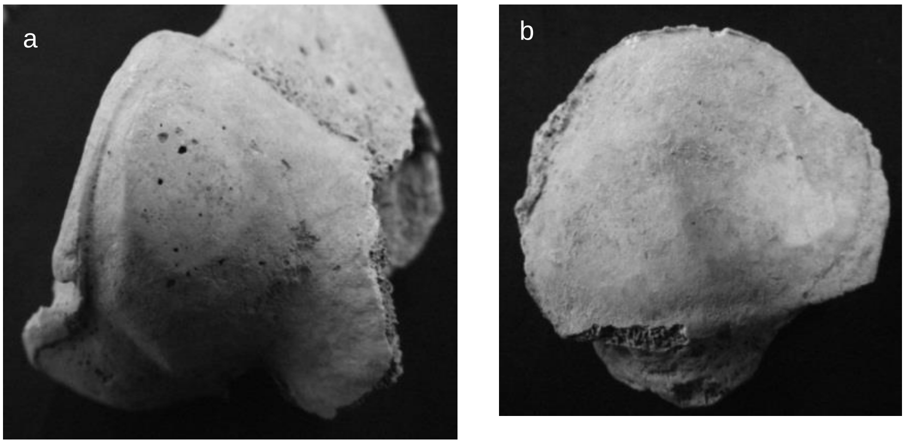

Figure 86. Osteoarthritis of the right knee, VR 72: (a) anterior view of the distal femur; (b) posterior view of the right patella.

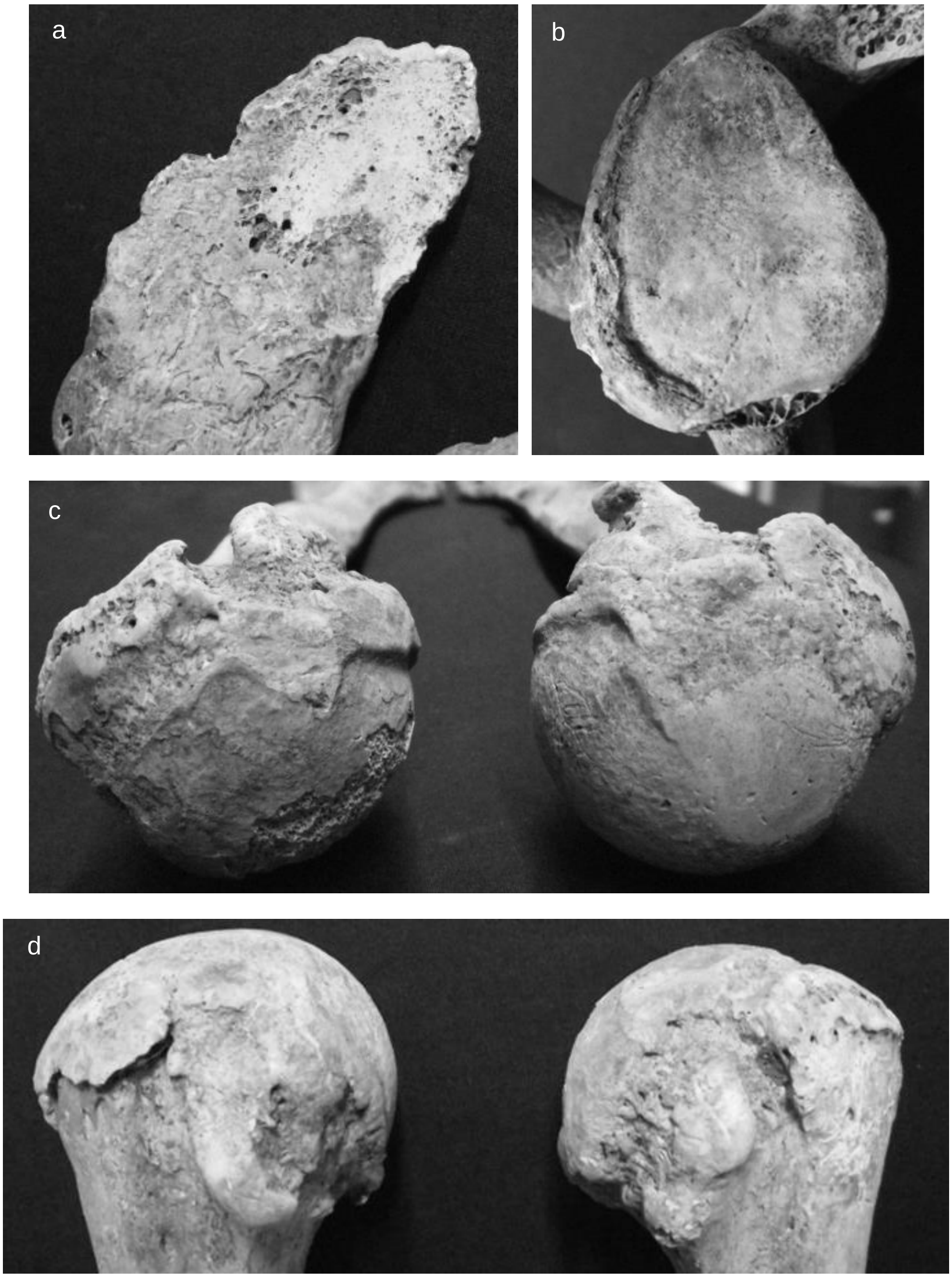

Figure 87. Rotator cuff disease, ANC 63: (a) inferior view of right acromion showing eburnation; (b) right glenoid fossa with new bone formation at margins; (c) superior view of humeri showing new bone formation at margins and eburnation at superior poles; (d) anterior view of humeri showing new bone formation at greater and lesser tuberosities.

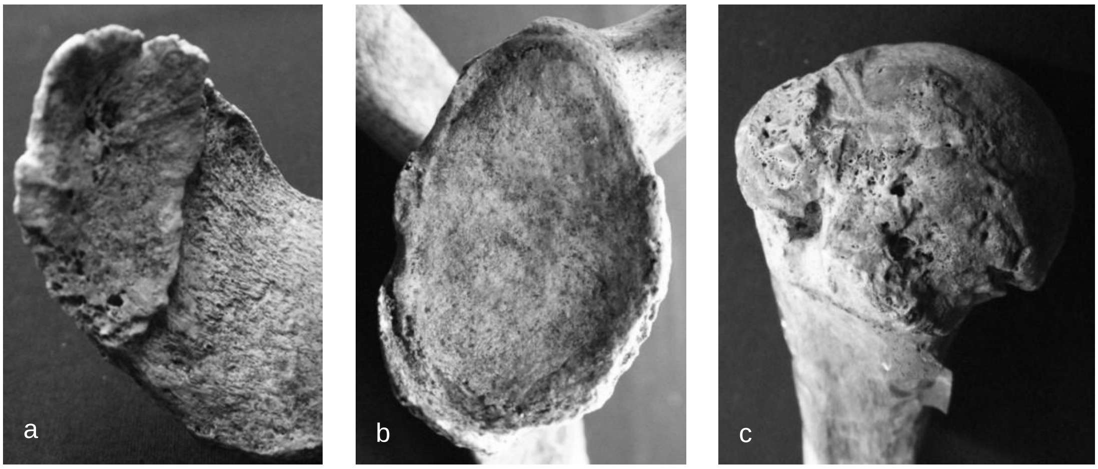

Figure 88. Rotator cuff disease, ANC 152 (a) inferior view of right acromion showing facet formation with porosity and eburnation; (b) right glenoid fossa with marginal new bone formation; (c) anterior view of right proximal humerus showing new bone formation at greater and lesser tuberosities.

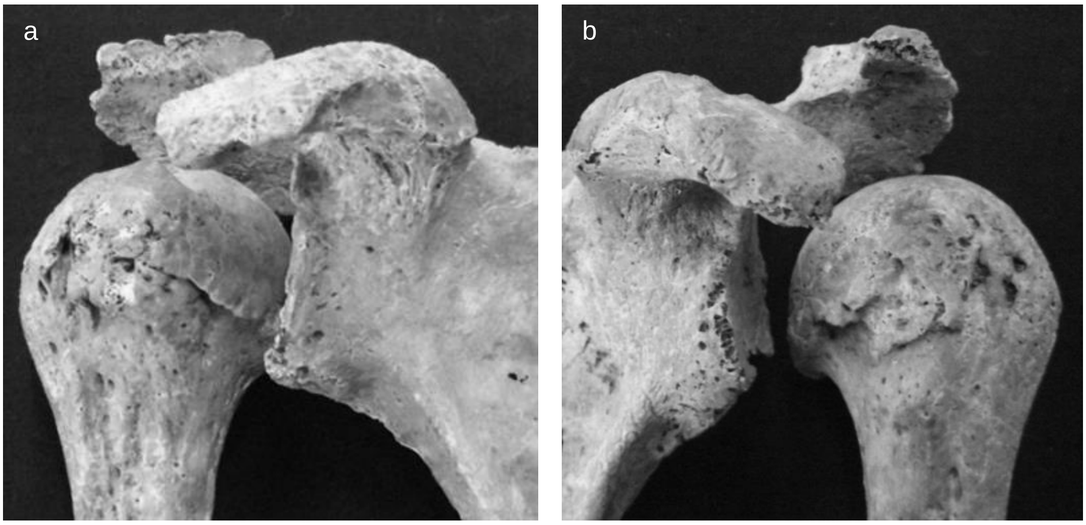

Figure 89. Rotator cuff disease, ANC 241: anterior views of (a) right and (b) left glenohumeral joints, showing marginal new bone formation at glenoid fossae and proximal humeri, porosity and eburnation at inferior aspects of acromial processes.

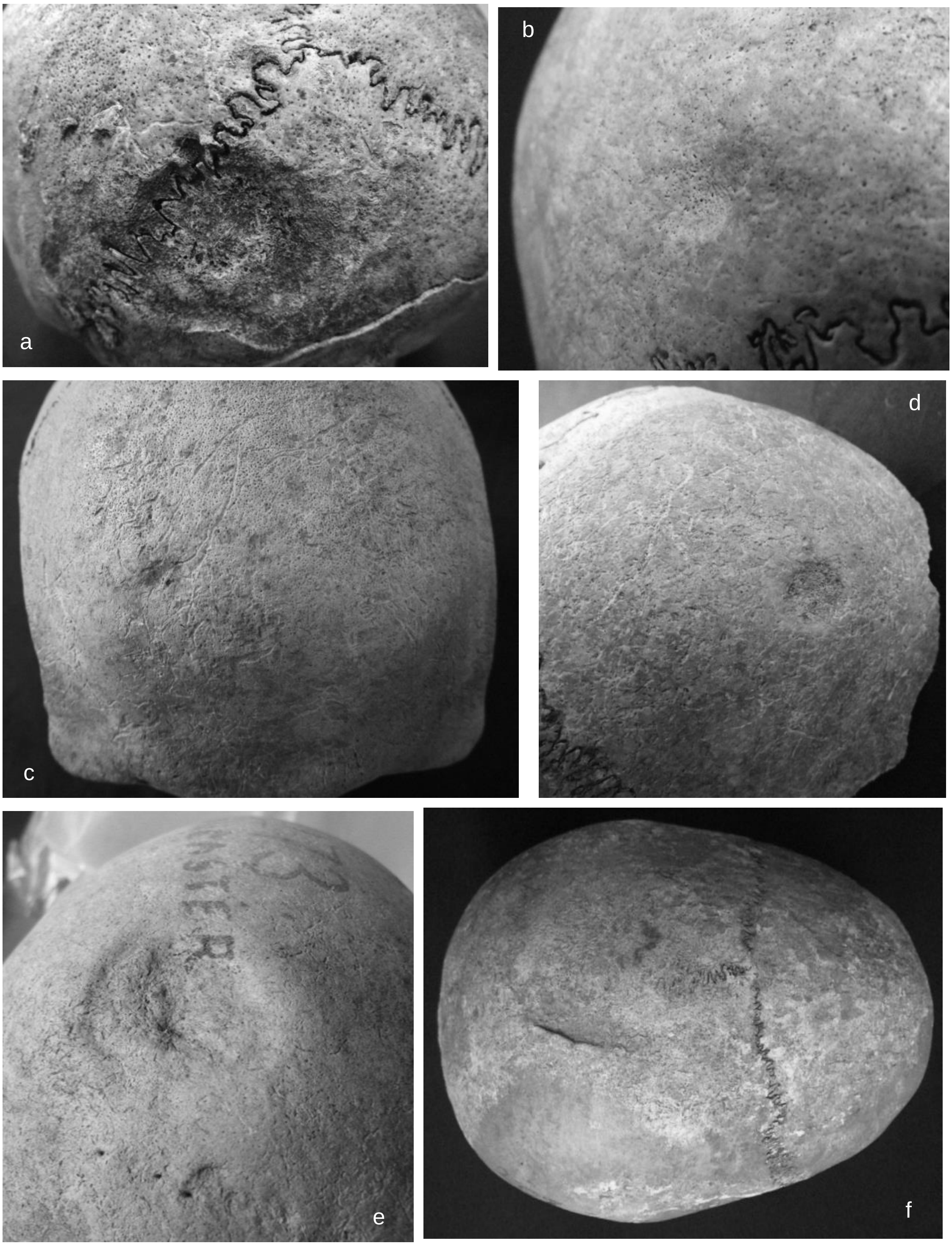

Figure 90. Cranial fractures, Ancaster: (a) ANC 140; (b) ANC 204A; (c) ANC 280; (d) ANC 282; (e) ANC 273; (f) healed sharp-force trauma to the right parietal, ANC 209.

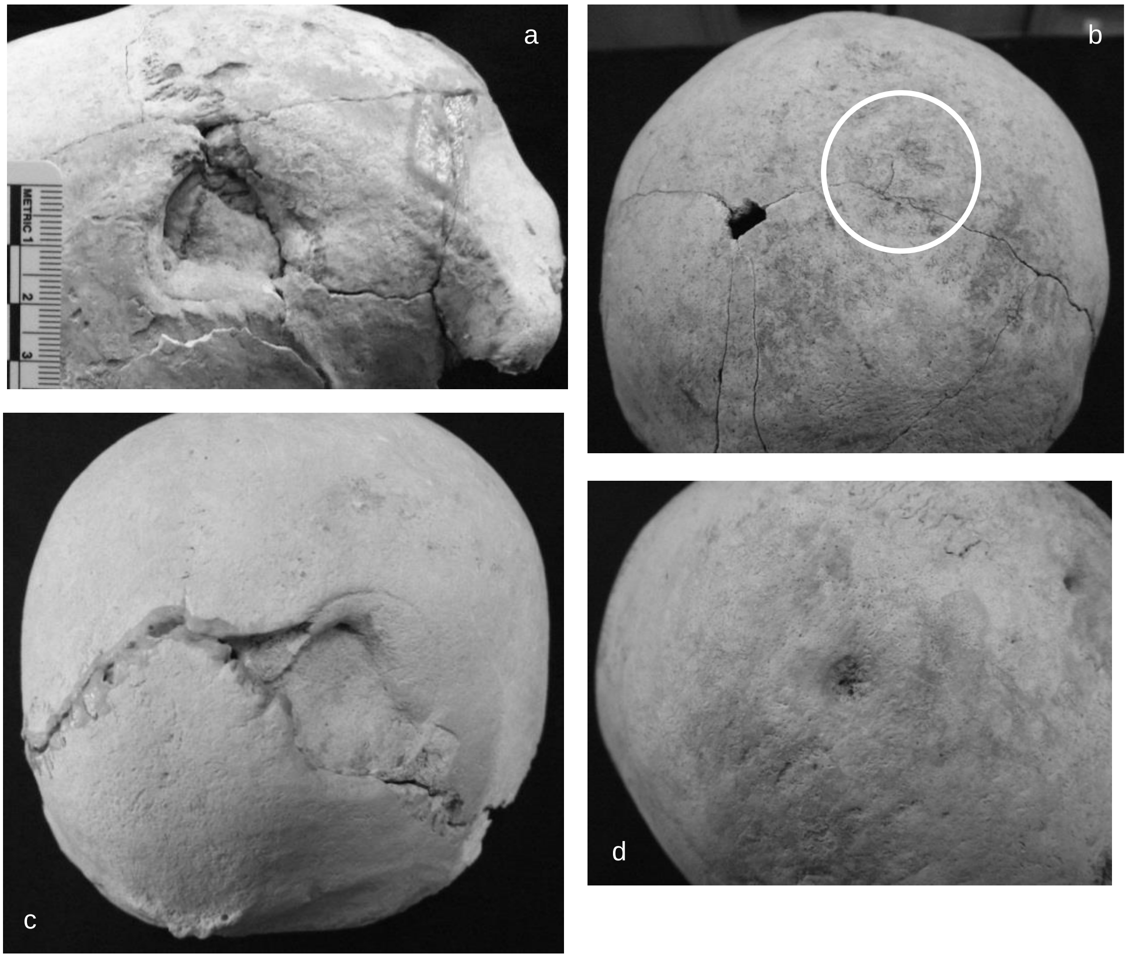

Figure 91. Cranial fractures, Winchester: (a) VR 45; (b) healed depression fracture of the right parietal (circles) and peri-mortem blunt force trauma, VR 66; (c) HYS 17; (d) VR 73.

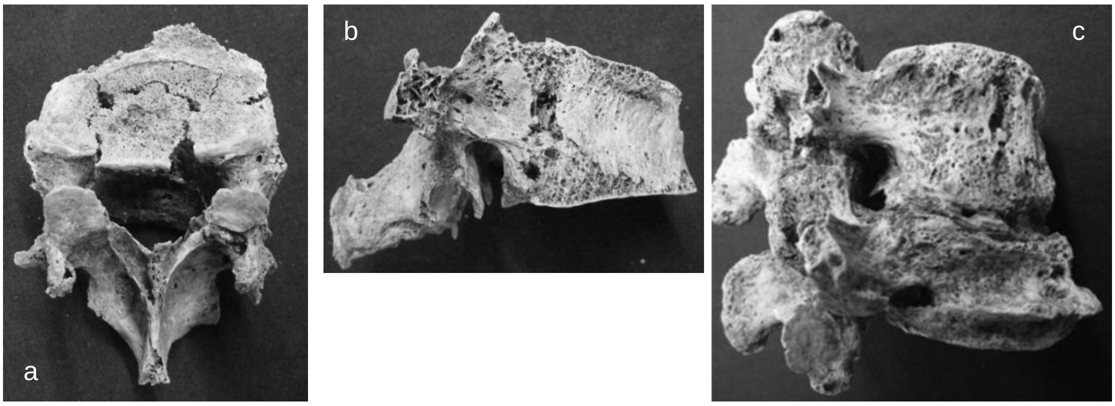

Figure 92. Vertebral fractures, Ancaster: (a) burst fracture of the L1, ANC 58; (b) compression fracture of the T12, ANC 58; (c) compression fracture of the L4 (with subsequent fusion to L3), ANC 184.

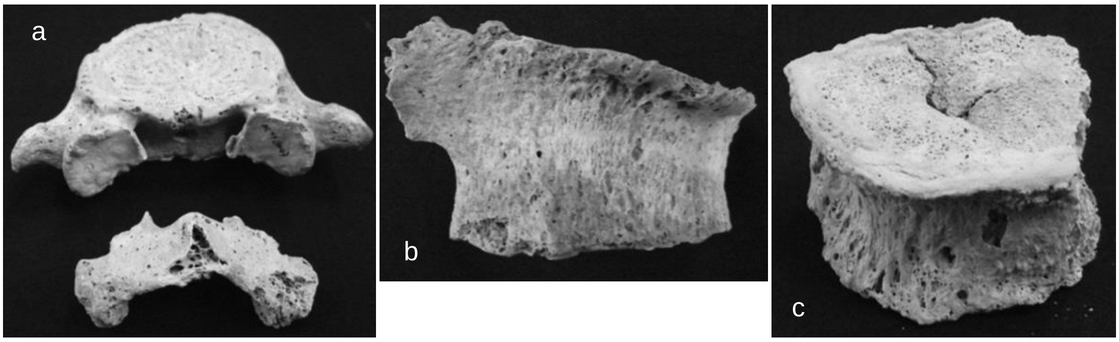

Figure 93. Vertebral fractures, Winchester: (a) bilateral spondylolysis, L5, HC 304; (b) compression of the L5, VR 81; (c) crush fracture of a thoracic vertebra, CFX 351.

Figure 94. Multiple rib fractures, ANC 121.

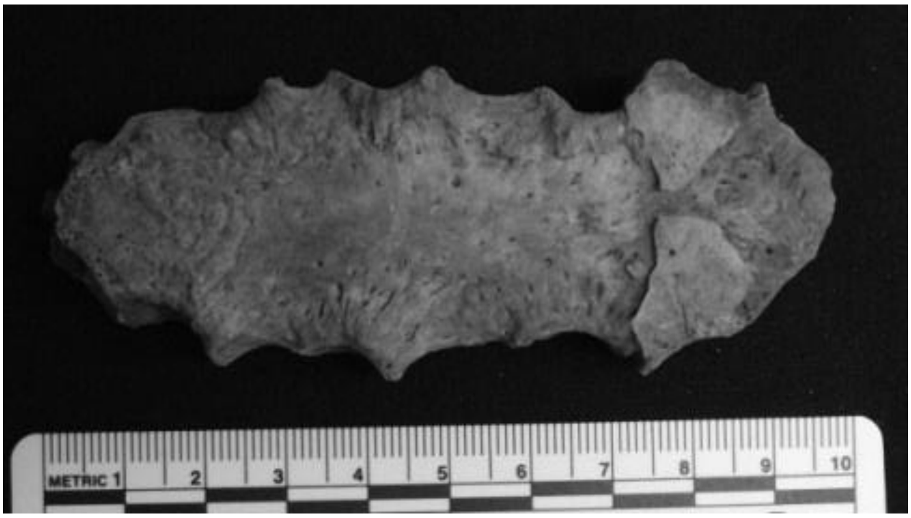

Figure 95. Fracture of the sternal corpus, ANC 5.

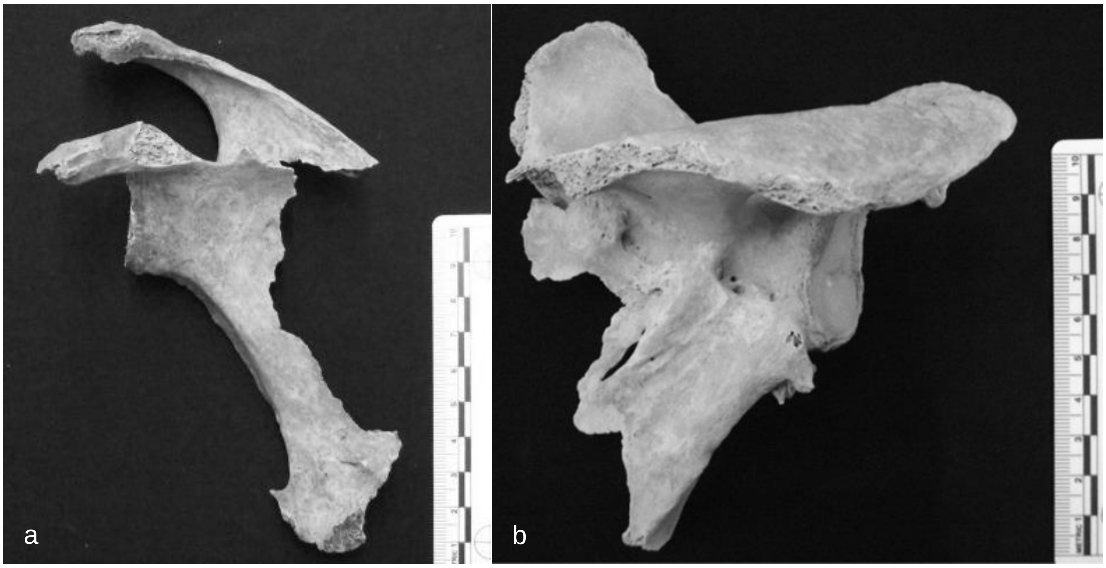

Figure 96. Fractures of the scapula: (a) right scapula, ANC 45; (b) right scapula, VR 26B.

Figure 97. Fractures of the clavicle: (a) right clavicle, ANC 244; (b) left clavicle, VR 59.

Figure 98. Healed fracture at the mid-shaft of the left humerus, CFX 351.

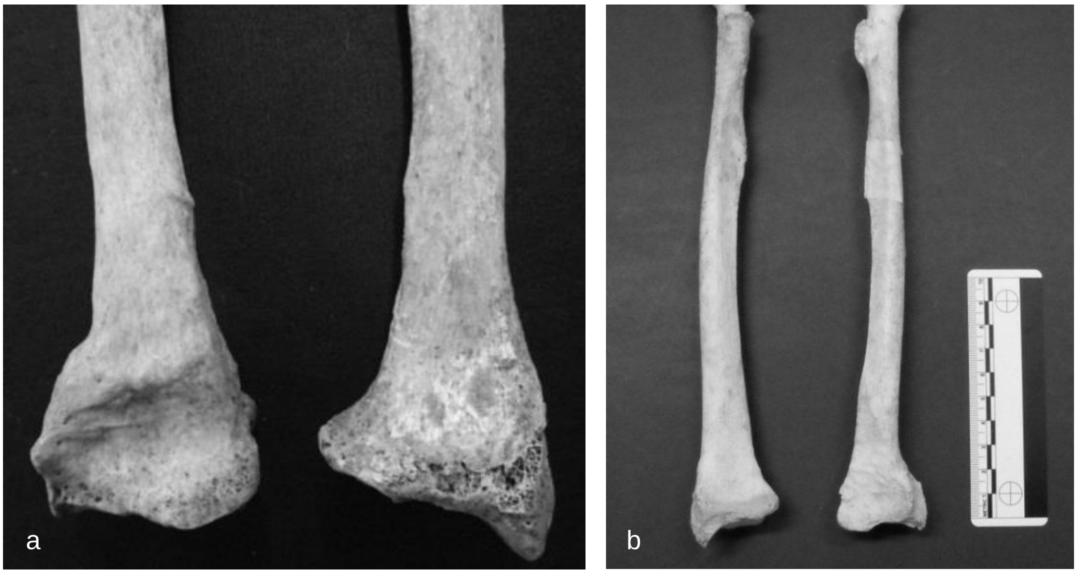

Figure 99. Colles' fractures of the distal radius: (a) anterior view of the distal radii, showing healed fracture of the right bone (shown on left), ANC 191; (b) anterior view of the radii showing healed fracture of the left bone (shown on right), AR 312.

Figure 100. Forearm fractures, Ancaster: (a) anterior view of right ulna and radius showing healed fractures with malunion, ANC 23; (b) healed fractures at mid-shafts with formation of a false joint, ANC 24; (c) healed (parry?) fracture at distal left ulna shaft (shown on right), ANC 225.

Figure 101. Forearm fractures, Winchester: (a) VR 54; (b) HYS 20; (c) CHR 595.

Figure 102. Fractures of the hands and feet: (a) third, fourth and fifth left metacarpals, ANC 117; (b) proximal hand phalanx, VR 48; (c) right metacarpal, HC 306; (d) right fourth metacarpal, RR F30; (e) right fourth metatarsal, CHR 612.

Figure 103. Fractures of the femur, Winchester: (a) proximal left femur shaft (show on right, medial view), VR 30; (b) distal shaft of left femur, CHR 580; (c) medial view and (d) detailed view of oblique fracture of the distal femur shaft, VR 58B.

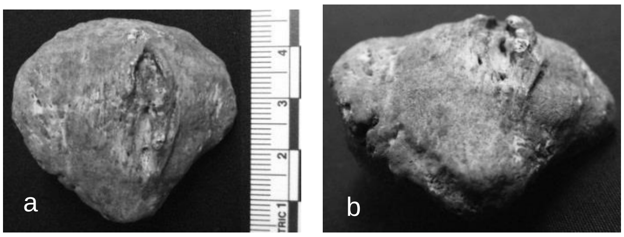

Figure 104. Healed sharp force trauma of the left patella, ANC 56: (a) anterior view; (b) inferior view.

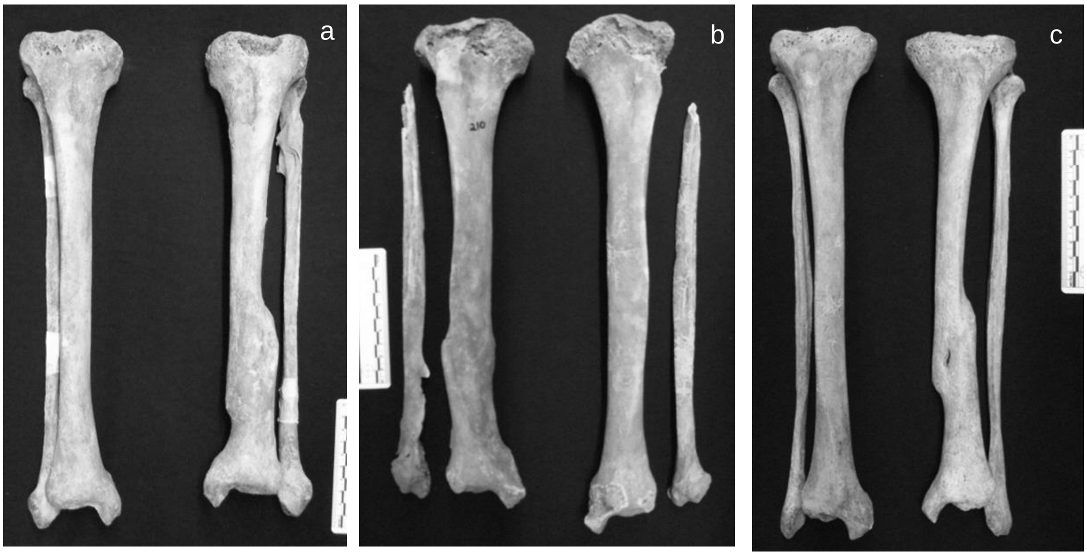

Figure 105. Factures of the tibia and fibula, Ancaster: (a) ANC 34; (b) ANC 210; (c) ANC 218.

Figure 106. Fractures of the tibia and fibula, Winchester: (a) VR 88; (b) VR 111; (c) HYS 15; (d) AR 318.

Figure 107. Isolated fracture of the right fibula (shown on left, medial view), ANC 247.

Figure 108. Healed fracture of the distal right fibula (anterior view) with subsequent ankylosis of the distal tibiofibular joint, HYS 24.

Figure 109. Osteochondritis dissecans of the knee, ANC 93: (a) inferior view of distal right femur; (b) detailed view of lesion showing eburnation and porosity.

Figure 110. Osteochondritis dissecans of the calcaneus, ANC 185A (superior view).

Figure 111. Possible ossified haematoma at the dorsal aspect of a proximal foot phalanx in a male from Ancaster (ANC 143).

Figure 112. Ankylosis of the first and second metatarsals and first and second cuneiforms in the left foot of a mature male from Winchester (VR 113).

Figure 113. Probable scurvy, VR 9: (a) inferior view of right orbit showing deposits of woven bone and cribra orbitalia; (b) lateral view of right frontal bone showing porosity at sphenofrontal suture; (c) medial view of left mandible showing porosity; (d) superior view of endocranial surface of the greater wing of the sphenoid; (e) lateral view of left temporal bone showing marked porosity.

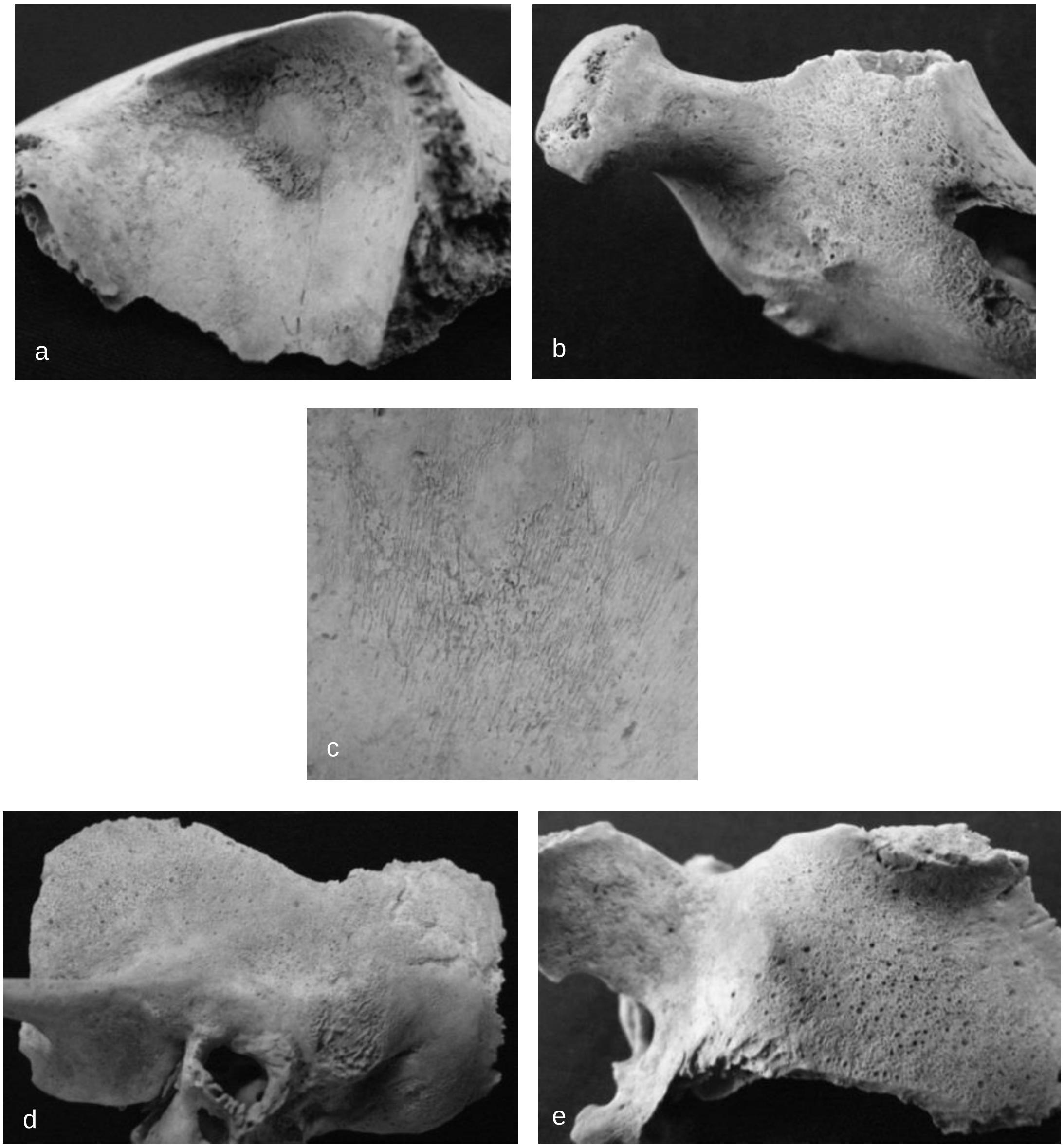

Figure 114. Probable scurvy, VR 15: (a) inferior view of left orbital roof showing new bone deposits; (b) medial view of left mandible showing porosity; (c) endocranial surface of cranial fragment with striated new bone; (d) lateral view of left temporal with porosity; (e) inferior view of sphenoid showing marked porosity.

Figure 115. Possible rickets, ANC 208: anterior views of radii, ulnae and femora showing slight flaring and porosity at the metaphyses.

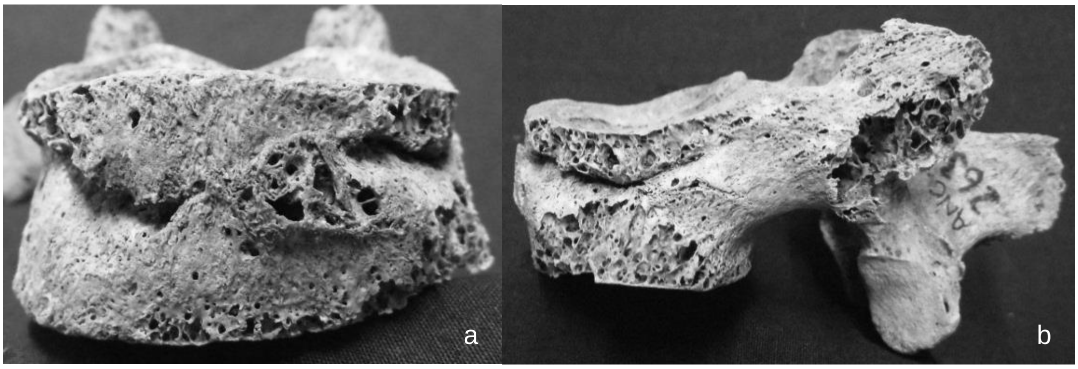

Figure 116. Osteoporotic fracture of the third lumbar vertebra, ANC 263: (a) anterior view; (b) left lateral view.

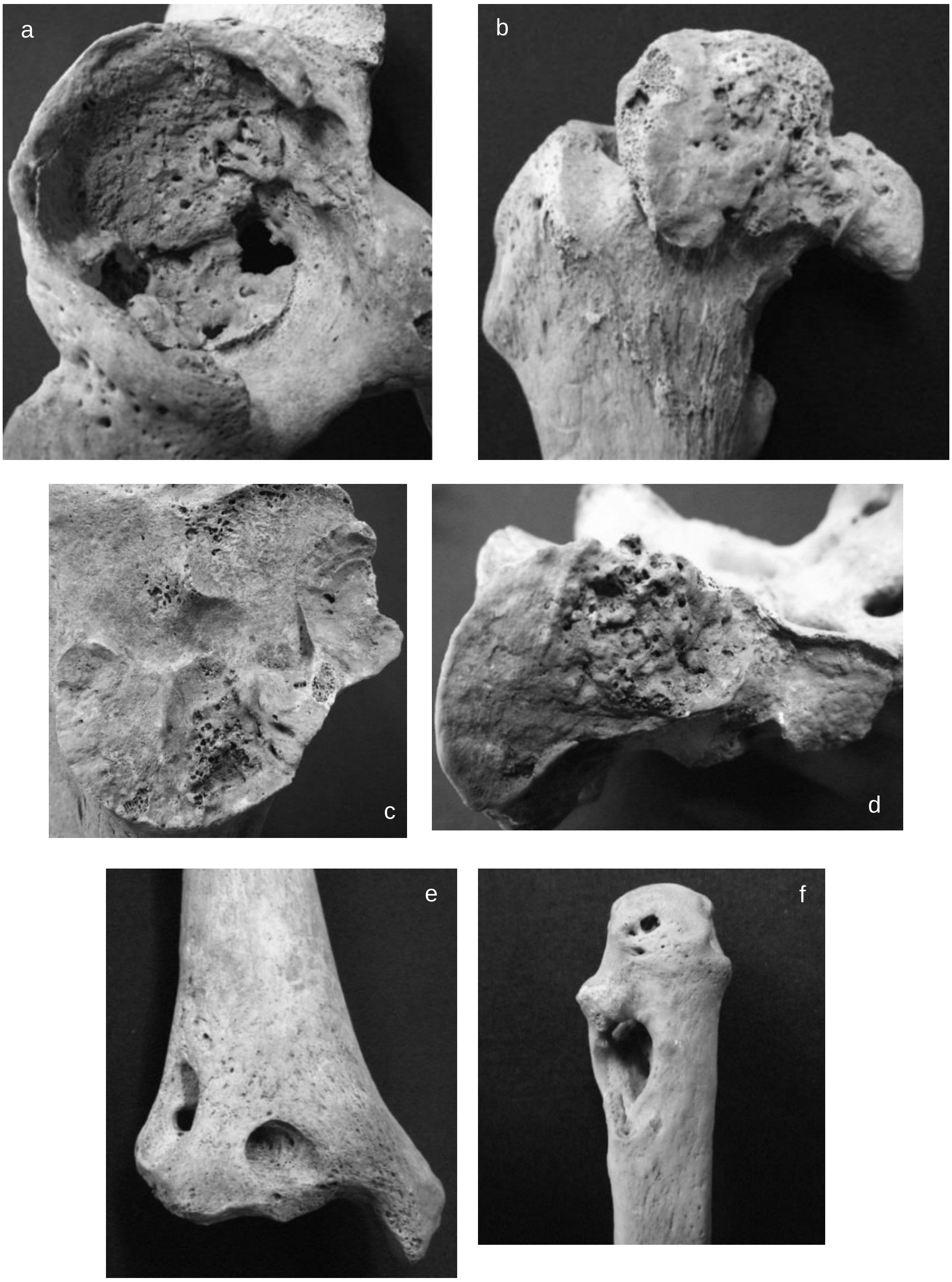

Figure 117. Tuberculosis, ANC 1: (a) acetabulum; (b) anterior view of proximal right femur; (c) medial view of the right auricular surface of the pelvis and (d) lateral view of the right auricular surface of the sacrum; (e) anterior view of the distal right tibia and (f) dorsal view of the right third metacarpal showing sinuses.

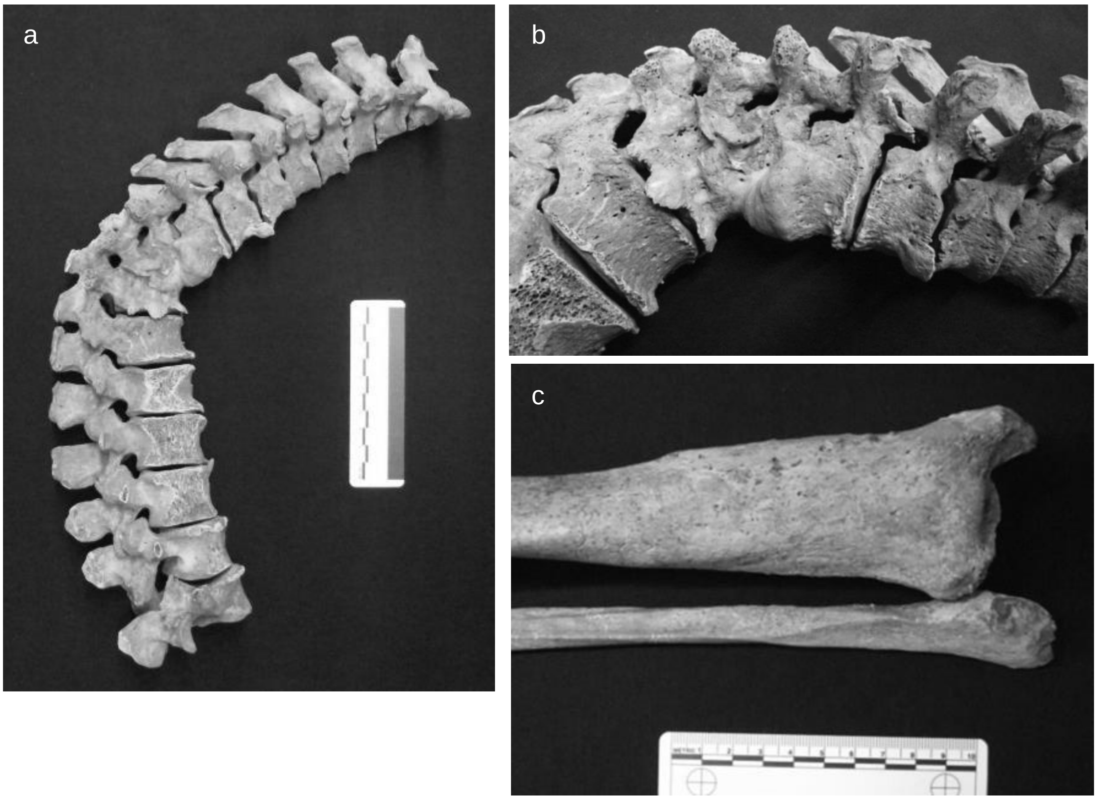

Figure 118. Tuberculosis, ANC 11: (a) right lateral view of thoracic and lumbar vertebrae showing anterior kyphosis due to collapse of T9 and T10 (Pott's spine); (b) detailed view of T9 and T10; (c) anterior view of right distal tibia and fibula.

Figure 119. Possible tuberculosis, ANC 46: distal joint surface of left tibia.

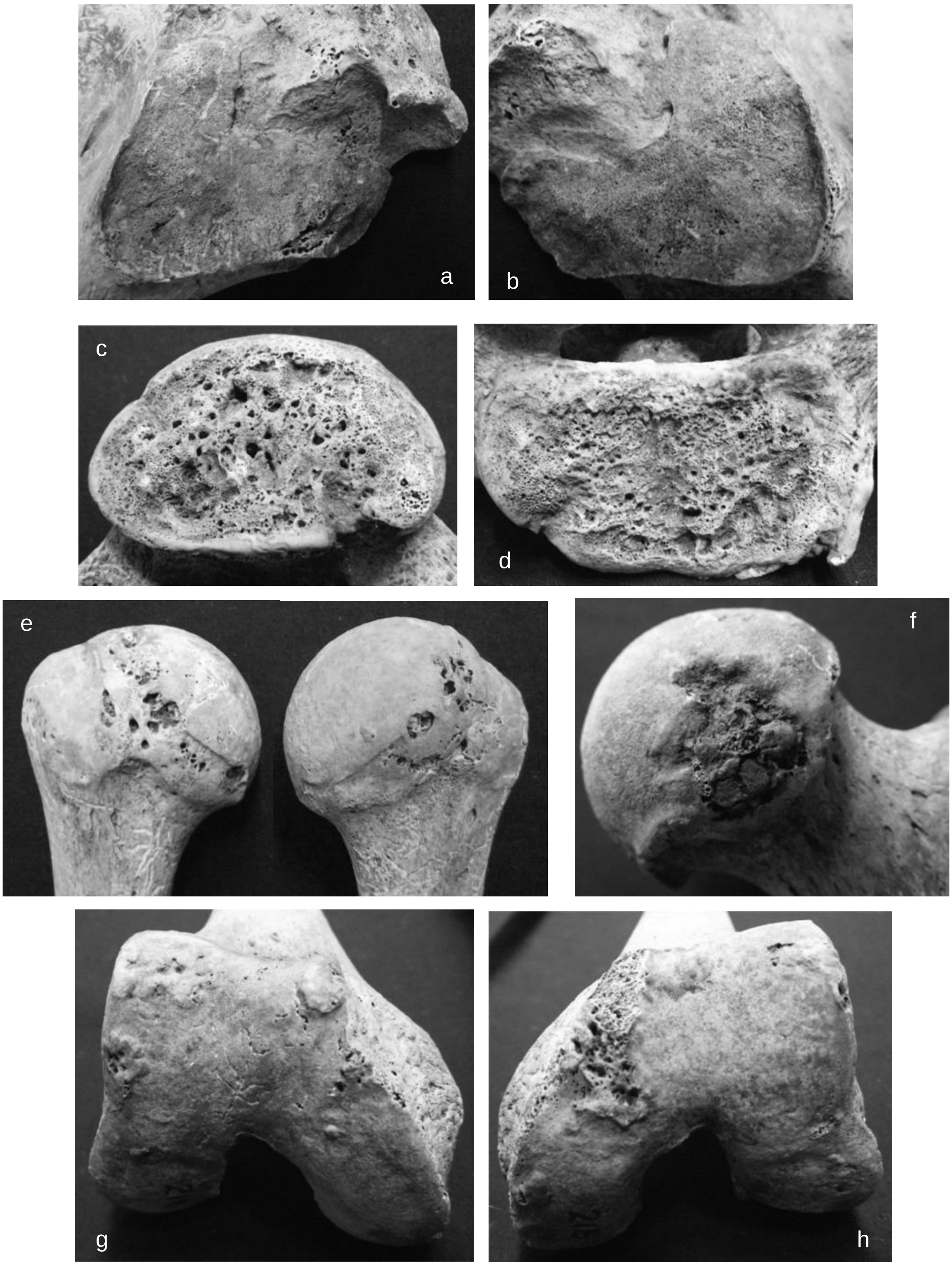

Figure 120. Tuberculosis, ANC 218: (a) auricular surface of right pelvis and (b) right auricular surface of sacrum showing lytic lesions and sclerosis; (c) inferior view of fifth lumbar vertebra and (d) superior surface of first sacral vertebra showing lytic lesions and sclerosis; (e) anterior view of proximal humeri, (f) posterior view of proximal femora and (g-h) anterior views of right and left femora.

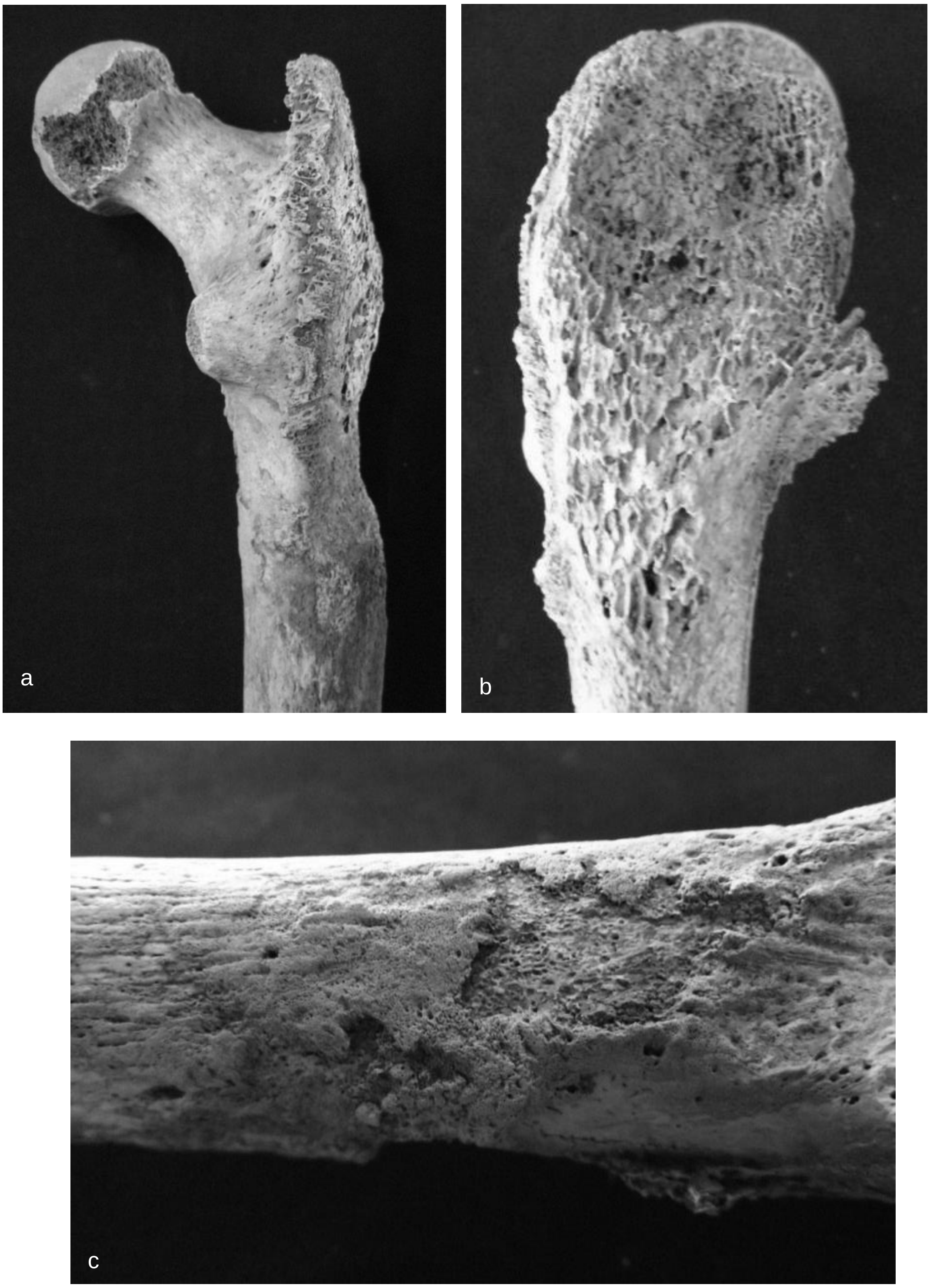

Figure 121. Tuberculosis, VR 129: (a) posterior view of proximal right femur showing destruction of the lateral portion of the greater trochanter and proximal shaft; (b) detailed view of lateral aspect of greater trochanter; (c) lateral aspect of proximal femur with woven bone.

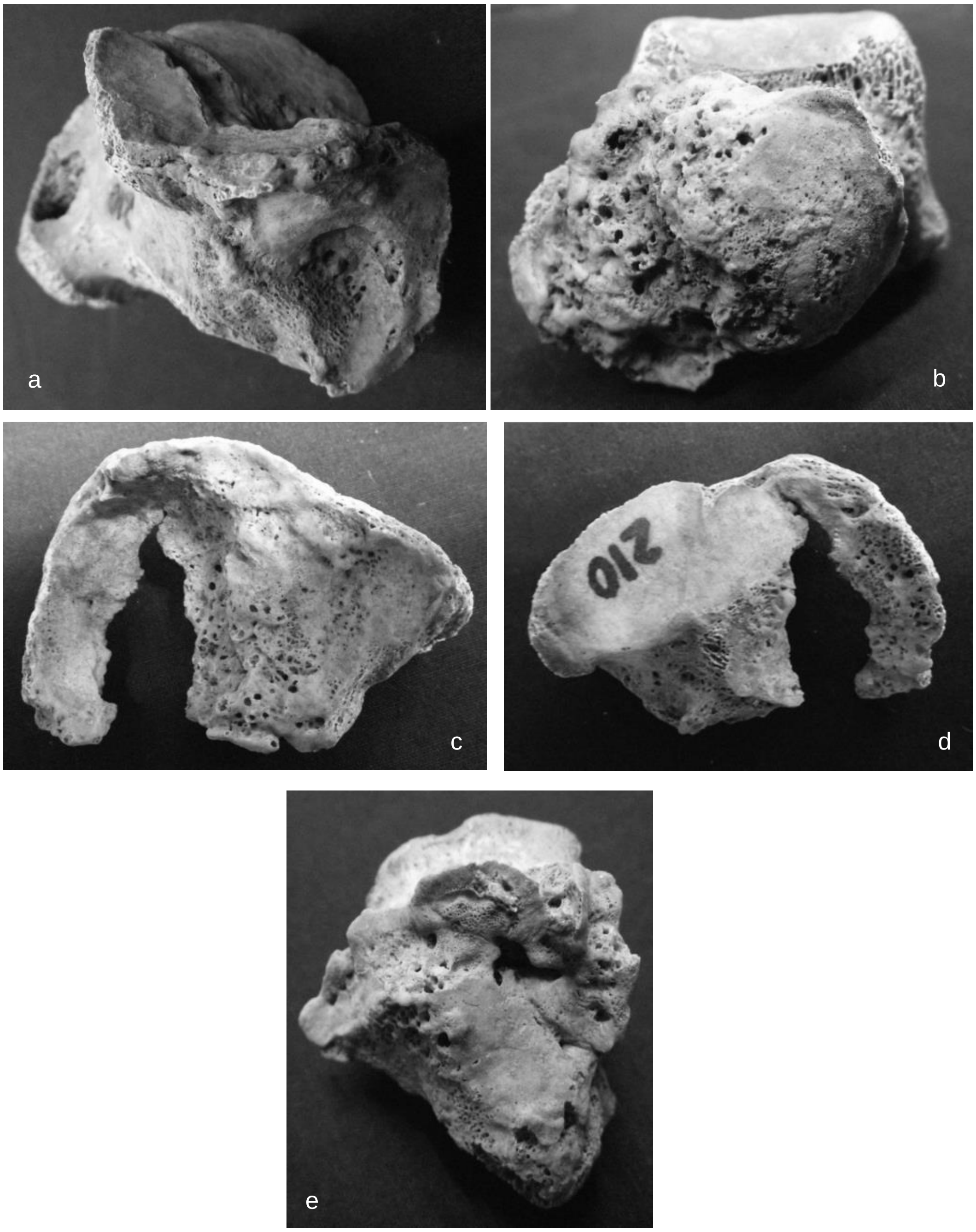

Figure 122. Possible tuberculosis, ANC 210: (a) view of distal end of left calcaneus showing lytic and sclerotic lesions (superior is up); (b) view of distal joint surface (for navicular) of left talus; (c) proximal (talus) and distal joint surfaces of left navicular showing destruction and sclerosis; (d) left cuboid.

Figure 123. Active new bone formation at the endocranial aspect of the frontal bone, ANC 82 (possible tuberculous meningitis).

Figure 124. Active periostitis at the visceral aspect of a rib, ANC 47 (possible pulmonary TB).

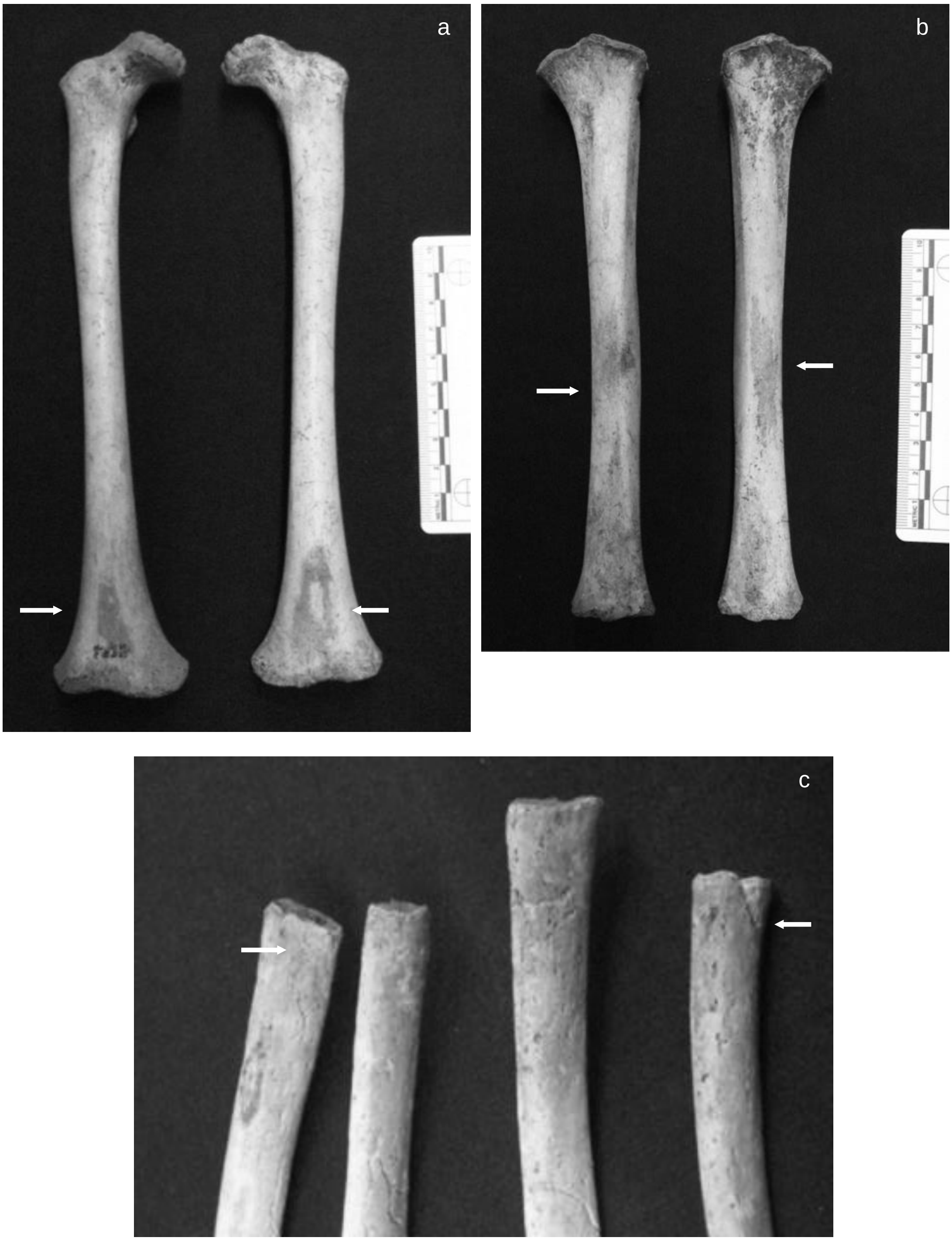

Figure 125. Possible hypertrophic pulmonary osteopathy, ANC 55: (a) anterior view of femora; (b) posterior view of tibiae; (c) visceral ribs with active periostitis at sternal ends.

Figure 126. Possible poliomyelitis, VR 95: (a) anterior view of humeri; (b) anterior view of femora; (c) detailed view of posterior aspects of proximal humeri; (d) detailed anterior view of proximal left femur showing porosity and *coxa valga* deformity.

Figure 127. Active periostitis at the medial aspect of the tibia, ANC 29.

Figure 128. Healed periostitis at the medial aspect of the proximal left tibia, AR 329, possibly due to localised infection and/or leg ulcer.

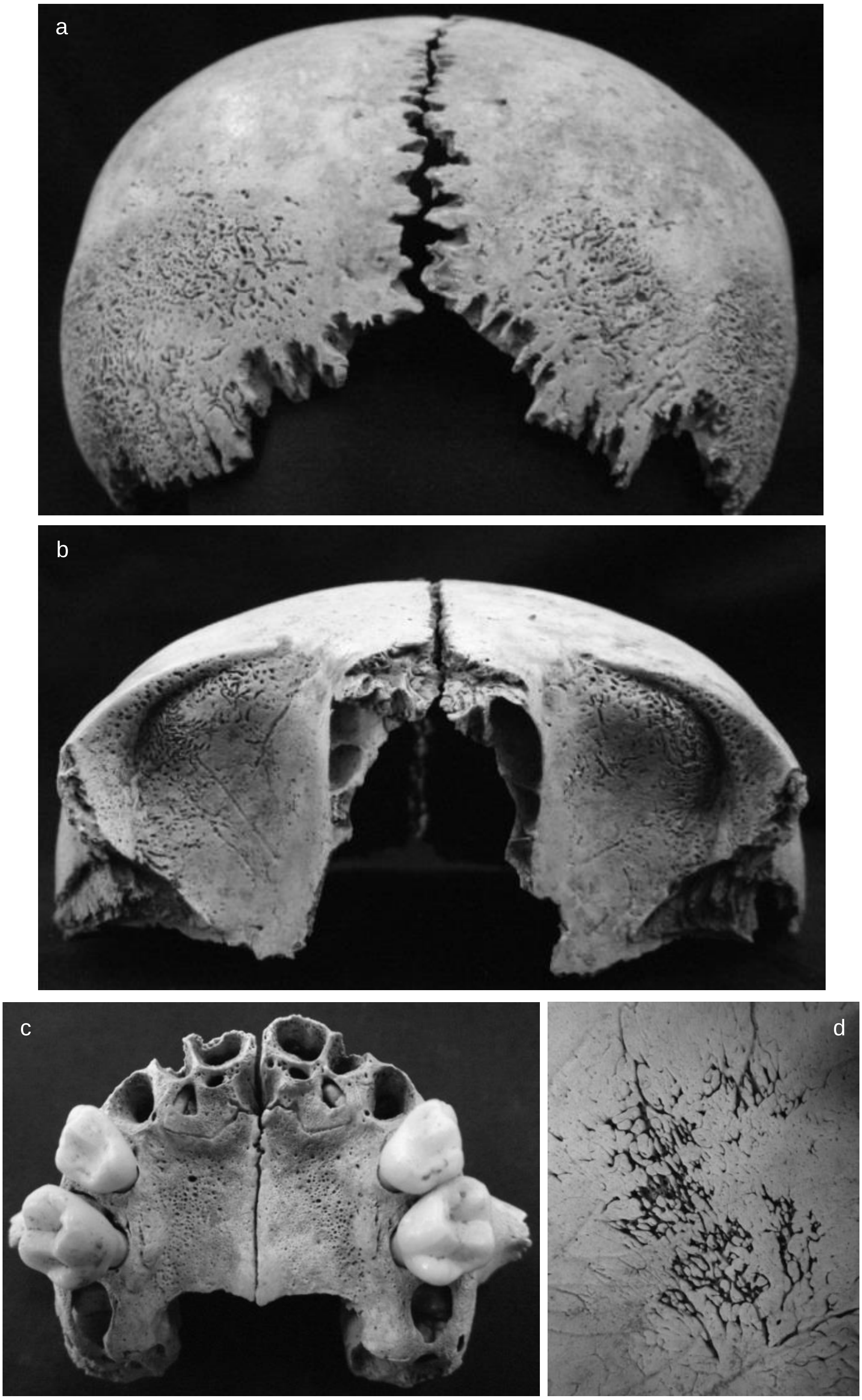

Figure 129. Anaemia(?), VR 121: (a) cribra orbitalia and (b) symmetrical porotic hyperostosis at posterior parietals; (c) porosity of the hard palate; (d) endocranial lesions.

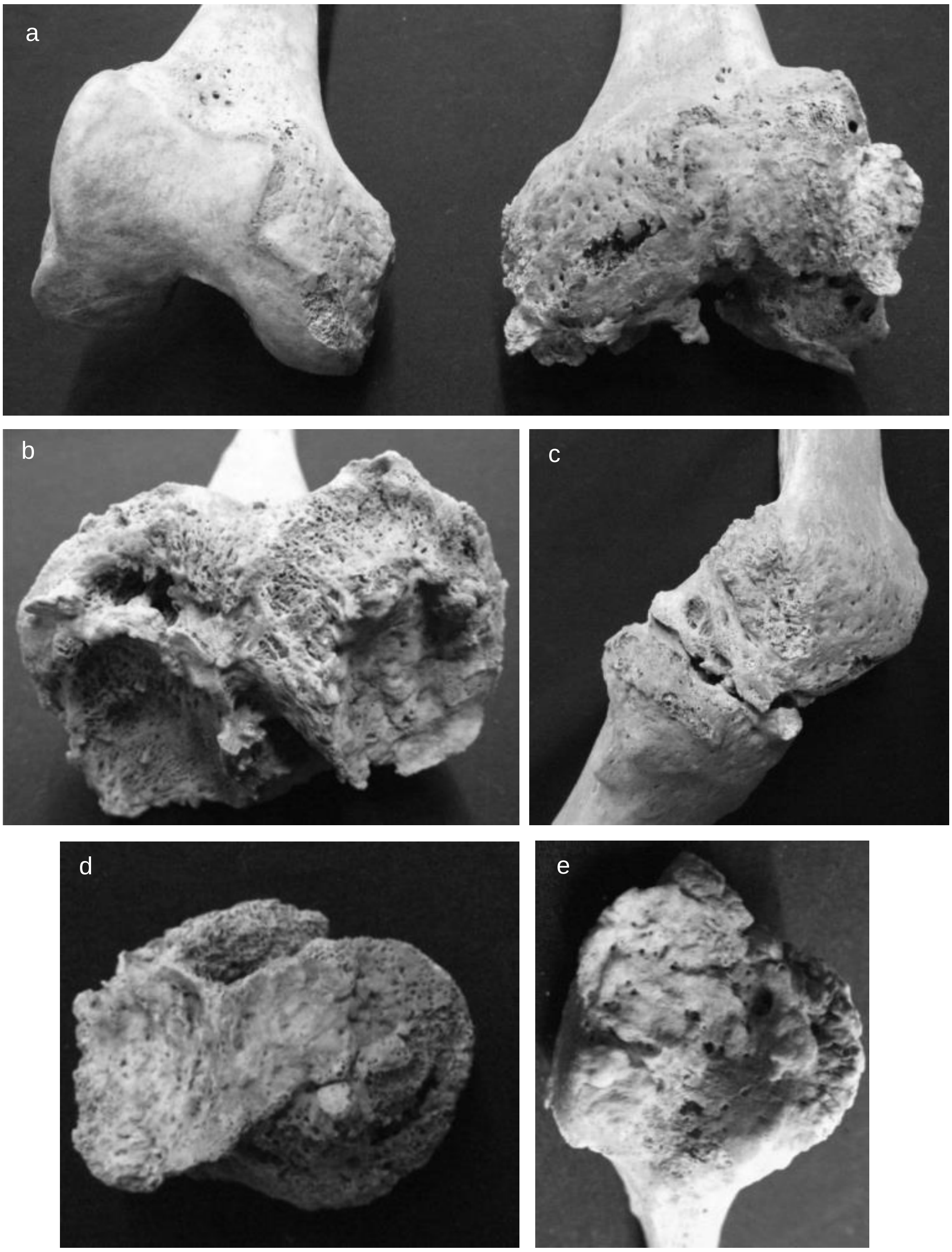

Figure 130. Probable septic arthritis, ANC 238 (a) anterior-inferior view of distal femora showing the normal right and abnormal left joint surfaces; (b) superior view of left proximal tibia; (c) medial view of left femur and tibia; (d) posterior view of left patella; (e) medial view of proximal left fibula.

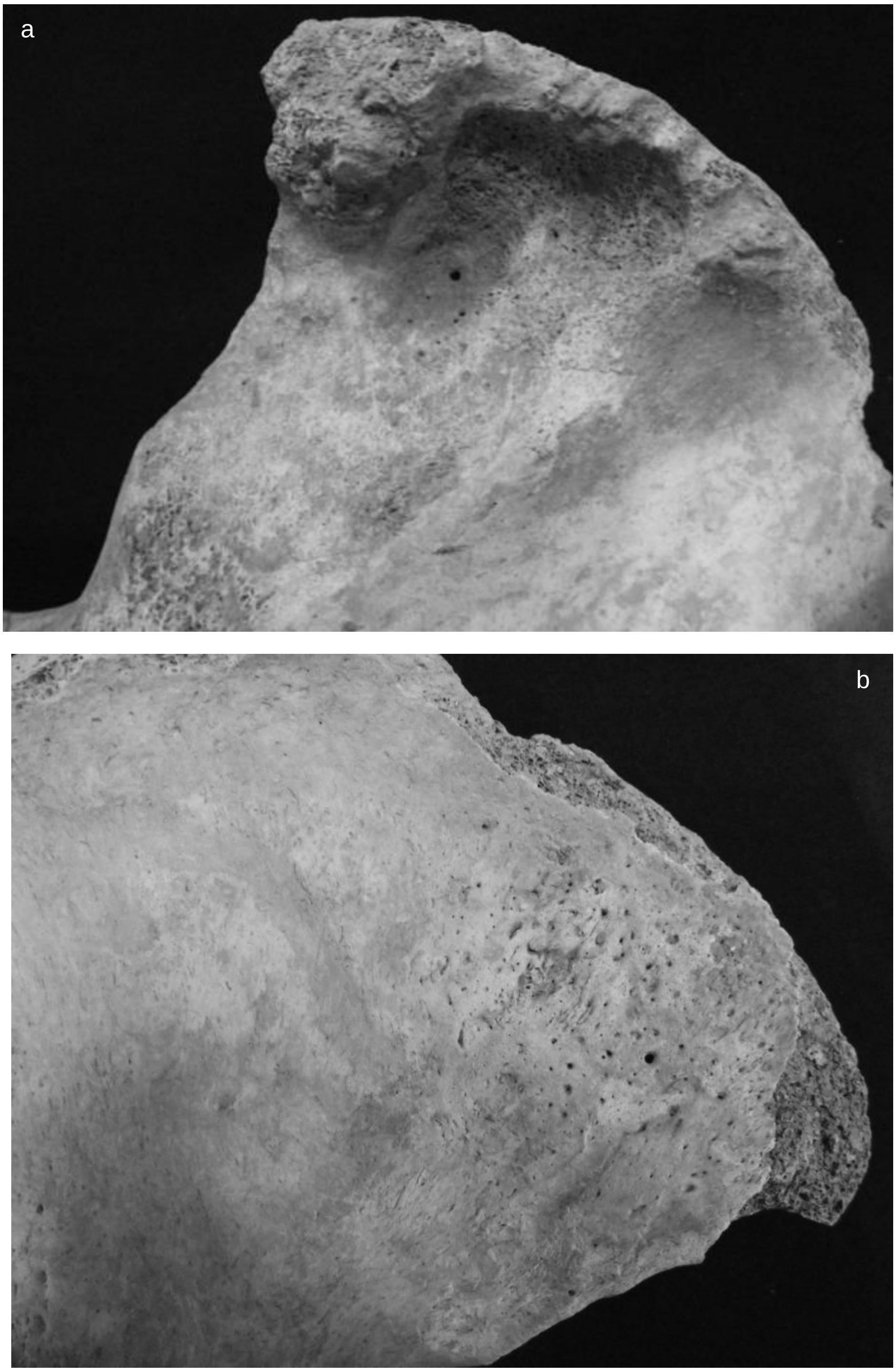

Figure 131. Unknown pathology (trauma or dislocation?) of the left sacroiliac joint in a young female from Winchester, VR 35: (a) medial view of left pelvis; (b) external (lateral) view of posterior ilium.

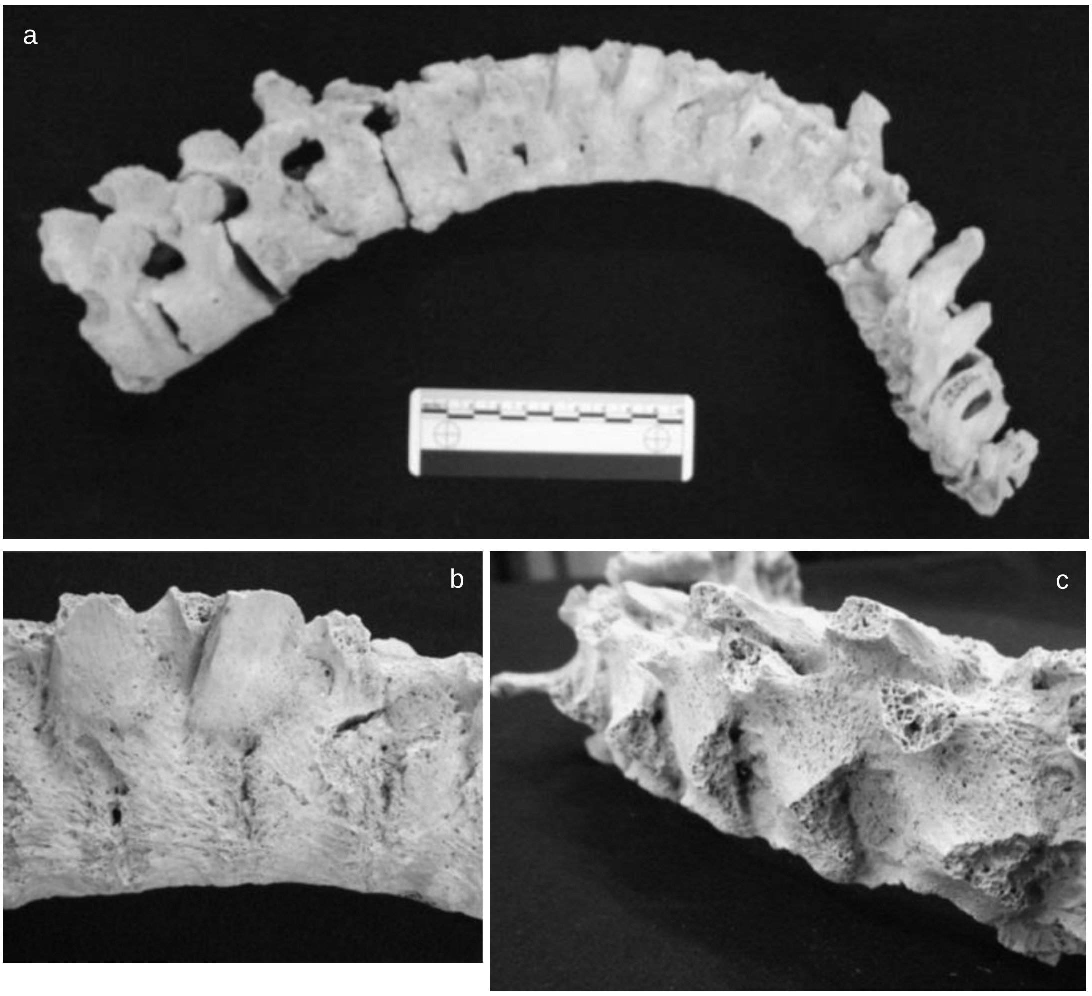

Figure 132. Possible ankylosing spondylitis in a female from Winchester, CHR 562: (a) right lateral view of spine showing fusion of the cervical and thoracic vertebrae; (b) detailed view of spine showing fusion of ribs and vertebrae; (c) posterior view of thoracic vertebrae showing fusion of facets.

Figure 133. Diffuse idiopathic skeletal hyperostosis, ANC 45. Right lateral view of thoracic spine showing ossification of the anterior longitudinal ligament.

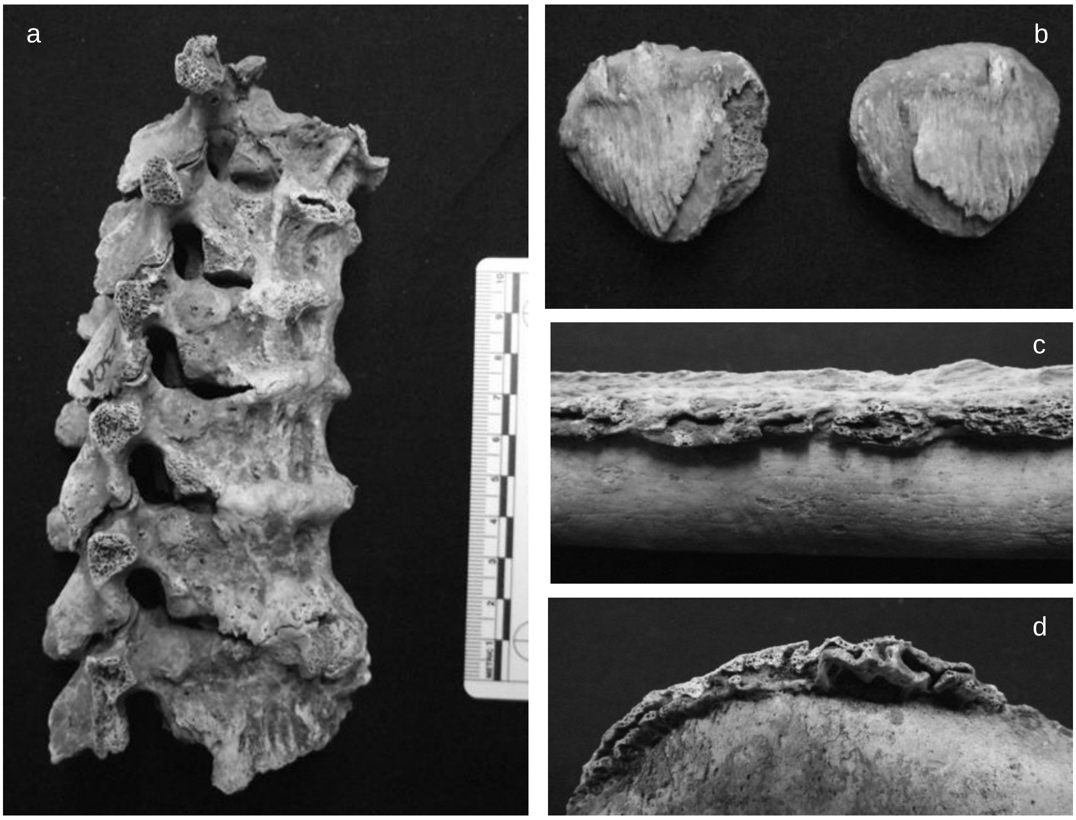

Figure 134. Diffuse idiopathic skeletal hyperostosis, ANC 230A: (a) right lateral view of thoracic vertebrae; (b) anterior view of patellae; (c) posterior view of femur; (d) extreme enthesophytes at the iliac crest.

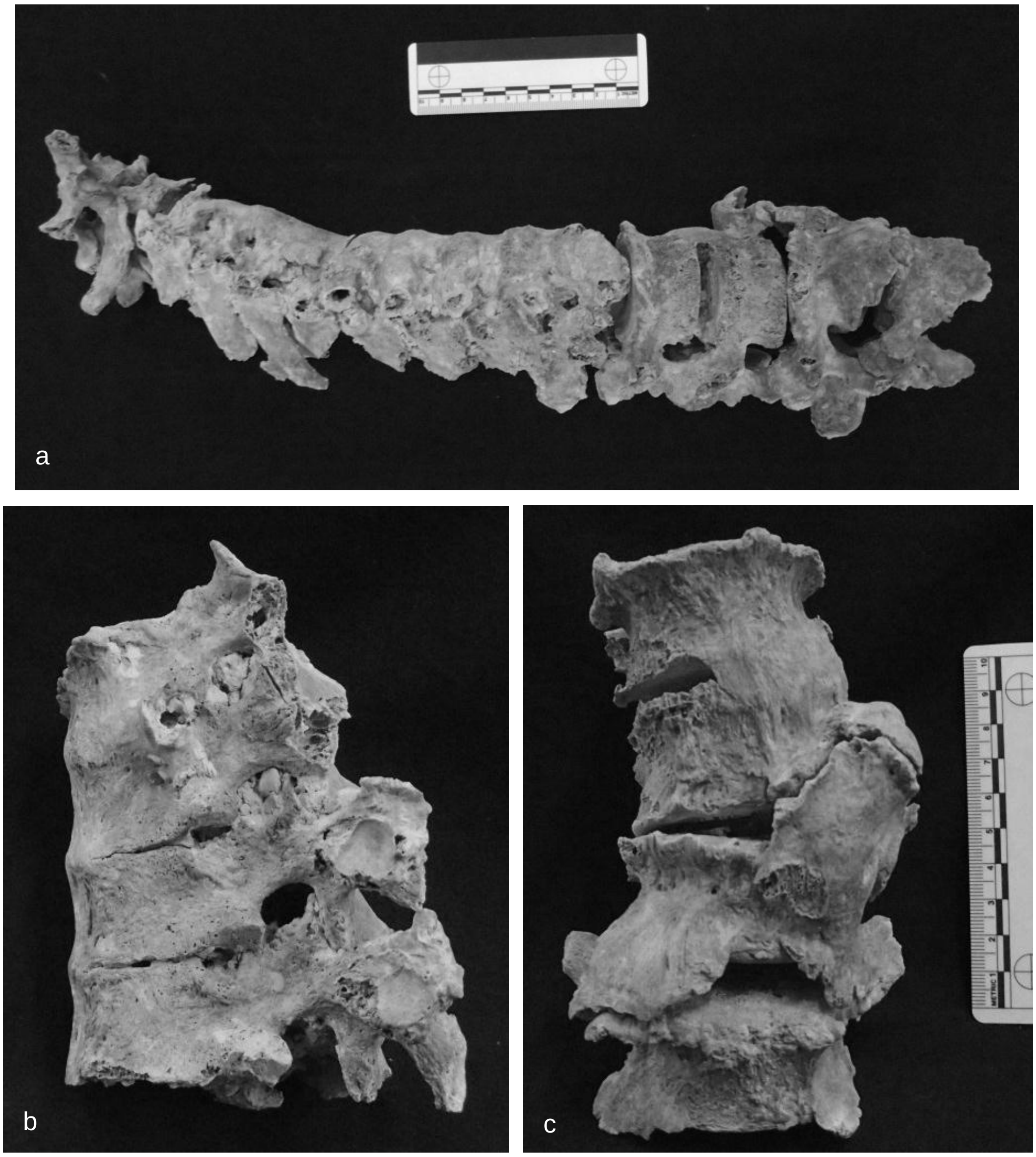

Figure 135. Diffuse idiopathic skeletal hyperostosis, AR 318: (a) right lateral view of spine; (b) left lateral view of thoracic vertebrae; (c) anterior view of lumbar vertebrae.

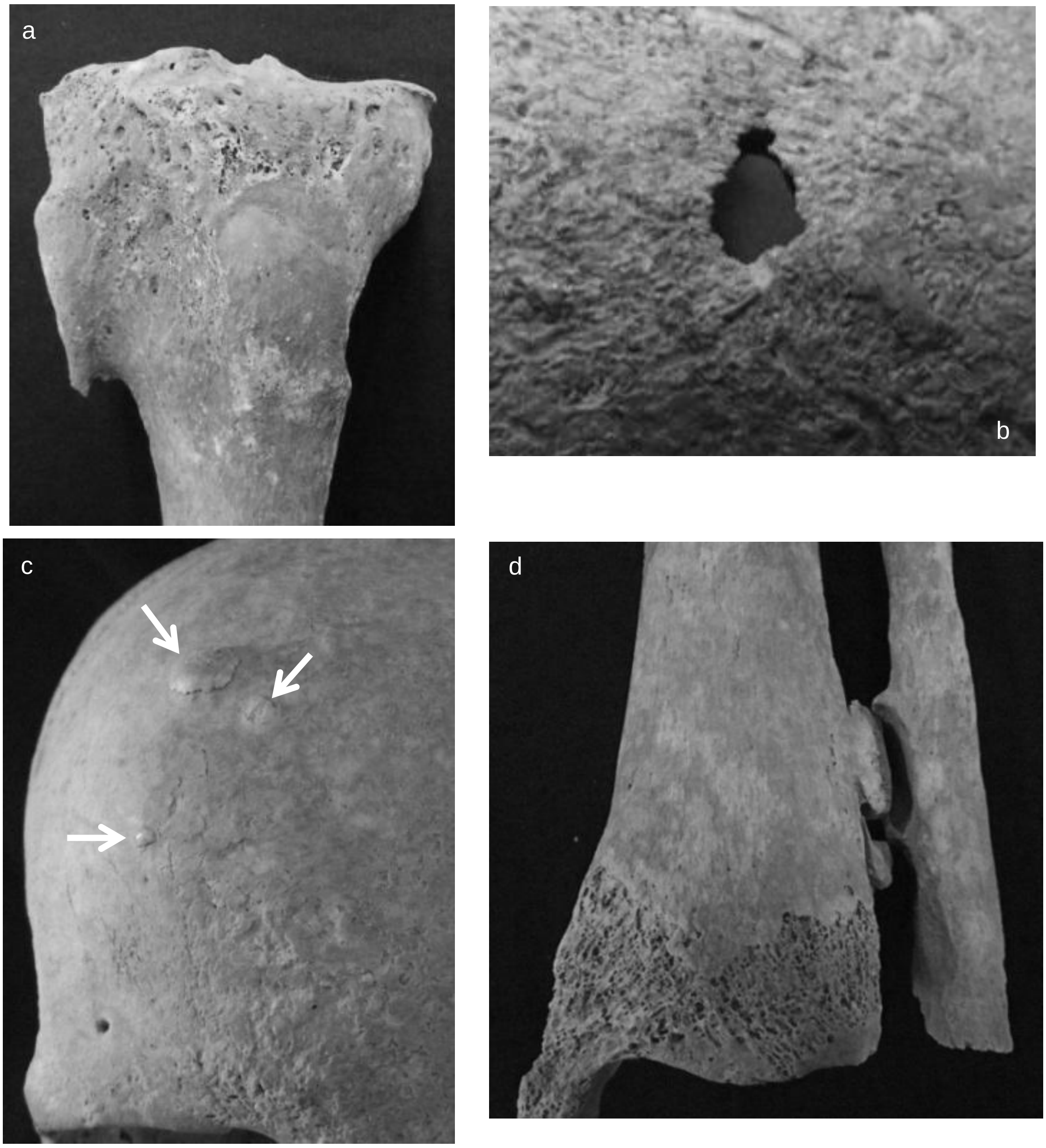

Figure 136. Benign neoplasms: (a) anterior view of left tibia showing probable benign osteochondroma, ANC 229; (b) possible meningioma at frontal bone, ANC 14; (c) anterior view of right frontal showing ‘button’ osteomata, HYS 13; (d) anterior view of distal left tibia and fibula showing probable osteochondroma, CFX 390.

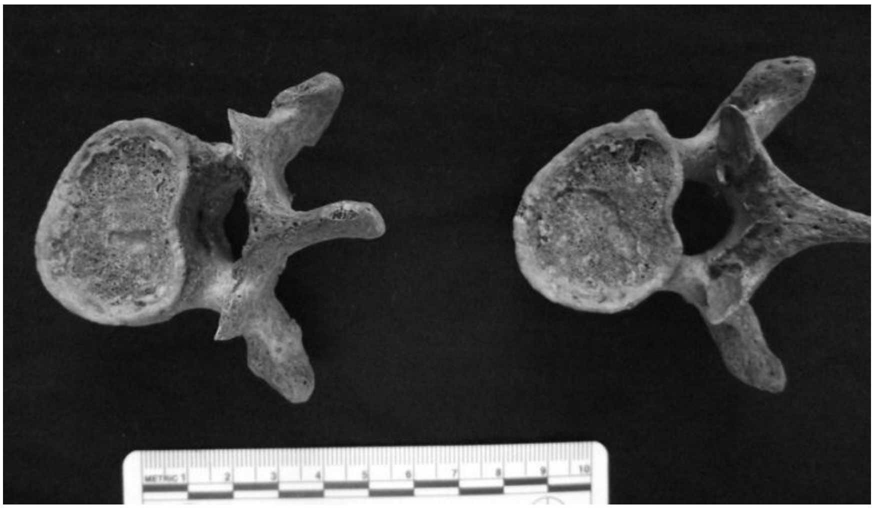

Figure 137. Slight scoliosis of the spine, ANC 282.

Figure 138. Congenital(?) ankylosis of the second and third cervical vertebrae, CHR 624.

Figure 139. Posterior view of right mandibular condyle showing probable congenital defect, ANC 129A.

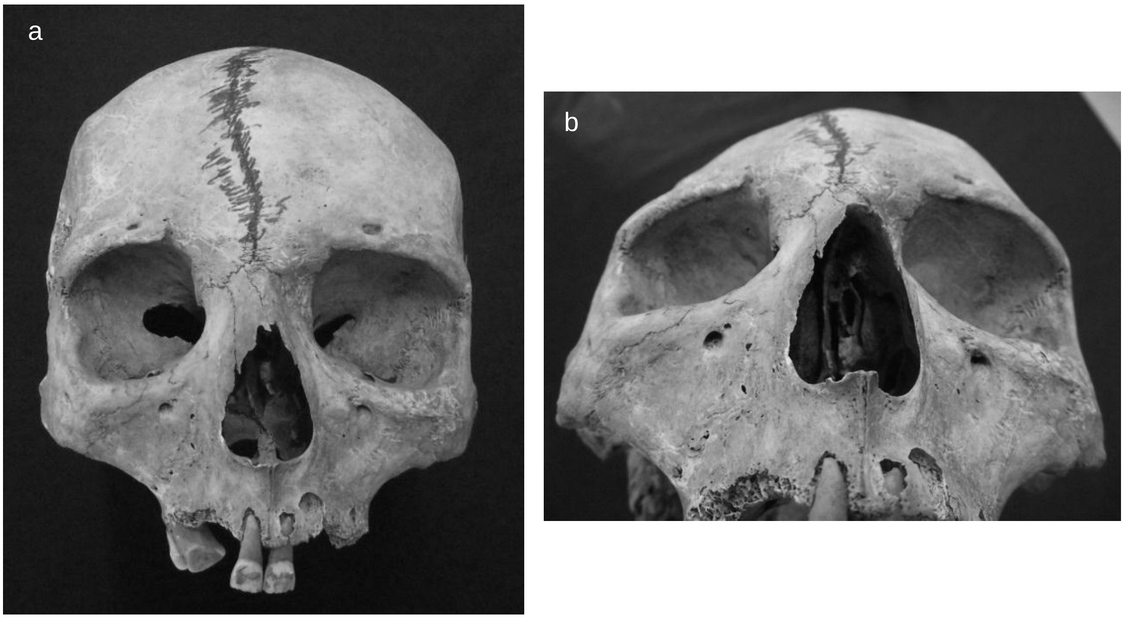

Figure 140. Asymmetry of the skull, ANC 176: (a) anterior view; (b) inferior view. (N.B. The black line at the frontal was drawn by a previous researcher).

Figure 141. Superior view of the skull of ANC 204A, showing broad parietals.

Figure 142. ‘Pigeon chest’ deformity of the sternum, ANC 45.

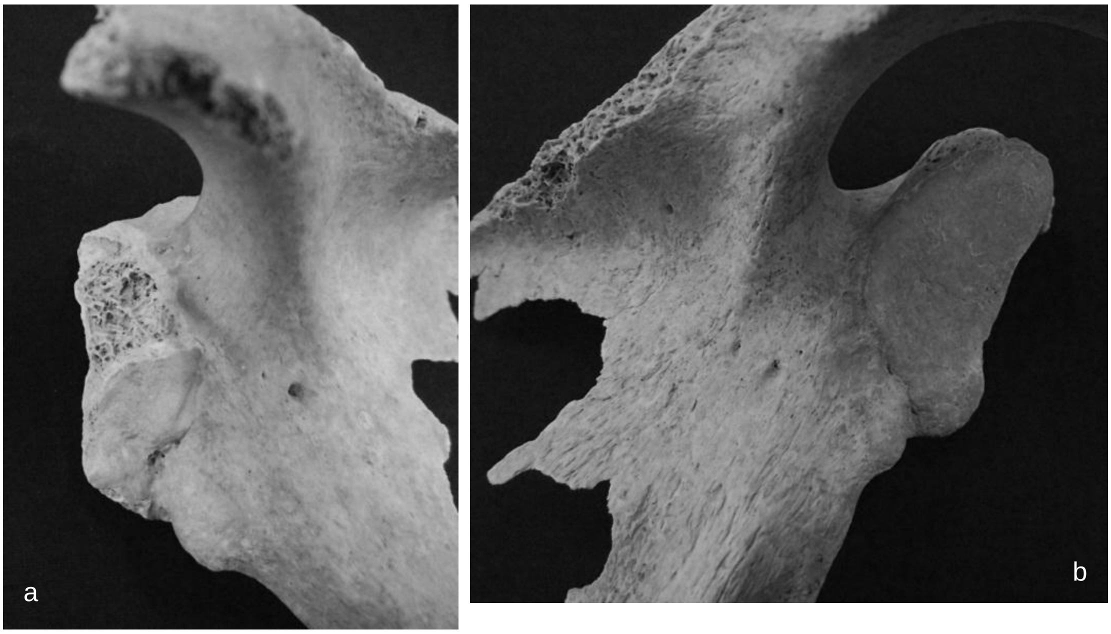

Figure 143. Primary scapular neck dysplasia, CHR 638: posterior views of (a) left and (b) right scapulae.

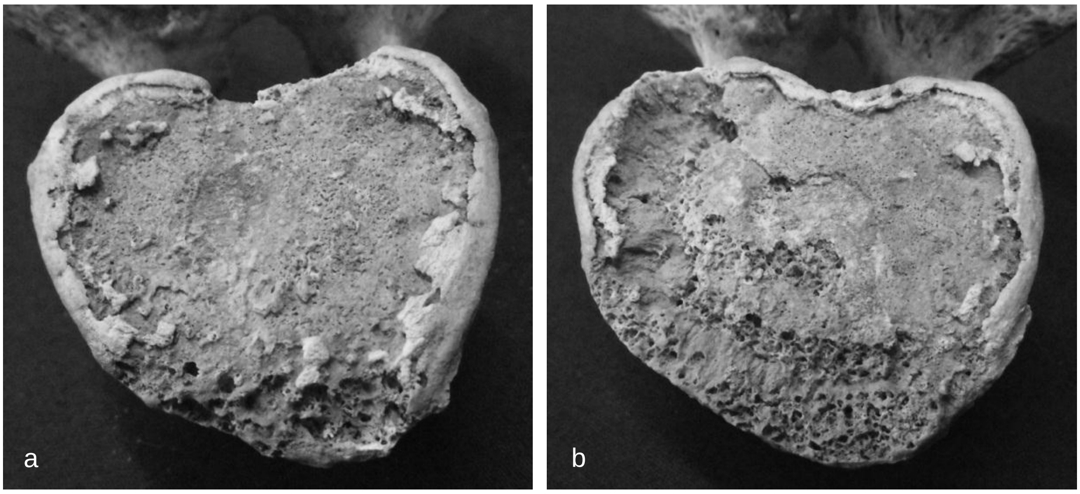

Figure 144. Vertebral lesions of uncertain aetiology, ANC 1: (a) inferior view of the T9 and (b) superior view of the T10.

Figure 145. Vertebral lesions of uncertain aetiology, ANC 201: (a) superior view of the T10 and (b) inferior view of the L4.

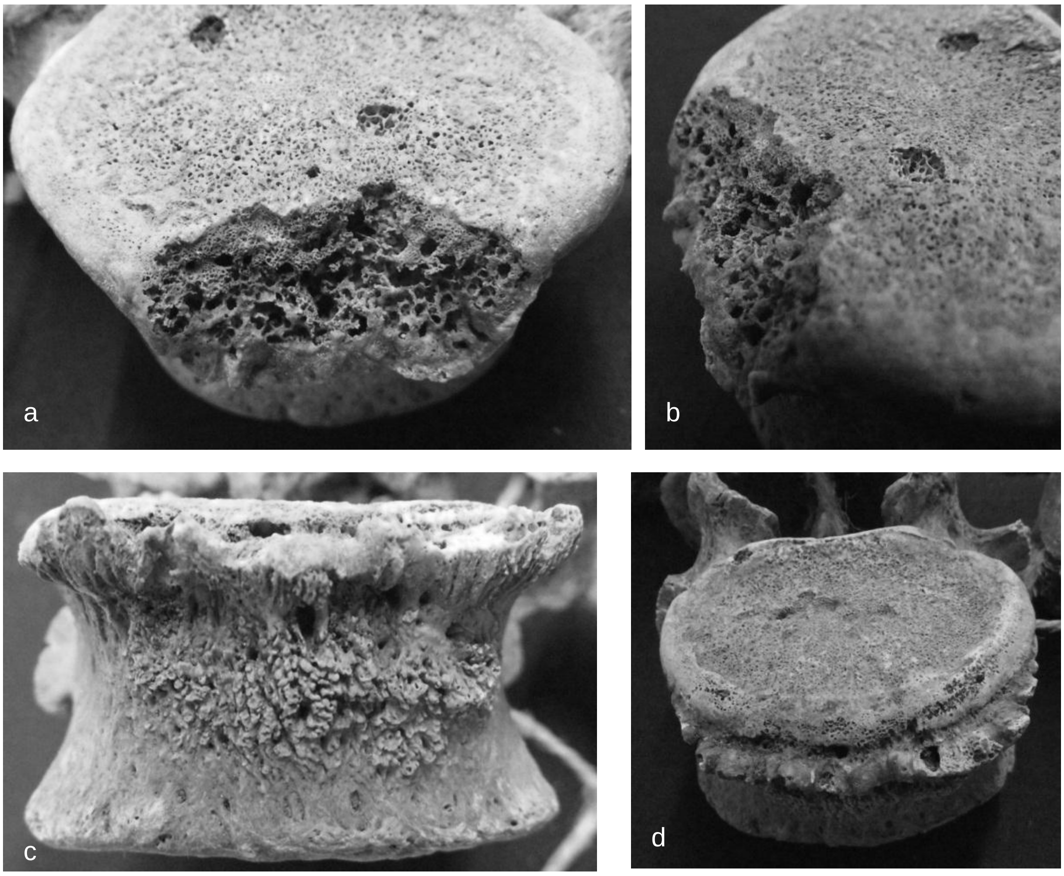

Figure 146. Vertebral lesions of uncertain aetiology, ANC 179: (a) anterior-superior view and (b) left lateral view of the L5; (c) anterior view of L4; (d) superior view of the L4.

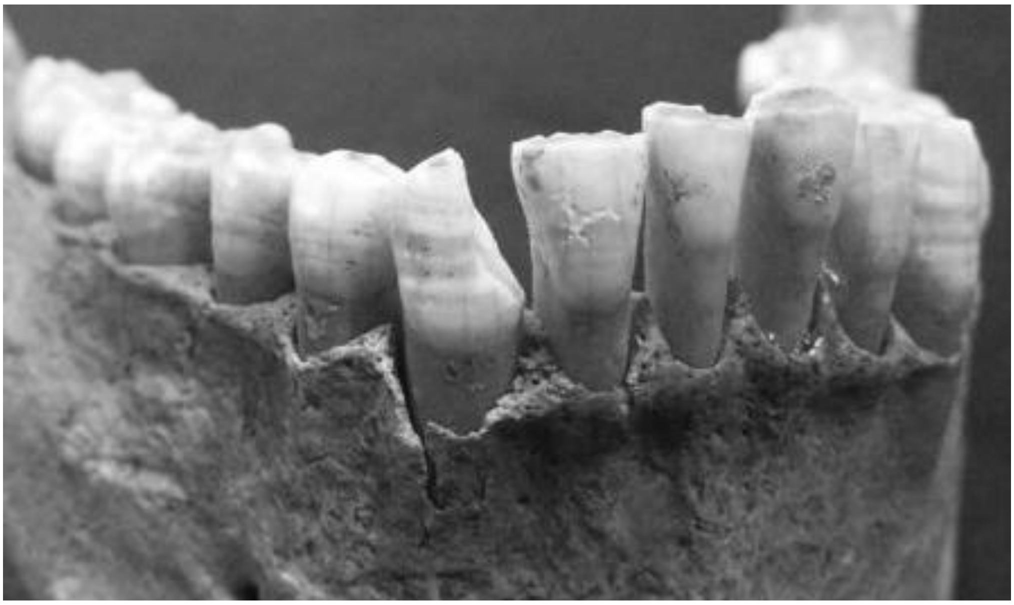

Figure 147. Dental enamel hypoplasia (ANC 12).

Figure 148. Enamel hypoplasia with associated caries (ANC 233).

Figure 149. Dental disease: (a) caries and associated abscess (VR 106); (b) periodontal disease and CEJ/root caries (ANC 3); (c) calculus (ANC 230); (d) edentulous mandible (ante-mortem tooth loss)(NR F393).